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In this paper, I estimate a dynamic structural model of labor supply, retirement, and informal care supply, incorporating labor market frictions and the German tax and benefit system. I find that informal elderly care has adverse and persistent effects on labor market outcomes and therefore negatively affects lifetime earnings, future pension benefits, and individuals' well-being. These consequences of caregiving are heterogeneous and depend on age, previous earnings, and institutional regulations. Policy simulations suggest that, even though fiscally costly, public long-term care insurance can offset the personal costs of caregiving to a large extent – in particular for low-income individuals.

Keywords: long-term care; informal care; long-term care insurance; labor supply; retirement; pension benefits; structural model
JEL Classification: I18, I38, J14, J22, J26

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1. Introduction

Long-term care (LTC)[1] is among the fastest growing branches of health care markets. In 2015, public LTC spending accounted for 1.7% of GDP across OECD[2] countries (OECD, 2017). Due to population aging, this spending on LTC as share of GDP is projected to double until the year 2060 (De la Maisonneuve and Martins, 2013). Today, throughout the industrialized world, most LTC is provided informally by the family. For example, about 70% of all LTC recipients in the U.S. and Germany rely on some kind of informal care (Skira, 2015; Pfaff, 2013). Yet, acting as an informal caregiver often competes with participating in the labor force and might hence result in sizable opportunity costs for the involved caregiver (e.g. Ettner, 1996; Bolin et al., 2008; Crespo and Mira, 2014). To mitigate negative effects of caregiving, many of the existing social security systems aim to insure against the financial risk of LTC, which often includes cash transfers that can be used to compensate the informal caregiver (Brugiavini et al., 2017). Therefore, key questions for investigation concern the effects of informal care provision on caregivers' labor supply, the resulting magnitude of individual costs, and how they are affected by public long-term care insurance (LTCI) or similar institutions. Another important question is how these policies affect total fiscal costs, accounting also for indirect costs such as reduced tax revenues or social security contributions.

In this paper, I address these questions by estimating a dynamic structural model that describes care choices, labor supply and retirement decisions of women in Germany. The model builds on work by Skira (2015) who emphasizes the importance of labor market frictions and human capital accumulation, when estimating consequences of informal caregiving. In this model, agents can make discrete decisions about their labor supply, their retirement state and whether they want to provide informal LTC to a relative. Each choice yields a payoff in the current period but also affects future payoffs due to the transition of state variables. Therefore, the agent makes decisions based on current and future discounted utility. Like Skira (2015), I model wages and job offer probabilities to depend on past labor market choices. In addition, I allow care and labor market choices to affect expected inheritance, benefits from LTCI, and annuities from the public pension system, which depend on the entire job history. The model is estimated using the years 2001 until 2015 of the German Socio-Economic Panel (SOEP) which includes nearly 11,000 households and about 30,000 persons each year. I concentrate on women aged 55 to 67.

I use the estimated model to simulate labor supply reactions and the personal costs of caregiving under different institutional settings. To quantify individual's costs of LTC I use two alternative measures. First, I follow Adda et al. (2017) who estimate career costs of children by calculating changes in lifetime income. Similar to childcare, women are often the primary providers for elderly care. Providing informal elderly

[1] Long-term care usually summarizes services which provide help to impaired individuals who cannot care for themselves for longer periods. It incorporates non-medical help to perform activities of daily living such as eating, dressing, or using the bathroom.

[2] The Organization for Economic Co-operation and Development.

care might, therefore, be an additional reason for the disadvantages of women regarding their income opportunities. Hence, I view changes in lifetime income as an informative measure for individuals' costs of elderly care. Second, I follow Skira (2015) and Coe et al. (2018) and measure the costs to well-being by calculating a lump-sum amount of money that is necessary to equal well-being between alternative scenarios. This measure does not only account for forgone income but additionally for consequences on leisure and (dis-)utility from caregiving.

While many papers have addressed effects of informal care provision on caregivers' labor supply (see Bauer and Sousa-Poza, 2015; Lilly et al., 2007, for reviews), the majority of those papers only considers short-run effects. However, accounting for long-run effects is important because the consequences of caregiving are more severe if the negative relationship between care and labor market outcomes is persistent. Reducing working hours or dropping out of the labor force might lead to a lower chance of future employment if, due to labor market frictions, caregivers are unable to take up employment again after their caregiving activity has ended (Skira, 2015; Schmitz and Westphal, 2017). Even if a new job can be found, the work interruption might affect human capital accumulation, result in missed promotion steps, or a worse bargaining position and could hence adversely affect future wage offers (Skira, 2015). Being a caregiver might therefore affect lifetime earnings by persistent lower wages and employment. Further, individuals might retire earlier to provide informal care (Meng, 2012; Van Houtven et al., 2013). In earnings-related pension systems, career interruptions and early retirement usually induce lower retirement income which further affects income opportunities until the end of life (OECD, 2015). Similar to childcare, costs of informal caregiving would be larger if long-run consequences are accounted for. Besides directly affecting caregivers, this would also have higher unwanted fiscal consequences due to, e.g., persistent lower tax payments, fewer social security contributions, or increased unemployment benefits.

Only few previous studies analyze the dynamics of LTC and labor supply. In general, these studies indicate that negative effects of caregiving on labor market outcomes persist into future periods (Michaud et al., 2010; Skira, 2015; Schmitz and Westphal, 2017). Only Fevang et al. (2012), who analyze Norwegian register data, cannot confirm persistence. Arguably, this might be due to the generous option of paid leave that is available to informal caregivers in Norway. It allows caregivers to temporarily leave employment to provide care without risking being unemployed after the care spell.[3] In line with this argument, Skira (2015) shows in counterfactual simulations that (paid) leave reforms can reduce the long-run consequences of informal caregiving.

While many countries provide benefits to informal caregivers, to the best of my knowledge, this is the first paper to analyze the dynamic consequences of an existing public LTCI. In general, if public LTCI is available, the negative consequences of caregiving should be less severe. For instance, in Germany, LTCI provides benefits to individuals with permanent impairments. The benefit scheme for home care consist

[3]In Norway, paid leave is equivalent to 100% of the previous wage (Colombo et al., 2011).

of two parts, informal care, in general provided by nonprofessional family members, and formal care, provided by professional health care services. Informal care benefits are given as cash transfer and are intended to reimburse informal caregivers. Additionally, if caregivers provide intensive care – i.e. more than 14 hours of care per week – the public pension system accounts for this care activity inducing increased pension benefits once retired. With these public institutions in place, the consequences of caregiving on labor supply, lifetime income, and well-being are more ambiguous because they set additional incentives to potential family caregivers. For example, Geyer and Korfhage (2015, 2018) emphasize that LTCI cash transfers impose income effects which tend to increase the negative effect on labor market outcomes.[4] If long-run consequences are also considered, the incentives set by the institutions are more complicated. The income effect that incentivizes reduced employment in the caregiving period could diminish if agents also account for reduced earning opportunities in future periods. In this paper, I isolate the effects of two features of LTCI – (1) cash benefits for care and (2) pension benefits for care – by simulating counterfactual scenarios in which the two benefits are switched off, respectively. This allows to disentangle the incentives set by each component of LTCI and its resulting implications to the costs of care.

Besides relating to the large literature looking at the general relationship between LTC and labor supply (Bauer and Sousa-Poza, 2015; Lilly et al., 2007), this paper contributes to a small emerging empirical literature looking at medium or long-run consequences of caregiving on labor market outcomes. It contributes to this literature in multiple ways: (1) While Skira (2015) focuses primarily on dynamics in wages and job offer probability, I additionally consider the pension system which imposes further dynamics that likely affect decisions about LTC and labor supply – especially close to retirement age. (2) Including this additional channel allows me to look at various dynamic linkages which have not been analyzed before. In particular, it allows to quantify the influence of LTC on future pension benefits and thus helps to understand individuals' full costs of informal care provision.[5] (3) I simulate specific reforms of the LTC system and analyze how they affect labor supply, informal family care, retirement decisions, pension benefits, lifetime income, and caregivers' well-being. More precisely, I analyze two specific features of German LTCI: cash transfers and pension benefits for care. By concentrating on regulations of an existing LTCI, the paper also relates to the theoretical literature analyzing the costs and benefits of public LTCI (e.g. Barczyk and Kredler, 2018). (4) In addition to analyzing the personal consequences of the different features of the LTCI, I also simulate the fiscal implication of informal caregiving under each policy scenario, amplifying the literature of short-run fiscal costs of LTCI (Geyer et al., 2017). (5) I use the German institutional setting, which offers several interesting features that are also important for other countries as well. German LTCI provides benefits solely based on recipients' needs of care. Most

[4] Similarly, Costa-Font et al. (2016) show that economic downturns in Europe – which likely affect the income of potential caregivers – can be associated with an increase in informal care receipt.

[5] By allowing for retirement choices, the paper also relates to the literature analyzing the effects of social security on retirement decisions (e.g. Rust and Phelan, 1997; Gustman and Steinmeier, 2005; French and Jones, 2011; Haan and Prowse, 2014).

(European) countries rely on a similar mix of informal and formal care and many of them provide cash support to family caregivers (Colombo et al., 2011; Brugiavini et al., 2017; Heger and Korfhage, 2018). With respect to retirement insurance, Germany is also an interesting example because the German public pension system is very generous and provides about 85% of the average retiree's income (Boeri et al., 2002).[6]

Simulation results show that informal caregiving reduces the probability of German women to participate in the labor market. Further, due to labor market frictions, informal care has adverse effects on later income opportunities and pension benefits and therefore decreases lifetime income and well-being. However, consequences of caregiving are heterogeneous and depend on age, previous income, and, to a large extent, on institutional regulations. LTCI cash benefits can partially compensate for income losses as long as individuals are still engaged in LTC. The extent of compensation crucially depends on the caregiver's position in the income distribution. Because German LTCI measures are not related to household income but only depend on the level of impairments, low-income individuals benefit (in relative terms) more from LTCI compared to individuals at the higher end of the income distribution. While cash transfers can compensate for family care at the time of caregiving, long-run consequences can be more detrimental. The income effect of the cash transfer increases the negative and persistent effect of caregiving on labor supply and thus has negative consequences for retirement benefits. However, as the German LTCI also contributes to the retirement insurance of informal caregivers, this negative effect on pension benefits can, on average, be offset for individuals at the lower end of the income distribution. Fiscal costs of LTC increase with both reforms. However, about one third of the total fiscal costs of informal LTC do not result from the payments of LTCI but from indirect costs due to reduced tax payments, lower social security contributions, and increased unemployment and social security benefits.

The paper is structured as follows: In sections 2 and 3, I introduce the setup of the structural model, including the German institutions, and its estimation strategy. Section 4 presents the data used and reports first descriptive statistics. In section 5, I show the estimation results before performing simulation exercises in section 6. Finally, section 7 concludes.

2. The behavioral model

I set up a dynamic single agent model. In its general set up the model builds on the structural model estimated by Skira (2015) in the U.S. context. Additionally, it considers the German tax and benefit system, inheritance as additional channel for care supply, and retirement as an additional choice variable. In this model individuals live in a world with T discrete time periods. In each period t they observe a vector of state variables s_t – such as socioeconomic conditions – and make decisions about their actions

[6] However, due to population aging and high unemployment rates, the German pension system faced increasing fiscal imbalance until the late 1990s. Consequently, policy makers tried to cope with this situation by increasing the eligibility age and by lowering replacement rates (Haan and Prowse, 2014).

d_t. In general, agents can make decisions about their labor supply and whether they want to provide care to a relative. They can choose from a discrete set of choice combinations $D(s_t)$ which depends on the observed state vector. Most importantly, agents can only decide to provide informal care if they have a relative in need for care, positive working hours can only be chosen if individuals have a job offer, and retirement only becomes an option if it is legally feasible. Individuals are rational in the sense that their preferences are based on underlying utility which is maximized by the agent. Individuals are forward looking and build expectations about future realizations of the state variables. When making their decisions the agents choose the action d_t that yields the highest discounted expected utility of the current as well as of all future time periods until the terminal period T. Decisions can only be made until the age of 67. After the age 67, all individuals are retired and cannot provide care.[7]

2.1. Discrete Choices

In each year, individuals make decisions on whether they want to provide care and how many hours of care they want to provide $C_t \in \{nc, lc, ic\}$. The discrete options are no care, light care, and intensive care. These discrete choices represent percentiles of the care hour distribution in the sample. lc equals 364 hours a year, corresponds to 7 hours a week, and represents the 25% percentile in the sample – conditional on positive care hours. Likewise, ic equals 1,092 hours a year, corresponds to 21 hours a week and represents the 75% percentile in the sample. The choice between lc and ic also has consequences for retirement benefits and inheritance as will be discussed later. Furthermore, individuals decide about their labor supply, by choosing between no work, part-time work, and full-time work $H_t \in \{nw, pt, ft\}$ as well as making decisions about retirement $R_t \in \{0, 1\}$. The discrete choices represent mass points in the working hour distribution. pt equals 1,040 hours a year, corresponds to 20 hours a week, and represents the 25% percentile in the sample – conditional on positive working hours. ft equals 2,080 hours a year, corresponds to 40 hours a week, and represents the 75% percentile in the sample. All feasible combinations of actions are collected in $D(s_t)$. Some combinations of choices are not feasible. For example, if a person has chosen to retire the only labor market choice available is $H_t = nw$. Other choices might not be feasible because of observed socioeconomic factors or past choices.

2.2. Flow utility

Each periods' actions and states yield immediate utility. Following Rust (1994), I formulate a random utility function (1) to describe current flow utility which combines a non-stochastic part with a random component $\epsilon_t(d_t)$ that cannot be observed by the researcher.[8] Following e.g. Skira (2015) or Geyer

[7]The data section 4 shows that this assumption is very reasonable with respect to working since at age 67 less than 2% of the sample are still employed. However, with respect to caregiving this assumption is more difficult to justify since many older individuals are still engaged in informal care – especially if they provide care for their spouse. The reason for making this simplifying assumption whatsoever is that in this paper I am mostly interested in the tradeoffs between caregiving and labor supply, which are less relevant after retirement.

[8]Note that for the matter of simplicity I abstract from individual indexing in all equations.

and Korfhage (2015), utility is not only affected by consumption and leisure but also by the caregiving choice. A priori, the direct effect of caregiving on utility is ambiguous. On the one hand, caregiving is likely burdensome and physically demanding. Especially the age group 55 years and older – which is studied in this paper – might be prone to physical stress and providing informal care could, hence, have negative consequences on utility. On the other hand, individuals might also have an altruistic motive to be a caregiver (Johnson and Lo Sasso, 2000). If for example parents prefer to be cared for by their children, then the altruistic individual could yield utility from knowing that the parent feels better receiving informal family care instead of formal care in a nursing home. Furthermore, individuals could experience *'guilt'* if they do not provide care to their parents (Li et al., 2010; Mommaerts, 2016). Yet, a care decision can also result for other reasons related to income – e.g. inheritance – or leisure. Flow utility is summarized in the following trans-log utility function.

$$u_t(s_t, d_t, m, \theta) = \theta_1 \ln(aY_t) + (\theta_{2,m} + \theta_3(age_t - 55)) \ln(L_t) + \theta_4 \mathbb{1}(C_t = lc) + \theta_5 \mathbb{1}(C_t = ic) + \epsilon_t(d_t) \quad (1)$$

Because the model abstracts from savings, yearly consumption equals disposable income Y.[9] To adjust income by household size, Y is multiplied by a. I 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 indicates hours available for leisure. According to the literature on retirement decisions, utility of leisure is allowed to vary by age (e.g. Heyma, 2004; French and Jones, 2011).[10] C represents yearly hours used to care for a relative. It enters the utility function as binary indicator for the light (lc) and intensive care (ic) choice respectively – the no care choice serves as the base category. θ is a vector of parameters to be estimated, $s_t \in S$ contains state variables of socioeconomic conditions which affect individual decisions in period t, and S represents the state space of all feasible realizations of the state variables. $d_t \in D(s_t)$ represents the decision made by the individual from a set of different feasible actions $D(s_t)$ in period t. The choice specific error term ϵ_t can be interpreted as an unobserved state variable (e.g., Rust, 1994; Rust and Phelan, 1997; Aguirregabiria and Mira, 2010). Further, I 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). By modeling the probability of belonging to type m as a function of the employment history at the initial age, I also account for non-random initial conditions (Wooldridge, 2005). For further details on the initial conditions, see appendix A.1.

[9] While savings a certainly important in inter-temporal decision making in general, they are less important in the German case because the public pension insurance finances the majority of old-age consumption. The public pension plan is embedded in the model.

[10] Y is further normalized by 12,000 euro each year and L is normalized by the maximum of leisure of 4,160 hours each year.

2.3. Budget constraints

Agent's decisions are subject to time and budget constraints. Equation (2) states that the yearly time available for leisure L, care C, and payed work H is limited. Leisure is determined by the difference between total time available L_{max} and hours used for care and payed work.[11]

$$L_t = L_{max} - C_t - H_t \tag{2}$$

Equation (3) explains disposable income Y which depends on working decisions but also to a large extent on the German tax benefit system. The most important source of income is labor income that depends on working hours H and wage w. As an important distinction compared to Skira (2015), the model includes additional sources of income, such as pension entitlements from the public retirement insurance $pension$ if retirement is chosen, unemployment benefits UB if a person is unemployed, and LTCI cash benefits CB if informal family care is provided. In all cases disposable income depends on non-labor income A, income of the spouse SI, inheritance IH, and social assistance SA as potential additional sources of income. Further, agents must pay income taxes Tax and social security contributions SSC for public health, LTC, unemployment, and retirement insurance. Most of these variables depend on institutional regulations and/or on past labor and caring choices. For instance, the wage is estimated to depend on labor market experience, which is determined by the sum of all past employment choices. To capture disposable income for each choice and state, the model simulates the entire German tax-benefit system. This is described in more detail in the subsections on income 2.7 and on institutions 2.8.

$$\begin{aligned} Y_t = {} & H_t w_t + A_t + SI_t + IH_t + \mathbb{1}(R_t = 1) pension_t \\ & + \mathbb{1}(R_t = H_t = 0) UB + SA_t - Tax_t - SSC_t + \mathbb{1}(C_t > 0) CB_t \end{aligned} \tag{3}$$

2.4. Dynamic programming

In response to the realization of the state vector s_t, the agent makes a choice d_t in order to maximize the expected discounted lifetime utility, given by

$$\max_{d_t \in D(s_t)} E_d \left\{ \sum_{j=t}^{T} \rho_t \beta^{j-t} u_j(s_j, d_j, \theta, \epsilon_j) | d_t, s_t, m, \epsilon_t \right\}, \tag{4}$$

in which ρ_t is an age specific survival probability and β is a discount factor. Following the Bellman's principle of optimality, the optimization problem can be stated as a two-period problem taking only into account the flow utility in t as well as expected value of discounted utility in $t+1$ (Bellman, 1957). Furthermore, if the utility function is additively separable in observable and unobservable components,

[11] $L_{max} = 4,160$ hours per year are assumed which corresponds to 80 hours per week.

the elements in 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[12] then Rust (1987) showed that the agent's value function has the closed form solution

$$v_t(s_t, d_t, m, \theta, \lambda, \psi) = u_t(s_t, d_t, \theta) + \rho_t \beta \sum_{s_{t+1}} \log \left[\sum_{d_{t+1} \in D(s_{t+1})} \exp\{v_{t+1}(s_{t+1}, d_{t+1}, m, \theta)\} \right] p_t(s_{t+1}|s_t, d_t, \lambda, \psi) \tag{5}$$

which can be solved by backward induction. Thereby $p_t(\cdot)$ is a Markov transition probability function representing agents' beliefs about future states. λ and ψ are parameter-vectors determining job offer and care demand probabilities which will be estimated. The exact specification of $p_t(\cdot)$ is described in subsection 2.6. For each feasible choice d_t, choice probabilities can be calculated by

$$P(d_t|s_t, m, \theta, \lambda, \psi) = \frac{\exp\{v_t(s_t, d_t, m, \theta, \lambda, \psi)\}}{\sum_{d'_t \in D(s_t)} \exp\{v_t(s_t, d'_t, m, \theta, \lambda, \psi)\}}, \tag{6}$$

where d'_t represents the other feasible choices.

2.5. State space

In each period the agent observes the state vector

$$s_t = \{H_{t-1}, R_{t-1}, C_{t-1}, JO_t, CD_t, expEQ_t, age_t, lrage_t, region_t, retyears_t, careyears_t, icareyears_t, mar_t, educ_t, malive_t, falive_t, mage_t, fage_t\}$$

which determines the current feasible action space $D(s_t)$, the utility of different choices, and beliefs about transitions into the future. The state space includes past choices of labor supply, informal care hours, and retirement $(H_{t-1}, C_{t-1}, R_{t-1})$. Job offer $JO_t \in \{0,1\}$ represents whether the agent receives a job offer in period t. Positive working hours are only feasible if a job offer exists. Likewise, care demand $CD_t \in \{0,1\}$ indicates whether a person within the agent's family is in need for care. A person can only decide to provide care if e.g. her father or mother demands care on a regular basis. Other state variables which have not been defined so far are the age (age_t) of the agent, years since retirement ($retyears_t$), the number of years care has been provided ($careyears_t$), the number of years in intensive care ($icareyears_t$), the agent's legal retirement age ($lrage_t$), whether the agent lives in East or West Germany ($region_t \in \{west, east\}$), existence of a spouse ($mar_t \in \{0,1\}$), level of education ($educ_t \in \{low, high\}$), whether the father ($falive_t \in \{0,1\}$) or mother ($malive_t \in \{0,1\}$) are alive, and the age of father ($fage_t$) and mother ($mage_t$) if they are still alive.

[12]CDF: $G(\epsilon_t|s_t) = \prod_{d \in D(s_t)} \exp\{-\epsilon_t(d) + \gamma\} \exp\{-\exp[-\epsilon_t(d) + \gamma]\}, \gamma = 0.577$

2.6. Transition probabilities

Equation (5) indicates that beliefs about transition probabilities $p_t(\cdot)$ are crucial to build rational expectations about future utility and thus have to be formulated in order to solve the agent's value function and to estimate structural parameters in the utility function. While some state variables are constant over time $(lrage_t, mar_t, educ_t, region_t)$ or evolve independently of the agent's actions $(age_t, mage_t, fage_t)$ other state variables depend on today's choices and/or have to be estimated.

Deterministic transitions of labor market experience and care years

Labor market experience is an important approximation for human capital accumulation. Furthermore, it determines pension entitlements once the agent is retired. The agent labor market experience depends on each period's working decision. If she decides to work full-time her experience increases deterministically by one additional year; if she decides to work part-time her experience increases by half a year.

$$expEQ_t = \begin{cases} expEQ_{t-1}, & \text{if } H_{t-1} = nw \\ expEQ_{t-1} + 0.5, & \text{if } H_{t-1} = pt \\ expEQ_{t-1} + 1, & \text{if } H_{t-1} = ft \end{cases} \tag{7}$$

Informal care years are important in explaining inheritance from parents. If the agent decides to provide intensive care, her care experience increases by one additional year; if she decides to provide light care it increases by 0.3 years.

$$careyears_t = \begin{cases} careyears_{t-1}, & \text{if } C_{t-1} = nc \\ careyears_{t-1} + 0.3, & \text{if } C_{t-1} = lc \\ careyears_{t-1} + 1, & \text{if } C_{t-1} = ic \end{cases} \tag{8}$$

Further deterministic state variables are years in intensive care and years in retirement. Both variables increase by one if agents provide intensive care or are retired, respectively. They are important for pension benefits and are further described in subsection 2.8 on the German institutions.

Job offer

Individuals can only work on the labor market if they receive a job offer. While in principle working is still possible after retirement, this is uncommon in Germany. Hence, in the model, retirement is an absorbing state, meaning that agents cannot return to the labor market once retired. Consequently, the probability of receiving a job offer is *zero* once agents have retired. On the other hand, if a person was employed in $t-1$ it is likely that she will receive a job offer from the same employer once again. I therefore abstract from layoff and assume a job offer probability of *one* if a person was employed in $t-1$.

Besides helping to identify the model parameters, in the German setting this assumption is reasonable due to the highly institutionalized protection against dismissal especially at higher ages. Only if the agent was not employed and not retired in the previous period, job offer probabilities are estimated. I formulate logit-probabilities that depend on a vector of variables Z_{t-1}. The job offer depends on the level of education, whether the agent lives in east or west Germany, and on being aged 65 or older which is the legal retirement age for most individuals in the sample. The parameter-vector λ will be estimated within the likelihood function (19).

$$P(JO_t = 1) = \begin{cases} 0, & \text{if } R_{t-1} = 1 \\ 1, & \text{if } H_{t-1} > 0 \\ \frac{\exp(\lambda Z_{t-1})}{1+\exp(\lambda Z_{t-1})}, & \text{else} \end{cases} \tag{9}$$

$$\lambda Z_{t-1} = \lambda_0 + \lambda_1 \mathbb{1}(age_{t-1} \geq 65) + \lambda_2 \mathbb{1}(educ_{t-1} = high) + \lambda_3 \mathbb{1}(region_{t-1} = east) \tag{10}$$

Care demand

Similar to the job offer, agents can only provide care if a parent or spouse depends on regular help, i.e. care can only be chosen if there is positive care demand. If a person has already provided care in $t-1$ and if no death has occurred within the family since the end of the last period ($rdeath_{t-1} = 0$), I assume with probability *one* that care will again be demanded in period t. In all other cases, I formulate beliefs as logit-probabilities depending on the vector Q_{t-1}. Care demand is explained by existence and the age of a mother, father, or a spouse (and interactions between them) because informal care is most often provided to parents or spouse and age is one of the most important indicators for LTC needs (e.g. Heger and Korfhage, 2018), The parameter-vector ψ will also be estimated within the likelihood function (19).

$$P(CD_t = 1) = \begin{cases} 1, & \text{if } C_{t-1} > 0 \text{ and } rdeath_{t-1} = 0 \\ \frac{\exp(\psi Q_{t-1})}{1+\exp(\psi Q_{t-1})}, & \text{else} \end{cases} \tag{11}$$

$$\begin{aligned} \psi Q_{t-1} = {} & \psi_0 + \psi_1(mage_{t-1} - 70)\mathbb{1}(malive_{t-1} = 1) + \psi_2(fage_{t-1} - 70)\mathbb{1}(falive_{t-1} = 1) \\ & + \psi_3 \mathbb{1}(malive_{t-1} = 1) + \psi_4 \mathbb{1}(falive_{t-1} = 1) + \psi_5 \mathbb{1}(malive_{t-1} = 1)\mathbb{1}(falive_{t-1} = 1) \\ & + \psi_6 \mathbb{1}(mar_{t-1} = 1) \end{aligned} \tag{12}$$

Survival

Beliefs about the probability of own survival and whether parents or the spouse could die in the future are not estimated. For simplicity, I expect that survival probabilities follow the statistical life tables provided by European Statistics (Eurostat).[13] Naturally, the probability of survival decreases with age.

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

2.7. Income processes

The set of state variables determines the income possibilities such as wage offers, non-labor income, spouse income, or inheritance. The income processes are important for the agent's decision making as some of the state variables depend on past choices.

Wage

The wage is determined by human capital, approximated by work experience ($expEQ$) and the level of education ($educ$), and by whether a person lives in east or west Germany ($region$). Returns to education are allowed to vary by labor market experience. Choosing labor supply in period t therefore has consequences for future income possibilities as it determines future work experience. Further, the wage offer function allows for heterogeneity between the unobserved type m by including a type specific intercept $\omega_{0,m}$. I estimate the parameters of the wage offer function ω inside the maximum likelihood function.[14]

$$\begin{aligned}\ln(wage_t) = \omega_{0,m} &+ \left(\omega_1 expEQ_t + \omega_2 (expEQ_t^2/100)\right) \mathbb{1}(educ_t = low) \\ &+ \left(\omega_3 expEQ_t + \omega_4 (expEQ_t^2/100)\right) \mathbb{1}(educ_t = high) \\ &+ \omega_5 \mathbb{1}(educ_t = high) + \omega_6 \mathbb{1}(region_t = east)\end{aligned} \tag{13}$$

Inheritance

With a certain probability $P(IH_t > 0)$ individuals can receive inheritance in each period. The most important sources for inheritance are parents who are most likely to inherit their wealth to their children. For at least two reasons informal caregiving might also be an important determinant for inheritance. First, Groneck (2017) finds evidence that parents might use bequest to compensate their children who provided needed care. Second, if parents do not receive informal care from their children, they would have to opt for more expensive formal care, which wears down their resources. Lockwood (2018) argues that parents have an incentive to hold on to assets to self-insure against long-term care risks. If children provide informal care instead, parent's precautionary savings are not used and allow higher bequest. If parents move to a nursing home, in Germany, on average, they have to provide about 1,500 euro/month out of pocket for accommodation.[15] If parents receive informal care, savings don't have to be spent on formal care. The higher savings might result in larger inheritance.

[14] When estimating the likelihood function, I follow, e.g., Haan et al. (2017) and include wage measurement error, which adds noise to sample wages but does not affect the received wages in the model. More specifically, I assume that sample log wages are given by $\ln(wage_t) + \mu_t$, where $\mu_t \sim N(0; \sigma_\mu^2)$ and is independent over individuals and years.

[15] See https://www.pflege.de/altenpflege/pflegeheim-altenheim/kosten/ for an overview of costs in nursing homes.

I model inheritance in two steps. First, in each period individuals can receive positive inheritance with probability $P(IH_t > 0)$. Equation (14) states this probability. It depends on age, region, education, informal care years and, importantly, on whether a parent has died in the previous period.

$$
\begin{aligned}
P(IH_t > 0) = Z_0 + Z_1 age_t + Z_2 (age_t^2/100) + Z_3 \mathbb{1}(region_t = east) \\
+ Z_4 \mathbb{1}(educ_t = high) + Z_5 carey_t + Z_6 deathL_t
\end{aligned} \tag{14}
$$

Second, the amount of inheritance depends on region, education, and years of informal long-term care. I estimate both equations, (14) and (15), outside the likelihood function.[16]

$$
\ln(IH_t) = \zeta_0 + \zeta_1 \mathbb{1}(region_t = east) + \zeta_2 \mathbb{1}(educ_t = 1) + \zeta_3 carey_t, \text{ if } IH_t > 0 \tag{15}
$$

Spouse income

If married couples share their joined household income, an important source of additional income results from the spouse. In a sub-sample of all spouses, $\ln(SI)$ is estimated using the following linear regression.[17]

$$
\begin{aligned}
\ln(SI_t) = \kappa_0 + \kappa_1 \mathbb{1}(educ_t = high) + \kappa_2 \mathbb{1}(region_t = east) \\
+ \kappa_3 age_t + \kappa_4 (age_t^2/100) + \kappa_5 \mathbb{1}(age_t \geq 65), \text{ if } mar_t = 1
\end{aligned} \tag{16}
$$

To reduce the size of the state space, I use the agent's age and education as a proxy for the spouses' age and education respectively.

Non-labor income

Finally, I use information on assets, rental, and private retirement insurance income to generate additional non-labor income. To describe non-labor income in the model, I estimate the following linear regression:[18]

$$
\begin{aligned}
\ln(A_t) = \eta_0 + \eta_1 age_t + \eta_2 (age_t^2/100) + \eta_3 \mathbb{1}(educ_t = high) \\
+ \eta_4 \mathbb{1}(region_t = east) + \eta_5 \mathbb{1}(mar_t = 1)
\end{aligned} \tag{17}
$$

2.8. Institutions

Apart from income processes, individuals make their decisions based on institutional settings determining e.g. taxes, social security contribution, and benefits from unemployment, retirement or long-term care insurance. Importantly these regulations affect disposable income and the budget constraint equation

[16] The full regression results can be found in tables 11 and 12 in appendix A.4.
[17] The full regression results can be found in table 13 in appendix A.4.
[18] The full regression results can be found in table 14 in appendix A.4.

Table 1: Eligibility criteria for LTC benefits

	Care level		
	I	II	III
Necessary care:	Limitations in at least two ADL (personal hygiene, feeding, mobility; so called "basic care" (*Grundpflege*) and limitations in at least one IADL. Average care needed per day of at least 90 minutes. More than 45 minutes must be necessary for basic care.	Average care needed per day of at least 180 minutes. More than 120 minutes must be necessary for basic care.	Average care needed per day of at least 300 minutes. More than 240 minutes must be necessary for basic care.

Source: Geyer and Korfhage (2018)

(3) and are therefore integrated into the model. In the model, agents do not expect policy changes but expect the status quo regulations to also hold in future periods.

Long-term care insurance

In Germany, the LTCI provides benefits to individuals with permanent (at least six months) impairments in at least two activities of daily living (ADL) and one instrumental activity of daily living (IADL).[19] Depending on the level of impairments, three care-levels are distinguished. They are assessed by an independent institution – the Medical Service of the Health Funds – and can therefore be interpreted as objective measures of health. Table 1 provides an overview of the eligibility conditions. LTCI consists of two parts, informal care, in general provided by nonprofessional family members and formal care provided by professional health care services.

The German LTCI hence offers multiple choices to the eligible individual. First, they can decide about the kind of benefits they prefer. Informal care benefits are given as cash transfer whereas formal care is organized as an in-kind transfer. In 2015 monthly benefits in cash for informal care ranged from 244 euro (in care-level I) up to 728 euro (in care-level III).[20] According to national statistics about 70% of all recipients choose cash benefits. This number is even higher if individuals can count on help from relatives (Geyer and Korfhage, 2015). In the model, individuals choose cash benefits if family care is provided to them.

Second, the German cash benefits are neither means tested, earmarked nor is their spending monitored. In general, eligible individuals could use the benefits for their own consumption rather than for reimbursement of family caregivers. However, the law explicitly intents cash benefits to reimburse informal caregivers[21] – which is why, e.g. Michaelis (2005) expects that cash benefits are largely transferred to

[19] Rothgang (2010) and Schulz (2010) provide detailed overviews about the LTC insurance in Germany.

[20] In-kind benefits for formal care are more generous. These range from 468 euro per month up to 1,612 euro and are directly paid to the service provider.

[21] On their homepage the German Federal Ministry of Health (BMG) states: *"Das Pflegegeld wird den Betroffenen von der Pflegekasse überwiesen. Sie können über die Verwendung des Pflegegeldes grundsätzlich frei verfügen und geben das Pflegegeld regelmäßig an die sie versorgenden und betreuenden Personen als Anerkennung weiter."* (*"The cash benefit is transferred to the person in need for long-term care. In general, they can freely dispose of the use of the long-term care allowance and regularly pass the long-term care allowance to the caring persons as recognition."*). See https://www.bundesgesundheitsministerium.de/.

Table 2: Features of the German Long-term Care Insurance 2000-2016

Year	Real in-cash benefits			assumed reimbursement of benefits	
	Care Level I	Care Level II	Care Level III	light care[1]	intensive care[2]
2000	205 euro	410 euro	665 euro	137 euro	399 euro
2001	205 euro	410 euro	665 euro	137 euro	399 euro
2002	205 euro	410 euro	665 euro	137 euro	399 euro
2003	205 euro	410 euro	665 euro	137 euro	399 euro
2004	205 euro	410 euro	665 euro	137 euro	399 euro
2005	205 euro	410 euro	665 euro	137 euro	399 euro
2006	205 euro	410 euro	665 euro	137 euro	399 euro
2007	205 euro	410 euro	665 euro	137 euro	399 euro
2008	205 euro	410 euro	665 euro	137 euro	399 euro
2009	215 euro	420 euro	675 euro	143 euro	405 euro
2010	225 euro	430 euro	685 euro	150 euro	411 euro
2011	225 euro	430 euro	685 euro	150 euro	411 euro
2012	235 euro	440 euro	700 euro	157 euro	420 euro
2013	235 euro	440 euro	700 euro	157 euro	420 euro
2014	235 euro	440 euro	700 euro	157 euro	420 euro
2015	244 euro	458 euro	728 euro	163 euro	437 euro
2016	244 euro	458 euro	728 euro	163 euro	437 euro

[1] 67% of cash benefits in care level 1.
[2] 60% of cash benefits in care level 3.

informal caregivers. In order to ensure quality of informal home care, a professional care service reviews recipients of cash benefits twice a year (Schulz, 2010). In the model, the transferred cash amount depends on the hours of provided informal care and relates to regulations of the LTCI. Table 1 summarizes the eligibility criteria for each care level. I imply that the care depended person needs at least the minimum criteria of care. For example, a person in the first care level needs 90 minutes of care each day. If the caregiver provides 60 minutes a day, she will provide about 67% of the necessary care. In the model, the informal caregiver will be reimbursed with 67% of the available cash benefits. This reimbursement is summarized in table 2. The model assumptions in table 2 can also be viewed as expected values of received benefits as they imply parents to be eligible for benefits.

Pension benefits

Public pension benefits in Germany are directly linked to the individual labor market history and the age of retirement. In each year t, individual's pensions are calculated following the German pension formula

$$pension_t = \left(\sum PenP_t\right) \times AF \times PV_t, \tag{18}$$

where $PenP_t$ denotes so called pension points, AF denotes a retirement age factor, and PV_t denotes a year specific pension value. Individuals accumulate pension points for every year of employment. They depend on personal labor earnings as well as on the mean gross population earnings in the period of

Table 3: Pension points for informal long-term care

Care Level	Min. Care Hours	Pension Points	Pension Points in Model
I	14	0.27	0.50
II	14	0.36	0.50
II	21	0.53	0.50
III	14	0.40	0.50
III	21	0.60	0.50
III	28	0.80	0.50

employment. They are calculated as $\min\{H_t w_t / \overline{H_t w_t}, Max_t\}$, where $\overline{H_t w_t}$ denotes the mean gross labor earnings in period t and Max_t denotes a year specific cap on pension points which varies roughly around two. If an individual earns exactly as much as the population average, she will thus receive exactly *one* pension point in that year. The mean gross earnings in east Germany is adjusted to account for lower salary in that region.

Additional to employment history other factors can impact pension points as well. Most notable for this paper is the treatment of time used to care for relatives.[22] Individuals collect pension points if all of the following conditions are satisfied: (1) if they give care to a relative who is eligible for benefits from LTCI (see Subsection 2.8), (2) if care is provided for at least 14 hours a week, (3) if the care dependent person lives at home, and (4) if they do not spend more 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 caregiving. If individuals are retired, they do not benefit from this regulation. In the model, individuals collect 0.5 $PenP_t$ if they do not work full time, provide intensive care, and are not retired. This is amount is not negligible as it is equivalent to earning 50% of the average population, which might be more as many women earn e.g. on an average part-time job. The model assumptions are summarized in table 3.

Importantly, age-based criteria regulate access to the pension benefits and its generosity. The most important age-based parameter is the full pensionable age. At this age the age factor AF is equal to *one* and individuals can receive a publicly provided pension with a value proportional to the sum of pension points accumulated until retirement. For the individuals under study the full pensionable age varies between 65 and 67. If individuals retire at younger ages, the AF is 0.003 lower for each month prior the full pensionable age. Individuals can decide to retire up to 5 years before the full pensionable age. In that case the AF is 0.82 instead of one and the pension is 18% lower compared to the scenario in which the full pensionable age is reached. If individuals retire at higher ages the AF increases by 0.005 for each month after the full pensionable age. The highest possible AF is 1.3 which is reached after 5 years. Importantly, the AF is determined in the first year of retirement and does not change afterward. That is, if a person retires early, pensions stay depreciated until the end of life.

[22] Further examples are children and maternity leave, education, or military service. The model abstracts from these factors.

The pension value PV_t is set each year to reflect the wage development in Germany, inflation, and demographic trends in the population.[23] Even though the German system does not provide a guaranteed minimum pension, individuals can apply for social assistance, if their pensions alone falls short to match the social assistance level. I provide detailed overviews of the assumptions made on $PenP$, AF, and PV in Tables 15 and 16 in appendix A.5.

Social security contribution

Each individual's income is subject to social security contributions (SSC) for public health, LTC, unemployment, and retirement insurances. The contributions total to about 20% of gross earnings. Pensions are also subject to SSC but only for health and LTC insurance. Further, the SSC is capped. This cap is higher in west Germany compared to east Germany (6,200 euro compared to 5,400 euro in 2016).

Income tax

Income tax is calculated on an annual basis and follows a smooth progressive income tax function (§32a EStG). Taxable income is defined as the sum of gross income from employment above an exemption threshold.[24] Up to a maximum amount, SSC are deducted. Between 2000 and 2016 the yearly tax-free allowance increased from 6,902 euro to 8,652 euro. The top marginal tax rate decreased from 51% to 45%. Additional to income tax, individuals have to pay an extra tax of 5.5% to finance the costs of German reunification (*Solidaritätszuschlag*). In the model, I specify the basic German tax formula as it is given by law. For more details see Table 17 in appendix A.6.

Unemployment Insurance and Basic Social Security

The German system distinguishes between two different kinds of unemployment benefits ALG1 and ALG2. After losing a job, non-employed individuals receive the first kind of unemployment benefits (ALG 1), which provides benefits of 60% of previous net earnings (capped at 1,880 euro per month) and is payed up to 12 months.[25] If individuals depend on benefits for longer than 12 month or if they are not eligible for other reasons, they receive the means tested ALG2. Within the observation period it increased from about 606 euro in 2000 to 712 euro in 2016. In the model set up, I abstract from ALG1 and imply that unemployed individuals always receive ALG2 if they pass the means test. If individuals are not capable of working – e.g., for health reasons – or if their pensions are below the basic social security level, they receive social security payments similar to ALG II. As both institutions provide very similar benefits, I treat them as one interchangeable benefit in the model. See Table 17 in appendix A.6.

[23] I assume that individuals expect the cohort-specific rules that define the public pension system will be maintained in the future. I assume that this modeling approach does not neglect any important anticipated future changes in the public pension system.

[24] Gross income from assets and income from renting are not considered in the model

[25] Unemployed individuals who are older than 50 years can receive unemployment benefits up to 24 months if they had been employed for more than 48 months.

3. Estimation

I estimate the dynamic model using maximum likelihood. My approach slightly diverges from the standard approach formulated in Rust (1994) and Rust and Phelan (1997). The reason is that the state variables *job offer* and *care demand* are unobserved. However, for both variables some information is recoverable. Individuals can only choose positive working hours conditional on a positive job offer and they can only decide to provide informal LTC conditional on positive care demand. Using this information, the latent variables are partially identified by the data. I apply a similar approach as in Iskhakov (2010) and use the probability functions (9) and (11) to integrate over the unobservables. Hence, the likelihood incorporates the probability distribution of $\{JO, CD\}$ and takes the following form

$$L(\theta, \lambda, \psi, \omega, \alpha) = \prod_{i=1}^{I} \Bigg[\sum_{m} P(m|s^i_{T^i_0 -1}, \alpha) \prod_{t=T^i_0}^{T^i} \sum_{(jo,cd)} q_t(jo, cd|s^i_{t-1}, d^i_{t-1}, \lambda, \psi) \\ P(d^i_t|s^i_t, m, \theta) f(ln(wage^i_t)|m, \omega) \Bigg] \tag{19}$$

with $P(d_t)$ representing the choice probability (6) which is derived in the dynamic model. (jo, cd) are the elements of all possible combinations of job offer and care demand and q_t is the probability of being in state (jo, cd) which is derived from functions (9) and (11). $P(m)$ represents the agents' probability of being the unobserved type m. This allows individuals to differ in permanent ways due to unobserved variables which are correlated to initial conditions. As individuals are observed for different time spans, T^i_0 indicates the first observation period and T^i her last observation. $f(ln(wage))$ is the density of the sample wage observation, again conditional on the individual's unobserved type.[26] To simplify notation, $f(\cdot)$ is set to one for non-employed and retired individuals, for whom the wage is not observed. The parameter vector $\{\theta, \lambda, \psi, \omega, \alpha\}$ will be estimated. I approximate the value function using interpolation as suggested in Keane and Wolpin (1994). I 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.1, A.2, and A.3, respectively.

Only accepted job offers and care demand are observed in the data, which makes it challenging to distinguish the labor supply and the informal care decision from the job offer and care demand probabilities. However, the functional form assumptions made in the model and exclusion restrictions allow me to separately identify utility parameters from the parameters in the job offer and care demand functions.

As the job offer probability equals *one* if individuals have worked in the last period and does not distinguish between part-time and full-time work, the utility of leisure is separately identified from the job offer parameters by the transitions from full-time to part-time, from part-time to full-time, from full-time to not working, and from part-time to not working. Moreover, age enters the utility function

[26] Recall, that the sample log wage is equal to the actual log wage plus a normally distributed measurement error.

linearly while only shifting the job offer probability if the age 65 is reached. The job offer function further includes parameters for high education and living in east Germany. These variables do not enter the utility function and therefore serve as additional exclusion restrictions in estimating the job offer probability.

Similarly, care demand equals *one* if care was provided in the previous period and parents did not die after the last period. Hence, the utility of care provision is separately identified from the care demand parameters by transitions from intensive care to light care and from light care to intensive care. Additionally, it is identified by transitions from light care to no care, and from intensive care to no care if parents did not die in the previous period. Furthermore, the ages of mother and father only enter the care demand function and therefore also serve as exclusion restrictions in the estimation of care demand.

4. Data

For the empirical analysis, I use data from the German Socio-Economic Panel Study (SOEP), which is an annually repeated representative panel survey on households and persons living in Germany. Since 1984 it includes nearly 11,000 households and about 30,000 persons each year.[27] I use the waves 2001 through 2015 since these include information on informal care provision and focus on women aged between 55 and 67 years, who are likely to be caregivers. After dropping all missing observations, I use 23,558 observations. About 10.5% are engaged in LTC.

4.1. Variable definition

The three choice variables of caregiving, working hours, and retirement are all constructed from self-reported measures assessed in SOEP. Each year, survey participants are asked to give detailed information about various employment characteristics in the previous year, including employment status and the month of retirement. Employed individuals are further asked about the hours (per week) they generally work, including any overtime. Furthermore, individuals are asked what their typical day is like and how many hours they spend on certain activities on a typical weekday. I use the answer on *"care and support for persons in need of care"* to construct the care choice variable.[28] The variable might therefore capture both personal and chore care activity.

4.2. Descriptive statistics

Table 4 summarizes the data vector $\{d_{it}, s_{it} : i = 1, 2, ..., N; t = 1, 2, ..., T_i\}$. On average, caregivers in the sample are less often employed and work fewer hours. Further, they are more often married and

[27] For a description of SOEP, see Wagner et al. (2007) and http://www.diw.de/soep, also including detailed questionnaires.
[28] In later waves it is also asked for care on Saturdays and Sundays. However, to keep the panel consistent, I only use the answers for weekdays in all waves.

their parents – especially mothers – are more often alive. These empirical results match expectations: as parents or spouses are usually the recipient of informal care, one of them must be alive for individuals to face care demand. The lower labor supply corresponds with the empirical findings in the literature (Lilly et al., 2007; Bauer and Sousa-Poza, 2015).

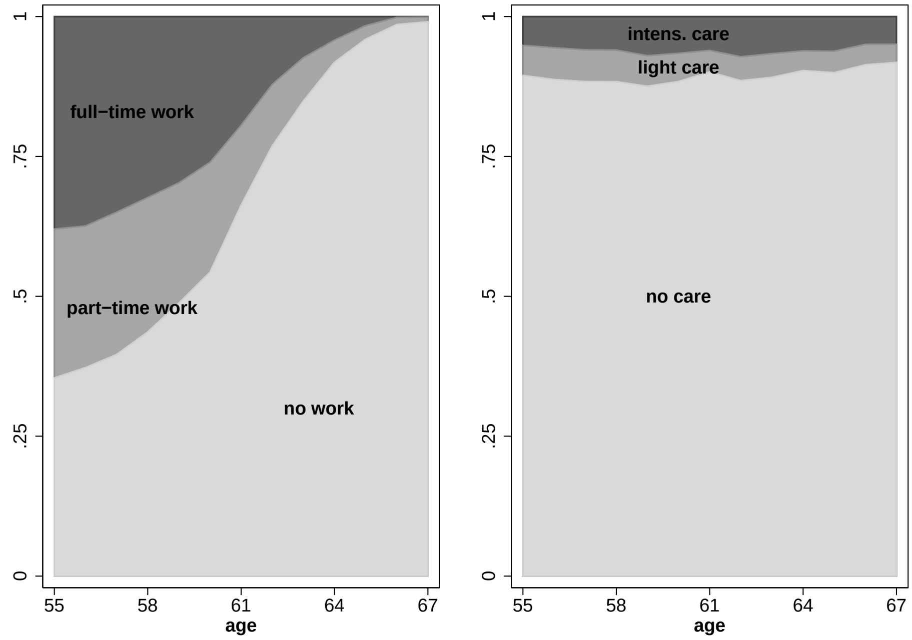
Table 4: Descriptive statistics

	(1) Non-carers		(2) Carers	
	mean	sd	mean	sd
Actions				
no work	0.67	0.47	0.72	0.45
part-time work	0.14	0.35	0.13	0.33
full-time work	0.19	0.39	0.15	0.36
no care	1.00	0.00	0.00	0.00
light care	0.00	0.00	0.43	0.50
intens. care	0.00	0.00	0.57	0.50
retired	0.39	0.49	0.38	0.49
State-variables				
age	61.14	3.81	60.78	3.69
region	0.26	0.44	0.28	0.45
educ	0.22	0.42	0.25	0.43
expEQ	23.33	11.55	22.78	11.34
carey	0.29	0.95	1.84	2.22
ecarey	0.08	0.51	0.68	1.60
malive	0.25	0.43	0.52	0.50
mage	84.23	5.35	86.17	4.97
falive	0.11	0.31	0.14	0.34
fage	85.87	5.79	86.64	5.23
mar	0.77	0.42	0.82	0.38
page	63.79	5.77	63.73	5.55
Observations	21074		2484	

Note: mage, fage, and page are conditonal on the existence of mother, father, and partner respectively.
Source: SOEP, own calculation.

Figure 1 shows the distribution of the working and caring choices over time. While at age 55 almost 75% of all women are employed, this share decreases with age. At age 67 less than 5% are still employed – and the share of full-time work is almost zero. With respect to informal care giving, individuals in the sample do not follow an obvious age profile – instead the fraction of caregivers stays almost constant at about 5-6% light and intensive care, respectively.

Figure 1: Work and care choices by age



Source: SOEP, own calculations.

5. Results

Table 5 presents the structural model estimates. Due to the interactions in the utility model, the coefficients in the utility function are difficult to interpret. However, consumption, which is measured in personal income, has a positive coefficient and yields positive utility. The utility of leisure crucially depends on age and the agent's unobserved type but is positive for all individuals. On the other hand, the caregiving coefficients are negative. On average, for caregivers the negative consequences, e.g. physical demanding tasks or resulting health problems, outweigh the positive spillover effects from parents' utility – if the individuals are altruistic.

The job offer probability – conditional on not working and not being retired in the previous period – decreases if agents are older than 65 or if they have *high* education. The conditional job offer probability is higher for women who live in East Germany. The care demand probability depends on the whether there is a living father or mother and on their ages. Since parents in the data are at least 70 years old, a living mother positively affects care demand – irrespective of the negative intercept. Care demand further increases if women have a spouse, but it cannot be explained by whether the father is alive. The wage offer increases with work experience for all individuals with decreasing marginal returns. The returns further vary by education level. High educated individuals, on average, receive higher wage offers and have higher returns from work experience compared to low educated individuals. On average, women in East Germany receive lower wage offers, which mirrors the still existing income gap between West

Table 5: Structural model parameter estimation results

Description	Parameter	Estimate	S.E.
Utility parameters			
Consumption	θ_1	2.293	0.064
Leisure hours (type 1)	$\theta_{2,1}$	0.548	0.076
Leisure hours (type 2)	$\theta_{2,2}$	1.291	0.314
Leisure age trend	θ_3	0.131	0.011
Light care	θ_4	−0.600	0.045
Intensive care	θ_5	−0.458	0.039
Job offer probability parameters			
Intercept	λ_0	−2.751	0.069
Aged 65 or older	λ_1	−1.473	0.373
High education	λ_2	−0.036	0.149
Lives in east Germany	λ_3	0.531	0.127
Care demand probability parameters			
Intercept	ψ_0	−2.345	0.046
Mother age if alive	ψ_1	0.042	0.010
Father age if alive	ψ_2	−0.004	0.018
Mother alive	ψ_3	−0.345	0.170
Father alive	ψ_4	−0.295	0.326
Mother and father are alive	ψ_5	0.043	0.191
Spouse alive	ψ_6	0.491	0.047
ln(wage) offer parameters			
Intercept (type 1)	$\omega_{0,1}$	2.167	0.008
Intercept (type 2)	$\omega_{0,2}$	1.046	0.059
Work experience with *low* education	ω_1	0.019	0.000
Work experience squared/100 with *low* education	ω_2	−0.014	0.001
Work experience with *high* education	ω_3	0.024	0.001
Work experience squared/100 with *high* education	ω_4	−0.030	0.002
High education	ω_5	0.547	0.015
Lives in east Germany	ω_6	−0.343	0.007
Unobserved type probability parameters			
Intercept	α_0	2.520	1.683
Age in initial period	α_1	−0.042	0.030
Labor market experience in initial period	α_2	0.101	0.010
Number of children	α_3	0.394	0.087
Other parameters			
Discount factor (not estimated)	β	0.98	
Obs.		23,558	

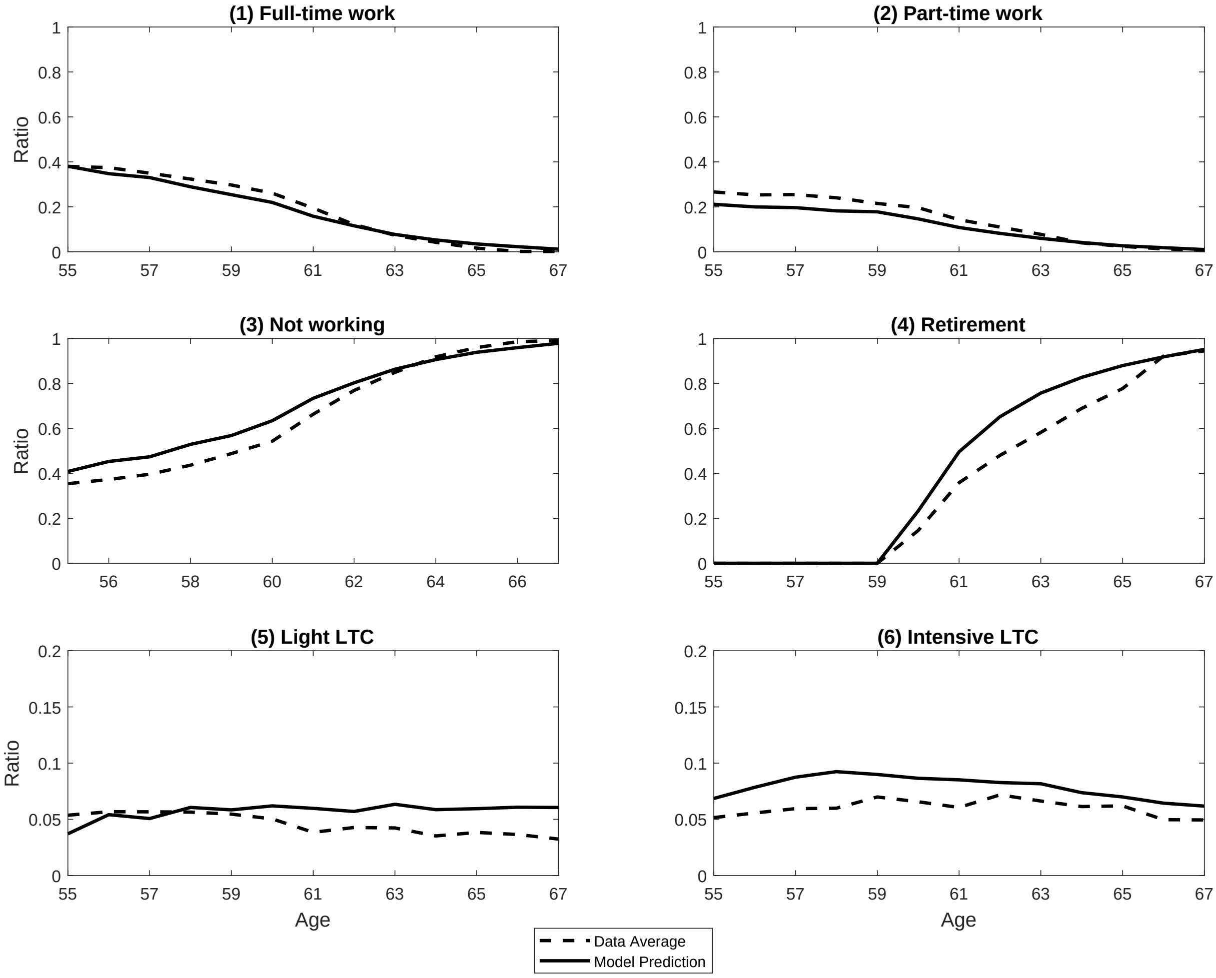
Source: SOEP, own calculations.

Germany and the formerly socialist East Germany. 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, 1995).

Figure 2 shows the fit of the model in the key outcomes of labor and informal care supply. To compare the data averages with the model predictions, a simulated sample was constructed using the dynamic model for five trajectories of action and state variables for each individual in the sample. To ensure comparability with the estimation sample, model predictions were only calculated for simulation outcomes from ages at which a person was also observed in the data. While overall the model fits the data well, caregiving and retirement are slightly over-predicted.

The model should not only fit choice trajectories but also transitions in caregiving and work status. Table 6 summarizes the transitions in the observed and in the simulated data. The model matches the high persistence of non-employment well, while it lightly over-predicts transitions from employment into non-employment. Similarly, for caregiving the model matches persistence in non-caregiving well, but slightly over-predicts transitions from caregiving to non-caregiving and vice versa.

Figure 2: Model fit



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 five trajectories of action 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.
Source: SOEP, own calculations.

Table 6: Model fit of transitions

	Data	Simulated
% Non-employed who are non-employed again next period	97.90	98.97
% Transition from employment to non-employment	17.48	24.35
% Transition from non-employment to employment	2.10	1.03
% Employed who are employed again next period	82.52	75.65
% Non-caregivers who are non-caregivers again next period	95.62	92.39
% Transition from caregiving to non-caregiving	38.37	47.90
% Transition from non-caregiving to caregiving	4.38	7.61
% Caregivers who are caregivers again next period	61.63	52.10

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 five trajectories of action 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.
Source: SOEP, own calculations.

6. Simulations

In this section, I use the structural model to simulate counterfactual scenarios. First, in subsection 6.1, I compare the status quo baseline with a care demand scenario, in which each woman in the sample is confronted with care demand. I use this simulation to assess the average response to increased care demand with respect to labor supply and the caregiving decision. As these choices affect income opportunities, I calculate the changes in labor earnings, retirement benefits, and total income, accounting for current and all future periods. I argue that for caregivers, the forgone income can be interpreted as personal (career) costs of care as it measures the total amount of income that caregivers, on average, loss (or gain) due to their caregiving decision. However, according to the German LTCI, in this simulation caregiving is a choice variable and some women might not provide care even if they are confronted with care demand. For a broader approach, I follow Skira (2015) and Coe et al. (2018) and calculate the costs to well-being as additional measure for the individual costs of informal care. To do this, I repeat the simulation before but remove the option of not providing care. The costs to well-being can then be calculated as a lump-sum amount of money that is necessary to equal well-being between the two scenarios. This measure does not only account for forgone income but also for consequences on leisure or (dis-)utility from caregiving. It can thus be interpreted as a comprehensive measure for the costs of informal care (Coe et al., 2018).

Second, in subsection 6.2, I attempt to disentangle how different features of the German LTCI affect the choices made by agents and their personal costs of care. That is, I repeat the same simulation scenario as before but remove two specific aspects of LTCI, which are intended to encourage and compensate informal care: cash benefits and pension points for caregiving, respectively. Finally, in subsection 6.3, I compare the personal costs of informal care with its fiscal costs. Thereby, I do not only consider the direct costs of care resulting from LTCI transfers, but also the indirect costs that stem from reduced labor supply – and consequently, decreased contributions to the tax and benefit system.

For each evaluated scenario, I create a new simulated data set. First, for each individual in the sample, I solve the model for 25 trajectories in a baseline specification. The simulations are based on the state variables observed in the first available age for each individual. The following state and choice variables result from the predictions made by the model. Second, I change the parameters of interest and solve the model again to compare outcomes with the baseline. To highlight the heterogeneity of LTC consequences, I differentiate between individuals at different positions in the income distribution and show all simulation results for different ages – 55, 59, and 63 – separately.

6.1. Consequences of long-term care demand in the family

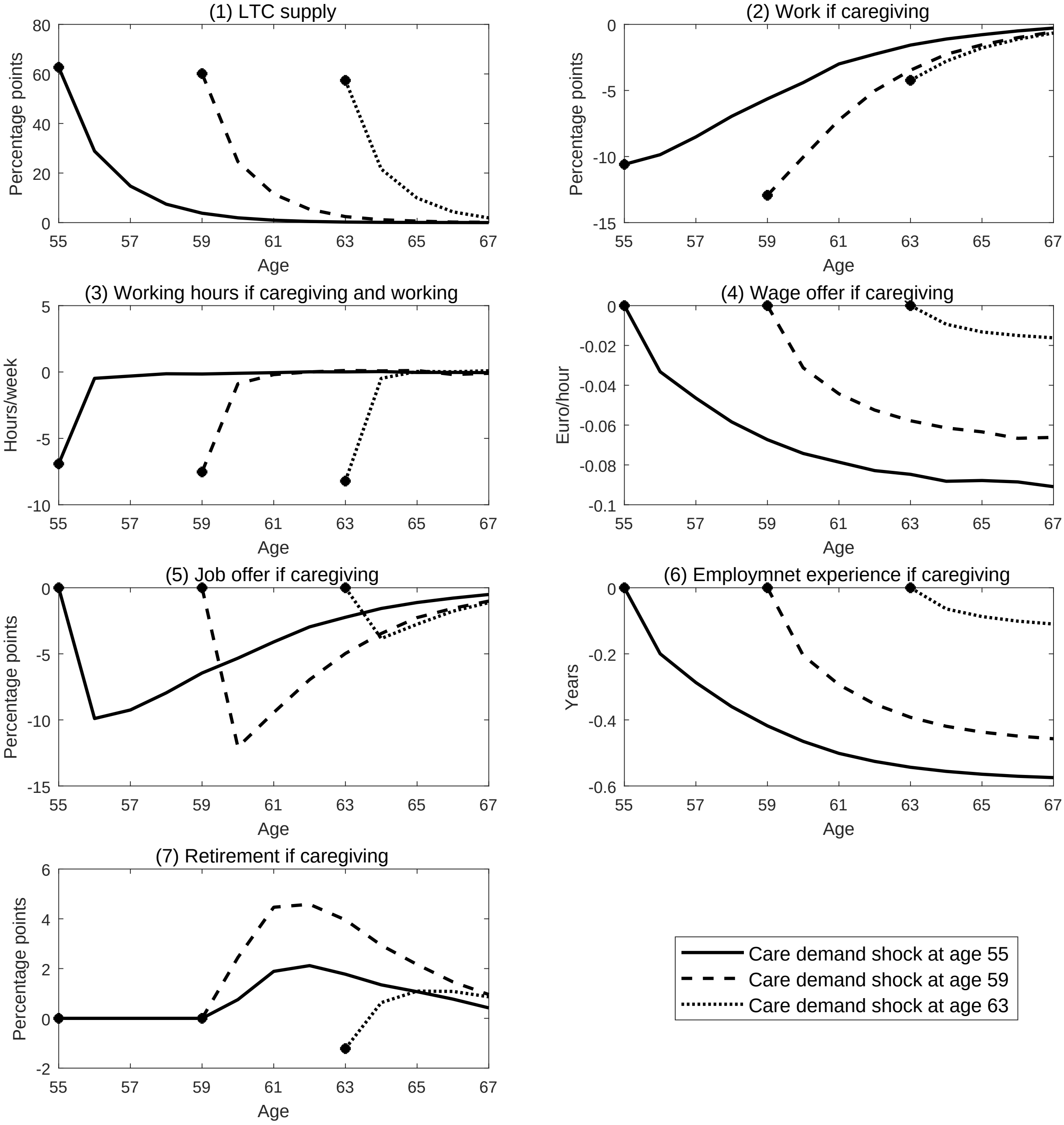
In a first step, I compare the baseline simulation with a scenario of increased care demand. In this scenario, each agent in the sample who has a living mother, father, or spouse is confronted with care demand by a family member. The changing environment comes as a surprise for the agent and is not incorporated in the decisions of previous periods. It therefore requires an adjustment of optimal behavior to deal with this new situation, given immediate consequences and expected changes of future outcomes. The decision to provide care affects utility in multiple ways: First, caregiving directly affects utility since one could like it or dislike it. Further, caregiving might place a physical burden on the caregivers or, alternatively, it could be rewarding to provide help to a relative in need. Second, caregiving *ceteris paribus* affects utility by reducing leisure time and income opportunities. As caregiving is compensated by cash benefits and pension points, agents can increase their expected income by providing care. Furthermore, expected inheritance increases as parents might save resources to be inherited to the caregiver. Yet, the agents simultaneously decide about care intensity and labor supply. If eligible, they also make a choice regarding retirement. To cope with the double burden of care and work, caregivers might reduce employment or working hours which negatively affects earnings in the current period as well as wages, employment opportunities, and pension benefits in future periods. Agents must consider these tradeoffs when adjusting their choices.

The increase in care demand is not permanent but evolves according to the estimated care demand function. Consequently, increased care demand will fade out after some time. I compare the care demand scenario to a baseline scenario in which care demand is set to *zero* in the initial period, which can be thought of as the counterfactual scenario without care demand. Since the simulations affect the entire population, comparing the two scenarios yields the average response to care demand according to the model estimates. This gives a first idea of the model dynamics related to long-term care. Further, results from this exercise can be compared to existing empirical studies, which allows to evaluate the quality of the model predictions. Figure 3 shows the average differences between the baseline and the care demand scenario. Each dot in the figure represents the first age specific period in which the care demand shock happens – ages 55, 59, and 63, respectively.

Chart (1) shows the average response in caregiving. As care demand increases, more women decide to be a caregiver. This is not surprising as agents can only choose informal care if care demand is positive. The response in caregiving is similar in each age group and increases by about 60 percentage points (PP) in the first year of the care shock. This response is similar at ages 55, 59, and 63. The difference in care supply compared to the baseline converges towards *zero* over time. The average observed care spell in SOEP ends after two years and the increased informal care demand therefore fades out quickly. This is because impaired relatives might pass away or move to a nursing home. To isolate the effects on caregivers, all other outcomes are reported conditional on the caregiving choice. That is, they are only reported for those women who decide to provide informal care in the first year of the care demand shock.

The exogenous change in care demand leads to reshuffling of time use, affecting care provision and working hours simultaneously. On average, women who provide care also reduce employment at the

Figure 3: Response to increased care demand



Note: Charts 2–7 are calculated conditional on caregiving in the first period the care demand shock happens. *Source:* SOEP, own calculations.

extensive margin (chart 2) and working hours at the intensive margin (chart 3) – which are measured conditional on working. The reduction might be due to increased engagement in informal care, or – alternatively – the reduction in labor supply yields increased care supply. If care demand increases at age 55, more than 10 PP of the women who decide to provide informal care stop working. This effect is slightly larger at age 59 and lower at age 63. Much fewer women aged 63 and older are employed in the baseline and can therefore not respond in labor supply at the extensive margin.

Due to labor market frictions, agents who are unemployed might not receive a job offer. Hence, some agents cannot return into employment after the care spell has ended. Even after caregiving has almost returned to the baseline level the job offer probability (chart 5) is still lower on average. This translates into persistent lower employment in later periods, lower employment experience (about 0.6 years on average at the terminal period – chart 6) and lower wage offers (chart 4). Women who stay in employment on average reduce working hours. While the effect is large in the first period (around 6 hours/week), the differences converge quickly to zero. The reason is that labor market frictions are only modeled on the extensive margin – the employment decision – and individuals can return to their previous working hours once they stop providing care.

Once individuals are eligible for retirement, they retire earlier on average if they have been confronted with care demand (chart 7). This is largely driven by the lower job offer. If women are eligible for retirement benefits and have no job offer, they have an additional incentive to opt for (early) retirement. The effect on retirement is, therefore, largest if women are confronted with care demand at age 59, just before they are eligible for retirement benefits. An interesting exception occurs if care demand increases at age 63. Agents can increase their future pension benefits by caregiving only if they are not yet retired at the time of caregiving. Therefore, the model predicts that retirement is postponed by almost 2 PP of women who provide care at age 63.

Even though results in the previous literature on the average effects of caregiving on employment and working hours are mixed, they are often smaller compared to these findings. For example, Schmitz and Westphal (2017), whose reduced form evidence is also based on German data, find only a 4 PP drop in full-time employment which persists at least 5 years in the future. For Europe, Bolin et al. (2008) find that a 10% increase in time spent on caregiving can be associated with a 3.7 PP decrease in employment. There are two likely explanation for the differences. First, I concentrate on a specific age group of women aged 55, 59, and 63 in the first caregiving period. In contrast, e.g. Schmitz and Westphal (2017) estimate their average effects for the entire population of women aged 25 to 64. It seems reasonable that individuals at higher ages might react stronger to the caregiving shock as they could be less capable to manage the double burden of care and work. Second, the findings in the literature suggest, that the effect size depends on the population of compliers under study. Studies using instrumental variables such as parents' health or the availability of secondary caregivers to account for the endogeneity of caregiving usually find larger

Table 7: Consequences of increased care demand for lifetime income

Δ NPV of labor earnings						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	−11364.01	−15.92	−9344.36	−25.00	−2385.75	−30.74
1st quartile	−1784.80	−12.63	−1118.58	−21.53	−300.74	−26.76
2nd quartile	−8010.80	−18.65	−5851.36	−28.69	−1053.65	−36.39
3rd quartile	−14126.60	−17.64	−11069.46	−28.45	−1962.71	−34.45
4th quartile	−19813.30	−14.16	−18456.57	−22.40	−6315.84	−28.84
Δ NPV of retirement benefits						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	−571.96	−0.75	−344.78	−0.40	50.93	0.06
1st quartile	1899.98	6.99	1603.79	6.27	507.95	2.43
2nd quartile	225.28	0.41	263.47	0.43	138.03	0.23
3rd quartile	−1484.50	−1.71	−987.57	−0.98	−74.90	−0.07
4th quartile	−2459.94	−1.95	−2006.08	−1.34	−297.27	−0.19
Δ NPV of total income at age of shock						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	−1109.02	−0.50	−1425.76	−0.81	2473.24	1.99
1st quartile	7184.85	5.27	5812.35	5.82	4419.05	7.16
2nd quartile	1860.37	1.03	1605.88	1.16	3677.74	3.92
3rd quartile	−3997.62	−1.70	−2983.47	−1.60	2725.58	2.06
4th quartile	−7973.02	−2.47	−9354.33	−3.48	−966.25	−0.48

Source: SOEP, own calculations.

negative labor supply effects (e.g. Crespo and Mira, 2014; Kolodziej et al., 2018). For example, Kolodziej et al. (2018), who use European data to estimate local average treatment effects (LATE) for a group of compliers whose willingness of informal care provision is altered by available alternatives of family care, find that caregiving decreases the probability of working by about 14 PP. In my simulation scenario individuals decide to provide care due to increased care demand, which is modeled to depend – among others – on parents' age. Hence, my results could be closer related to the LATE estimates in those studies.

Lower employment, working hours, employment experience, and earlier retirement have implications for income and pension benefits. At the same time, the German LTCI includes measures that are designed to compensate informal caregivers. Hence, the total effect of the care shock on lifetime income and pension benefits is ambiguous. In table 7, I use the simulation results to calculate the consequences of caregiving on income and pension benefits, taking into account all behavioral adjustments predicted by the model. I calculate the net present value (NPV) of disposable lifetime income in order to account for the dynamic nature of the effect. Further, I distinguish agents regarding their position in the income distribution. While the opportunity costs for caregiving should be higher for high income individuals, LTCI benefits are provided without a means test. Hence, it sets heterogeneous incentives depending on the position in the income distribution. For example, because cash benefits provided by LTCI do not depend on previous earnings or wealth, they are larger (in relative terms) for individuals at the lower end of the income distribution compared to individuals at the top of the distribution. Moreover, the pension points that agents can collect for caregiving might be a real gain in terms of future pension benefits if individuals have no job offer or outside options with low wage offers. On the other hand, individuals with high income can collect more pension points if they stay in employment.

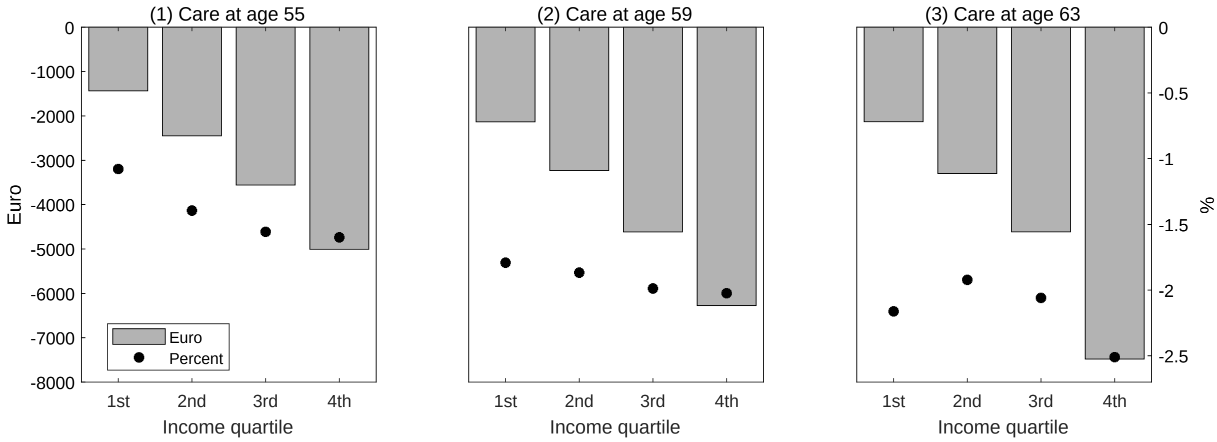
The first panel of table 7 collects the simulated changes of expected NPV of the remaining labor earnings. That is, earnings until the terminal age 85 are discounted by the discount factor β and survival probability ρ. Likewise, the second panel collects the simulated changes of expected NPV of the remaining pension benefits. In the third panel, I show the change in expected NPV of total disposable income at the point of the care shock. Additional to the labor earnings and pension benefits, this measure also includes non-labor income, and all benefits form the social security system such as social assistance or benefits from the long-term care insurance.

Since caregiving negatively affects labor supply, the care shock results in a large average decrease in labor earnings, which is higher for individuals at the upper end of the income distribution (panel 1). The simulation results suggest that if a woman in the fourth quartile of the income distribution is confronted with care demand at age 55, on average her NPV of labor earnings is decreased by more than 19,800 euro. For women in the same age but in the first quartile of the income distribution, the NPV of earnings is only decreased by about 1,800 euro. If the shock happens at higher ages, fewer women are still employed and can respond with their labor supply and their affected time span before retirement is shorter. Consequently, labor earnings are less affected (in absolute euros) the later women are confronted with care demand.

Likewise, the effect on pension benefits depends on the position in the income distribution and on the age of increased care demand (panel 2). Women at the lower end of the distribution benefit in terms of pension benefits since they can often not adjust labor supply when they become a caregiver. Most of them are unemployed when they are confronted with care demand and their employment status – that determines pension benefits – is not affected. Further, caregiving gives them the opportunity to collect additional pension points. The simulation results suggest that if a woman in the first quartile of the income distribution is confronted with care demand at age 55, on average, her NPV of pension benefits is about 1,900 euro (7%) higher compared to the baseline. For women at the upper end of the income distribution pensions are negatively affected by caregiving. This group is more likely to adjust labor supply and care demand hence affects their employment history and reduces pension benefits by up to 1.95% if they are caregivers at age 55.

If we consider all sources of income (panel 3) the heterogeneity between low- and high-income individuals is even more notable: the reason is that cash benefits have higher relevance for women at the lower end of the income distribution. If women earn high wages and work many hours, reducing labor supply

Figure 4: Caregivers' costs to well-being



Source: SOEP, own calculations.

and being a caregiver is costly, because of high opportunity costs of forgone income. In contrast, low-income individuals without employment benefit from the cash transfers but cannot further reduce their labor supply. Individuals in the first quartile of the income distribution can thus increase their lifetime income by up to 7.2% if they are informal caregivers at age 63. Again, this is different for individuals at the higher end of the income distribution who reduce labor supply due to caregiving. Despite the cash transfer provided by LTCI, remaining lifetime income decreases by up to 9,354 euro (3.5%) for women in the fourth quartile who start providing care at age 59. The negative effect is generally higher if the care shock happens at younger ages because lower income accumulates due to lower wages and lower job offer probabilities over the following periods.

Additionally, I follow Skira (2015) and Coe et al. (2018) and calculate costs of caregiving to well-being. To do this I repeat the simulation before but remove the option of not providing care. I calculate the costs to well-being as a lump-sum amount of money that is necessary to equal well-being between the two scenarios. Well-being is calculated using the agent's value function. For those women who have already decided to provide care before, the difference in utility is zero. Therefore, I calculate the costs to well-being for those individuals, who have not voluntarily provided care before. Informal caregiving affects individuals' well-being in different ways. Caregiving directly affects well-being as agents might have a taste or an aversion to caregiving. Further, it indirectly affects well-being due to adjusted leisure and modified income (which affects consumption) in the current and future periods.

Figure 4 summarizes the effects on well-being for women in different ages and income quartiles. The gray bars represent the absolute change in well-being in euro if women must provide care for one year. The dots represent the changes relative to the NPV of lifetime income. If women must provide care at age 55, their well-being is reduced in all income quartiles. The changes in absolute and relative terms are largest in the fourth income quartile and smallest in the first income quartile. To equal their reduced well-being, on average, women in the first income quartile would need to receive a lump sum transfer of about 1,000 euro; in the fourth income quartile this payment would be almost 5,000 euro. Again, women in the higher income quartile have a higher probability to be employed, hence, due to diminishing returns to leisure, for this group, caregiving results in larger average utility losses. Further, women on the lower end of the income distribution often cannot further reduce employment or working hours. Caregiving can thus not affect their labor supply with resulting changes in consumption. At higher ages, the consequences of caregiving on well-being increase in relative and absolute terms. The main reason is that agents value leisure higher if they get older and hence give higher costs to reduced leisure time.

Interestingly, the estimated costs to well-being are much smaller compared to the findings of Skira (2015) and Coe et al. (2018) who use a very similar approach for the U.S. For example, Coe et al. (2018) estimate the median costs of informal caregiving to well-being to be approximately $180,000. Accounting for the exchange rate[29] and the fact that their results are estimated for two years instead of one, Coe et al. (2018) results are still more than ten times larger compared to the findings I am presenting in this paper. Potential reasons for these differences might include different preferences and/or different institutions. First, the costs to well-being are sensitive to how individuals value consumption, leisure and caregiving. For example, if woman in the U.S. have higher preferences for leisure on average, their costs to well-being are likely higher. Second, arguably, an important difference between the U.S. and Germany are the more generous social security regulations in Germany that make informal caregiving and reduced employment participation less costly – e.g. more generous pension benefits, unemployment benefits, and benefits from the LTCI.

6.2. Consequences of long-term care insurance

In this subsection, I use policy simulations to assess the behavioral effects of public LTCI as well as its consequences for lifetime income and well-being. More precisely, I simulate the same increase of care demand as in the first simulation in the previous subsection but simultaneously change the characteristics of LTCI to evaluate its effects on woman's behavior, income, and costs to well-being. First, I simulate the care demand increase in the absence of cash benefits. Second, I simulate the care demand increase while intensive caregiving is not awarded with pension points.

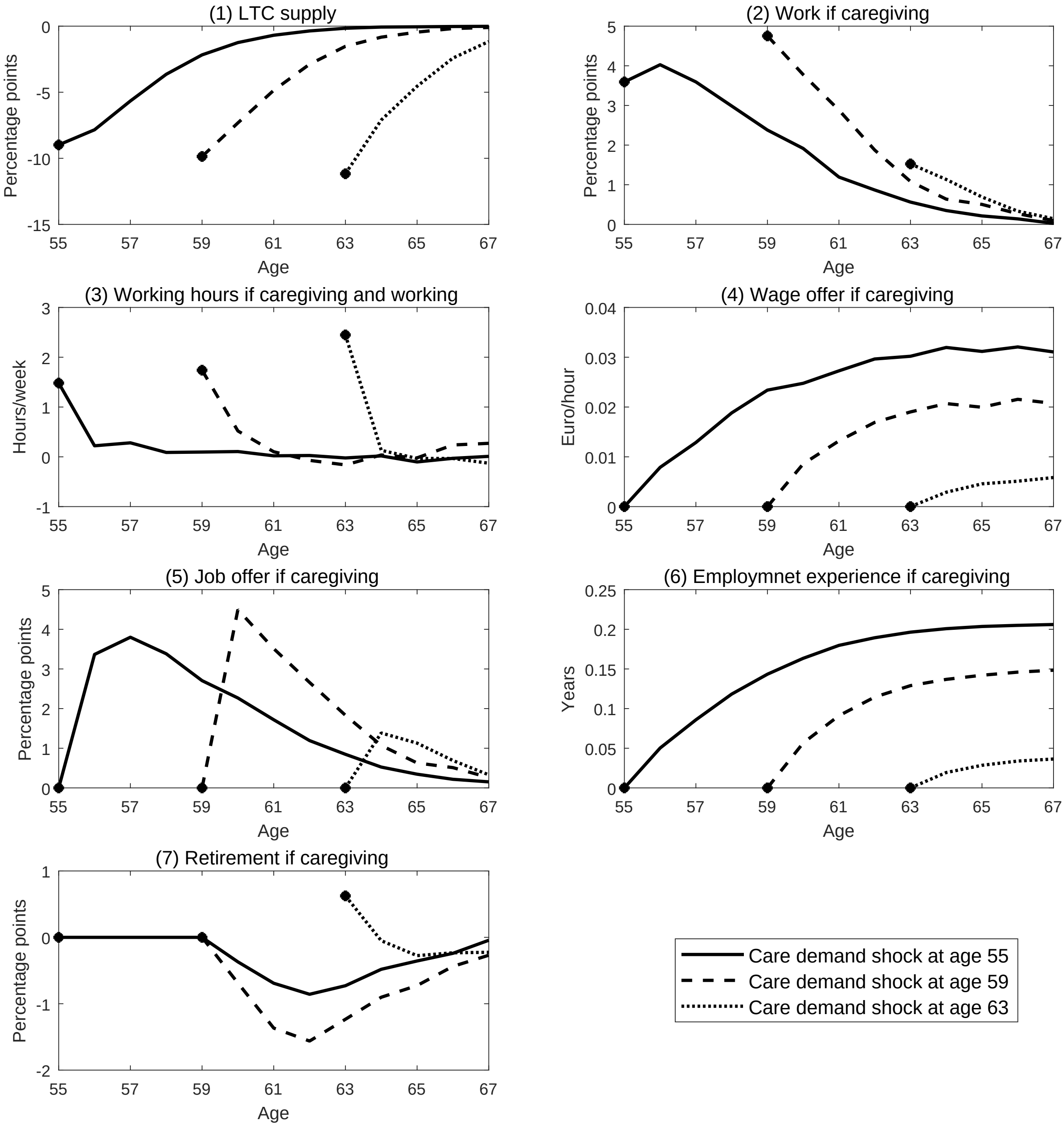
Effect of cash benefits

Figure 5 shows results for the simulation without cash benefits. Each line draws the difference between the first simulation with increased care demand in subsection 6.1 and the new scenario in which care demand increases in the absence of cash benefits.[30]

[29] In 2019, $1 $\approx$ 0.9 euro.

[30] In the simulation, I abstract from adjusting the contribution rate for LTCI which, in general, could be lower without cash benefits.

Figure 5: Response to increased care demand – influence of cash benefits



Note: Charts 2–7 are calculated conditional on caregiving in the first period the care demand shock happens. *Source:* SOEP, own calculations.

Table 8: Consequences of abolished cash benefits on lifetime income

Δ NPV of labor earnings						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	7966.43	11.16	5486.46	14.68	1232.69	15.88
1st quartile	2891.47	20.46	1144.59	22.03	158.93	14.14
2nd quartile	7079.54	16.48	3551.66	17.42	456.79	15.78
3rd quartile	8909.95	11.12	6670.16	17.14	1014.39	17.80
4th quartile	11954.38	8.54	10093.09	12.25	3357.93	15.33
Δ NPV of retirement benefits						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	603.12	0.80	210.14	0.24	−4.52	−0.01
1st quartile	−613.75	−2.26	−575.95	−2.25	−194.93	−0.93
2nd quartile	345.10	0.63	−72.38	−0.12	−51.82	−0.09
3rd quartile	1024.06	1.18	568.17	0.56	45.54	0.04
4th quartile	1405.12	1.11	811.50	0.54	155.95	0.10
Δ NPV of total income at age of shock						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	−3000.21	−1.35	−2426.40	−1.38	−3863.61	−3.12
1st quartile	−8210.64	−6.02	−6549.94	−6.56	−4882.95	−7.91
2nd quartile	−4397.41	−2.43	−4318.90	−3.12	−4627.34	−4.94
3rd quartile	−1521.02	−0.65	−1308.26	−0.70	−4051.75	−3.06
4th quartile	1120.65	0.35	2015.01	0.75	−1840.46	−0.91

Source: SOEP, own calculations.

If cash benefits are not provided, the situation is different for the potential caregiver because opportunity costs of caregiving increase without financial compensation from LTCI. This is shown in figure 5. The first chart shows that informal care supply is about 8 PP lower in the new scenario, yet, many women decide to provide informal care even in the absence of immediate financial compensation. To maintain income, about 4 PP fewer caregiving women aged 55 quit employment to ease their time constraint (chart 2). As a result, the drop in employment experience (chart 6) and wages (chart 4) is lower. Further, the influence of caregiving on labor market outcomes is less persistent as job offer probabilities are on average higher. At the intensive margin, women aged 55 work about one and a half hours more per week in the first care period, but labor supply reactions are similar in the following periods compared to original scenario (chart 3). As persistent effects are smaller over time, fewer people choose early retirement (chart 7). However, if the increase in care demand occurs at age 63, agents retire earlier compared to the scenario with cash transfers. Without cash transfers it is less beneficial to postpone retirement to collect pension points. In that case they have to live solely on unemployment benefits or social welfare for the transition periods in unemployment.

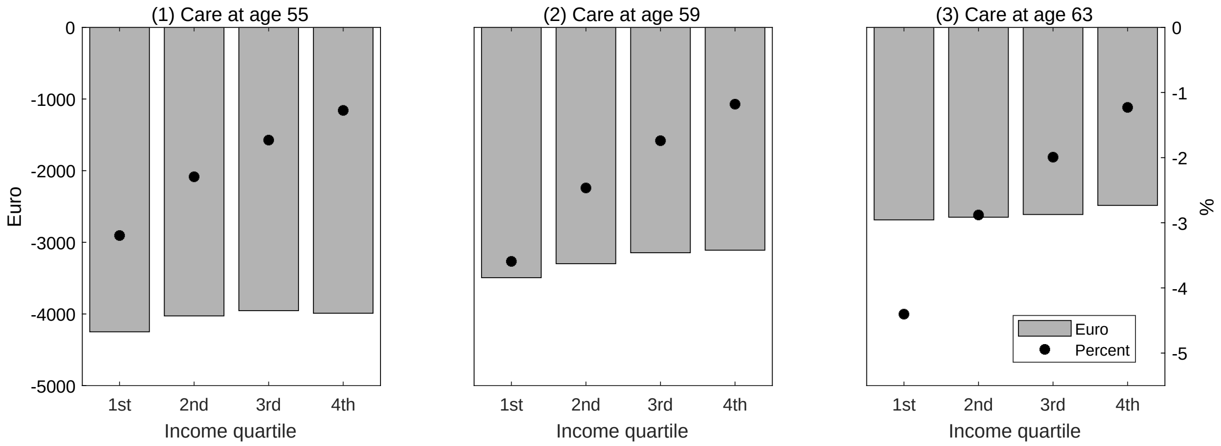
Table 8 summarizes the impact of cash benefits on disposable income and retirement benefits of caregivers. It compares the income outcomes of caregivers with and without cash benefits. The effect is ambiguous. While the cash transfer has a positive effect on income *ceteris paribus*, it negatively affects labor supply and therefore labor income and retirement benefits. Table 8 reveals the ambiguity of the cash benefit. On average, labor earnings increase if cash benefits are not available. Since the cash benefits relax the agent's budget constraint, they give incentives to reduce labor supply. Without cash benefits, more caregivers stay in employment and thus have higher earnings on average. While this is true throughout the income distribution, individuals at the higher end of the income distribution earn higher wages and therefore have a larger absolute (but not relative) increase in earnings if they stay in employment. Further, low-income individuals might have more difficulties to react with their labor supply because they are often without a job and have thus a lower probability of receiving a job offer.

In general, pension benefits also increase as agents stay longer in employment. This is due to the strong principle of equivalence in the German pension scheme. Lower contributions to the pension insurance directly lead to lower benefits in old age. However, because the timing of retirement is also affected the total effect on the NPV of pension benefits is ambiguous.

The total effect combines the income effects due to adapted labor market choices with the change in income due to decreased benefits from LTCI. If women are faced with care demand at age 55 without cash benefits, on average, the NPV of lifetime income is 3,000 euro (1.35 PP) lower compared to the scenario in which cash benefits are available. If care demand increases at ages 59 or 63 this negative effect is similar. Yet, the total effect on NPV crucially depends on the position in the income distribution. Individuals at the lower end of the income distribution are often not employed or work part-time with low wages. For them, cash benefits are a real gain for total income. In contrast, for individuals at the higher end of the income distribution the reduced labor supply is more costly. While they also receive cash benefits, due to labor supply adjustments total effects are smaller – in particular if the care demand increases at younger ages. While in the scenario with cash benefits, individuals at the lower end of the income distribution would benefit from caregiving in monetary terms, without cash benefits this is different: Summing up the total income effects in table 7 and table 8 reveals that effects on NPV of total income would be negative on average – irrespective of age or the position in the income distribution.

Figure 6 summarizes the changes to well-being if individuals are forced to provide care. Again, the figure shows changes compared to the care demand scenario with cash benefits. If individuals have to provide care at age 55, their costs to well-being is about 4,000 euro larger if cash benefits are not provided. This is similar in all income quartiles and decreases if the care shock happens at higher ages. Thus, individuals benefit less from cash transfers if they are older.

Figure 6: Caregivers' costs to well-being of abolished cash benefits



Source: SOEP, own calculations.

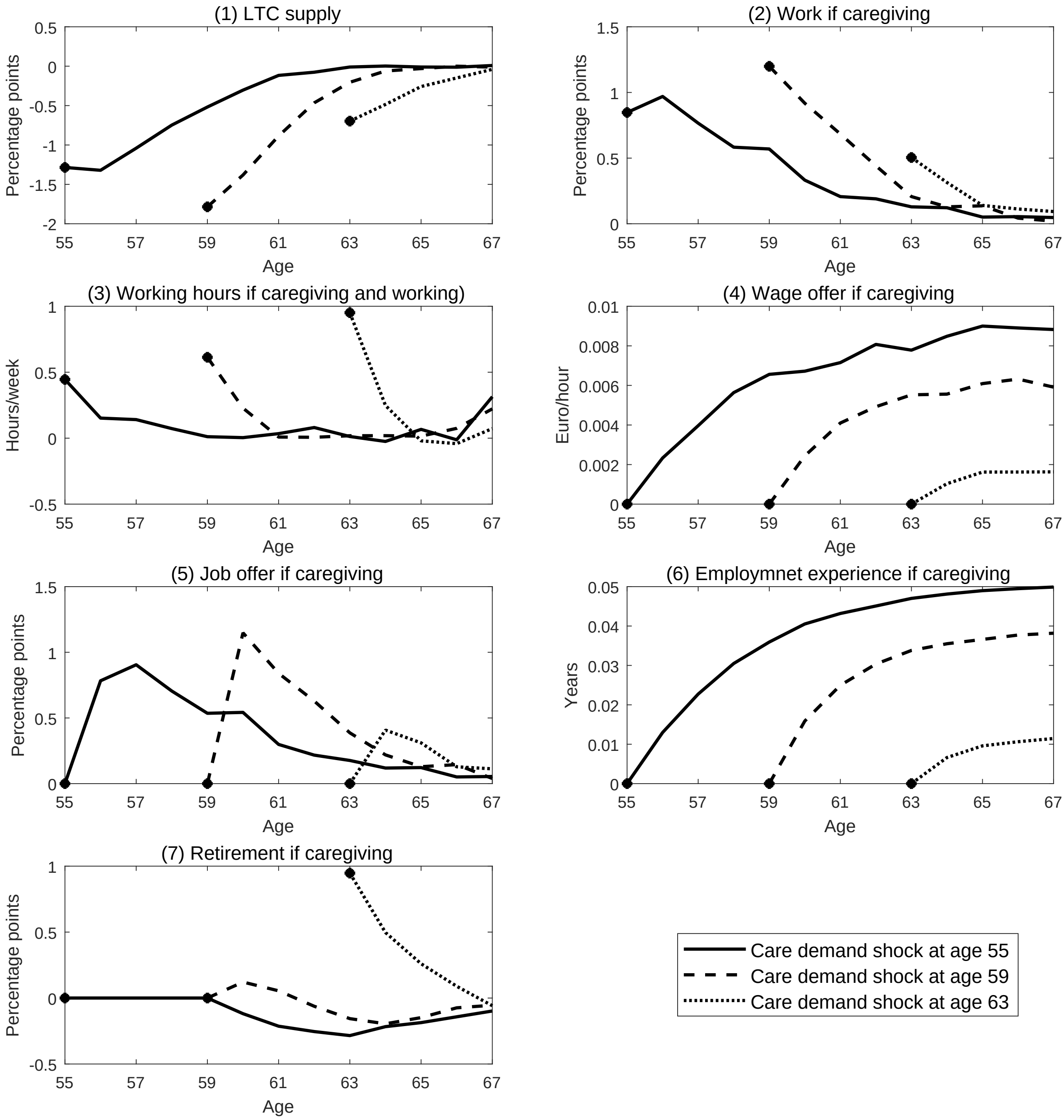
Effect of pension points for caregiving

The German LTCI includes an additional instrument to compensate informal caregivers. This measure addresses the problem that informal caregivers who are unable to provide informal care while still working full time, collect fewer pension points and thus receive fewer pension benefits once retired. Therefore, LTCI contributes to the public pension insurance if individuals provide intensive care, do not work more than 30 hours a week in payed employment, and are not retired. In this subsection, I evaluate the behavioral consequences of this feature of the insurance scheme. Further, I address its consequences for income and pensions over time as well as its costs to well-being. In a sense this feature of the LTCI is similar to a cash transfer but materializes much later – after retirement – and, therefore, provides lower incentives in the current period as future benefits are discounted.

This relation is displayed in figure 7, which draws the differences between the care demand scenario under status quo regulations and the new scenario in which caregiving is not compensated with payments to the pension insurance any longer. Behavioral differences compared to the original simulation are much smaller but in general similar to the scenario without cash benefits. Without pension points for care, about 1.2 PP fewer women provide care at age 55. Conditional on the caregiving decision, almost 1 PP fewer women reduce labor supply at the extensive margin and 0.5 hours per week at the intensive margin. Adjustments are slightly larger if care is provided at age 59. At age 63, reactions at the extensive margin are smaller, but larger at the intensive margin. The retirement decision reveals an interesting incentive set by the policy. Women, who first provided care after the legal retirement age, retire earlier if they are not compensated with pension points for care because they cannot postpone retirement to collect pension points any longer.

While behavioral consequences of this element of LTCI are small, they still have consequences for retirement benefits. This can be seen in table 9, which summarizes the differences in NPV of different

Figure 7: Response to increased care demand – influence of pension points for caregiving



Note: Charts 2–7 are calculated conditional on caregiving in the first period the care demand shock happens. *Source:* SOEP, own calculations.

Table 9: Consequences of abolished 'pension points for caregiving' on lifetime income

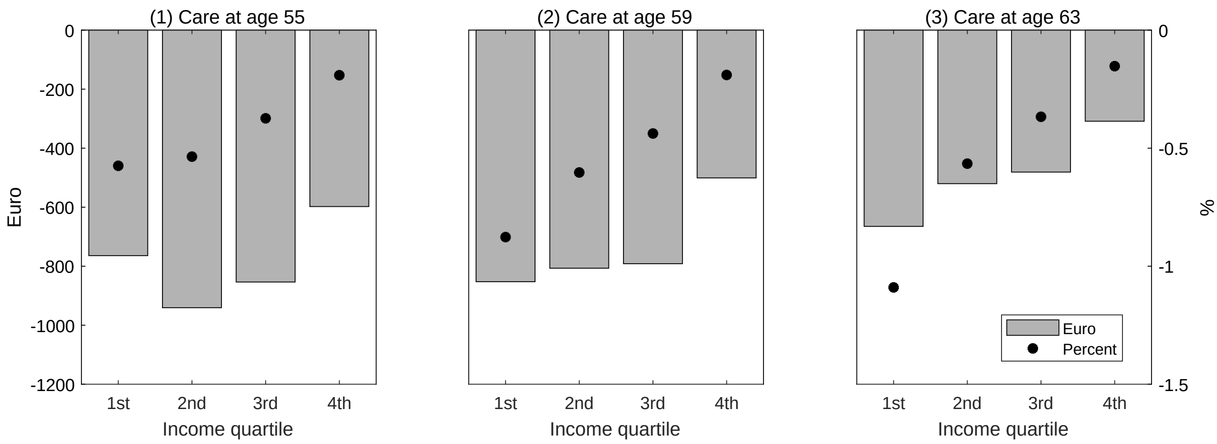
Δ NPV of labor earnings						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	1962.85	2.75	1270.21	3.40	341.95	4.41
1st quartile	397.10	2.81	180.61	3.48	57.12	5.08
2nd quartile	1806.91	4.21	985.77	4.83	137.01	4.73
3rd quartile	2281.48	2.85	1619.93	4.16	240.27	4.22
4th quartile	3026.03	2.16	2149.40	2.61	961.53	4.39
Δ NPV of retirement benefits						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	−1984.06	−2.62	−1787.78	−2.07	−591.88	−0.68
1st quartile	−3164.11	−11.64	−2568.42	−10.05	−1023.92	−4.90
2nd quartile	−2592.61	−4.70	−2256.18	−3.64	−558.08	−0.94
3rd quartile	−1525.60	−1.76	−1636.00	−1.62	−542.36	−0.53
4th quartile	−839.98	−0.67	−760.99	−0.51	−302.74	−0.19
Δ NPV of total income at age of shock						
Age of care demand shock	55		59		63	
	Euro	%	Euro	%	Euro	%
total	−1022.80	−0.46	−1034.86	−0.59	−439.55	−0.35
1st quartile	−3097.68	−2.27	−2440.22	−2.44	−1091.71	−1.77
2nd quartile	−1880.93	−1.04	−1672.83	−1.21	−544.93	−0.58
3rd quartile	−454.20	−0.19	−762.52	−0.41	−510.88	−0.39
4th quartile	993.51	0.31	591.47	0.22	361.78	0.18

Source: SOEP, own calculations.

earning outcomes compared to the scenario in which care is compensated with pension points. Like the effects of cash benefits the total effect is driven by ambiguous factors. *Ceteris paribus*, the possibility to collect pension points for caregiving increases future pensions of caregivers since – through the pension formula (18) – all future pensions are positively affected by additional pension points. Yet, this feature also incentivizes reduced labor supply as it decreases opportunity costs of working. This does not only affect current earnings but also induces secondary effects on pension benefits, as fewer years in employment entail lower pension point accumulation. As the timing of retirement is also affected, the consequences on lifetime earnings are even more ambiguous.

The results indicate that, overall, individuals receive reduced pension benefits without pension points for care. This is true irrespectively of age or the position in the income distribution; yet, the effects are largest for younger individuals at the lower end of the income distribution. As low-income individuals are often unemployed, the additional pension points cause a real gain, while the negative secondary effects of reduced employment are less important. In particular for individuals at the higher end of the income distribution, the negative effect of reduced pension points for care is compensated by increased labor supply inducing higher earnings and higher future pensions.

Figure 8: Costs to well-being of abolished pension points for care



Note: Source: SOEP, own calculations.

Overall, on average, total NPV of income decreases without pension points for care. If women are confronted with care at age 55, the reduced pension benefits are worth about 1,022 euro in NPV. The effect is smaller closer to retirement. The policy is most beneficial for low-income individuals.

Figure 8 summarizes consequences in well-being. Again, the figure shows changes compared to the care demand scenario with pension points for care. If individuals have to provide care at age 55 their costs to well-being are up to 900 euro higher as pension points for care are not provided. Overall, this is slightly less important in the higher quartiles of the income distribution and decreases if the care shock happens at higher ages.

Simulating increased care demand without cash benefits and pension points for care shows that these features indeed reduce individuals' costs to well-being of informal elderly care. Without these two features, costs to well-being that result from having to provide care for one year would be up to 5,000 euro higher, reaching values of up to 10,000 euro. This is equivalent to more than half the average of yearly disposable income of women in Germany. Yet, these costs are still much lower compared to the findings of Skira (2015) and Coe et al. (2018) estimated in the U.S. context. This might be due to additional institutions in the German tax and benefit system or due to different cultural aspects influencing preference about consumption, leisure, or LTC provision.

6.3. Fiscal consequences

In order to evaluate LTCI measures it is important to also know about their fiscal consequences. It is misleading to only account for the direct costs which result from the take up of LTCI benefits. As Geyer et al. (2017) argue informal care can induce additional (hidden) fiscal costs that result from decreased labor supply. For example, if individuals provide informal care and reduce their working hours, this will not only affect their personal income but also their tax payments and their contributions to the social

Table 10: Fiscal consequences of LTC

I Care shock at age 55	Total consequences		Cash benefits for LTC		Pension points for LTC	
	Euro	%	Euro	%	Euro	%
Pension payout	1220.91	1.00	−162.53	−13.31	2042.07	167.26
Social security benefits	−995.42	−1.57	365.33	36.70	−1335.16	−134.13
LTCI cash benefits	−11402.59		11402.59	100.00	356.72	3.13
Social security contributions	−3449.13	−11.31	1063.07	30.82	−58.43	−1.69
Income tax	−3145.57	−14.41	875.20	27.82	14.04	0.45
Net effect	−17771.80		13543.66	76.21	1019.25	5.74
II Care shock at age 58	Total consequences		Cash benefits for LTC		Pension points for LTC	
	Euro	%	Euro	%	Euro	%
Pension payout	1336.44	1.04	−259.17	−19.39	1714.70	128.30
Social security benefits	−1022.33	−1.85	267.89	26.20	−1045.32	−102.25
LTCI cash benefits	−10168.45		10168.45	100.00	392.71	3.86
Social security contributions	−2973.55	−14.70	853.82	28.71	−20.94	−0.70
Income tax	−2874.82	−20.32	763.09	26.54	27.63	0.96
Net effect	−15702.72		11794.08	75.11	1068.78	6.81
III Care shock at age 63	Total consequences		Cash benefits for LTC		Pension points for LTC	
	Euro	%	Euro	%	Euro	%
Pension payout	132.11	0.11	−11.92	−9.03	460.71	348.73
Social security benefits	−168.91	−0.33	46.71	27.66	−286.99	−169.91
LTCI cash benefits	−9349.49		9349.49	100.00	153.39	1.64
Social security contributions	−742.59	−7.03	228.19	30.73	0.78	0.10
Income tax	−737.57	−10.71	225.74	30.61	4.21	0.57
Net effect	−10866.45		9838.21	90.54	332.09	3.06

Source: SOEP, own calculations.

security system. Furthermore, caregivers who drop out of the labor force might depend on additional public transfers like social assistance which also increases the fiscal costs of caregiving.[31]

Since the structural model accounts for the tax and transfer system, it allows to calculate fiscal costs in counterfactual situations accounting for direct costs due to LTCI benefits and indirect costs due to changed labor supply decisions. Table 10 summarizes the total costs of informal caregiving under the different institutional settings described in the previous sections. The first two columns summarize the average fiscal consequences of informal caregiving due to care demand at ages 55, 59, and 63, respectively. Columns 3-4 summarize the influence of the German cash transfers for caregiving and columns 5-6 provide average costs of the LTCI contribution to the public retirement insurance for individuals who are intensive caregivers. All numbers are expressed from a fiscal point of view. That is, negative numbers indicate additional fiscal costs and positive numbers indicate a fiscal gain. I calculate costs as average costs per caregiver and aggregate the entire expected remaining costs and benefits until the caregivers' end of live.

If women start to be caregivers at the age of 55, under the status quo LTCI regulations this has direct fiscal consequences due to the transfer of cash benefits. On average these costs account for about 11,402 euro for each caregiving women. Due to lower labor supply, the total costs are even higher: they lead

[31]If caregiving also induces negative health effects (e.g. Schmitz and Westphal, 2015) which are not accounted for in this study, the fiscal consequences of caregiving would be higher since the public health insurance would also face additional costs.

to a 995 euro (1.57%) increase in social security payment, 3,449 euro (-11.3%) decrease in social security contributions, and 3,145 euro (-14.4%) decrease in tax payments. As caregiving women on average receive lower pension this decreases the pension payout by 1,221 euro (1%) which is a financial gain from a fiscal perspective. Overall, the average fiscal costs of caregiving account for about 17,771 euro which is a large amount if one considers that today Germany has about 2 million female informal caregivers, a number which is expected to further increase in the future. If women start to be caregivers at higher ages, the fiscal costs are lower, but still economically significant with 15,702 euro if care is first provided at age 59 and 10,866 euro if care is first provided at age 63, respectively.

The costs of cash benefits account for the largest fraction of the total fiscal costs. Columns 3-4 of table 10 summarize the fiscal effect of the cash transfer. Naturally, the largest position is the cash benefit payment itself. Additionally, the cash transfer also affects labor supply which further increases the costs of this transfer. For example, without cash benefits the increase in social security payments to caregivers would be about 36% lower for women who are first caregivers at the age of 55. The same is true for social security contributions (31%) and tax payment (28%). Only the fiscal costs of pension payouts would be lower (-13%). Overall, the fiscal costs of the cash transfer account for about 76% of the total fiscal costs of informal caregiving at age 55. This is similar at all initial caregiving ages with 75% at age 59 and 90% at age 63.

Compared to the costs of cash benefits, the contribution of pension points for intensive caregiving is much lower (columns 5-6 of table 10). While it increases the average costs for pension payouts between 332 euro (age 63) and 1,019 euro (age 55), it only accounts for 3% (age 63) up to 5.7% (age 55) of the total fiscal costs of informal caregiving.

The fiscal costs of informal care must be evaluated in the context of formal care costs. In Germany, the average price for nursing homes is about 36,000 euro per year.[32] On average, about half of the costs are provided by LTCI or social assistance. Hence, on average the fiscal yearly costs of formal nursing home care accounts for about 18,000 euro. In comparison, the costs of informal care are thus lower on average. Yet, they are not perfectly comparable since individuals in nursing homes have often worse health conditions and often move to nursing homes once family care is not feasible any longer. Nevertheless, the simulation results show that a one-to-one comparison of direct costs is likely misleading and that behavioral consequences of caregivers must be considered for a full comparison of fiscal costs between different kinds of care.

7. Conclusion and discussion

In this paper, I analyze long-run effects of caregiving and how they are affected by regulations of a long-term care insurance (LTCI). I set up a dynamic model that describes care choices, labor supply

[32] See https://www.pflege.de/altenpflege/pflegeheim-altenheim/kosten/, visited April 2019.

and retirement decisions of women in Germany. I estimate the model using the years 2001 until 2015 of the German Socio-Economic Panel (SOEP). I concentrate on women aged 55 to 67 because this group is usually still able to be active on the labor market and is most likely to be informal caregivers. I use the estimated model to simulate counterfactual situations which are compared to the status quo baseline. The simulations allow to calculate long-run costs of informal care accounting for labor market frictions and the tax benefit system. The costs on the individual level measured in lifetime income are contrasted with the fiscal consequences of caregiving measured in tax revenues and social security contributions. Furthermore, I use counterfactual policy simulations to analyze how different features of the German LTCI affect the behavior of caregivers and the resulting costs of caregiving.

The results indicate that being a caregiver has adverse effects on labor market outcomes. In line with previous literature (e.g. Crespo and Mira, 2014; Skira, 2015; Schmitz and Westphal, 2017; Kolodziej et al., 2018), the model predicts negative responses in employment and working hours, which persist even after care spells have ended. The reason is that labor market frictions make it difficult to immediately adjust the employment status, e.g., if no job offer arrives that would allow to return to employment again. In general, the persistent employment effects lead to lower lifetime income, to reduced pension entitlement, and induces costs to individual's well-being. Similar to child care, the provision of informal care can hence be associated with significant career costs – even though they are much lower compared to the costs of childcare as LTC spells are shorter and LTC is usually provided at higher ages that are less important for career decisions.[33]

Under the German LTCI, individuals in need for care can opt for cash benefits that are intended to reimburse family caregivers. Further, if individuals provide intensive informal care and work fewer than 30 hours a week, the LTCI contributes to their public retirement insurance. The simulation results in this paper show, that both measures can (partially) compensate for the forgone income opportunities of caregiving. The extent of compensation crucially depends on the caregiver's position in the income distribution. Opportunity costs of caregiving are larger for employees with a higher remuneration. As LTCI measures are not related to household earnings but only depend on the level of impairments, low-income individuals benefit (in relative terms) more from LTCI compared to individuals at the higher end of the income distribution. Particularly for individuals at the lower end of the income distribution who are not employed, it can be financially beneficial to provide care for a relative who is eligible for LTCI cash benefits. The reason is that cash transfers are not subject to income tax and payments from the unemployment insurance are also unaffected. While cash transfers can compensate for family care at the time of caregiving, long-run consequences can be more detrimental. The income effect of the cash transfer increases the negative and persistent effect of caregiving on labor supply and thus has negative consequences for retirement benefits. However, since the LTCI also contributes to the retirement

[33]For example, Adda et al. (2017) estimate that having children might reduce the NPV of lifetime income by up to 35%.

insurance of informal caregivers, this negative effect on pension benefits can, on average, be offset for individuals at the lower end of the income distribution.

Compensation described here does not imply that individuals have the same earning opportunities in informal care as they have on the labor market. On average, the additional hours in informal care a much larger than the reduced working hours. Hence, individuals might not lose in monetary terms but pay with less leisure or with negative consequences for their own health – which is not analyzed in this paper but found e.g. by Schmitz and Westphal (2015).

The average fiscal costs of informal family care can reach up to 17,771 euro for each caregiving women, which is a considerable amount if one considers that Germany has about 2 million female informal caregivers, a number which is expected to further increase in the future. While these costs are lower compared to the average fiscal costs for care in nursing homes (about 18,000 euro per year), the results highlight the importance of not only considering the direct costs of transfers from the LTCI but also the indirect costs that result e.g. from lower tax payments and lower contributions to the social security system. The results in this paper show, that the indirect costs account for about one third of the total costs.

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A. Paper appendix

A.1. Unobserved type probability

The probability of belonging to type m is modeled conditionally on working experience, and on age in the initial period T_0. As additional exclusion restriction, I further use the number of children a woman has, which should also affect the labor market history. The probability is estimated within the structural model.

$$P(m=1) = \frac{\exp(\alpha M_{T_0})}{1+\exp(\alpha M_{T_0})}$$
$$\alpha M_{T_0} = \alpha_0 + \alpha_1 \; age_{T_0} + \alpha_2 \; expEQ_{T_0} + \alpha_3 \; children_{T_0} \tag{20}$$

By making the type probability function conditional on state variables in the initial period, I account for non-random initial conditions at the initial period. This approach follows Wooldridge (2005). It requires that the initial condition is random conditional on working experience, age, and employment in the previous period.

A.2. Approximation of the value function

Instead of solving the value function at the entire state space, I approximate the value function using interpolation as suggested in Keane and Wolpin (1994). That is, starting at the terminal age T, I calculate the value functions at a subset of the state space. This grid includes four values of labor market experience (0, 15, 30, 45), two values of years in retirement (0, 6), years in care (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), married (0, 1), education (low, high), and regions (east, west). This results in a total of 8.192 grit points. While solving the model recursively, I use a linear interpolation function to predict the value function at values of the state variables that are not included in the grit.

A.3. Numerical maximization of the likelihood function

The log-likelihood function takes the form $LL(\theta) = \ln L(\theta)$, where $L(\theta)$ is function (19). 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 methods, see for example Train, 2009, Ch. 8). It is defined as

$$\theta_{\tau+1} = \theta_\tau + \lambda B_\tau^{-1} g_\tau, \tag{21}$$

where $g_\tau = \left(\frac{\partial LL(\theta)}{\partial \theta}\right)_\tau$ is the gradient vector of first derivatives and B_τ is the approximation of the negative Hessian, the matrix of the second derivatives $H_\tau = \left(\frac{\partial^2 LL(\theta)}{\partial \theta \, \partial \theta'}\right)_\tau$. 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 I calculate the score as

$$s_i(\tau) = \frac{LL_i(\theta_\tau + h) - LL_i(\theta_\tau)}{h}, \tag{22}$$

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.4. Additional regression tables

Table 11: Probability of positive inheritance after parents death

	P(inheritance>0)	
inheritance>0		
age	0.662	(0.490)
age^2/100	−0.565	(0.402)
region=east	−0.505***	(0.126)
educ=high	0.546***	(0.105)
(1/3) years light care + years inten. care	0.100***	(0.030)
deathL	2.828***	(0.108)
Constant	−23.667	(14.853)
Obs.	23558	
R^2		

∗ p <0.10, ∗∗ p <0.05, ∗ ∗ ∗ p <0.01
Source: SOEP, own calculation.

Table 12: Inheritance after parents death

	ln(inheritance)	
region=east	−1.345***	(0.164)
educ=high	0.263**	(0.133)
(1/3) years light care + years inten. care	0.113***	(0.041)
Constant	10.288***	(0.087)
Obs.	463	
R^2	0.14	

∗ p <0.10, ∗∗ p <0.05, ∗ ∗ ∗ p <0.01
Source: SOEP, own calculation.

Table 13: Partner income

	ln(partner income)	
educ=high	0.140***	(0.014)
region=east	−0.154***	(0.013)
age	−0.084	(0.082)
$age^2/100$	0.042	(0.069)
age≥65	0.059**	(0.030)
Constant	10.486***	(2.440)
Obs.	18215	
R^2	0.03	

$*$ p <0.10, $**$ p <0.05, $***$ p <0.01
Source: SOEP, own calculation.

Table 14: Non-labor income regression

	ln(non-labor income)	
age	0.396***	(0.126)
$age^2/100$	−0.265**	(0.103)
mar=1	1.360***	(0.031)
educ=high	0.690***	(0.031)
region=east	−1.173***	(0.030)
Constant	−10.244***	(3.840)
Obs.	23323	
R^2	0.15	

$*$ p <0.10, $**$ p <0.05, $***$ p <0.01
To controll for outliers the top 1% of the wage distribution is droped.
Source: SOEP, own calculation.

A.5. Pension System cont.

Table 15: Features of the German public pension system 2000-2016

	Pension Points			Benefits	
Year	Average income west	Adjustment factor east	Cap on pension points	Pension value west	Pension value east
2000	27,741	1.20	1.90	24.84	21.61
2001	28,231	1.20	1.89	25.31	22.06
2002	28,626	1.20	1.89	25.31	22.06
2003	28,938	1.19	2.11	25.86	22.70
2004	29,060	1.19	2.13	26.13	22.97
2005	29,202	1.18	2.17	26.13	22.97
2006	29,494	1.18	2.14	26.13	22.97
2007	29,951	1.18	2.10	26.13	22.97
2008	30,625	1.19	2.07	26.27	23.09
2009	30,506	1.17	2.12	26.56	23.34
2010	31,144	1.17	2.12	26.56	23.34
2011	32,100	1.17	2.06	27.20	24.13
2012	33,002	1.18	2.04	27.47	24.37
2013	33,659	1.18	2.07	28.07	24.92
2014	34,514	1.17	2.07	28.14	25.74
2015	34,999	1.17	2.07	28.61	26.39
2016	36,267	1.15	2.05	29.21	27.05

Table 16: Legal retirement age by birth cohort

Year of birth	Legal retirement age without reduction true age	Legal retirement age without reduction in model	Earliest possible retirement age true age	Earliest possible retirement age in model
≤1946	65 years	65 years	60 years	60 years
1947	65 years + 1 month	65 years	60 years + 1 month	60 years
1948	65 years + 2 months	65 years	60 years + 2 months	60 years
1949	65 years + 3 months	65 years	60 years + 3 months	60 years
1950	65 years + 4 months	65 years	60 years + 4 months	60 years
1951	65 years + 5 months	65 years	60 years + 5 months	60 years
1952	65 years + 6 months	66 years	60 years + 6 months	61 years
1953	65 years + 7 months	66 years	60 years + 7 months	61 years
1954	65 years + 8 months	66 years	60 years + 8 months	61 years
1955	65 years + 9 months	66 years	60 years + 9 months	61 years
1956	65 years + 10 months	66 years	60 years + 10 months	61 years
1957	65 years + 11 months	66 years	60 years + 11 months	61 years
1958	66 years	66 years	61 years	61 years
1959	66 years + 2 months	66 years	61 years + 2 months	61 years
1960	66 years + 4 months	66 years	61 years + 4 months	61 years
1961	66 years + 6 months	67 years	61 years + 6 months	62 years
1962	66 years + 8 months	67 years	61 years + 8 months	62 years
1963	66 years + 10 months	67 years	61 years + 10 months	62 years
≥1964	67 years	67 years	62 years	62 years

A.6. Tax Benefit System cont.

Table 17: Features of the German tax and transfer system 2000-2016

Year	Social Security Contribution				Income Tax				Basic Social Security
	Cont. rate worker (%)	Cont. rate pensioners (%)	Max Cont. west per month	Max Cont. east per month	Tax free allowance per year	Min marginal tax rate (%)	Top marginal tax rate (%)	Solidarity tax (%)	per month
2000	20.55	7.65	4,300	3,550	6,902	22.9	51.0	5.5	606
2001	20.45	7.65	4,350	3,650	7,206	19.9	48.5	5.5	617
2002	20.65	7.85	4,500	3,750	7,235	19.9	48.5	5.5	629
2003	21.00	8.00	5,100	4,250	7,235	19.9	48.5	5.5	634
2004	20.95	7.95	5,150	4,350	7,426	16.0	45.0	5.5	643
2005	20.95	7.95	5,200	4,400	7,664	15.0	42.0	5.5	653
2006	20.95	7.95	5,250	4,400	7,664	15.0	42.0	5.5	653
2007	20.35	8.30	5,250	4,550	7,664	15.0	45.0	5.5	655
2008	19.96	8.36	5,300	4,500	7,664	15.0	45.0	5.5	659
2009	19.78	8.43	5,400	4,550	7,664	14.0	45.0	5.5	667
2010	19.78	8.43	5,500	4,650	8,004	14.0	45.0	5.5	667
2011	20.18	8.73	5,500	4,800	8,004	14.0	45.0	5.5	672
2012	20.03	8.73	5,600	4,800	8,004	14.0	45.0	5.5	682
2013	19.73	8.78	5,800	4,900	8,130	14.0	45.0	5.5	690
2014	19.73	8.78	5,950	5,000	8,354	14.0	45.0	5.5	699
2015	19.78	8.93	6,050	5,200	8,472	14.0	45.0	5.5	707
2016	19.88	9.03	6,200	5,400	8,652	14.0	45.0	5.5	712