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FUNDAMENTALLY REFORMING THE DI SYSTEM:
EVIDENCE FROM GERMAN NOTCH COHORTS

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Fundamentally Reforming the DI System: Evidence from German Notch Cohorts
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ABSTRACT

In 2001, Germany abolished public occupational disability insurance (ODI)—the second tier of public DI—for post-1960 cohorts. First, overall DI inflows decreased by a third in the long run. Second, representative data show at best modest increases in private ODI take-up in an individual risk-rated market without guaranteed issue. Third, an equilibrium model featuring interactions between the safety net, the first tier of public DI, and the private market illustrates that coverage denials and weak insurance demand due to complementary social insurance produce modest private ODI take-up with steep gradients by income and health. Finally, we simulate complementary reforms.

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Fundamentally Reforming the DI System: Evidence from Germany

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Abstract

In 2001, Germany abolished public occupational disability insurance (ODI)—the second tier of public DI—for post-1960 cohorts. First, overall DI inflows decreased by a third in the long run. Second, representative data show at best modest increases in private ODI take-up in an individual risk-rated market without guaranteed issue. Third, an equilibrium model featuring interactions between the safety net, the first tier of public DI, and the private market illustrates that coverage denials and weak insurance demand due to complementary social insurance produce modest private ODI take-up with steep gradients by income and health. Finally, we simulate complementary reforms.

Keywords: occupational disability insurance, individual private DI, coverage denials, risk rating, private information, adverse selection, social safety net

JEL Classifications: H53, H55, I10, I14, I18, I48, J14, J26, G22

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1 Introduction

For decades, the design of social insurance systems has been at the core of economic research (Chetty and Finkelstein, 2013; Aizawa et al., 2025). Three integral strands exist in all OECD (2010) countries: unemployment insurance (Lalive et al., 2015), Workers' Compensation (Powell and Seabury, 2018), and public disability insurance (Autor et al., 2019). Thus, experiences from one OECD country might hold important lessons for other countries (Besharov and Call, 2022).

A rich literature in economics has studied the implications of public disability insurance (DI) for labor supply (Deshpande, 2016), earnings and consumption (Ruh and Staubli, 2019), beneficiaries' health and well-being (Gelber et al., 2023), multigenerational welfare cultures (Dahl et al., 2014), and firm accommodation (Aizawa et al., 2023). Although Dutch reforms that introduced experience-rated premiums for employers have received considerable attention (cf Koning and Lindeboom, 2015), there is less evidence about a 2001 German DI reform that reduced generosity to transition to a mixed public-private insurance system. This may be surprising as U.S. reform proposals explicitly mention these fundamental DI reforms in Germany and the Netherlands, arguing that the private market could compensate for the reduced generosity of public DI (Autor and Duggan, 2010; Burkhauser and Daly, 2022).

This paper studies how the private DI market has responded to a fundamental German DI reform that eliminated public Occupational Disability Insurance (ODI) for cohorts born after 1960, effective 2001. ODI insures the lifecycle risk of becoming work disabled in the *previous occupation* or a comparable occupation (called ”social status protection”). As Germany has maintained a coexisting public ”Work Disability Insurance” (WDI) that insures the risk of becoming work-disabled for *any* job in the economy, along with a means-tested cash transfer program, ODI primarily insures better-educated and higher-income employees against income drops to these consumption floor levels. All five German center-left and center-right political parties favored abolishing public ODI due to concerns about inequality and ODI's *regressive* nature. For example, the preamble in the draft of the bill[1]:

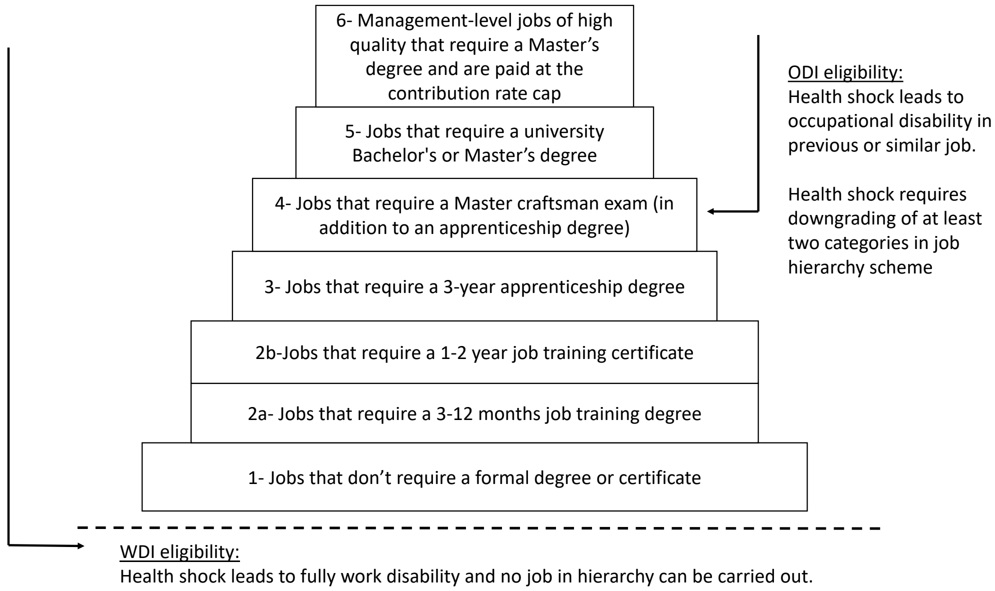
> ”There is widespread agreement among experts and academics, as well as in the political arena, that a DI reform is needed. As an example, the *Bundesrat* [second federal chamber] and the *Bundesrechnungshof* [Federal Audit Office] have urged and repeatedly requested [such a reform] from the *Bundestag* [German parliament] and the federal government. [...] In particular, public ODI has been criticized as it has become a 'prestige pension' for insured with particular qualifications in high-level positions.” (Bundestag, 2000)

While for low-income, basic jobs, not being able to work in the previous occupation generally implies not being able to work any job, this is typically not the case for the better educated, for whom public ODI served as a publicly-funded supplemental insurance for their social status. Figure 1 illustrates the basic eligibility principle of ODI and WDI, developed by the German Federal Social Court (*Bundessozialgericht*). Accordingly, there are six job categories, the highest referring to managerial positions and the lowest to unskilled basic work in the labor market. ODI eligibility is established when a work disability prevents workers from carrying out their previous job or a job one category below. WDI eligibility, by contrast, is established when the worker is unable to carry out any of the jobs in the six categories. It immediately follows that the ODI insurance value differs by job category. It was thus labeled a ”prestige [DI] pension” in the quote above. As these institutional details are crucial for understanding private ODI take-up in response to the abolishment of public ODI, this paper's theoretical framework models the interaction between public WDI, public ODI, and the private ODI market from the insurer's

[1] A previous draft proposal of the bill by the three center-right parties makes the same point: *”As a consequence, public ODI pensions are a privilege of insurees with extraordinary education and in elevated positions. However, the insurance principle [...] requires that insurees [...] must have equal opportunities to claim benefits.”* (Bundestag, 1997), produced by the center-left coalition of Social Democrats and Greens, reads [loosely translated from German]

and consumer's perspectives.

Figure 1: Job Hierarchy Scheme Illustrating WDI and ODI Eligibility



Source: own illustration and translation following §240 SGB VI and Deutsche Rentenversicherung (2025). . The Federal Social Court has developed a job hierarchy scheme, according to which ODI eligibility is established if a worker is unable to perform their previous job or a job in a category below the last job due to health issues. For blue-collar jobs, no job categories five and six exist. Appendix Figure A1 provides further details on ODI and WDI edibility.

Before introducing the theoretical framework, however, we demonstrate that the reform had a tangible impact on the treated cohorts. Using administrative data in an event study design, we show that the 2001 reform significantly reduced the overall DI inflow (WDI+ ODI) by more than 30% ten years after the reform. Next, we study private ODI market responses. Using representative survey data and Regression Discontinuity (RD) approaches with birth year as the running variable, we find, at best, modest increases in take-up in response to the reform. These modest take-up effects are consistent with concurrent research using data from a single private insurer (Seibold et al., 2025), see more below. Our 95% confidence intervals let us exclude private ODI take-up increases to more than 50% in the general population.

Why has private ODI take-up not increased above 50% in the population? To better understand the underlying economic driving forces of the take-up response, we employ a novel equilibrium model to capture key demand and supply aspects of the German private DI market. To do so, we strongly rely on the model by Braun et al. (2019), which we tailor to capture German market regulation and social insurance interaction. The model features an optimal contracting framework that endogenizes the insurer's supply side and private ODI policies offered. Specifically, the insurer offers two types of policies for each of the 750 risk groups in the model: one for high- and one for low-risk types, where the ”true type” is unobserved by the insurer. Pricing is based on observables and features health risk rating, as in reality.

Moreover, as another crucial market feature that we model, coverage denials are an integral part of the model. Similar to U.S. health insurers in the pre-ACA era, in Germany, it is common knowledge that (i) private ODI insurance applicants must report all current diseases, diagnoses, as well as past healthcare use, (ii) this information is centrally stored in a shared database and accessible for other insurers, producing (iii) strong selection into applying for coverage (Finanztip, 2017; informa HIS GmbH, 2025). Our rating agency data on the near universe of private ODI insurers show that, *conditional on applying*, a sixth get entirely or partially denied coverage, e.g., through pre-existing condition clauses. This number is conditional on the selective sample of ”official” applicants and reported by insurers. A highly respected consumer magazine reported that the industry would reject 235K applications annually, implying rejection rates of almost 50%.[2] Further, an audit study requesting 110 anonymous health assessments for 59 policies found that 81% of applicants were offered less generous coverage than desired and often entirely denied coverage, even those with minor health issues (Ökotest, 2014). Thus, one of the model's key features aligns with a key market characteristic: insurers routinely deny coverage based on observables. In addition to risk rating and coverage denial as key market features, our framework considers Germany's means-tested cash transfer program, the public WDI program, and administrative costs. These are all critical determinants of the demand for private ODI.

To our knowledge, this is the first paper to model disability insurance supply and demand within an equilibrium framework that incorporates endogenous private policy offerings and allows for risk rating and coverage denials. The model is rich enough to replicate the substantial income and health gradients in take-up in our representative data. It provides a framework for understanding modest private ODI take-up responses to a fundamental reform that eliminated public ODI entirely. Specifically, the modest private ODI take-up response is explicable by a relatively generous means-tested cash transfer program and public WDI, in conjunction with coverage denials and risk rating. Recall that ODI provides ”social status protection” to insure the risk that one's income may fall to the consumption floor due to bad health, see Figure 1.

[2]Such a number is plausible, given that there is the possibility to request anonymous pre-assessments before ”officially” applying and having one's information stored in the HIS database Verbraucherzentrale (2024).

Thus, we observe crowding-out of private by public ODI coverage primarily among the healthy and higher-income populations. The paper's final part simulates potential complementary policies. They show that private ODI coverage will remain incomplete under all (realistic) marginal policies.

The interaction of various social insurance programs and their spillovers to the private market has contributed to a small but crucial international economics literature

This paper thus contributes to studying the interaction effects of social insurance and private insurance markets (Borghans et al., 2014; Autor et al., 2019; Leung and O'Leary, 2020; Ahammer et al., 2023). While this literature focusing on public and private health insurance has clearly demonstrated crowd out of public insurance (Cutler and Gruber, 1996; Clemens, 2015), the DI literature on whether and how private markets could substitute for reductions in public DI is much thinner. Institutional differences across countries could be a barrier. Although *individual* private DI exists in Canada and the United States (Autor et al., 2014), the market for *group* policies, provided by employers, is much bigger in the U.S. This group market also includes *short-term* DI (also called "medical leave" or "Temporary Disability insurance, TDI"), also see Pichler and Ziebarth (2024). Stepner (2021) finds that such employer-provided *private short-term* DI provision has positive spillover effects on *public long-term* DI caseloads.[3] Autor et al. (2014) study determinants of private DI spells in the U.S. group market, whereas Cabral and Cullen (2019) find that employees value public DI more than twice its costs in the U.S.; it has also been found to insure more than just health risks (Deshpande and Li, 2019), similar to health insurance (Lee M. Lockwood, 2024).

In complementary work to ours, Seibold et al. (2025) also study private ODI take-up in response to the 2001 reform. Using data from a single private insurer, and consistent with our findings from representative data, they find modest increases in private ODI sales and a low "observed willingness-to-pay of many individuals." However, Seibold et al. (2025) use different data, different assumptions, and the Einav et al. (2010) (EFC) model to study selection. For example, Seibold et al. (2025) use their cost curve estimates from claims data in a sufficient statistics approach (cf Kleven, 2020) and argue that distributional concerns would justify public ODI provision.

While this paper and Seibold et al. (2025) share several consistent findings, such as modest

[3]Outside the U.S., short-term DI—sickness spells of several months while still employed—is typically publicly covered via *long-term sickness insurance* (Ziebarth, 2013; Markussen et al., 2018).

private ODI take-up responses and a low willingness of consumers to pay, they also differ in many dimensions. Specifically, our work contributes to the literature above and beyond Seibold et al. (2025) as follows: First, this paper utilizes representative and rich survey data, rather than data from a single insurer. In particular, the paper employs two long-running representative surveys, SAVE and SOEP to extract key data moments. Second, these moments are fed into an equilibrium model that features the supply and demand sides of the insurance market within the classical Rothschild and Stiglitz (1976) optimal contracting framework. Thus, the model adopts a *long-run* perspective and produces equilibrium outcomes. Instead, Seibold et al. (2025)'s modeling approach is static, reduced-form, and uses sufficient statistics to evaluate marginal policy changes. The approach takes the supply as given and abstains from coverage denials as well as modeling coexisting social insurance strands.

Third, our model's supply side endogenizes the contract design, including risk rating and coverage denials, both key features for understanding market reactions to the reform. In particular, coverage denials are a crucial mechanism for understanding take-up effects and socio-demographic gradients in take-up. This paper thus relaxes Seibold et al. (2025)'s assumption of no coverage denials.

Fourth, our model's demand side approximates how individuals make private ODI take-up decisions when entering the labor market, considering future (uncertain) lifetime income, health shocks, the public WDI system, and the means-tested safety net. Note that we calibrate and export the moments for the health distribution and the probability of lifecycle work disability over the income distribution—along with employees' lifecycle income development, including shocks. Fifth, unlike Seibold et al. (2025), we find empirical evidence of adverse selection and thus model private information on the demand side. Importantly, Hendren (2013) has shown¡ theoretically and empirically that particularly bad risks hold private information, leading to rejections by insurers. This important finding is consistent with our framework. Finally, we explicitly model the interaction between public WDI and private ODI, and how these two public programs, along with Germany's means-tested cash transfer program affect private ODI demand.

Existing work has already described the German private ODI market (Soika, 2018; McVicar et al., 2022) and studied aspects of the reform. For example, Börsch-Supan et al. (2022) do not find that the reform has improved target quality, and Hanel (2012) does not find much evidence that lower WDI *benefit levels* affect DI inflows. Not evaluating the 2001 reform but using the same claims data as Seibold et al. (2025), Seitz (2024) estimates a dynamic lifecycle model to conclude that, with a coexisting private market, the welfare-maximizing public DI program would be less generous than in a world without private markets. This important finding is also consistent with our framework.

This paper also contributes to a rich and growing literature on selection and supply-side competition in insurance markets (Fang et al., 2008; Aizawa and Kim, 2018; Dickstein et al., 2024). For example, Cabral et al. (2018) and Curto et al. (2021) study insurer surplus in the Medicare Advantage market and find that pricing alone cannot be used to attract different risk types, consistent with our framework. Many more papers have analyzed insurer-provider interactions in U.S. health insurance (Ho and Lee, 2017; Shepard, 2022), as well as the interaction between public and private insurer-provider reimbursement (Clemens and Gottlieb, 2017; Carey, 2017; Lavetti and Simon, 2018). While all these papers demonstrate the crucial role of supply-side aspects in insurance markets, private DI markets typically resemble life insurance and pure financial contracts (Fang and Wu, 2020), as managed care and provider pricing are largely absent.

Finally, this paper contributes to the international economics literature on DI. For example, Dahl et al. (2014) use the Norwegian case to study financial incentives of DI recipients to return to work—a common cross-country theme in times of rising recipiency rates (Hoynes and Moffitt, 1999; Koning et al., 2022). Dahl et al. (2014) study a return-to-work reform that allowed DI recipients to keep a larger share of their earnings. The program was effective, increasing labor supply, reducing program costs, and demonstrating substantial work capacity among DI recipients, in line with Bound (1989) and Maestas et al. (2013). Using a sufficient statistics welfare framework and two Austrian reforms, Haller et al. (2024) show that tighter DI eligibility rules outperform benefit cuts. Barriers to applying for DI, such as health screening, determine the inflow of DI beneficiaries (Autor and Duggan, 2003; De Jong et al., 2011).

2 The German Disability Insurance System

2.1 Social Insurance in Germany

In an international comparison, Germany has a generous social safety net consisting of public Unemployment Insurance (UI), Workers' Compensation (WC), Health Insurance (HI) and Long-Term Care (LTC) insurance (Schmieder et al., 2016; Bauernschuster et al., 2020; Hackmann et al., 2025). Among employees, eligibility for sick and medical leave is universal and among the most generous worldwide (Ziebarth and Karlsson, 2010, 2014).

Moreover, Germany has Statutory Pension Insurance (SPI) (Geyer, 2021), and a universal means-tested cash transfer program. This means-tested cash transfer program provides a guaranteed minimum income floor with, for a single, monthly benefits of €563 (in 2024) in addition to costs for accommodation and utilities.[4] Later, we will analyze the role of this means-tested cash transfer program for the low private ODI take-up rates among low-income individuals.

2.2 The Public Disability Insurance Reform of 2001

Germany's public DI program is part of SPI. Employers and employees are each subject to a payroll tax (since 2018: 9.3%) of their monthly gross earnings up to the social insurance contribution ceiling (€7.550 per month in 2024). To qualify for public DI, employees must have paid the payroll tax in at least three out of the last five years before applying.

Prior to 2001, the German public DI system consisted of two schemes: (a) work disability insurance (WDI), and (b) occupational disability insurance (ODI). The 2001 reform abolished public ODI for cohorts born after 1960 (our treatment group). Cohorts born before 1961 were grandfathered in (our control group) and were eligible for public ODI before *and* after the 2001 reform.[5] Appendix Figure A1 illustrates the main principles after 2001.

The two-tiered system could be considered a combination of a basic (WDI) and supplemental (ODI) scheme. In this context, it is crucial to understand that the insurance value of ODI is structurally higher for higher-income groups. This higher value for better-paying jobs is a function of the eligibility criteria, see Figure 1 and A1. WDI provides insurance for *general work disability* when a poor health status prevents employees from working *in any job* in the labor market. ODI, by contrast, provides insurance for *occupational* work disability through

[4]For those with work capacity, it is Unemployment Insurance II (*Arbeitslosengeld II*) of about 100% FPL in U.S. terms. A reform in 2004 introduced *Arbeitslosengeld II*, which decoupled means-tested benefits from previous labor income, and reduced the maximum duration of standard UI benefits (see Dustmann et al. (2014)). The reforms did not differentially affect the treatment and control groups of the 2001 reform (see Section 2.2), but generally cut the generosity of these alternative social insurance strands.

[5]In the course of the reform, an entirely new Social Code Book IX was passed. It regulates "Rehabilitation and Participation in Social Life" (*Rehabilitation und Teilhabe von Behinderter Menschen*) for people with disabilities and handicaps in Germany. Before 2001, most of these regulations were included in the *Schwerbehindertengesetz*.

"social status protection."[6] Importantly, "occupationally disabled" are those who (Deutsche Rentenversicherung, 2023a): *"[...] due to health reasons, are unable to work in either their trained or a comparable occupation in terms of the education and skills required."*

Public ODI was never intended to provide the entire means for a living. Instead, benefits compensated for a *partial* loss in work capacity when employees either had to switch to a lower-paid occupation or from full to part-time work. As shown in Figure 1, for the most basic jobs in the economy, WDI and ODI converge because, generally, those employees cannot switch to a more basic, lower-paid occupation (Benen, 2023). By design, employees with higher-paying jobs benefited more from ODI than those with lower incomes. Note that individual private ODI is also available in other countries, such as the U.S., where it is sold as "own-occupation DI" and marketed explicitly to higher-income professions, such as physicians or lawyers (Brian SO Insurance, 2023).

Benefit Calculation. Benefits are calculated as an "early retirement pension" with actuarial reductions (Appendix Figure A1). Specifically, it is assumed that recipients would have earned their pre-DI labor market income up to the age of 60, and then actuarial deductions of 3.6% per year apply for each year prior to 63, up to 10.3%.[7] Thus, benefits are a function of recipients' earnings histories and are not adjusted for family composition, income, or assets. Appendix D provides detailed simulations of public ODI benefits. Post-reform, the simulated replacement rate at age 46 is 12% of average gross earnings. In 2000, the average public ODI benefits were €587, and the average public WDI benefits were €731 per month (Deutsche Rentenversicherung, 2023b).

2001 Reform. The reform cut public ODI for cohorts born after 1960. However, the entire reform package entailed various additional changes, see Appendix Figure A1. However, these extra elements did not differentially affect the birth cohorts. For example, the reform also changed how work capacity was medically assessed: from an earnings capacity test to the hour capacity test discussed above. Moreover, WDI benefits were slightly reduced for all, and

[6] That is, occupational disability "to less than half of that of a physically, intellectually, and mentally healthy person with similar training, knowledge and abilities" (§43, §240 of Social Code Book VI; Viebrok (2018)).

[7] Several studies document a high poverty risk among WDI recipients (Krause et al., 2013; Geyer, 2021; Becker et al., 2023). Consequently, policymakers increased WDI benefits again by increasing the "reference age" for new recipients to 62 in July 2014, and to 65 years and eight months in 2019. It now equals the statutory retirement age and will increase to 67 years by 2031. Similarly, the age threshold for actuarial deductions has been raised.

ODI benefits were reduced for the grandfathered cohorts (Appendix D).[8] Although Hanel (2012) finds little evidence for this, the reduced benefit level may have decreased the relative attractiveness of applying for ODI. Then, our estimates on how abolishing public ODI has affected overall DI inflows would represent a lower-bound estimate.

2.3 Private Disability Insurance in Germany

Basic Principles. The German private disability insurance market is primarily an individual market, not a group market like in the U.S. (Autor et al., 2014). Like the long-term health insurance market in Germany (Atal et al., 2019, 2025), the private individual ODI market is individually underwritten. Guaranteed issue does not exist. Private disability insurance follows private insurance law (*Versicherungsvertragsgesetz*) and features private contracts between insurers and policyholders. Premiums depend on factors such as age, medical diagnoses, health behaviors, income, and occupation. This information is elicited by insurers in questionnaires like Appendix Figure C1. As a result, premiums can easily be several hundred dollars for high-risk occupations, and often, applicants are denied coverage (Ökotest, 2014).

Age at Inception & Claiming. The insurance industry relies on its own medical examiners (BBP, 2020). The average age when signing a policy is 32, and the average age of work disability is 46; the average contract runs until age 64. We use these figures in our theoretical framework to model the decision to purchase private ODI.

Coverage Denials and Policy Heterogeneity. Rating agency data from private insurers covering almost five million ODI policies show that, in 2019, 23% of new applications were either rejected (8%), included pre-existing condition clauses (11%), or included risk-premia (4%) due to pre-existing conditions (Morgen & Morgen, 2021). Note that these shares are *conditional* on applying for a policy. In reality, brokers and online calculators can easily inform potential applicants in advance whether their application has a chance of success or not. According to industry experts, the industry would reject 235K private ODI applications per year, which would be a rate of almost 50% (Morgen & Morgen, 2021). Further, in an audit study with 120 fake applications, a German consumer magazine found that 81% were offered a policy with less generous coverage than desired (Ökotest, 2014).

[8] Pre-reform, the applicant must be unable to earn more than 640 DM (about €320 in 2001 or $480 today).

Premiums & Benefits. In 2019, monthly premiums varied between \$50 and \$200 for insured monthly benefits of between \$750 and \$2000 (Ökotest, 2014). The average insured benefit was €13,296 per year for average annual premiums of €924 (Morgen & Morgen, 2021). Importantly, as they are not means-tested, private and public DI benefits do not crowd each other out. Rather, private ODI tops up public WDI or public ODI benefits.

Market Structure. The market is characterized by freedom of contract between insurers and applicants. Many online calculators yield advice on a wide range of policy elements that can be individually customized, leading to hundreds of different policies. However, even for the same policy and applicant, premiums differ substantially across insurers (Ökotest, 2014). In 2002, only 26 private ODI insurers existed, with the three largest (Allianz, Debeka, ERGO) collectively holding a market share of roughly two-thirds of newly signed ODI policies (Morgen & Morgen, 2021). This suggests monopolistic market structures, which our model assumes. Monopolistic market structures are also justifiable by the healthy ODI profit margins. Although they are a well-kept secret, the German Financial Regulatory Agency (BaFIN) lists aggregated risk returns of the entire life insurance segment, of which ODI was a key driving force (Bundesanstalt für Finanzdienstleistungsaufsicht (BaFin), 2004). The total share of profits (of which, by law, the majority flows back to the policyholders) was 33% of total premiums in 2000; key single components made up 20% (capital returns) and 7% (risk return due to lower than assumed/calculated claiming and lapsation), see Bundesanstalt für Finanzdienstleistungsaufsicht (BaFin) (2002).

Below, we will further characterize the private German ODI market, carve out several stylized empirical facts, and then use a general equilibrium model to model interactions between public WDI, ODI, and the means-tested cash transfer program. Following reality, the framework also includes risk rating and coverage denials.

3 Impact of Reform on Public DI Inflows Using Administrative Data

This section provides evidence on the first-stage effects of the 2001 reform. We estimate its impact on the inflow of new public DI recipients. Note that the outcome is *total public DI*, the sum of WDI and ODI as we do not observe ODI and WDI separately in the data. We use administrative data from the SPI in a Difference-in-Differences (DD) model to do so. The data are available by year, region, gender, and birth year.

DD Method. We normalize inflows by cohort for each year using population data from the German Federal Statistical Office. Further, we focus on cohorts 1954 and 1966 and ages 29 and 59 in a given calendar year. Then, using data from 1995 to 2019, we compare our treatment group—cohorts who became ineligible for public ODI from January 2001, to our control group—grandfathered cohorts born before 1961 via the following DD model:

$$y_{ct} = \alpha + \beta D_c \times T_t + \delta_t + \rho_c + \epsilon_{ct} \tag{1}$$

where y_{ct} denotes the share of new public DI recipients of cohort c in year t; D_c is a treatment dummy; T_t is a post-reform dummy that turns on after 2000; δ_t are year fixed effects; and ρ_c are cohort fixed effects. ϵ_c denotes the error term we cluster at the cohort level.

The main identification assumption implies that absent the reform, the inflow of new public DI recipients of the treated cohorts would have developed similarly to those of the grandfathered control cohorts. Note that our setting is not a staggered DD setting (Goodman-Bacon, 2021).

[Insert Figure 2 about here]

Results. To illustrate the main findings, Figure 2 plots an event study using equation (1) but replaces T_t with a series of year dummies, where 2000 serves as the baseline year. Whereas the five pre-treatment years show no trending, and the relative inflow differences between treated and control cohorts are not significantly different from zero, we observe a sharp decline in inflows beginning in the first post-reform year 2001. This decline further accelerates in subsequent years, up to point estimates exceeding -0.2 percentage points, or about 35% relative to the pre-reform mean.

By 2011, one decade after the reform implementation, the inflow differential between the two groups had flattened out. From then on, it remained highly significant at -0.2 percentage points. This represents the long-run effect of the reform.[9] Recall that ODI benefits decreased for the grandfathered cohorts; see Appendix D for details. Using administrative microdata, Hanel (2012) finds no evidence that these lower benefit levels affected DI inflows. However, if reduced benefits significantly affected DI inflows, our estimates would represent lower bound estimates.

Figure A2 (Appendix) shows the same event studies separately by gender. Again, we observe reassuringly stable pre-reform trends, followed by substantial inflow reductions among

[9]For this number, we use as pre-reform mean the mean entry rate of untreated cohorts, which was 0.58% for cohorts born between 1954 and 1960.

the treated cohorts. However, not surprisingly, the reform-induced decrease in inflows is substantially larger for males; males are more likely to be eligible for DI due to a stronger labor market attachment. Moreover, males are more likely to work in physically demanding occupations and industry jobs that carry a higher risk of work disability.

Table A1 (Appendix) shows the DD regression model estimates. Panel A shows results for the full sample, Panel B for men, and Panel C for women. Each column in each panel stands for one separate DD model, as in equation (1). The findings align with the event study estimates. First, the estimates are robust to including cohort and year fixed effects and control for "East Germany." The average decline in male inflows translates into a 20% decrease relative to the control group's mean. The decline for women is only half as large at 10%. Note that the long-term effect from 2011 is about twice as large as the average effect; see Figure A2.

Validation. Results in Appendix B validate these findings using representative survey data from the German Socio-Economic Panel Study (SOEP) and an alternative identification approach. The SOEP measures the stock of recipients; see Goebel et al. (2019). The alternative identification is Regression Discontinuity (RD), with the birth year 1961 representing the cutoff. The main RD identification assumption is the absence of another factor that could have affected the outcome discontinuously at the birth year level. The appendix also shows the state-of-the-art robustness checks. We will use a very similar RD identification approach to estimate the reform's impact on private ODI take-up using yet another representative dataset. Overall, the findings from both approaches illustrate that the 2001 reform had bite among the treated generations who were no longer eligible for public ODI.

Financial Impact of Health Shock. Results in the appendix also estimate the pre and post-reform financial impact of a work-limiting health shock using the SOEP. The results cast light on the financial consequences of work disability—in the context of the German safety net—to inform our private ODI demand estimates below. Table B3 shows a general reduction in total annual pre-tax household income of €4,117, in line with Di Meo and Eryilmaz (2024). However, there is little evidence that the financial impact was larger for the treatment group without public ODI access. These findings and Di Meo and Eryilmaz (2024) do not provide much evidence for a substantial financial impact of health shocks on post-tax household income, mostly because of (other) public benefits, progressive taxation, and intra-household self-insurance.

4 The 2001 Public DI Reform and the Private Individual ODI Market

This section studies the interaction between the German public and private ODI market in a reduced-form setting. It also provides representative empirical evidence on take-up of private ODI policies in the German individual market, one of the biggest in the world. We carve out several empirical stylized facts in the context of its market regulation; see also Section 2. Then, in Section 5, building on Braun et al. (2019), we use a novel version of their general equilibrium model (GEM) to model the interaction between public WDI and ODI, the safety net, the reform, and explain the stylized empirical facts around take-up of private ODI.

4.1 Impact of the 2001 Reform on the German Private Individual ODI Market

We first test whether the treated cohorts purchased private ODI policies at higher rates than the control cohorts to compensate for the loss of public ODI coverage. It is a straightforward hypothesis that the reform may have crowded in demand for private ODI. A rich economics literature has studied the reverse effect, crowd-out of private health insurance through public health insurance expansions (Cutler and Gruber, 1996; Clemens, 2015).

Data. We use representative survey data from SAVE (Saving for Old Age in Germany, *Sparen und AltersVorsorgE in Deutschland*). Coppola and Lamla (2013) provide a detailed overview of the SAVE data. It includes rich sets of questions about preferences, savings, retirement, health, and standard socio-demographics. Some measures are typically unobserved by researchers and insurers. Thus, this unique survey helps us to (a) mimic the risk classification of private ODI insurers and (b) assess the relevance of private information that drives insurance market selection in the spirit of Akerlof (1970), Rothschild and Stiglitz (1976), and Hendren (2017). It also informs our modeling decision by assessing socio-demographic predictors of private ODI take up.

Sample Selection. We use all SAVE waves with information on private ODI coverage from 2001 to 2010, which were conducted annually (except for 2002 and 2004). We focus on employees below the early retirement age of 63 and exclude civil servants and the self-employed who were unaffected by the public ODI reform. Table C1 shows the summary statistics of our primary sample. 32% of all households are ODI policyholders, the average age is 45, and 33% hold the highest schooling degree in Germany after 13 school years ("high school"). We observe the birth year as a separate variable to identify the treated cohorts.

[Insert Figure 3 about here]

Figure 3 shows the main result on private ODI take-up for the full sample; Figure C3 (Appendix) shows robustness checks for alternative samples; clockwise, starting from the upper left: (1) the full sample as in Figure 3, (2) those who paid SPI contributions at the time of the interview, (3) childless households, and (4) one-person households. In all graphs, the x-axis displays the birth year, and the y-axis displays the outcome variable, *Private ODI*. We plot unconditional scatters by birth year, overlaid with linear plots for each cutoff side; we vary polynomials in robustness checks.

The figures show an increasing slope in the birth year. In other words, younger people are much more likely to have private ODI. This is not surprising. After substantial expansions of social insurance in the decades after WWII, a series of structural reforms of the statutory pension and DI system in the 1980s and 1990s reduced generosity, see Burkhauser and Daly (2022). The structural reforms were accompanied by strong messaging and education (also in high schools) from consumer advocates. This outreach mainly argued that private insurance policies for old age would be crucial for young people, given the reduced generosity of social insurance. Further, younger applicants are less likely to get rejected by ODI insurers due to their better health. Healthier applicants are also offered lower premiums and are less likely to incur pre-existing condition clauses, see Section 2. At the same time, the figures do not show a noticeable discontinuous jump in the likelihood of having private ODI insurance for the treated compared to the control cohorts.

[Insert Table 1 about here]

Table 1 shows local polynomial RD results for all four samples. The column headers indicate the four samples, and the rows indicate whether the estimates are based on bias-corrected, robust, or conventional polynomial RD estimates (Calonico et al., 2014, 2017, 2019). The bias-corrected and robust RD estimates in columns (1) and column (2), based on the full sample and those who are currently SPI insured, show four positive point estimates of about 14 percentage points (ppt). The estimates are somewhat imprecise. However, based on our data, we can exclude take-up increases larger than 5ppt in column (1).

In robustness checks, we vary the bandwidth (Figure C4, Calonico et al. 2020), study discontinuities in covariates (Figure C5), plot the density of the running variable (Figure C6, McCrary 2008), correct for the discrete running variables (Kolesár and Rothe, 2018) and alter polynomials (Figure C7). For this exercise, we use our preferred model in column (1) with exogenous controls (age, gender, year, and state fixed effects) and find consistent results.

4.2 Some Stylized Facts on the German Individual Private ODI Market

Overall, an estimated increase in the private ODI take-up rate of 14ppt is, at best, a modest effect, leaving the majority of German employees uninsured. This begs the question, "Why is that? And how can we explain this general coverage effect?" Note that the observed coverage effect is an equilibrium outcome resulting from an interplay between demand, supply, and market regulation.

Thus, Section 5 employs a general equilibrium model (GEM) to trace the underlying supply and demand driving forces of this take-up response. We first present stylized facts about private ODI take-up in Germany. Again, we rely on the representative SAVE and SOEP surveys to study the empirical ODI take-up pattern as well as lifecycle income and health risk profiles. As we will see, the extended GEM based on Braun et al. (2019) is rich enough to reproduce private ODI take-up patterns by health and income.

Before doing so, however, Appendix Table C2 shows simple socio-demographic variable means from SAVE to characterize those who took up vs did not take up private ODI by treatment and control groups. This exercise may inform our modeling decisions. Here, we focus on SAVE years up to and including 2005 to minimize deviations from the reform and limit the aging effect in our sample. Column (1) shows the characteristics of those who lost access to public ODI and purchased private ODI. Column (2) shows those who lost access to public ODI and did *not* purchase private ODI, whereas column (3) focuses on the control cohorts up to age 50 who did purchase private ODI (in addition to being covered by public ODI), and column (4) shows controls who did not purchase private ODI.

The findings are consistent with market regulation and economic intuition, especially when comparing those who purchased vs. those who did not purchase private ODI. Those who purchased private ODI are more likely to be married, have children, and live in bigger households. They are also more likely to be full-time employed, are better educated, are more likely to hold white-collar jobs, and have higher incomes. These findings are confirmed in a multivariate regression with socio-demographic predictors displayed in Appendix Figure C2.

Coming back to Table C2, importantly, those who are covered by private ODI are healthier, have better subjective health, and also have lower incidence rates for stroke, cancer, heart attacks, high blood pressure, and high cholesterol. Further, they are less likely to be smokers. These empirical findings align with sick applicants being denied coverage or charged very high, risk-rated premiums. Finally, those with ODI are more likely to believe that saving for unexpected life events and for old age is important, are less likely to say that they cannot save, and expect higher incomes and inheritances in the future.

Health Risk Score. Table C1 shows a detailed list of health measures in the representative SAVE. SAVE features the standard self-assessed health (SAH) measure and the 0-10 Likert scale health satisfaction measure along with questions on health concerns and whether respondents have serious health issues (Ziebarth, 2010). As already implied above, it also includes the most common medical conditions, such as heart disease, stroke, cancer, high blood pressure, high cholesterol, or chronic lung disease, which have all been elicited for each respondent as well as smoking status. Finally, SAVE elicits the previous year's doctor visits and hospital nights. All this information reflects what private disability insurers ask in their health assessment questionnaires before deciding about risk surcharges, pre-existing condition clauses, or outright coverage denials. Appendix Figure C1 shows such a health assessment questionnaire.

[Insert Figure 4 about here]

To investigate take-up by a one-dimensional health risk measure, we use the health measures in a principal component analysis to summarize and aggregate all available objective and subjective health measures into a continuous health risk score (Jolliffe, 2002). We do so for two reasons: First, it follows the common practice of insurers and is standard in the literature (Ghili et al., 2024; Handel et al., 2024; Atal et al., 2025). Second, it allows us to summarize the multi-dimensional health information in a compact empirical representation. The distribution of this normalized health risk score ranges between 0 and 1 and is in Figure 4. It is reassuring to see a typical left-skewed health risk distribution with a long right rail as standard for health risk distributions (Karlsson et al., 2016, 2024; Handel et al., 2024).

Lifecycle Risk for Severe Health Limitations. Next, we circle back to the representative SOEP panel. The SOEP has existed since 1984 for more than 40 years. Thus, it allows us to measure the *lifecycle risk* of occupational disability. To do so, we focus on a sample of SOEP respondents whom we observe at least once working full-time between the ages of 25 and 35 when Germans typically enter the labor market and decide on signing ODI policies. We then cut a SOEP lifecycle sample such that we also observe *the same individuals* at least once between the ages of 55 and 60. Following Burkhauser and Schroeder (2007), we elicit a broad and representative measure of the lifecycle risk of occupational disability among German employees.

[Insert Figure 5 about here]

Figure 5a plots the lifecycle risk of having a severe health limitation that limits respondents' ability to execute their jobs (according to self-reports) against the quintiles of self-reported health satisfaction between 25 and 35. Given limited data availability over all 33 years, we use health satisfaction as a proxy for health.[10] It also stratifies the risk by the quintiles of household net income.

Figure 5a plots the pattern without correcting for socio-demographics. First, the lifecycle risk of a severe health-limiting shock is considerable. Second, it remains significant even for the healthiest employees. On average, it is 49% for those 20% with the lowest health satisfaction, then drops to 26% for the next quintile, and drops to 8% for those most satisfied with their health. Third, it entails a clear income gradient, which is 31% for the lowest income quintile, 20% for the second lowest, and then drops to 10% for the wealthiest quintile. Figure 5b shows the same graph but first traces out socio-demographics, job, and educational characteristics (but not income and health). The curves flatten substantially over the baseline health status but maintain a clear income gradient. Further, the lifecycle risk remains high, above 20% for most health and income groups. These patterns are consistent with Meyer and Mok (2019), who report similar statistito purchase private ODI policies, as described in.

ODI Take-Up by Health and Income. Figure 6 summarizes key stylized facts of private ODI take-up compactly. The figure shows take-up on the y-axis and the population quintiles of the health risk score (Figure 4) on the x-axis. The quintiles of net household income additionally stratify the downward-sloping lines, as in the previous figure.

[Insert Figure 6 about here]

[10]Unfortunately, the SOEP only includes health satisfaction (and the standard SAH measure) over the entire 33 years we use. The quintiles are not exact as they are derived from the 0-10 Likert scale.

We can summarize: First, take-up strongly decreases from the second lowest to the highest health risk quintile, where a higher quintile indicates *worse* health. This pattern is unsurprising, given that insurers can deny coverage and premiums are risk-rated. As discussed in Section 2, even conditional on applying for coverage, a sixth of all policies are either rejected or contain a pre-existing condition clause. Because it is well known that insurers store and exchange applicants' health data in a shared database, consumer advocates strongly advise sick, potentially interested applicants to apply via an anonymous route (which is not included in the official conditional rejection data above).

Second, Figure 6 shows that, across the entire health risk distribution, the lowest income quintile has take-up rates that are substantially lower than all other income quintiles, between 25% for the healthiest and below 10% for the sickest people. In other words, the poorest 20% of the population have private ODI take-up rates of just 10 to 25%. The second lowest income quintile also has substantially lower take-up rates than quintiles three to five (but higher rates than the lowest quintile).

In conclusion, health gradients in take-up exist for all income groups, indicating that take-up consistently decreases with worsening health. Take-up also decreases with lower income. These patterns are consistent with Appendix Table C2 and Appendix Figure C2.

[Insert Figure 7 about here]

Private Information. Finally, we use the rich SAVE data to provide evidence for private information. Figure 7 plots private ODI take-up rates on the y-axis and the five health risk score quintiles on the x-axis, as above. However, now we plot two lines differentiating by whether SAVE respondents *expect to retire and receive SPI benefits before age 60*, which proxies for expected work disability (disability benefits are the only SPI benefits that one can receive before age 60). As seen, over the entire health distribution, those who expect work disability are more likely to have private ODI insurance. Note that unambiguously proving an adversely selected market would require empirical proof that private information causally leads to more insurance take-up. We are unable to run the standard (but also imperfect) positive correlation test as we do not have claims data. However, Figure 7 is consistent with an adversely selection market, even though it just correlates expectations about work disability with coverage.

Summary. Below, we use the suggestive evidence on private information to inform our GEM modeling decisions. We will also feed the lifecycle work incapacity moments into our model, along with other data moments. The model will then target and replicate the 25 empirical take-up moments by income and health in Figure 6. Finally, we will simulate the reform and investigate demand and supply driving forces to explain why the effects of public-private interaction have been limited.

5 An Equilibrium Model to Study Demand and Supply Responses

This section develops a new version of the general equilibrium model (GEM) by Braun et al. (2019), which is based on Rothschild and Stiglitz (1976), Stiglitz (1977) as well as Chade and Schlee (2020). On the demand side, this new version models the interplay between German public WDI, public ODI, the means-tested cash transfer program, and private ODI. It also includes private information of applicants whose premiums are otherwise risk-rated depending on their health and occupation. In this context, it is crucial to understand that the value of ODI is a function of the job's complexity. As income is usually a good proxy for job complexity, for the most basic, low-income jobs in the economy, ODI and WDI converge—as occupational disability then equals work disability, see Figure 1. Further, for employees in low-income jobs, Germany's means-tested basic income program provides relevant insurance and a consumption floor. These factors are crucial in determining income-dependent demand for private ODI.

On the supply side, the model incorporates an endogenous menu of contracts offered by insurers, including coverage denial, a key institutional characteristic of the German private ODI market. As stated in Section 2.3, there is strong selection into official applications due to the data sharing between insurers, but even those conditional numbers tell us that one-sixth of all applicants are either entirely denied coverage or incur pre-existing condition clauses (this number can be interpreted as unexpected rejections). According to industry experts, in total, 235K applications would annually get rejected (Versicherungsbote, 2014), and a big audit study revealed that 81% of applicants would not be offered the desired level of coverage (Ökotest, 2014). Given those numbers and institutional acts, it seems paramount to model coverage denial as a key ingredient of the supply side; by doing so, we relax the key assumption in Seibold et al. (2025). Further, our model features risk rating by health and occupation, allows insurers to make profits, and also includes administrative costs, all characteristics of the German private

ODI market.

Appendix E provides possible equilibria and optimal insurance policies for two risk groups.

5.1 Quantitative Model

5.1.1 Individual's problem

In reality, individuals purchase private ODI insurance at an average age of 32. The average age when occupational work disability hits is 46, and the average contract runs until age 64 (Morgen & Morgen, 2021). Accordingly, one can simplify an individual's decision-making problem by two time periods, see Figure 8.

[Insert Figure 8 about here]

Period 1: Labor Market Entry and Endowments. In the first period, individuals enter the labor market between the ages of 25 and 35. At the time, they draw a health endowment h, an economic endowment—consisting of the wage in period 1 w_1, the wage in period 2 w_2—and an occupation o. Individuals decide on how much to consume (c_1) and how much to save (s):[11] $c_1 = w_1 - s$. Health, wages, and occupation are jointly distributed with density $f(h, w_1, o)$.

As illustrated by Figure 8, individuals also observe their disability risk type, which is private information, $\theta^i_{h,w,o}$, $i = b, t$, with $\theta^b < \theta^t$.[12] With probability $\rho = b$, individuals will realize a low risk of disability, and with probability $1 - \rho = t$, individuals will realize a high risk of disability. While insurers can observe health (h), wages (w), and occupation (o), which are noisy indicators of the true occupational disability risk, they cannot observe the true type of individuals ($i = b$ or $i = t$), because the true type is individuals' private information.

In the model, all individuals apply for private ODI and decide whether to purchase private ODI in case of an offer. Insurers either reject applicants or offer private ODI contracts $\{\Pi(h, w, o), b\}$, where $\Pi(.)$ is the insurance premium, and b are contracted benefits. Policies are offered based on applicants' observed characteristics— health, wages, and occupation—which determine 750 risk groups. Insurers offer two contracts to each risk group (where risk groups are defined by similar observables): one for low-risk types and one for high-risk types, where

[11] At this time, educational decisions—a major driver of occupation and lifecycle income is completed for the great majority of the population (Carneiro et al., 2011; Atal et al., 2025). When using SOEP and SAVE data, we condition the empirical moments for Period 1 on individuals who we observe working full-time between the ages 25 and 35.

[12] For simplicity, we assume that the probability of survival in period 1 is 1.

the actual type is unobserved by the insurer. The design of contracts follows participation and incentive constraints; see below.

Period 2: Income and Health Shocks. Period 2 represents individuals' main work lives and stretches from age 35 to retirement (Figure 8). During this period, individuals earn a wage of w_2. However, during their work lives, they may incur either a health shock that affects their work capacity and thus their wage, or they may incur a health-independent income shock (e.g., through an economic recession) with density $q(\tau)$, where $\tau \in [\underline{\tau}; \bar{\tau}]$. Income shocks may lead to eligibility for the means-tested basic income program that provides a consumption floor of C. In that case, they will receive a social insurance transfer Ψ.

A health shock may lead to full work disability or to occupational disability. Following the institutional setting, work disability implies that individuals cannot earn *any* labor income but qualify for WDI, the basic work disability scheme that existed pre- and post-reform; see Table A1. WDI benefits are roughly 30% of previous income; see Section 2. Occupational disability, by contrast, implies that individuals cannot work in their *previous occupation* anymore or only part-time. Following the institutional setting, we assume that individuals with an occupational disability (but no full work disability) still have enough work capacity to earn half their previous wage. In Period 1, when individuals decide on whether to purchase private ODI, they consider the expected income loss due to occupational or work disability, denoted as $l(h)w_2$, where $l(h)$ is a loss function. Note that, in case of full work disability, individuals will receive public WDI benefits *and* the private ODI benefit (b) if individuals are covered by private ODI. Following reality, the latter tops up and does not crowd out public WDI benefits. By contrast, post-reform and in the case of occupational disability, individuals will earn half their previous wage, as discussed, and also receive private ODI benefits if they are covered by private ODI.

In both cases, work and occupational disability, individuals receive a top-up by the means-tested social insurance up to the consumption floor if their total income falls below the consumption floor.

Decision Problem. Individuals, characterized by their health, wage, and occupation (h, w, o), solve the following utility maximization problem where we omit subscripts for readability:

$$U(h,w,o) = \max_{s,c_{DI},c_0} u_1(c_1) + \beta[\rho u_2(h,w_2,o,\theta^b,\Pi,b) + (1-\rho)u_2(h,w_2,o,\theta^t,\Pi,b)] \qquad (2)$$

where

$$u_2(h, w_2, o, \theta^i, \Pi, b) = \int_{\underline{\tau}}^{\bar{\tau}} \{u(\tau w_1) + \alpha[\theta^i u(c_{DI}) + (1-\theta^i)u(c_0)]\} q(\tau) d\tau$$

subject to

$$c_1 = w_1 - s \tag{3}$$

$$c_{DI} + \tau w_1 = w_2 - l(h)w_2 + (1+r)s - \Pi + b + \Psi_{DI} \tag{4}$$

$$c_0 + \tau w_1 = w_2 + (1+r)s - \Pi + \Psi_0 \tag{5}$$

where r is the real interest rate on savings, s. β is the discount factor. c_{DI} represents consumption in case of work incapacity with private ODI and $\{\Pi, b\}$, while c_0 represents consumption without work incapacity.[13] Ψ is a social insurance transfer via the German means-tested basic income program, with $\Psi_{DI} = max[0, C - ((1-\tau)w_2 - l(h)w_2 + (1+r)s - \Pi + b)]$ in case of work incapacity and $\Psi_0 = max[0, C - ((1-\tau)w_2 + (1+r)s - \Pi)]$ without work incapacity.

5.1.2 Insurer's problem

Applicants for private ODI have to indicate h, w, and o on their application, but the true disability risk $\theta^i_{h,w,o}$ remains private information. The insurer either denies coverage or offers a menu of contracts $\{\Pi(h, w, o), b\}$ to profitable applicants. The insurer operates in a monopolistic market and maximizes profits Ξ as follows:

$$\Xi(h, w, o) = \max_{\Pi, b} \rho[\Pi^b - \theta^b[\lambda b^b + \gamma I(b^b > 0))] + (1-\rho)[\Pi^t - \theta^t(\lambda b^t + \gamma I(b^t > 0))] \tag{6}$$

where the insurer's variable costs are λ, e.g., claims processing, and the insurer's fixed costs are γ, e.g., broker commissions. The incentive compatibility constraint (*"I prefer my policy over the policy designed for the other risk type"*) is

$$u_2(s, \theta^i, \Pi^i, b^i) \geq u_2(s, \theta^i, \Pi^j, b^j) \; \forall i, j \in \{t, b\}, i \neq j \tag{7}$$

and the participation constraint (*"I prefer my policy over no policy"*) is

$$u_2(s, \theta^i, \Pi^i, b^i) \geq u_2(s, \theta^i, 0, 0) \; \forall i \in \{t, b\} \tag{8}$$

[13]When no private ODI is purchased, Π and b become 0.

5.2 Parameterization of Model

Following Braun et al. (2019), the parametrization of this model proceeds in two steps; Table 2 shows the parameter values. First, we assign parameter values using actual data moments without computing equilibria. Second, we calculate the remaining parameter values by minimizing the distance between the actual data moments and the model equivalents. As stated in Braun et al. (2019), the model has a very high computational intensity and, thus, is not formally estimated. One reason is that the menus of optimal insurance policies that insurers offer must be calculated for each of 750 different risk groups. The risk groups consist of combinations of health risk (h), income (w), and occupational groups (o).

5.3 First step: Calibration of Model Parameters

We normalize the risk-free interest rate r to zero. Further, we employ a standard utility function with constant-relative risk aversion $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$ and set the risk aversion parameter σ to 2. The preference parameter is set to $\beta = 0.94$.

[Insert Table 2 about here]

Health Risk. Figure 4 shows the actual health risk distribution computed from representative SAVE data. A beta distribution with $\beta(1.2269; 6.9219)$ approximates this skewed distribution reasonably well. As illustrated in Figures 5 to 7, we categorize the continuous health risk score as well as household income and focus on population quintiles to keep the data and modeling process tractable. The mean risk scores by the five income quintiles are in Table C3. We assume that their joint distribution follows a Gaussian copula with parameter φ, chosen to match the data points in Table C3.

Lifecycle Income. We use the representative German SOEP to extract the wage distribution of those who enter the labor market at the beginning of their work lives between age 25 and 35. We model it as a log-normal distribution and normalize Period 1 (Figure 8) to 1. Following Braun et al. (2019), we express the consumption floor as a share of *permanent* lifecycle income, which is 0.1258 for Germany.[14] Similarly calculated are the costs of work disability that individuals incur for 16 years after a health shock, on average between age 46 and early retirement at age 62, see

[14]Permanent income is simply the average gross wage (2019: €47,928, Statistisches Bundesamt (2022)) multiplied by the average contract duration (31.5 years), which is roughly the number of years between signing a contract and retirement. The consumption floor equals the value of the means-tested basic income (2019: €11,868, Bundesagentur für Arbeit (2019)).

Figure 8.[15] For the fixed (γ) and variable (λ) administrative costs, we take industry averages of 3% of lifetime and 10% of annual premiums, respectively; see Table 2 (Finanzberatung Bierl, 2023).

Disability Costs. Next, we turn to the disability costs. As discussed, in the case of full work disability, individuals cannot earn any labor income but receive public WDI benefits, roughly 30% of their previous income.[16] Occupational disability, by contrast, implies that individuals cannot work in their previous occupation anymore or only part-time. As mentioned, a reasonable approximation of the institutional setting is that they lose 50% of their previous wage. Thus, the loss function, $l(h_i)$, of work incapacity is:

$$l(h_i) = P(WDI|WDI \vee ODI) * 0.7 * w_2 + P(ODI|WDI \vee ODI) * 0.5 * w_2 \tag{9}$$

Work Incapacity Risk. The probability of a work-disabling health shock differs by occupation and health risk. Specifically, suppose employees in the most basic (low-wage) occupation, Category 1 in Figure 1, experience a work-limiting health shock. In that case, it will always lead to WDI as there is no wedge between a high(er) occupational status and being able to do the most basic work in the economy. By contrast, this is not the case in the most skilled, highest-status occupations, Category 6 in Figure 1. Here, we assume employees' occupational disability risk would be 80% (and the full work disability risk would be 20%), and extrapolate these conditional ODI risks for the intermediate categories. Thus, our assumed work vs. occupational disability risks by quintiles 1 to 5 are $P(WDI|WDI \vee ODI) = [0.2, 0.4, 0.6, 0.8, 1]$. Inserting those probabilities in equation (9), we obtain the following expected disability costs as a share of previous wages by risk quintiles: $l(h_i) = [0.54, 0.58, 0.62, 0.66, 0.7]$. This is our parameterization of the key criticism of public ODI by the Federal Audit Office (*Bundesrechnungshof*) and all five democratic parties that resulted in the fundamental DI reform in the first place (Tempel, 2018). Namely, public ODI was funded by all private sector employees via a payroll tax[17], but benefited the higher-status employees over proportionally.

Income Uncertainty. Finally, the distribution of income uncertainty in period 2, τ, is calibrated using representative SOEP data. We calculate individuals' labor income at age 35 (representing period 1) as a share of the weighted household income (using the OECD equiva-

[15] (€ 47,928-€ 11,868)×16/(€ 47,928×31.5)

[16] Full work disability implies a more significant health shock than occupational work disability, meaning that those with private ODI also receive private ODI benefits in case of full work disability. Recall that, in Germany, private ODI benefits do not crowd out public WDI benefits.

[17] As the payroll tax has a contribution ceiling, the funding is actually regressive too.

lence scale) at age 45 (representing the midpoint of period 2). Further, we use the empirical 1% and 99% bounds of that distribution as bounds of a 1-τ truncated log-normal distribution in the model. Those values are -2 and 0.5, respectively, meaning that most individuals experience an increase in their equalized household income between periods 1 and period 2.[18]

5.4 Second step: Matching Simulated Moments

In the second step, we calculate model equilibria and set key parameters to minimize the distance between the actual data moments and the model equivalents. The calibration algorithm aims at two targets: The first is the 25 realized work-disabling probability moments by income and health risk quintiles; see Figure 5. The second is private ODI take-up rates by health and income quantiles; see Figure 6.

We then minimize the distance between actual and target moments by searching for the optimal combination of the type-specific expected probabilities of ever being work disabled. We do so for the 25 work disability moments by health and income quintile (Figure 5), and also by type, ending up with 50 moments and the fraction of good types ψ in the population. The resulting fraction of good types ψ is 0.6222.

[Insert Table 3 about here]

Table C3 (Appendix) shows actual data moments and model counterparts for the health risk score by the five income quintiles. As seen, the model produces a very close match between the two. The other target is private ODI take-up rates by health and income quantiles. Table 6 shows a close fit between the empirical and model moments.

5.4.1 Model Validation and Reform Simulation

Next, we simulate the 2001 reform. Unfortunately, no pre-reform SAVE data exists. Hence, we use the model to simulate the *reverse* reform effect and benchmark it with the estimated reduced-form reform effect in Section 4.1. To do so, we require an assumption about the pre-reform replacement rate for public ODI to specify the pre-reform costs of an occupational disability in percent of former income. Appendix D illustrates our stylized benefit simulation.[19]

[18] Negative numbers for τ represent increases in equalized household income over the lifecycle.

[19] Importantly, we assume that the individual starts working at age 25 and earns 60% of the average German wage when entering the labor market. We assume that the wage position then increases linearly to 140% if the individual worked until age 65.

In addition, using representative SAVE data, an alternative assessment uses information about the individual expected pension replacement rate and the current wage. Reassuringly, both methods produce almost identical average replacement rates.[20]

Figure 9 shows an average simulated pre-reform private ODI take-up rate of 19% and an average post-reform take-up rate of 33%, yielding a 14ppt increase due to the reform as our untargeted model reform prediction. In the representative SAVE data, 22% of all households born prior to 1961 have private ODI, while 42% of households born after 1960 have a private ODI policy. Additionally, using rating agency data, Seibold et al. (2025) show that, in the long run, the private ODI take-up rate increased from below 10% in 1997 to 26% in 2015. Importantly, our (admittedly noisy) reduced-form point estimates in Table 1, columns (1) and (2), produce almost identical point estimates.

Overall, we conclude from these multiple sources of evidence that our model predictions map up very well with external data sources and our representative reduced-form estimate.

5.4.2 Policy Simulations

Finally, we use the model to simulate alternative policies. We combine the actual reform with specific additional policies and then simulate take-up effects. Specifically, we simulate how the reform would have affected private ODI take-up rates—in the general population and by health categories—had policymakers combined it with:

- An increase in WDI benefits by 10%.
- An increase in WDI benefits by 25%.
- A reduction of the means-tested safety net benefits by 10%.
- An elimination of variable administrative costs, e.g. through minimum benefit ratios.
- An elimination of fixed administrative costs, e.g. through banning broker commissions.
- An elimination of private information, e.g. through genetic testing.

The results are in Figure 9. As seen, the increase in take-up would have been one percentage point larger had policymakers simultaneously increased WDI benefits by 10% and a substantial

[20] Specifically, we exploit a SAVE question about the expected statutory pension replacement rate as a share of the last net wage. As we do not know the precise individual work history, exploiting this individual-level information succinctly summarizes individual knowledge and expectations about future pensions. Then, following the institutional details, we assume that the public ODI pension would have been half the expected statutory pension, and we also apply a 10% actuarial deduction as the large majority of recipients receive public ODI before age 60, see Section 2 and Appendix D. To calculate hypothetical public ODI replacement rates, we relate the hypothetical public ODI benefit (average: €341) to (a) the current gross wage (average 17%) as well as the (b) current net household income (average 12%). We use the latter as default but results are similar when using the former.

22ppt larger had policymakers increased WDI benefits by 25%. Not just the form but also the latter would have been a reasonable and likely bipartisan policy option. Increasing WDI benefits increases the value of ODI policies, especially for low-income populations, as it becomes less likely that the means-tested consumption floor crowds out private ODI benefits (recall that public and private ODI benefits do not crowd each other out in Germany).

[Insert Figure 9 about here]

Further, a reduction in the means-tested German cash assistance program by 10% would have increased private ODI take-up by 23ppt to an overall coverage rate of 42%. Here, again, the intuition is that such a measure would increase the value of private ODI policies for large parts of the population as the consumption floor decreases. An extreme thought experiment would be to entirely abolish the German safety net (which would be unconstitutional). In such a scenario, private ODI take-up rates would have more than tripled to 81% in the population (results available upon request), illustrating the key role that the safety net plays for take-up in private ODI. Note that this finding is in stark contrast with Seibold et al. (2025) who do not model coexisting social insurance explicitly.[21]

The next two bars in Figure 9 illustrate the increase in take-up without fixed or variable administrative costs. Note that either heavily limiting or even banning broker fees is a realistic policy option that is under active debate not just in Germany (Bundesanstalt für Finanzdienstleistungsaufsicht (BaFin), 2018) but is, in fact, under active consideration by the European Union (Reuters, 2023). Lobby groups and academics sometimes criticize such regulatory measures, arguing that unintended cost-shifting or shifting of business activities could be a consequence (Inderst and Ottaviani, 2012; Braegelmann and Schiller, 2025). However, in the U.S., when the Affordable Care Act was introduced, the regulator implemented so-called ”medical loss ratios” to limit administrative spending by insurers, a regulation that largely worked as intended (Born et al., 2023; Kaiser Family Foundation, 2024). In any case, according to our simulations, take-up would have increased to 45% (no variable admin) and 46% (no fixed admin), respectively. The increase through lowering admin costs is bound at 54% for the unrealistic case of zero admin costs (results available upon request).

Another rather unrealistic upper bound scenario is represented by the last bar in Figure 9.

[21] In their Appendix Table A5, column (5) of Panel B, they run a simple DD test with treated$\times$2005 on 480 cohort-year observations to test whether the welfare reform in that year affected take-up. From the non-significant point estimate, they conclude that "[...] the generosity of social assistance is not a major driver of private DI take-up."

It indicates the increase in take-up had the reform been combined with measures to eliminate information asymmetries. One extremely controversial policy that would not even achieve a complete elimination of information asymmetries could be genetic testing. Take-up would have increased to 64%, assuming that private information could be eliminated.

[Insert Table 4 about here]

Further, Table 4 lists how other relevant outcome measures would have evolved, both for the general population and by the good and bad risk types, θ^b and θ^t, unobserved by the insurer. Table 4 shows that the market is adversely selected by unobserved risk types, with only 3% of good risks purchasing policies but 45% of bad risks in the pre-reform era. As a result of the reform, take-up increases by 10ppt among the good and by 20ppt among the bad risk types.

Second, the share of costs covered is higher for bad than good risk types. Bad risks receive relatively favorable terms because insurers cannot identify bad risks with certainty. Thus, they must design contracts under incentive compatibility constraints, limiting their profits. Interestingly, while the share of costs covered by ODI policies remains constant over the reform at 84% for bad risks, for good risks, it increased by 10ppt through the reform, illustrating that good risks demanded and were offered more generous ODI policies.

Third, the loading factor, defined as one minus the ratio of the expected value of benefits to premia[22], decreases for both good and bad risks. Thus, on average, the reform reduces how much insurers can extract surplus from consumers. The policies to eliminate variable and/or fixed admin costs would further reduce the load for bad risks (and increase it for good risks)—and would strongly increase take-up to around 80% for bad risks.

Equity. Figure C8 (Appendix) takes another cut at the simulations by studying take-up by (observable) health quintiles. The black solid line shows take-up post-reform; the other lines illustrate how take-up would have evolved if combined with the alternative policies, as seen above. We conclude: First, take-up never exceeds 60%. Second, none of the combined policies eliminates the health gradient. Eliminating administrative costs comes close to that potentially desirable goal but not for the sickest health group. Recall that administrative costs are substantial in this individual market—fixed costs like broker commissions amount to an estimated 3% of lifetime premium payments over roughly 30 years, in addition to 10% reoccurring annual

[22]A load of zero would indicate an actuarially fair contract

administrative costs. Administrative costs drive up the price of insurance coverage. They lead to higher denial rates and applicants unwilling to pay higher premiums—given the consumption floor, their expected lifetime income, and expected health shocks during their main working age. Third, lowering the consumption floor would have left the health gradient in take-up intact and shifted take-up upward by between 5 and 12ppt.

In conclusion, our simulations illustrate that policymakers could have undertaken reasonable and realistic policy measures to further increase private ODI take-up—if policymakers desired such a higher private ODI coverage rate. Because of the potentially bipartisan support, the most promising policy options to achieve such a goal would be an increase in WDI benefits or regulatory limitations of administrative costs, for example, through a ban on broker commissions as envisioned by the European Union (Reuters, 2023).

Welfare. Next, we discuss welfare. Welfare could include individuals' utility, insurer profits, and government spending. Panel A of Table 4 lists insurer profits and individuals' ex-ante utility. Note that this utility includes utility from insurer income transfers (and thus insurer profits); it also includes changes in consumption due to changes in public DI and safety net transfers and allows us to assess welfare compactly. Also, because CRRA has a risk preference factor of 2, utility is negative; thus, less negative utility implies improved welfare. In total, we display three rows of transfers: (i) a DI transfer, (ii) a means-tested safety net transfer, and (iii) the total transfer, the sum of (i) and (ii).

Eliminating administrative costs would reduce consumption floor transfers by almost the same amount as lowering the consumption floor directly by 10% or increasing WDI benefits by 10%. All these measures would increase take-up and private ODI benefits in the case of work disability, thereby reducing safety net spending. Note that the "DI transfer" is much larger than the safety net transfer. However, while spending on public DI is reduced due to the reform, it is not reduced further due to the additional policy measures in columns (5) to (7). However, with higher WDI benefits, it increases again (columns (3) and (4)).

Assuming average pre-reform public ODI benefits (Figure A1) and a decrease in inflows by a third per cohort per year, the reform reduced expenditures of the German Statutory Pension Insurance by €789 million in the first year, or about €12 billion after 15 years, when the first affected cohorts had basically aged through their work lives. Assuming that the reduction in public DI spending would be entirely passed through, SPI contribution rates would be one percentage point lower. This translates to reduced employer and employee payroll deductions of €500 per year for an annual income of €50,000. Moreover, the annual reduction in spending equals about 5% of actual total WDI spending when the long-run equilibrium was reached in 2012 (Deutsche Rentenversicherung, 2023c). One could use that reduction in public DI spending to increase WDI benefits by 5%, for example.

Despite rising insurer profits through the reform, overall consumer utility (which includes insurer profits) decreased slightly from -1.455 to -1.461 as public ODI eligibility was cut. However, this does not consider the reduction in public spending, which could either lead to lower contribution rates, higher WDI benefits for all, or more government debt or general taxpayer subsidies to SPI. As seen in columns (3) to (8), welfare could have been higher had policymakers combined the reform either with increases in WDI benefits or measures to eliminate either fixed or variable administrative costs.

Summary. When holistically assessing the counterfactual simulations in conjunction with their implied policy alternatives, a relatively clear picture emerges. First, Germany has recently increased means-tested safety net benefits by around 25% and its asset eligibility thresholds by 50% (Deutscher Bundestag, 2022), and also reduced possibilities to sanction those who receive cash benefits but are unwilling to cooperate with caseworkers. This has led to polls showing that a majority of Germans favor decreases in the means-tested cash benefit levels (infratest dimap, 2023), but it is unclear if this would be constitutional as the consumption floor represents a guaranteed minimum existence right. Alternatively, policymakers could have increased WDI benefits, which would have been a bipartisan and likely voter-popular option.

Second, while eliminating frictions and asymmetric information would be desirable (Boyer et al., 2020), given the relatively unregulated market and vast possibilities to risk-rate policies, there is no apparent policy to eliminate private information. Policymakers could allow genetic sampling, which would not eliminate private information and be highly controversial, especially in Germany, given its history. Moreover, this option—like none of the policy options—would not eliminate the gradients in coverage.

The final policy option, reducing administrative costs (along with increasing WDI benefits), emerges as desirable and feasible. Our findings show that this option has the potential to increase take-up substantially, and the health gradient in coverage would flatten significantly. Most importantly, regulatory tools with bipartisan support exist to implement such a policy, such as a cap on commission fees or minimum benefit ratios. Benefit loss ratios would cap the ratio of benefit payouts to administrative costs, e.g., insurers' spending on marketing.

Nevertheless, while all these additional policy measures would have increased take-up above the current levels, none would have increased take-up above 60% at the population level. If policymakers' objective were to achieve coverage rates above 60%, more fundamental policy reforms such as an individual mandate and guaranteed issue would be necessary.

6 Discussion and Conclusion

This paper empirically and theoretically studies a fundamental reform of the public disability insurance system in Germany, using reduced-form approaches and a general equilibrium model along with administrative and survey data. Starting in 2001, the reform cut access to public occupational disability insurance (ODI) for cohorts born after 1960. The main reason for the reform, which all five democratic parties supported, was its regressiveness and that it was "a privilege of insurees with extraordinary education and in elevated positions." (Bundestag, 1997)

This paper first studies the first-stage effects of the reform on public DI inflows to demonstrate that the reform had "bite." Then it studies interaction effects with the biggest private individual ODI market in the world. However, this private individual market is relatively unregulated. Guaranteed issue does not exist, premiums are risk-rated and coverage denials are common. Most applicants purchase policies below the age of 30 when entering the labor market. They keep their policies for an average of 31 years, covering the crucial time period of their work lives until early statutory retirement is possible.

While we find that the reform reduced public DI inflows by more than 30% in the long run, we also find (at best) modest private ODI take-up response by the treated cohorts. As these public-private interaction effects are an equilibrium outcome, we build on Braun et al. (2019) and extend and tailor their equilibrium model to fit the regulation of the German private DI market. In particular, the model features important supply and demand driving forces, reflecting reality. Crucially, we model how private ODI demand is affected by the existing basic WDI benefit system and the German means-tested public cash benefit program. The latter provides a consumption floor to all residents. These coexisting public insurance programs are key to understanding the demand for private ODI policies. In addition to health-risk rating and routine coverage denials on the supply side, they are also key to explaining why private ODI take-up is much larger among higher-income, better-educated, and healthier populations. First, healthier applicants receive lower premium offers and coverage denial rates are much lower. Second, the ”social status projection” function of private ODI produces a much larger insurance value for higher-income populations.

Finally, our policy simulations suggest that policymakers could have increased take-up more by either (i) streamlining the means-tested basic income program, (ii) increasing WDI benefit levels, or (iii) allowing insurers to collect even more data to reduce private information further, e.g. via genetic samples which would most likely be unconstitutional and reject by a large majority in the population. Lastly, policymakers could (iv) implement reforms to lower administrative costs in this market. For example, it is very common that broker commissions amount to several monthly ODI premiums, where a monthly premium can be as high as several hundred dollars for high-risk groups. Concrete policy proposals could cap or even ban such high commission fees (Reuters, 2023). Alternative policy proposals could impose “benefit loss ratios” akin to the regulation of U.S. health insurers imposing medical loss ratios. Targeting administrative costs could substantially increase take-up rates across the entire risk distribution and reduce the health gradient in take-up, even under risk rating. Further, our simulations predict that the share of costs covered by private ODI policies—as well as take-up of less expensive policies—would increase for good and bad risks. However, none of these policy measures would increase private ODI take-up to more than 60% of the population. Should that be a desirable policy goal, heavier market regulation, such as individual mandates and/or community rating, would be necessary.

A fruitful avenue for future research is to understand why a third of all German households are covered by private individual disability insurance, despite health risk rating and coverage denials, whereas it is predominately a group market in the U.S. (cf Herbst and Hendren, 2024). Further, interaction and substitution effects between different types of private policies are worthwhile to explore. For example, a very popular insurance product in Germany is capital endowment life insurance. The number of new policies strongly increased at the time of the reform; it could have been a substitute for private ODI among those who were denied private ODI coverage.

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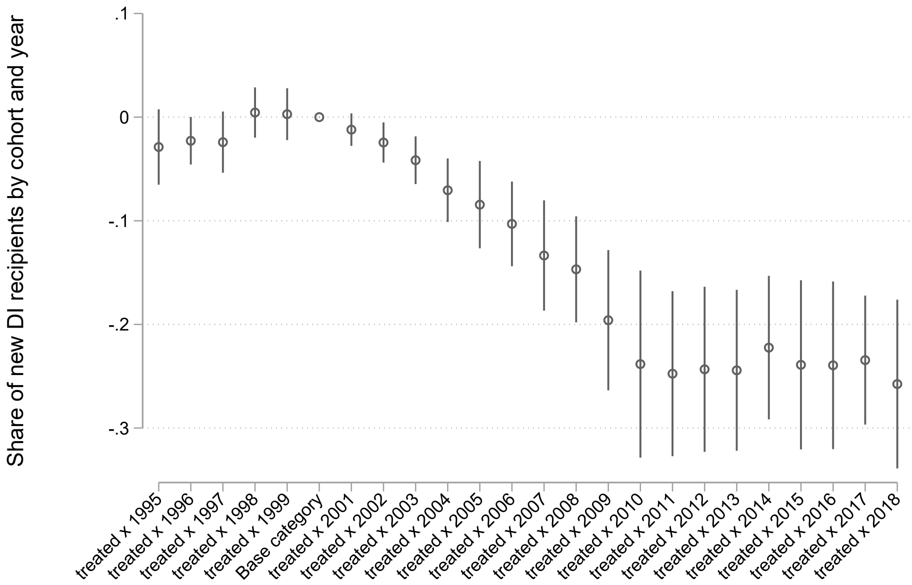
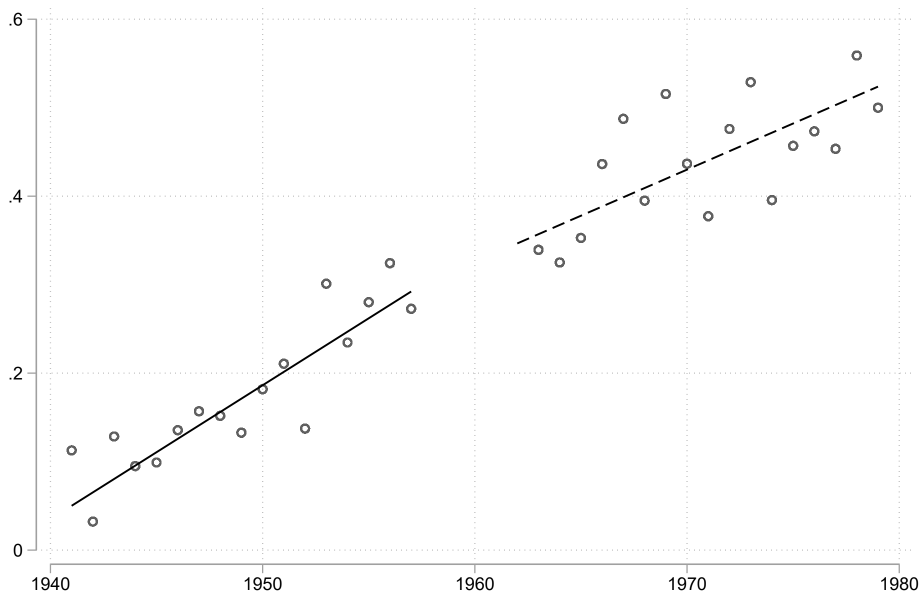
Figure 2: Effect of 2001 Reform on Public DI Inflows Using Administrative Data



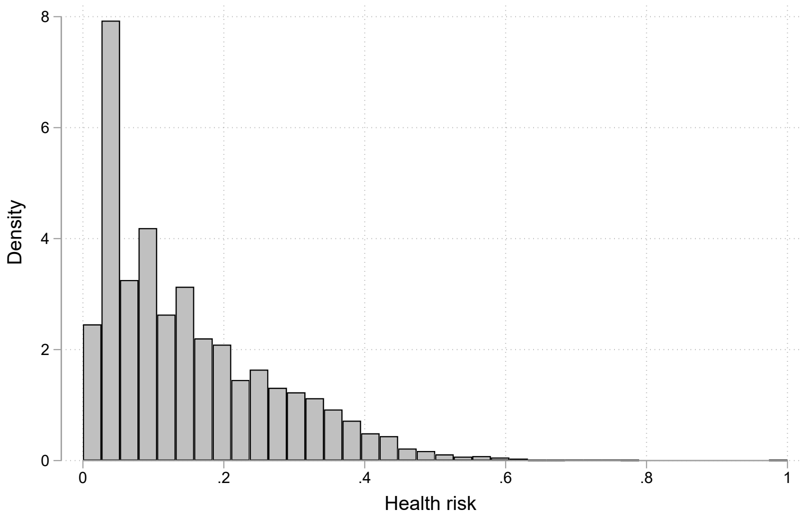
Source: Administrative SPI data on new public DI recipients by cohort and year. Treated cohorts are those born after 1960 and the treatment group; grandfathered cohorts are those born before 1961 and the control group. Figure plots $\beta D_c \times T_t$ estimates from equation 1 but with the post-reform indicator T_t replaced by a series of year dummies where 2000 is the base year.

Figure 3: Effect of 2001 Reform on Private ODI Policies Using Representative SAVE Data



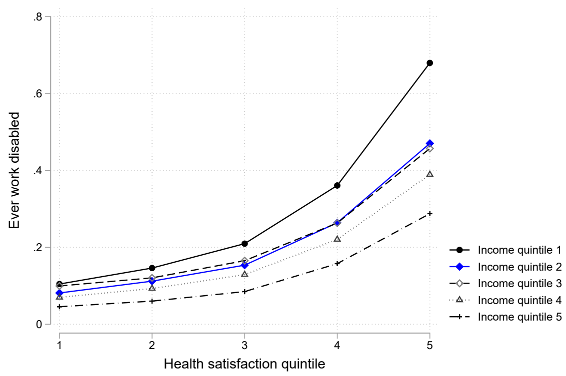
Source: SAVE data 2001-2010. The figure shows the raw nonparametric means of private ODI coverage by birth year, overlaid with separate linear trends before and after the cutoff. Other robustness checks vary the sample (Figure C3), vary the bandwidth (Figure C5, Calonico et al. 2020), study the smoothness of covariates (Figure C6), carry out density plots of the running variable (Figure C7, McCrary 2008), and vary polynomials as well as run donut RDs (Figure C3).

Figure 4: Distribution of Health Risk Score

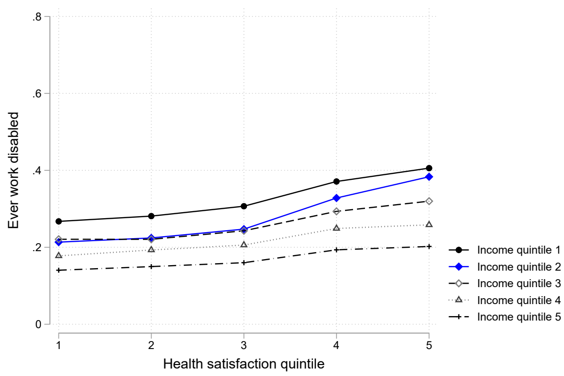


Source: SAVE data 2001-2010. Health risk score is produced using principal component analysis and subjective and objective health measures from SAVE.

Figure 5: Lifecycle Risk of Work Disability by Income and Health Risk Score



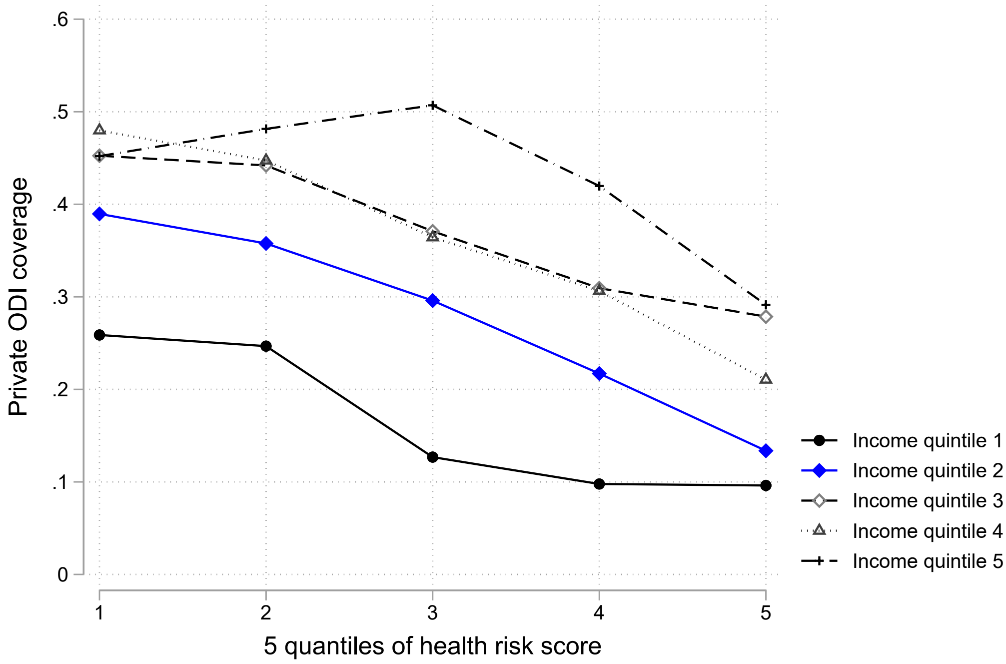
(a) unconditional



(b) conditional

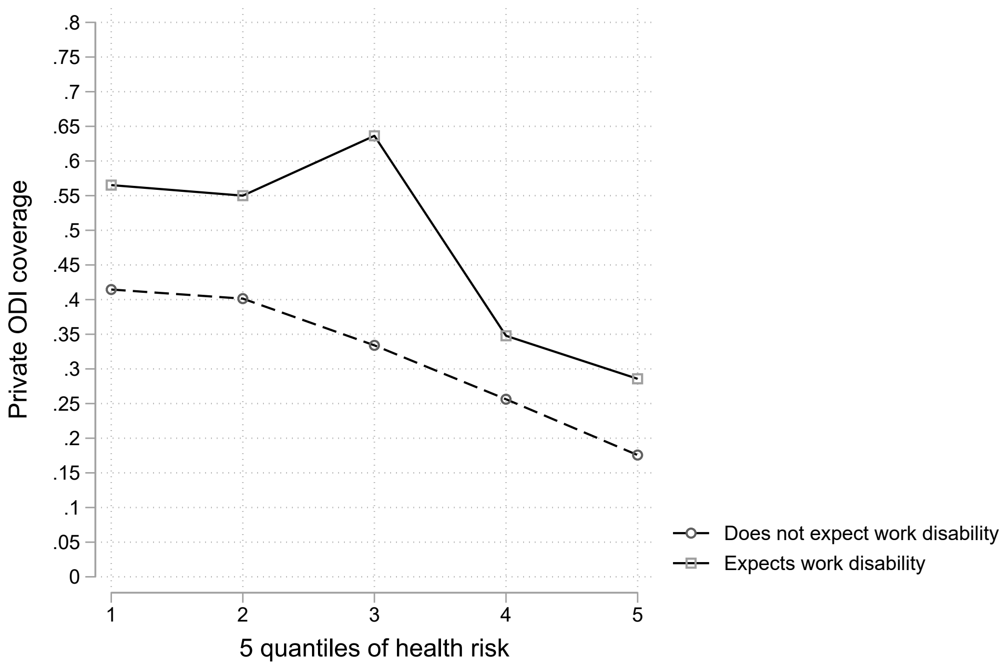
Source: SOEP v.33 – 95% sample. Figure 5a plots the unconditional risk of a severe health limitation over the working ages by the health satisfaction quintiles and the five net household income quintiles. Figure 5b first regresses the lifecycle risk of severe health limitations on socio-demographics, job, and educational characteristics, predicts the risk at the individual level, and then plots this conditional risk by the health satisfaction quintiles and the five net household income quintiles.

Figure 6: Take-Up of Private ODI Policies by Health Risk and Income



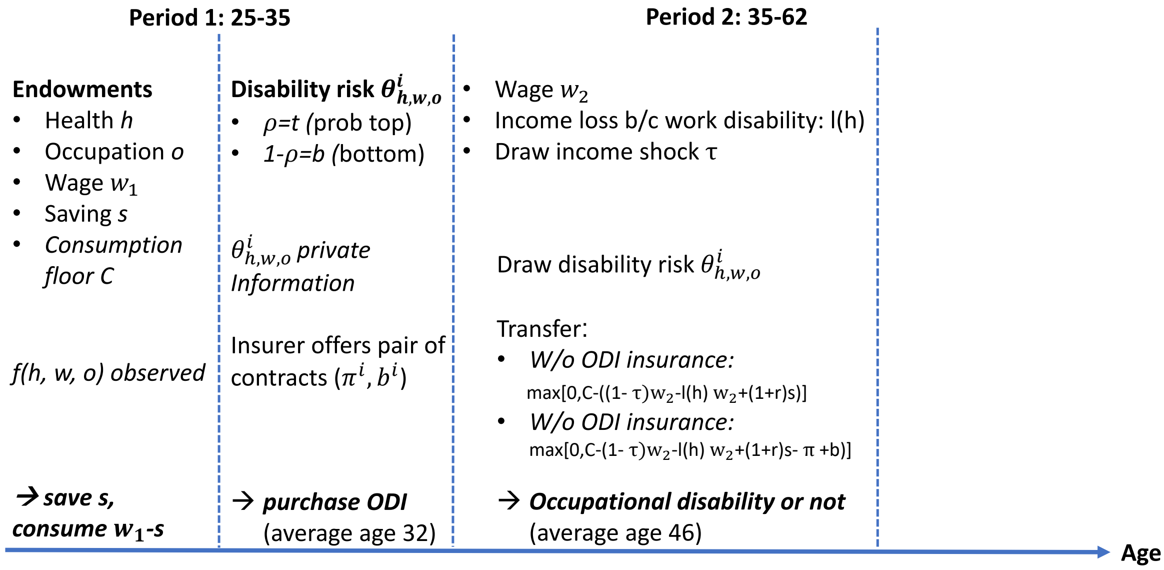
Source: SAVE data 2001-2010. Figure plots take-up rates of private ODI policies against the quintiles of the health risk score in Figure 4 and stratifies these curves by the five net household income quintiles.

Figure 7: Take-Up by Health Risk and Private Information



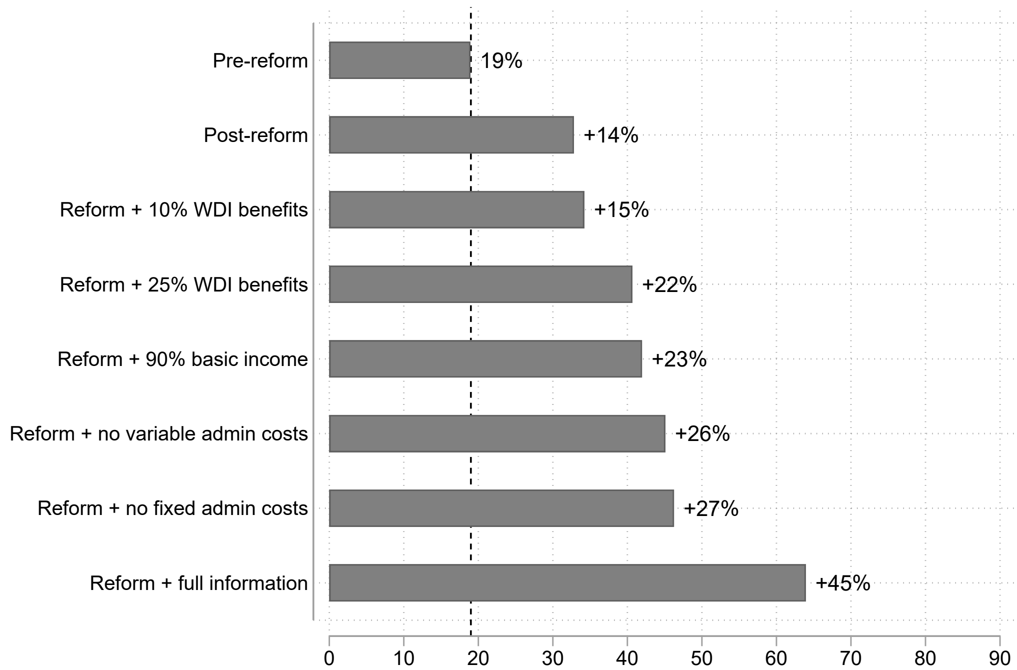
Source: SAVE data 2001-2010. Figure plots take-up rates of private ODI policies against the quintiles of the health risk score in Figure 4 and stratifies these curves by expected retirement before age 60. The latter information is directly elicited in the SAVE survey and proxies expected work disability.

Figure 8: Illustration of Lifecycle Time Periods in Baseline Model



Source: The figure illustrates the lifecycle decision-making process of a customized version of the GEM model by Braun et al. (2019). For more details, please see main text.

Figure 9: Effect of 2001 Reform on Private ODI Policy Take-Up: Simulation



Source: The bars show model predictions for average population-level reform effects. The private ODI take-up is simulated.

Table 1: Effect on Private ODI Coverage Using Representative SAVE Data

	(1) Full sample	(2) SPI insured	(3) No kids	(4) One-person HH
Bias-corrected	0.140	0.141	-0.018	0.246*
	(0.0924)	(0.1042)	(0.0372)	(0.1267)
Robust	0.140	0.141	-0.018	0.246*
	(0.0982)	(0.1150)	(0.0473)	(0.1434)
Conventional	0.108	0.129	-0.035	0.202
	(0.0924)	(0.1042)	(0.0372)	(0.1267)
Year FE	yes	yes	yes	yes
State FE	yes	yes	yes	yes
Age + gender	yes	yes	yes	yes
Observations	10,395	7,868	5,131	1,899

Source: SAVE data 2001-2010. See Coppola and Lamla (2013) for more details about SAVE. Only respondents below 63 are included; civil servants, the self-employed, and birth years 1960 and 1961 are omitted. The tables show point estimates of local polynomial regressions similar to equation (10) (Calonico et al. 2014, 2017, 2018, 2019) using a data-driven optimal bandwidth selection, a univariate kernel, and a linear polynomial. Column (1) is the default sample, column (2) focuses on those eligible for Public DI, column (3) focuses on the childless, and column (4) on one-person households. Other robustness checks vary the bandwidth (Figure C4, Calonico et al. 2020), study discontinuities in covariates (Figure C5), carry out density plots of the running variable (Figure C6, McCrary 2008), and vary polynomials (Figure C7).

Table 2: Model Parameters

Interest rate	r	0
Risk aversion	σ	2
Health risk distribution	f	$\beta(1.2269; 6.9219)$
Copula parameter	φ	-0.29
Period 1 wage distribution	w	ln(w) $\sim$ N(-0.32, 0.64)
Means-tested cash transfer consumption floor	c	0.1258
Work disability costs ($w - C$)	m	0.3822
Insurer's variable costs	λ	1.1
Insurer's fixed costs	γ	1.03
Preference discount factor	β	0.94
Income shock distribution	τ	1-τ truncated log normal
τ bounds	μ_τ	[-2;0.5]
Fraction good types	ψ	0.6222

Sources: SAVE for health risk score distribution f, SOEP for period 1 wage distribution w, and the income shock distribution τ all of which are calibrated; various sources for insurer administrative costs and the welfare consumption floor (Bundesagentur für Arbeit, 2019). Interest rate r, risk aversion σ, and discount factor β are set following the literature.

Table 3: Model Fit: Private ODI Take-Up by Income and Health Quintiles

	Health Risk Quintile				
Income Quintile	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Panel A: Data					
Q1	0.2588	0.2468	0.1268	0.0978	0.0962
...	0.3896	0.3577	0.2959	0.2171	0.1337
...	0.4525	0.4420	0.3709	0.3094	0.2786
...	0.4799	0.4474	0.3643	0.3064	0.2105
Q5	0.4521	0.4815	0.5069	0.4198	0.2914
Panel B: Model					
Q1	0.2685	0.2736	0.1243	0.0975	0.1169
...	0.3963	0.3813	0.2996	0.1954	0.1535
...	0.4144	0.4515	0.3467	0.3070	0.2935
...	0.5037	0.4482	0.3778	0.3249	0.2685
Q5	0.4731	0.4564	0.5288	0.4411	0.3262

Source: Table shows private ODI take-up rates by Health Risk (columns) and Income Quintiles (Rows). Q1 is the healthiest and poorest quintile, whereas Q5 is the sickest and richest quintile. Panel A shows the raw data from SAVE, and Panel B shows the private ODI take-up rates as produced by the general equilibrium model.

Table 4: Take-Up, Loading, and Risk Insured: Policy Simulations

	(1) **Pre-Reform**	(2) **Post-Reform**	(3) **No variable admin**	(4) **No fixed admin**	(5) **Full Info**	(6) **↑ 10% WDI**	(7) **↑ 25% WDI**	(8) **↓ 10% basic income**
Panel A: Total								
Take up	0.1894	0.3283	0.4510	0.4627	0.6387	0.3427	0.4069	0.4198
Denial	0.5452	0.3514	0.2188	0.1778	0.2319	0.3413	0.3258	0.3519
Share of cost	0.8085	0.7313	0.8354	0.6838	0.9428	0.7114	0.6242	0.7754
Load	0.2775	0.2890	0.1786	0.2729	0.5095	0.2792	0.3020	0.3126
Profits	0.0118	0.0247	0.0337	0.0296	0.0535	0.0230	0.0206	0.0277
Ex-Ante Utility	-1.4555	-1.4611	-1.4597	-1.4596	-1.4621	-1.4597	-1.4572	-1.4664
Govt total transfer	0.0726	0.0613	0.0603	0.0605	0.0613	0.0664	0.0740	0.0603
DI transfer	0.0743	0.0576	0.0576	0.0576	0.0576	0.0634	0.0720	0.0576
Basic income tranfer	0.0038	0.0037	0.0027	0.0028	0.0037	0.0030	0.0020	0.0027
Panel B: Good risks								
Take up	0.0283	0.1338	0.2505	0.2444	0.6833	0.1508	0.2446	0.2811
Share of cost	0.2891	0.4026	0.4638	0.4452	0.9383	0.4021	0.3771	0.4109
Load	0.6609	0.5855	0.6617	0.6412	0.6153	0.6072	0.7107	0.6607
Panel C: Bad risks								
Take up	0.4548	0.6486	0.7812	0.8222	0.5651	0.6587	0.6742	0.6481
Share of cost	0.8617	0.8430	1.0317	0.8006	0.9519	0.8280	0.7719	1.0359
Load	0.2382	0.1883	-0.0766	0.0926	0.2988	0.1555	0.0577	0.0638

Source: Table shows private ODI take-up rates, the fraction being denied coverage, the share of costs insured, loading factors, insurer profits, consumer utility, transfers and all scenarios by good and bad risk types. All policies in columns (3) to (8) are combined with the 2001 ODI reform.

A Appendix

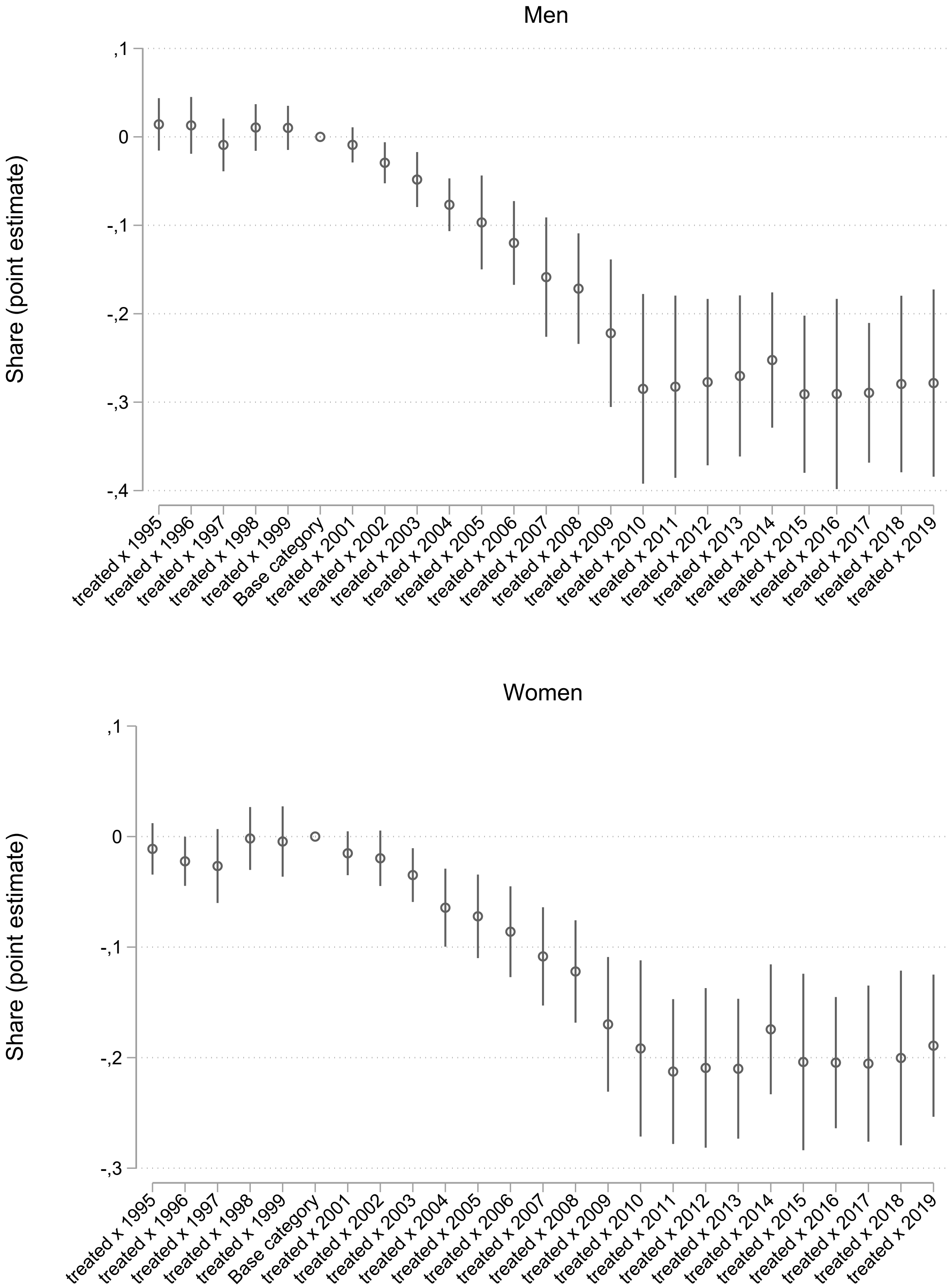
Figure A1: Illustration of WDI and ODI Schemes

Scheme	*Main criterion*	*Work eligibility*	*Health Assessment*	*Benefits*	*Calculation (Appendix B)*	*Notes*
Work DI (WDI)	Work disability in any job	Social contributions paid in last 3/5 years. 5-year waiting period after labor market entry.	Does health status allow 3 hours of work per day in any job?	100% 2000: €731 2005: €730	Similar to early retirement pension. Assuming applicant would have earned last wage until 60. Actuarial deduction of 3.6% for each life year of receipt before 60 up to 10.3%	Available throughout the entire time period for all cohorts.
Occupational DI (ODI)	Work disability in last or trained occupation	Social contributions paid in last 3/5 years. 5-year waiting period after labor market entry.	Does health status allow 6 hours of work per day in previous/trained occupation?	50% *(same as partial WDI post-2000[1])* 2000: €584 2005: €515	Same as WDI but is supposed to solely compensate for partial work capacity loss. About 12% of gross wage with average age at first receipt of 47, see Appendix B for details.	Cut for cohorts born after 1960. Effective insurance value is higher, the higher wage in the last occupation, cf Figure 1. WDI and ODI converge for low-income jobs

[1] Work capacity between 3 and 6 hours per day results in partial WDI at 50% of the benefits. Pre-2001, ODI benefit was 2/3 of WDI.

Source: own illustration. See main text for details. ODI was abolished for cohorts born after 1960, effective 2001. Appendix D provides details on the benefit calculation; changes in benefits affected all birth cohorts equally. Further, pre-2001, the health assessment applied an earnings threshold. The change to an "hours capacity assessment" affected all cohorts equally.

Figure A2: Effect of 2001 Reform on Public DI Inflows by Gender



Source: Administrative SPI data on new public DI recipients by cohort and year. Treated cohorts are those born after 1960, and the treatment group; grandfathered cohorts are those born before 1961 and the control group. Figure plots $\beta D_c \times T_t$ estimates from equation 1 but with the post-reform indicator T_t replaced by a series of year dummies where 2000 is the base year.

Table A1: Impact on Public DI Inflows Using Administrative SPI Data

Panel A. All	(1)	(2)	(3)	(4)	(5)
$D_c \times T_t$	-0.0907***	-0.0907***	-0.0907***	-0.144***	-0.0514***
	(0.0293)	(0.0219)	(0.0184)	(0.00992)	(0.0105)
D_c	0.364***	0.485***	0.485***	0.762***	0.774***
	(0.0199)	(0.0344)	(0.0289)	(0.0192)	(0.0204)
T_t	-0.159***	-0.266***	-0.266***	-0.397***	-0.0782***
	(0.0255)	(0.0290)	(0.0243)	(0.0137)	(0.0101)
N	1,300	1,300	1,300	1,164	388
Control group mean	0.61	0.61	0.61	0.58	0.50
Panel B. Men					
$D_c \times T_t$	-0.127***	-0.127***	-0.127***	-0.174***	-0.0649**
	(0.0224)	(0.0230)	(0.0231)	(0.0275)	(0.0170)
N	650	650	650	582	194
Control group mean	0.65	0.65	0.65	0.61	0.52
Panel C. Women					
$D_c \times T_t$	-0.0548**	-0.0548**	-0.0548**	-0.115***	-0.0378**
	(0.0221)	(0.0227)	(0.0227)	(0.0177)	(0.0100)
N	650	650	650	582	194
Control group mean	0.56	0.56	0.56	0.54	0.48
Year FE	no	yes	yes	yes	yes
Cohort FE	no	yes	yes	yes	yes
East German + gender	no	no	no	yes	yes
Age groups	29-59	29-59	29-59	32-58	32-58
Cohorts	1954-1966	1954-1966	1954-1966	1954-1966	1959-1962

Source: German Pension Insurance, administrative data on public DI inflows, 1995-2019. Each column in each panel is from one DD model as in equation 1. Panel A also controls for East Germany and gender, and Panels B and C control for D_c, T_t, but all those coefficients are omitted for readability. See the main text for more details.

B Impact on Public DI Case Load Using SOEP Survey Data

This section validates our first-stage findings in the main text using representative household data from the German Socio-Economic Panel Study (SOEP) and an alternative identification approach. The SOEP allows us to observe representative samples of each cohort, not just inflows, as with the administrative data. Goebel et al. (2019) provides more details on the SOEP.

Sample Selection. We select years 1995 to 2016 and respondents between the ages of 25 and 59 as we can then unambiguously identify whether they receive public DI. In addition, we focus on birth cohorts from 1950 to 1970. Table B1 shows summary statistics, with our primary outcome variables in the upper panel and the covariates in the lower panel.

RD Method. As we are now using a representative sample of the underlying population of interest, we can study the impact of the 2001 reform using a Regression Discontinuity (RD) design. The discontinuity is the birth year 1961. It determines whether respondents belong to the treated or the control cohorts. A standard linear parametric RD model is:

$$y_{it} = \alpha + \beta D_i + \psi(1 - D_i) f(z_i - c) + \gamma D_i f(z_i - c) T_t + X'_{it}\tau + \delta_t + \rho_s + \epsilon_{it} \qquad (10)$$

Where y_{it} indicates whether the respondent receives public DI benefits, D_i is one if the respondent belongs to the treated cohorts. The cohort measure z_i enters in difference to the reform cutoff c, 1961. Including linear trends and polynomials in the running variable $f(z_i - c) = z_i - c$ allows for different slopes before and after the cutoff.

All regressions include year (δ_t) and state (ρ_s) fixed effects. X'_{it} represents a rich set of socio-demographic, educational, and job-related control variables as listed in Table B1. For example, 45 is the average age, 52% are women, and 71% are married. About 20% finished the highest educational track in Germany, and 21% are part-time employed; 42% are white-collar employees.

We follow the recent literature on the topic and do not cluster standard errors ϵ_{it} (Cunningham, 2021). Further, we follow the literature and estimate nonparametric local polynomial regressions with univariate weights and cubic terms as our baseline model (Calonico et al., 2014). The main results are that we present robust and bias-corrected estimates (Calonico et al., 2018). We also vary the bandwidth, use data-driven bandwidth selection (Calonico et al., 2020), and covariates (Calonico et al., 2019).[23] Moreover, our estimates are robust to implementing

[23]We also implement procedures for optimal local polynomial order selection following Pei et al. (2022).

methods for discrete running variables following Kolesár and Rothe (2018).

The central RD identification assumption implies that no other factor would have affected public DI caseload trends discontinuously at the birth year level. We are unaware of another reform or factor that could invalidate this assumption; the appendix provides further evidence that other covariates trend smoothly at the cutoff c.

Outcome. The SOEP Group provides a time-consistent longitudinal binary variable that indicates whether individuals receive an old-age pension due to work disability. We call this variable *Public DI I*. Moreover, the SOEP Group provides a second generated variable indicating the annual income stream from old age, disability, or civil servant pensions, which we use to create a second binary indicator, *Public DI II*.[24] According to Table B1 and *Public DI I*, 3.3% of the German working age population have been on DI between 1995 and 2016—this share matches the share from official data in Figure A1 very well.

Results. Figure B1 plots public DI recipiency rates by birth cohorts for the pre-reform years in the left column (as placebo test), and the post-reform years in the right column. Further, the figure employs two different SOEP measures of DI receipt. The graphs show unconditional scatters by birth year, overlaid with polynomial quadratic smoothing plots. The visual evidence corroborates the findings from the administrative data: we see a clear discontinuous decrease in the probability of receiving a public DI pension for the treated cohorts in post-reform years. Note that the DI level is higher for post-2001 years as our respondents are older compared to 1995 to 2000. The decreasing slopes imply decreasing DI rates by birth cohort.

Table B2 shows the RD results using local polynomial RD methods for the post-reform period from 2001 to 2016. The column headers indicate the outcome measure; the lower panel adds socio-demographic and educational covariates as indicated. The models in columns (3) and (4) use *Public DI I* but restrict the sample to non-married respondents and single households, respectively. The table shows the results from 24 different models; for each column and panel, we present results from conventional, bias-corrected, and robust RD models; see Calonico et al. (2014, 2017, 2019) for details.

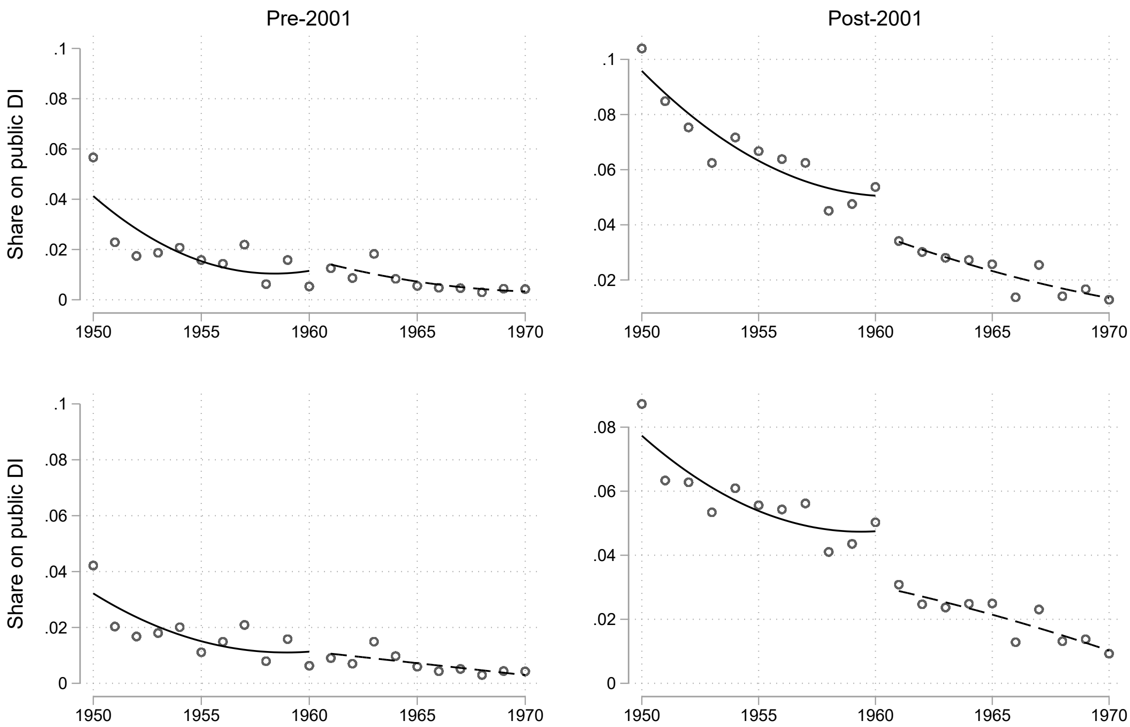
As seen, we find statistically significant results for 22 out of 24 models; all 24 models produce consistently negative point estimates, in line with Figure B1. Our preferred bias-corrected and robust estimates of the first column are -1.6 percentage points (upper panel) and -1.5 percentage

[24] Here, we use only respondents with a positive pension amount who do not receive a civil servant, a veteran's, a miners' or a farmers' pension.

points (lower panel). Relative to the mean recipiency rate of the nontreated cohorts, 6.7%, the latter estimates translate into a decrease of 22%. The decrease in size for households with one member is very similar, whereas the decrease for non-married people is even larger. Overall, the findings confirm and validate the results from administrative data that focus on inflows.

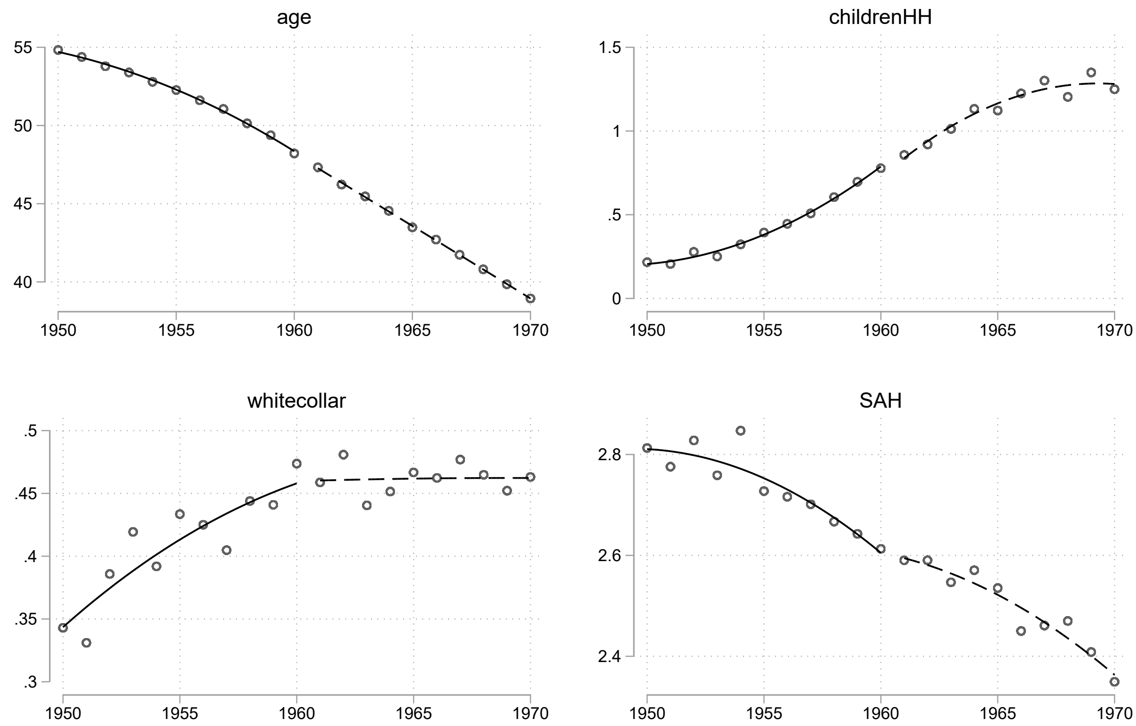
Robustness checks in Cao et al. (2022) vary the bandwidth and polynomials, the weights, runs donut RD models and adds set of covariates (Calonico et al., 2019, 2020; Pei et al., 2022); Figure B2 shows that covariates such as age, children in the household, white collar, or Self Assessed Health (SAH) trend smoothly at the cutoff 1961. Figure B3 carries out a McCrary (2008) density plot of the running variable.

Figure B1: Effect of 2001 Reform on Public DI Using Representative SOEP Data



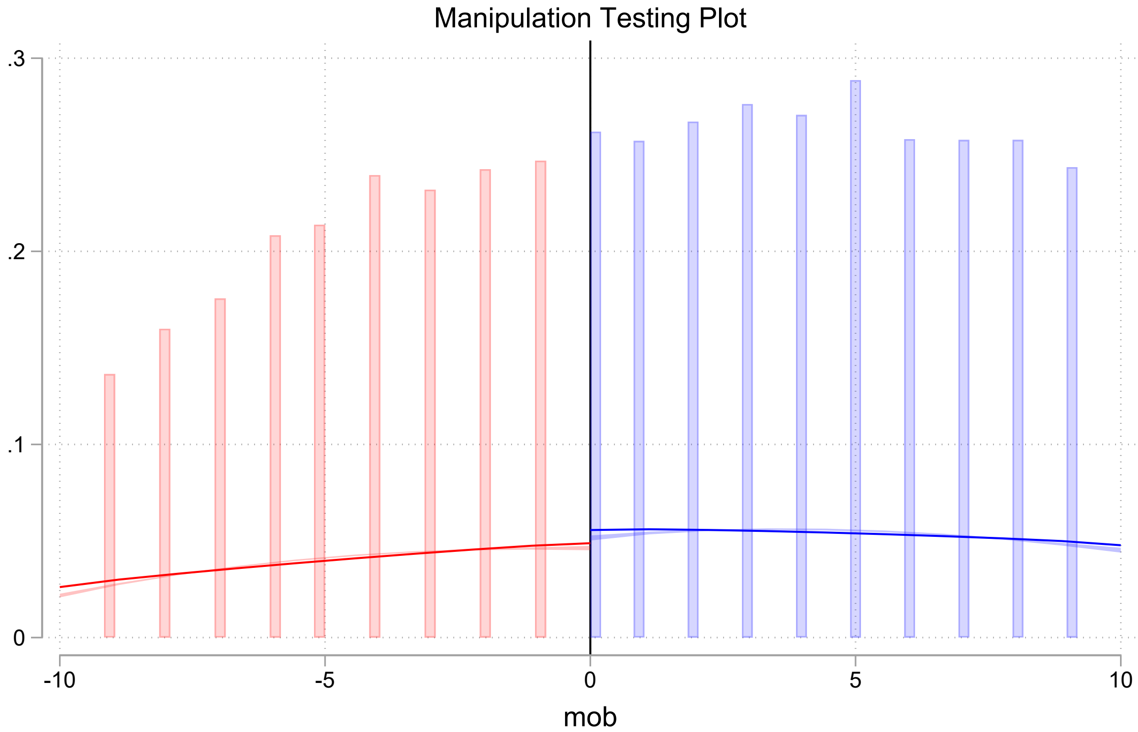
Source: SOEP v.33 – 95% sample. The left column shows pre-reform, and the right column shows post-reform years. The first row shows *Public DI I*, and the second row shows *Public DI II*. All figures show the raw nonparametric means of public disability receipt by birth year, overlaid with separate quadratic trends before and after the cutoff. Other robustness checks vary the bandwidth and polynomials, the weights, run donut RD models and add covariates (Cao et al., 2022); study the smoothness of covariates (Figure B2), and carry out density plots of the running variable (Figure B3, McCrary (2008).

Figure B2: Effect of 2001 Reform—Smoothness of Covariates



Source: SOEP v.33 – 95% sample. The figures show the raw nonparametric means of covariates as indicated by birth year, overlaid with separate quadratic trends before and after the cutoff. Other robustness checks vary the sample and indicator (Figure B1), vary the bandwidth and polynomials, the weights, run donut RD models and add covariates (Cao et al., 2022), and carry out density plots of running variables (Figure B3, McCrary 2008).

Figure B3: Effect of 2001 Reform—Density Plot



Source: SOEP v.33 – 95% sample. The figures show a density plot of the running variable for RD models similar to equation (10), estimated using local polynomial regressions with quadratic polynomials and univariate weights. Other robustness checks vary the sample and indicator (Figure B1), the bandwidth and polynomial (Cao et al., 2022), study the smoothness of covariates (Figure B2), and carry out density plots of running variables (Figure B3, McCrary 2008).

Table B1: Descriptive Statistic, SOEP Data, 1995-2016

	Mean	SD	Min	Max	N
Panel A. Outcomes					
Public DI I	0.0331	0.1790	0	1	163574
Public DI II	0.0289	0.1676	0	1	163574
Severe health limitations	0.01842	0.134464	0	1	163574
Non employed	0.1865	0.3895	0	1	163574
Full-time employed	0.5951	0.4909	0	1	163574
Individual total income (equivalized)	28,574	30,981	0	2,580,000	163574
Subjective well-being	6.9350	1.7781	0	10	163574
Panel B. Socio-demographics					
Age	44.5985	7.7230	25	59	163574
Female	0.5223	0.4995	0	1	163574
Married	0.7098	0.4539	0	1	163574
Single	0.1289	0.3351	0	1	163574
Children in household	0.9130	1.0672	0	10	163574
Adults in household	0.3596	0.6707	0	7	163574
Household size	1.2726	1.1667	0	12	163574
Dropout	0.0229	0.1496	0	1	163574
Schooling 9 yrs	0.2556	0.4362	0	1	163574
Schooling 10 yrs	0.3595	0.4798	0	1	163574
Schooling 13 yrs	0.2045	0.4033	0	1	163574
Civil servant	0.0594	0.2363	0	1	163574
Self-employed	0.0965	0.2952	0	1	163574
White collar	0.4230	0.4940	0	1	163574
Public Sector	0.2085	0.4063	0	1	163574
Part-time employed	0.2148	0.4107	0	1	163574
In job training	0.0024	0.0491	0	1	163574

Source: SOEP v.33 – 95% sample. Years 1995 to 2016. Only respondents below 60 and birth cohorts from 1950 to 1970 are included. See Goebel et al. (2019) for more details about the SOEP.

Table B2: Effect of 2001 Reform on Public DI Using Representative SOEP Data

Panel A	*Public DI I* (1)	*Public DI II* (2)	Non-Married (3)	Single Households (4)
Bias-corrected	-0.016***	-0.022***	-0.035***	-0.022***
	(0.0038)	(0.0037)	(0.0086)	(0.0077)
Robust	-0.016***	-0.022***	-0.035***	-0.022*
	(0.0061)	(0.0058)	(0.0134)	(0.0121)
Conventional	-0.012***	-0.014***	-0.005	-0.016**
	(0.0038)	(0.0037)	(0.0086)	(0.0077)
Year FE	yes	yes	yes	yes
State FE	yes	yes	yes	yes
Age & Gender	yes	yes	yes	yes
N	120,211	120,211	34,958	41,434

Source: SOEP v.33 – 95% sample. Years 2001 to 2016. Only respondents below 60 and birth cohorts from 1950 to 1970 are included. See Goebel et al. (2019) for more details about the SOEP. The tables show the point estimates using local polynomial regressions similar to equation (10) (Calonico et al. 2014, 2017, 2018, 2019) using a bandwidth of ten, a univariate kernel, and a quadratic polynomial. Column (2) shows results for an alternative *PublicDI II* measure. Column (3) selects non-married respondents, and column (4) selects single households. Other robustness checks show results for the pre-reform period (Figure B1), vary the bandwidth and polynomials (Cao et al., 2022), study the smoothness of covariates (Figure B2), and carry out density plots of running variables (Figure B3).

B1 Pre- and Post-Reform Consequences of a Health Shock.

In this subsection, we shed light on the question: For the treated cohorts without access to public ODI, how does a health shock materialize compared to the non-treated cohorts, given other social insurance strands and intra-household risk sharing? The findings show how the German social insurance system absorbs the financial consequences of a work-limiting health shock.

Table B3 uses SOEP panel data from 2001 to 2016 and runs simple OLS models with year and state fixed effects. Each column is one model that includes, as (lagged) regressors, a binary indicator for severe health limitations, a dummy for whether respondents belong to the treatment group (born after 1960), and the interaction between the two. The dependent variables are whether, in the year after a severe health shock, (1) the respondent is on public DI, (2) the respondent is not employed, (3) the respondent's total (market and non-market) income as well as (4) her subjective well-being.

As seen in Table B3, the onset of a severe health limitation more than doubles the likelihood of being on public DI in the next year (column (1)) and, by the same share of 9ppt, increases non-employment. Further, total annual income decreases significantly by €4.2K (-14%, cf. Table B1) as does subjective well-being (-0.18 points on a 0-10 Likert scale). Moreover, while the interaction term between the health shock and the treatment dummy yields a point estimate in line with Figure B1 and Table B2 (less likely to be on public DI), it is imprecisely estimated. Similarly, the interaction effects suggest (imprecise) increases in non-employment by about 4ppt and small and insignificant effects for changes in income and well-being.

Table B3: Consequences of a Health Shocks: Treated vs. Nontreated

	Public DI (1)	Not Employed (2)	Total Income (3)	SWB (4)
Severe Health Limitation (t-1)	0.0907***	0.0929***	-4,117***	-0.1765**
	(0.0162)	(0.0183)	(623)	(0.0847)
Treated×	-0.0115	0.0397	125	-0.1463
Severe Health Limitation (t-1)	(0.0203)	(0.0252)	(828)	(0.1112)
Treated	-0.0056	-0.2161	-17,365	-1.6655**
	(0.0274)	(0.3367)	(14,193)	(0.6866)
N	45,571	45,571	45,571	45,446
R^2	0.0593	0.0314	0.0469	0.0094
Control group mean	0.56	0.56	0.56	0.54
Year + State FE	yes	yes	yes	yes
Socio-demographic	yes	yes	yes	yes
Education	yes	yes	yes	yes

Source: SOEP v.33 – 95% sample. Years 2001 to 2016. Only respondents below 60 and birth cohorts from 1950 to 1970 are included. See Goebel et al. (2019) for more details about the SOEP. See Burkhauser and Schroeder (2007) for more details about creating the *Severe Health Limitations* variable. The indicator is lagged by one period; the treated dummy is one for respondents born after 1960. The dependent variables are indicated in the column headers; column (3) measures total individual income, including various streams of social insurance benefits such as unemployment, sick and maternity leave, and all types of pension benefits. SWB stands for subjective well-being.

C Impact on Private ODI Take-Up Using Representative SAVE Data

Figure C1: Standard Health Assessment Questionnaire of Private ODI Insurer

42f	Nehmen oder nahmen Sie innerhalb der **letzten 10 Jahre** Drogen, verschreibungspflichtige Medikamente, Betäubungs-, Suchtmittel oder werden oder wurden Sie innerhalb der **letzten 10 Jahre** wegen der Folgen des Konsums von Alkohol beraten oder behandelt?	☐ ja	☐ nein	BAS

Ärztliche Behandlung, Operationen und Krankhausaufenthalte

51a	Sind oder waren Sie in ambulanter Behandlung von Ärzten, Psychologen, Psychotherapeuten oder Angehörigen sonstiger Gesundheitsberufe (z.B. Krankengymnast, Heilpraktiker, Physiotherapeuten)?	☐ ja	☐ nein	BAS
51b	Sind Sie **derzeit** oder waren Sie innerhalb der **letzten 5 Jahre** länger als 2 Wochen in Behandlung von Ärzten, Psychologen, Psychotherapeuten oder Angehörigen sonstiger Gesundheitsberufe (z.B. Krankengymnast, Heilpraktiker, Physiotherapeut)?	☐ ja	☐ nein	CA
51c	Sind Sie in den **letzten 5 Jahren** durch **Ärzte** oder **andere Behandler** (z. B. Heilpraktiker, Psychotherapeuten) untersucht, beraten oder behandelt worden?	☐ ja	☐ nein	NAV, DIA, ALL
51d	Sind oder waren Sie in den **letzten 5 Jahren** in psychotherapeutischer Behandlung	☐ ja	☐ nein	STG
51e	Waren Sie in den **letzten 5 Jahren** wegen Beschwerden oder Krankheiten der Psyche, des Rückens, des Bewegungsapparats, des Herzens, des Kreislaufs oder einer Krebserkrankung in ärztlicher, physiotherapeutischer oder psychotherapeutischer Behandlung?	☐ ja	☐ nein	BAS
52	Wurden Sie in den **letzten 10 Jahren** wegen einer Sucht- bzw. Abhängigkeitserkrankung ärztlich beraten oder behandelt?	☐ ja	☐ nein	BAS
53a	Erfolgten in den **letzten 5 Jahren** Operationen, Krankenhaus- bzw. Kuraufenthalte oder haben Sie einen Unfall, Verletzungen oder Vergiftungen erlitten?	☐ ja	☐ nein	CA
53b	Haben in den **letzten 5 Jahren** Krankenhaus-, Rehabilitations-, Kuraufenthalte oder ambulante Operationen stattgefunden oder sind solche beabsichtigt oder ärztlich empfohlen?	☐ ja	☐ nein	CA, GEN
53c	Haben in den **letzten 5 Jahren** Krankenhaus-, Rehabilitations-/Kuraufenthalte oder ambulante Operationen (z.B. Laserung der Augen, Athroskopie) stattgefunden oder sind solche für die nächsten 2 Jahre ärztlich empfohlen oder beabsichtigt?	☐ ja	☐ nein	STG
53d	Wurden Sie in den **letzten 10 Jahren** in einem Krankenhaus-, Rehabilitations-, Kureinrichtungen untersucht, beraten, behandelt oder sind solche für die nächsten 12 Monate empfohlen oder beabsichtigt ?	☐ ja	☐ nein	DIA
53e	Wurden Sie in den **letzten 10 Jahren** ambulante Operationen durchgeführt, z.B. an inneren Organen, Haut, Bändern oder Augen?	☐ ja	☐ nein	DIA
53f	Haben in den **letzten 10 Jahren** Krankenhaus-, Rehabilitations-, Kuraufenthalte oder ambulante Operationen stattgefunden oder sind solche derzeit ärztlich empfohlen oder beabsichtigt?	☐ ja	☐ nein	BAS, ALL

Sonstiges

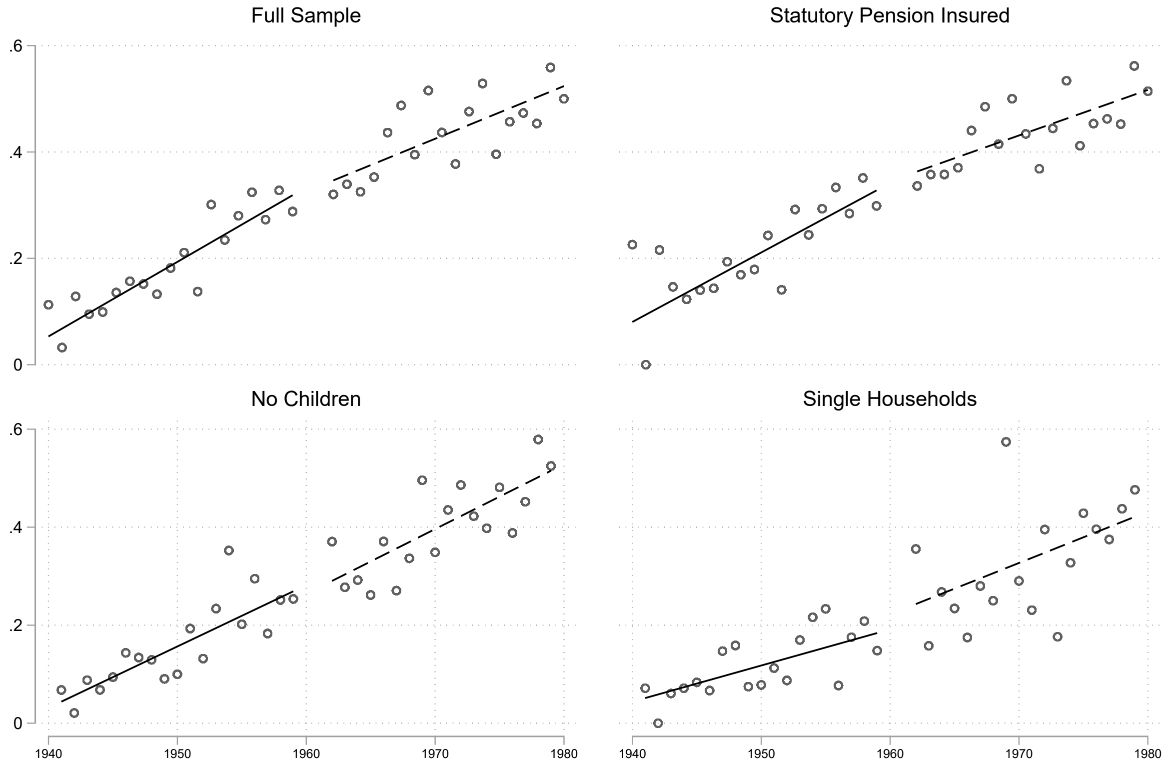
61	Haben Sie in den letzten 12 Monaten Zigaretten, Zigarren oder Pfeife geraucht, Schnupftabak oder Kautabak oder sonst Nikotin aktiv zu sich genommen?	☐ ja	☐ nein	CA
62	Haben Sie in den letzten 12 Monaten Zigaretten geraucht? Wenn ja, wie viele Zigaretten rauchen Sie täglich?	☐ ja	☐ nein	BAS, GEN

Source: The figure shows a standard health assessment questionnaire by a German private ODI insurer. In addition to age, occupation, medical diagnoses and diseases, and smoking status, all outpatient healthcare visits of the past 5 years and all inpatient healthcare of the past 10 years.

Figure C2: Socio-Demographic Preditors of Private ODI Coverage

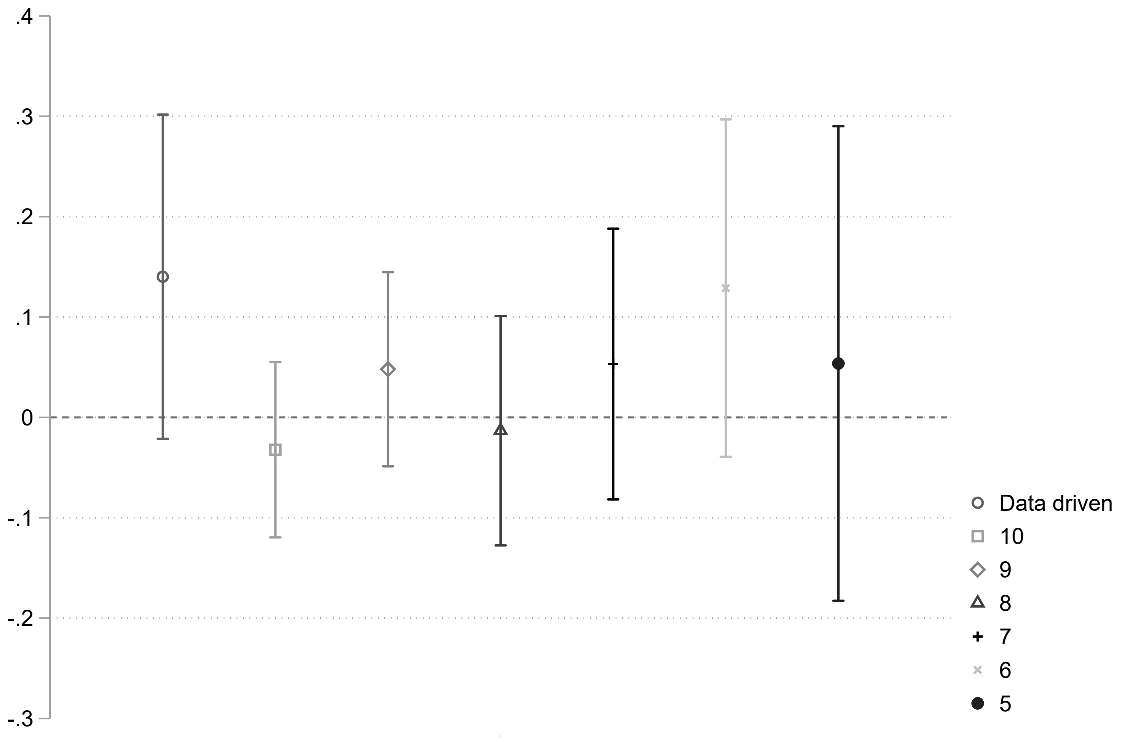
Source: The figure shows coverage predictors for private ODI policies. They stem from a multivariate regression and include the self-employed and civil servants, while the latter are omitted as the baseline category. Other omitted baseline categories are individuals who did not work at the time of the interview, those who do not have bachelor's or master's degrees, and those with a degree after 9 years of schooling or dropouts.

Figure C3: Effect on Private ODI Coverage Using Representative SAVE Data (II)



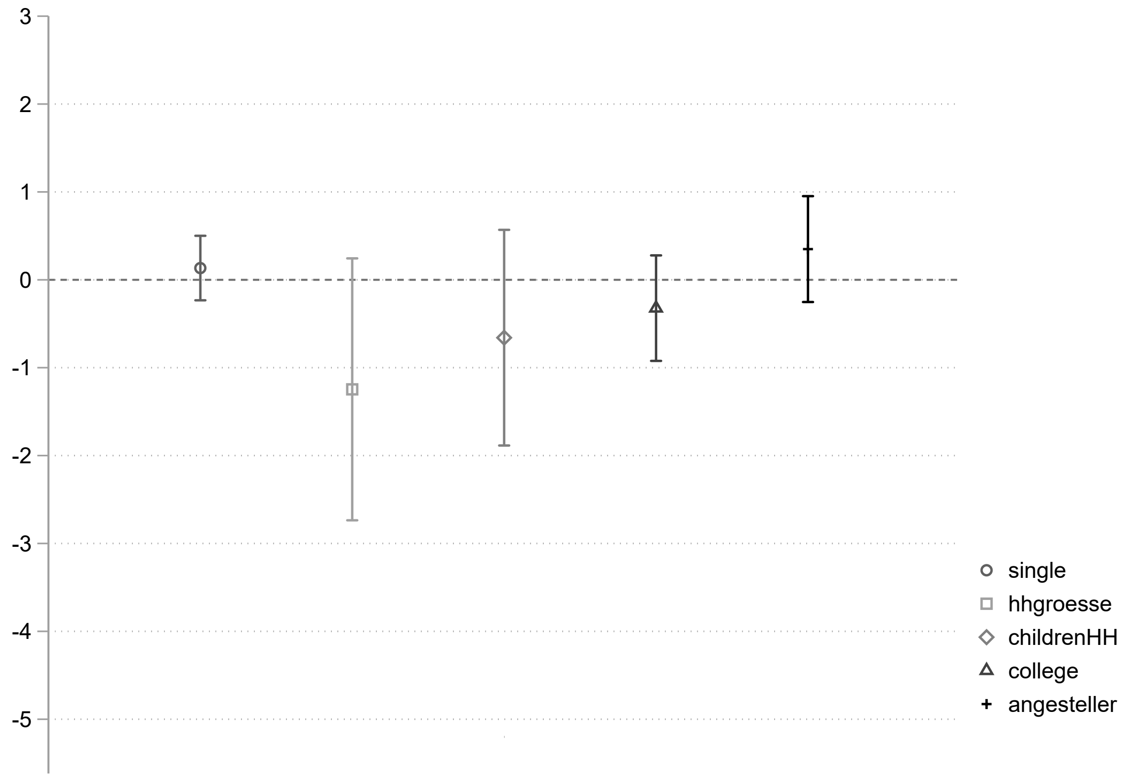
Source: SAVE data 2001-2010. The figures show the raw nonparametric means of private ODI coverage by birth year, overlaid with separate linear trends before and after the cutoff. The upper left graph is the default Figure (3), the upper right figure focuses on those eligible for Public DI, the bottom left focuses on the childless, and the bottom right focuses on one-person households. Other robustness checks vary the bandwidth (Figure C4, Calonico et al. 2020), study discontinuities in covariates (Figure C5), carry out density plots of the running variable (Figure C6, McCrary 2008), and vary polynomials as well as run donut RDs (Figure C7).

Figure C4: Effect on Private ODI Coverage—Local Polynomial RD Varying Bandwidth



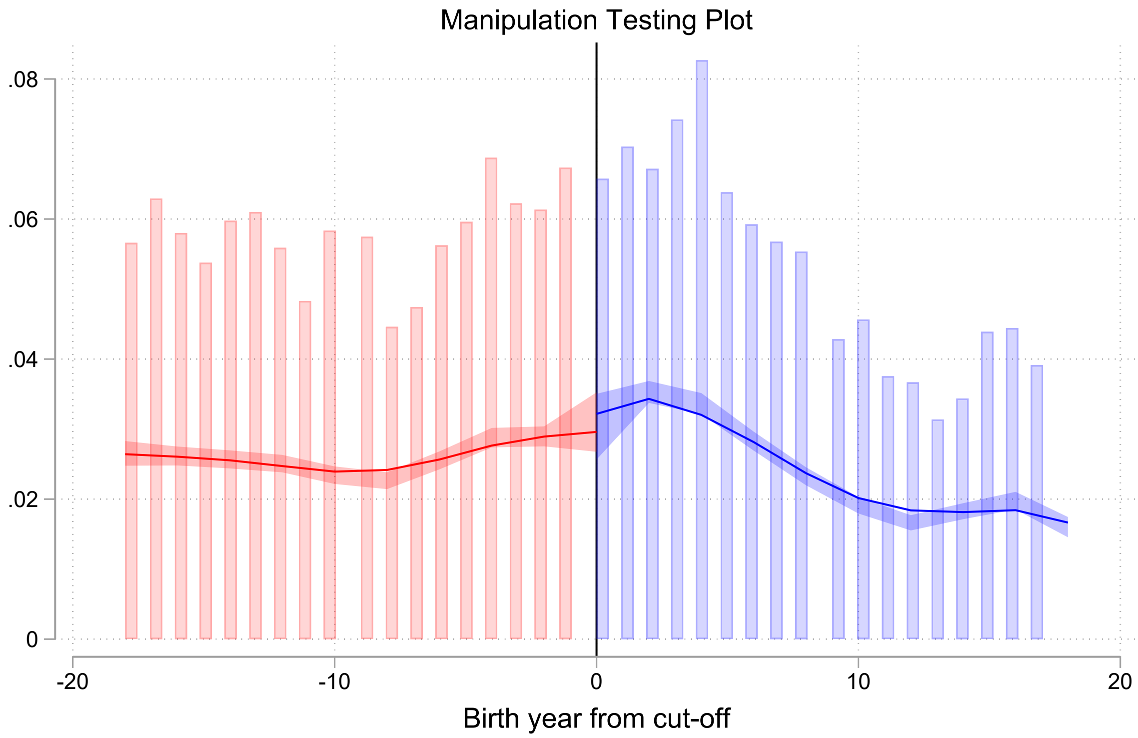
Source: SAVE data 2001-2010. The figures show point estimates of robustness checks varying the bandwidths of RD models similar to equation (10), estimated using local polynomial regressions with quadratic polynomials and univariate weights (Calonico et al. 2014, 2017, 2018). Other robustness checks vary the sample (Figure C3), study discontinuities in covariates (Figure C5), carry out density plots of running variables (Figure C6, McCrary 2008), and vary polynomials as well as run donut RDs (Figure C7).

Figure C5: Effect on Private ODI Coverage—Discontinuities in Covariates



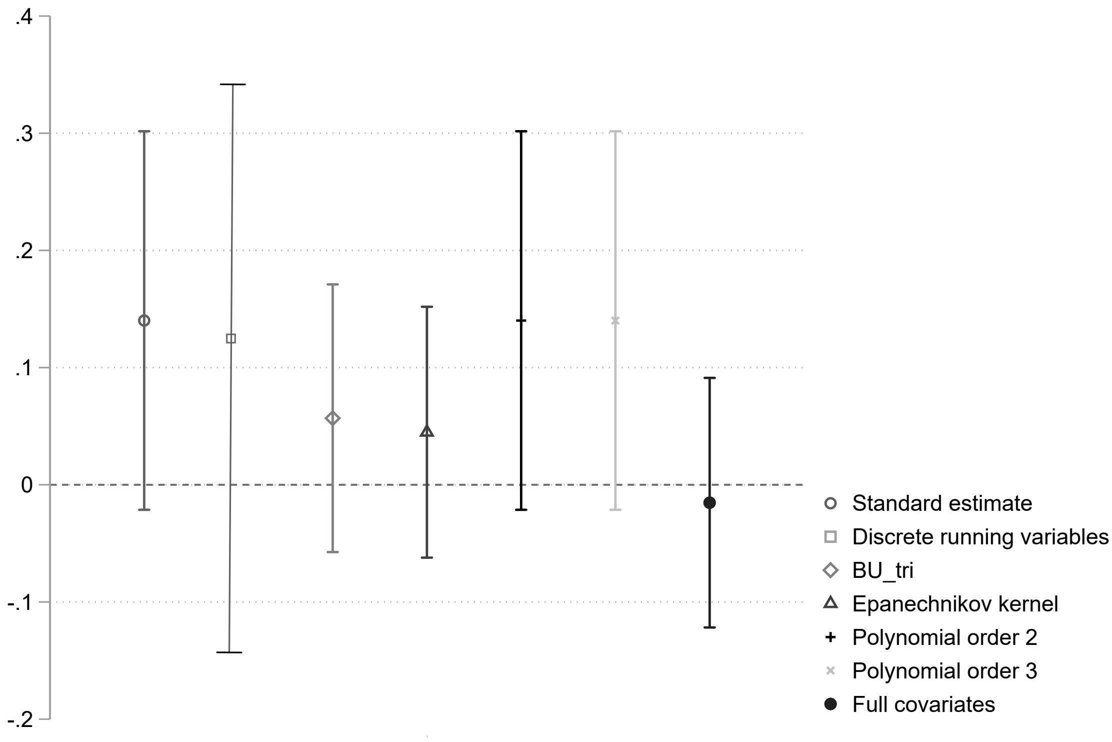
Source: SAVE data 2001-2010. The figures show point estimates of robustness checks testing for discontinuities in covariates using RD models similar to equation (10), estimated using local polynomial regressions with quadratic polynomials and univariate weights (Calonico et al. 2014, 2017, 2018). Other robustness checks vary the sample (Figure C3), vary the bandwidth (Figure C4, Calonico et al. 2020), carry out density plots of running variables (Figure C6, McCrary 2008), and vary polynomials as well as carry out donut RDs (Figure C7).

Figure C6: Effect on Private ODI Coverage—Density Plot



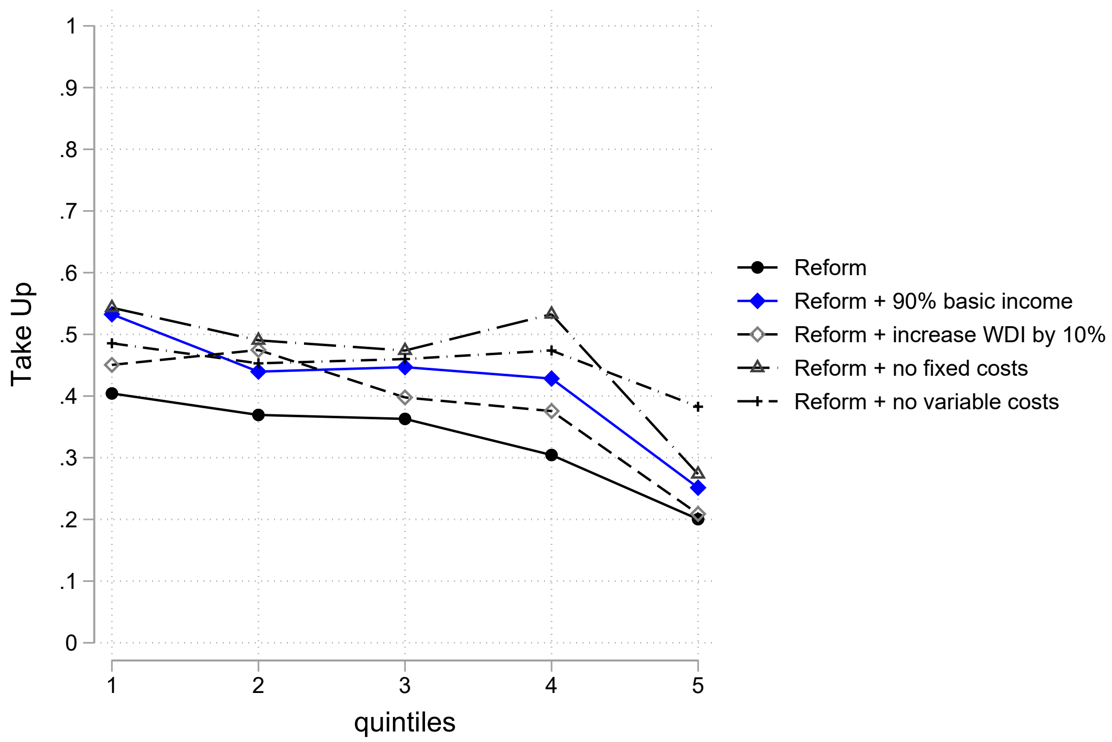
Source:: SAVE data 2001-2010. The figures show a density plot of the running variable for RD models similar to equation (10), estimated using local polynomial regressions with quadratic polynomials and univariate weights (Calonico et al. 2014, 2017, 2018). Other robustness checks vary the sample (Figure C3), vary the bandwidth (Figure C4, Calonico et al. 2020), carry out density plots of running variables (Figure C6, McCrary 2008) and vary polynomials as well as run donut RDs (Figure C7).

Figure C7: Effect of 2001 Reform: Local Polynomial RD—-Further Robustness



Source: SAVE data 2001-2010. The figure shows the point estimates of a robustness check, using methods for discrete running variables (Kolesár and Rothe, 2018), varying the order of the polynomials, varying weights, adding covariates in RD models similar to equation (10), estimated via using local polynomial regressions (Calonico et al. 2014, 2017, 2018, 2019). Other robustness checks vary the sample (Figure C3), vary the bandwidth (Figure C4, Calonico et al. 2020), study discontinuities in covariates (Figure C5), and carry out density plots of running variables (Figure C6, McCrary 2008).

Figure C8: Take-Up Rates by Health Risk Score: Policy Simulations



Source: The solid black line represents the baseline private ODI take-up rates by the quintiles of the health risk score in Figure 4. The other lines show take-up rates for alternative policy simulations by health risk quintiles using the general equilibrium model (see Section 5).

Table C1: Descriptive Statistic, SAVE Data, 2001-2010

	Mean	SD	Min	Max	N
Panel A. Key variables					
Private ODI	0.3239	0.4680	0	1	10721
Expects Retirement Pre-60	0.0260	0.1592	0	1	10721
Panel B. Socio-demographics					
Age	45.35	10.26	22	62	10721
Female	0.5153	0.4998	0	1	10721
Married	0.669	0.4706	0	1	10721
Single	0.1794	.3837	0	1	10721
Children in household	0.8714	1.0449	0	8	10721
Household size	2.656	1.2654	1	13	10721
High school degree	0.3353	0.4721	0	1	10721
Master degree	0.2684	0.4432	0	1	10721
College degree	0.3962	0.4891	0	1	10721
Full-time	0.4556	0.498	0	1	10721
Part-time	0.138	0.3449	0	1	10721
Blue collar	0.2101	0.4074	0	1	10721
White collar	0.4032	0.4906	0	1	10721
Household net income (in 000s)	2.429	2.442	0	120	10721
Panel C. Subjective and Objective Health					
Health satisfaction 0-4/10	6.648	2.509	0	10	10721
Concerns about own health	0.2171	0.4123	0	1	10721
SAH	2.4553	0.8551	1	5	7811
Serious Health Issues	0.4672	0.4990	0	1	7811
Heart disease diagnosed	0.0648	0.2462	0	1	7811
Stroke	0.0193	0.1377	0	1	9580
Chronic Lung Disease	0.0604	0.2383	0	1	7811
Cancer	0.0454	0.2083	0	1	7811
High Blood Pressure	0.2284	0.4198	0	1	7811
High Cholesterol	0.1369	0.34378	0	1	7811
# doctor visits	0.6104	0.847	0	9	5706
# days hospital	0.2012	0.9268	0	27	5706
Smoker	0.359	0.4797	0	1	10721
Normalized health risk score	0.1547	0.125	0	1	5706
Panel D. Expectations and attitudes					
Subj. life expectancy low	0.1825	0.3863	0	1	9757
Subj. life expectancy high	0.1324	0.339	0	1	9757
Savings 4 Unexp. Important	0.6956	0.4602	0	1	9757
Savings 4 Old Age Important	0.7256	0.4462	0	1	9757
No savings possible	0.2108	0.4079	0	1	9757
No savings, enjoy life	0.0197	0.1389	0	1	9757
Higher-income expected	2.0909	2.9554	0	1	10721
Inheritance expected	0.0358	0.1858	0	1	10721

Source: SAVE data 2001-2010. Respondents below 63, civil servants and self-employed are omitted; see main text for more details on sample selection. See Coppola and Lamla (2013) for more details about SAVE.

Table C2: Complier Analysis, SAVE Data, 2001-2005

	Treated <46	Treated <46	Controls <51	Controls <51
Panel A. Key variables				
Private ODI	1	0	1	0
Panel B. Socio-demographics				
Age	34.34	34.10	46.71	46.83
Female	0.455	0.496	0.406	0.449
Married	0.663	0.543	0.812	0.697
Single	0.293	0.349	0.073	0.117
Children in household	1.124	1.028	1.209	1.024
Household size	2.925	2.697	2.940	2.668
High school degree	0.471	0.416	0.385	0.323
Master degree	0.231	0.148	0.265	0.183
College degree	0.705	0.687	0.650	0.687
Full-time	0.613	0.484	0.667	0.570
Part-time	0.132	0.144	0.158	0.123
Blue collar	0.213	0.225	0.226	0.226
White collar	0.465	0.344	0.479	0.393
Household net income (in 000s)	2.634	2.256	2.891	2.539
Panel C. Subjective and Objective Health				
Health satisfaction 0-4/10	7.673	7.576	7.077	6.600
Concerns about own health	0.072	0.109	0.111	0.191
SAH	2.078	2.090	2.208	2.570
Serious Health Issues	0.307	0.294	0.283	0.504
Heart disease diagnosed	0.009	0.025	0.038	0.058
Stroke	0.000	0.006	0.000	0.017
Chronic Lung Disease	0.005	0.023	0.000	0.033
Cancer	0.009	0.014	0.038	0.033
High Blood Pressure	0.046	0.076	0.113	0.182
High Cholesterol	0.028	0.040	0.038	0.066
Smoker	0.367	0.453	0.389	0.464
Panel D. Expectations and attitudes				
Subj. life expectancy low	0.123	0.140	0.150	0.177
Subj. life expectancy high	0.188	0.134	0.192	0.146
Savings 4 Unexp. Important	0.725	0.649	0.705	0.642
Savings 4 Old Age Important	0.808	0.644	0.812	0.683
No savings possible	0.107	0.276	0.090	0.238
No savings, enjoy life	0.013	0.018	0.009	0.016
Higher-income expected	2.775	2.468	2.077	1.696
Inheritance expected	0.044	0.025	0.051	0.024

Source: SAVE data 2001-2005. Respondents below 63, civil servants and self-employed, are omitted; see main text for more details on sample selection. See Coppola and Lamla (2013) for more details about SAVE.

Table C3: Mean Health Risk Score by Income Quintiles (SAVE)

	Income Q1	Income Q2	Income Q3	Income Q4	Income Q5
Health Risk SAVE	0.1882	0.1648	0.1436	0.1338	0.1196
Health Risk Model	0.1848	0.1583	0.1428	0.1292	0.1056

Source: Tables shows the average health risk score as in Figure 4 by income quintiles. The first row shows the empirical moments from SAVE, and the second row those produced by the model.

D Benefit Calculation

We illustrate the effects of the 2001 pension reform on benefits by running a simple simulation assuming a stylized employment history. As explained in Section 2, public DI is a part of SPI. Therefore, we first describe the primary method of calculating statutory retirement benefits. Then, we explain how disability benefits are calculated.

The German SPI is based on a point system. The gainfully employed earn pension points (pp_{it}) during their work lives. A pension point equals the ratio of *individual* labor income (I_{it}) to *average* labor income ($\bar{I}_t$) in a given year t:

$$\mathrm{pp}_{it} = \frac{I_{it}}{\bar{I}_t} \tag{11}$$

At retirement, the sum of pension points is multiplied by the current "point value" (CPV_t, in €). The value is indexed annually to gross wages and a few other variables. Further, pensions are multiplied by a "pension type factor" (PT_i), which equals one for regular old-age and full WDI pensions. Since 2001, it has been 0.5 for partial WDI and ODI benefits. Moreover, a fourth factor accounts for actuarial deductions (AD_i) if people retire before the statutory retirement age. Deductions amount to 0.3% per month before reaching the statutory retirement age. The pension, P_{it}, is then calculated as:

$$P_{it} = \sum pp_{it} \times CPV_t \times AD_i \times PT_i \tag{12}$$

DI Benefits. They are calculated like regular old-age pensions. However, as work disability implies leaving the labor market before the statutory retirement age, pensions based on prior contributions would be relatively low. Hence, disability benefits assume a "reference age." For the period between entry of work disability and this reference age, individuals' *average* pension points are applied. Before 2001, the reference age was 55, and the years until age 60 were valued with $1/3 \times$ average pension points. A person who entered DI at age 40 would get an additional 15 + 5/3 years of her average pension points. Before 2001, there were no actuarial deductions for WDI or ODI ($AD_i = 1$). The factor PT_i was 0.66 for ODI and 1 for full WDI benefits. Starting in 2001, PT_i has been 0.5 for partial WDI and grandfathered ODI and remained 1 for full WDI benefits.[25]

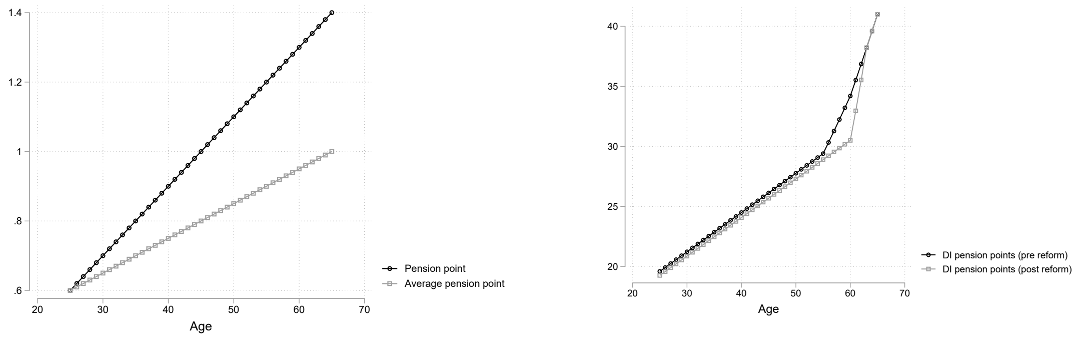
[25] However, if reasonable part-time work was unavailable, full benefits could be granted (Viebrok, 2018).

The reform in 2001 also increased the reference age to 60 but introduced actuarial deductions for retirement before age 60.[26] These deductions are capped at 36 months or 10.8% ($AD_i = 0.892$). As the large majority of disability inflows occur before age 60, the share of DI recipients with maximum deductions of 10.8% exceeds 90%.

Simulation. Next, we simulate the effects of the 2001 reform on benefits for a stylized individual. We assume an increasing relative wage position approximately equals one over the lifecycle. The individual starts working at age 25 and earns 60% of the average wage ($pp_{it} = 0.6$). The wage position then increases linearly to 1.4 until age 65. Figure D1a shows average pension points by age.

Figure D1: Pension Points by Age and Pre- vs. Post-Reform

(a) Average Pension Points by Age **(b)** Total Pension Points by Age, Pre and Post



Source: own illustration. Note that the post-reform benefits apply to the grandfathered cohorts who can still claim ODI benefits or the newly introduced partial DI benefits for people who can work more than three but less than 6 hours a day in any job.

The introduction of actuarial deductions and the increase of the reference age to 60 approximately cancel each other out for most ages. Figure D1b shows that the sum of pension points is slightly lower in the post-reform period. The largest difference applies between ages 56 to 61.[27]

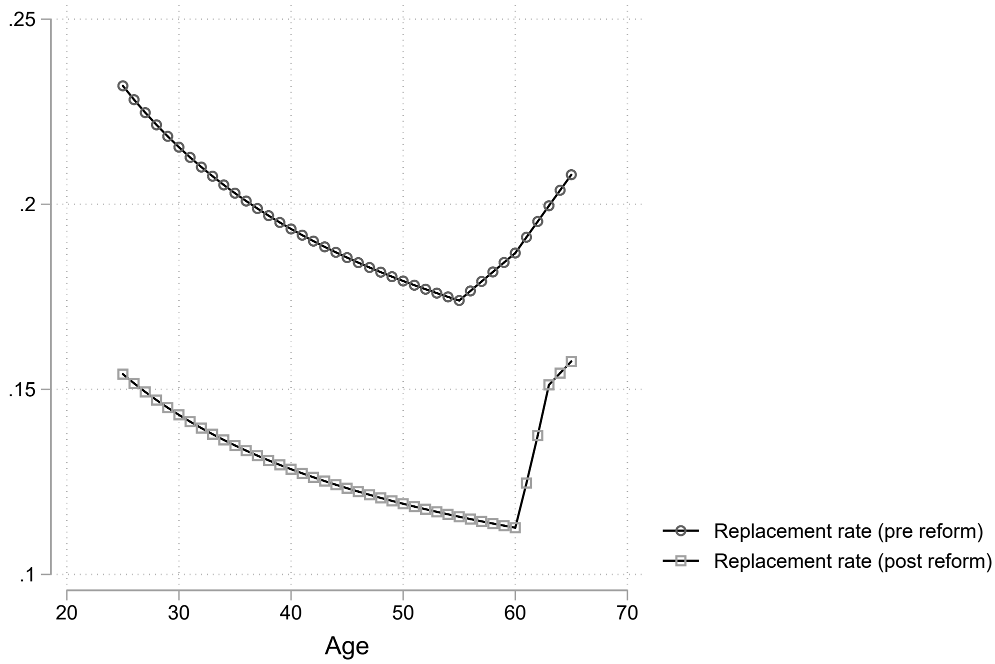
Next, we calculate replacement rates by age, assuming a single individual without other income. To calculate the replacement rate, we divide disability benefits by labor income. Figure D2 shows ODI replacement rates in the pre and post-reform periods. Before 2001, the replacement rate was highest at 0.23 at age 25 and then decreased linearly to 0.17 up to the reference age of 55, after which it sharply increased again. After 2001, the general pattern remained unchanged, but we observed a downward level shift with a lower replacement rate,

[26] In the meantime, the reference age has further increased to 63.

[27] As mentioned, PT_i decreased from 0.66 to 0.5. As a result, benefits—for partial WDI and for the grandfathered cohorts who are still eligible for ODI—are lower as well. The treated cohorts are ineligible for ODI post-reform.

ranging from 0.11 to 0.16. Note that these benefit reductions solely applied *for the grandfathered cohorts* and for partial WDI, that is, people who can work more than three but less than six hours a day in any job. At age 46, the mean age of DI entries, the stylized replacement rate is 0.18 (pre-reform) and 0.12 (post-reform).

Figure D2: Replacement rate (pre and post-reform)



Source: own illustration. Note that the post-reform benefits apply to the grandfathered cohorts who can still claim ODI benefits or the newly introduced partial DI benefits for people who can work more than 3 but less than 6 hours a day in any job.

Application & Health Assessment. Details of the application procedure are in German Social Law and Deutsche Rentenversicherung (2018). Applicants apply at an SPI field office and submit medical records. An independent third-party physician reviews the case.[28] Note that 44% of all public DI applications are rejected; this share has remained stable since 2000 (Deutsche Rentenversicherung, 2023b).

Today, only public WDI exists. The main WDI eligibility criterion is whether applicants' health limitations prevent them from working three hours per day in *any* job (Appendix Figure A1, column four). If applicants' work capacity is less than three hours daily, full WDI is granted; if it is between three and six hours daily, partial WDI is granted (Deutsche Rentenversicherung,

[28]Sometimes these are state-employed physicians (*Amtsärzte*), and sometimes they are regular specialists practicing in the county of residence of the applicant. They must not have a pre-existing relationship with the applicant.

2020). Benefits are re-certified every three years and become permanent after nine years.[29]

[29] If work capacity is not expected to improve, permanent DI benefits can be granted earlier, which applies to half of all new cases.

E Optimal Contracts

This section summarizes optimal insurance contracts in the standard model with private information when adding administrative costs and allowing for a (means-tested) consumption floor. We rely on and refer the interested reader to Braun et al. (2019), especially the proofs therein. For reasons of tractability, we assume a single monopolistic insurer and a single risk group that includes a continuum of risk-averse individuals who know that they are either good risks and at the bottom of the disability risk distribution, θ^b, or bad risks and at the top, θ^t.

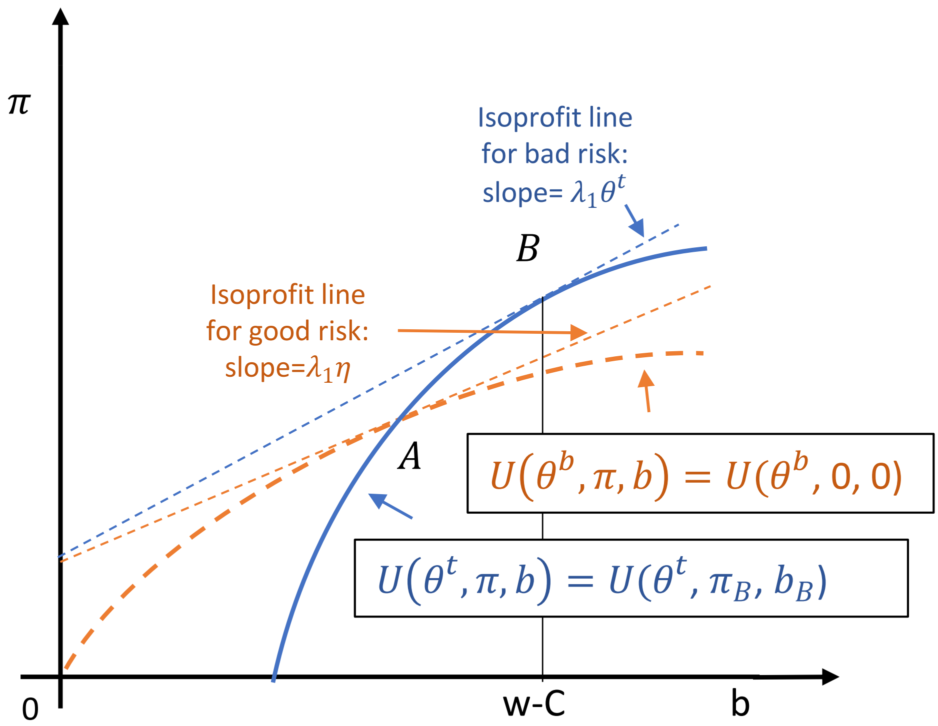
E1 Standard Case: Just Private Information

The core of the standard case goes back to Rothschild and Stiglitz (1976) and Stiglitz (1977). Given the participation and incentive compatibility constraints, the insurer maximizes profits (see equation (6)). Figure E1 illustrates optimal contracts under the standard case. The x-axis shows the insured benefit b and the costs of an occupational disability, $w - C$, where w represents the wage in the trained occupation and C is the consumption floor. The y-axis shows the premium Π, increasing coverage levels b.

The flatter indifference curve represents the good risks, and the steeper indifference curve represents the bad risks. The slopes indicate the willingness to pay for a marginal increase in benefits. As can be seen, the bad risks have a higher marginal willingness to pay. The dashed curve intersecting with (0,0) represents the participation constraint when binding. The participation constraint—indicating that good and bad risks prefer the contracts designed for them over no insurance—binds in the standard case for the good risks. The incentive compatibility constraint—indicating that good and bad risks prefer the contracts designed for them over the other contract—binds in the standard case for the bad risks; the bad risks' indifference curve intersects with the good risks indifference curve. Along the indifference curves, we observe combinations of possible insurance contracts (Π, b) that produce the same utility for individuals, given the participation and incentive compatibility constraints (both binding in the standard case).

Consequently, we obtain the optimal contract for the good risks where the flatter isoprofit curve of the insurer touches the indifference curve of the good risks at point A. Compared to the optimal contract for the bad risks at B, the benefits and premium are lower; the contract solely provides partial insurance, whereas the optimal contract for the bad risks in B provides

Figure E1: Standard Case of Optimal Contracts with Private Information: Separating Equilibria



Source:: The dashed indifference curve shows optimal contracts for good risks at the bottom of the work disability distribution θ^b trading off premia (Π) on the y-axis and coverage levels (b) on the x-axis. The solid indifference curve shows optimal contracts for bad risks at the top of the work disability distribution θ^t. The flatter dotted linear line is the insurer's isoprofit curve for the good risks, and the steeper dotted line is the isoprofit curve for the bad risks.

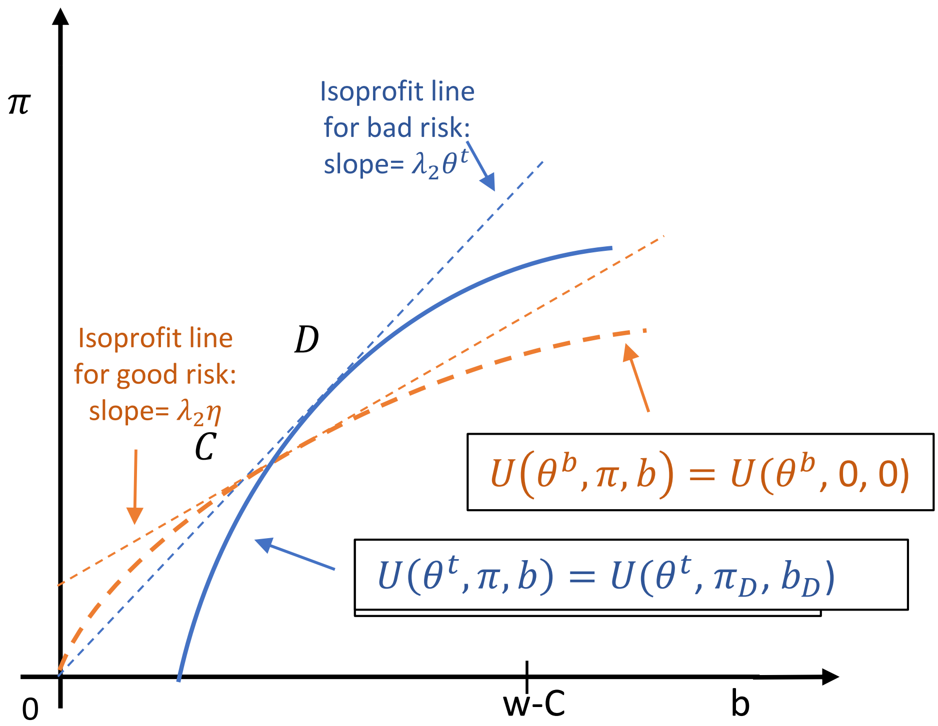
full insurance with $w_o - w_l = b$. We obtain a separating equilibrium.

As discussed, the standard case cannot produce coverage denials by insurers. Only the good risks can be voluntarily uninsured with (0,0) and make an ODI take-up that is not 100%. In other words, insurers always offer policies. Such a scenario can happen when the share of the population with low occupational disability risk, ρ, is small, but the dispersion of the true disability risk θ^i—that is unobserved by the insurer—large. In this case, the good types are offered a profitable contract by the insurer but prefer to remain uninsured.

E2 Extended Case I: Private Information and Administrative Costs

Chade and Schlee (2020) show theoretically that including administrative costs can produce coverage denials by insurers, as observed in reality. Braun et al. (2019) build on this insight and integrate administrative costs into their model. They show that coverage denials can produce four different scenarios: (i) separating equilibria, (ii) pooling equilibria, (iii) no insurance for anyone, and (iv), in practice, a rather unlikely case where only the bad risks are insured.

Figure E2: Optimal Contracts with Private Information and Admin Costs: Separating Equilibria



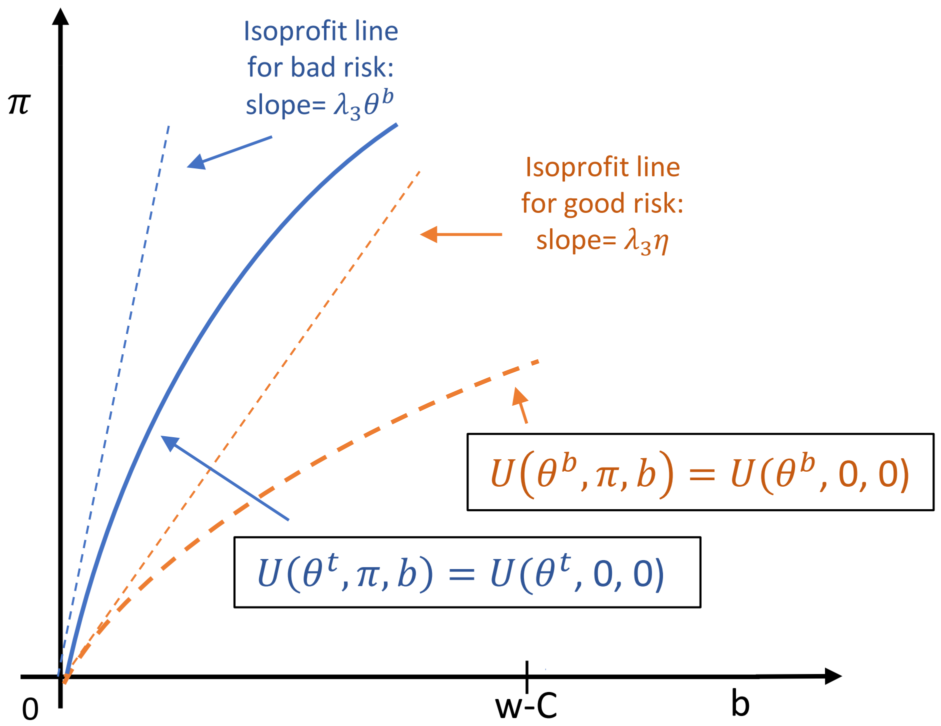
Source:: The dashed indifference curve shows optimal contracts for good risks at the bottom of the work disability distribution θ^b trading off premia (Π) on the y-axis and coverage levels (b) on the x-axis. The solid indifference curve shows optimal contracts for bad risks at the top of the work disability distribution θ^t. The flatter dotted linear line is the insurer's isoprofit curve for the good risks, and the steeper dotted line is the isoprofit curve for the bad risks.

Once variable administrative costs are introduced, optimal contracts for good and bad risks never provide full insurance. Further, it could be that all members of a risk group are denied coverage. These are the two relevant cases in practice. As seen in Figure E2, administrative costs lead to steeper isoprofit curves for insurers. This implies that, in a separating equilibrium, the insurer offers policies with lower benefits and premiums. Hence, in Figure E2, optimal contracts for both groups provide less coverage and lower premiums (points C and D).

An alternative case would be a pooling equilibrium (not shown), when administrative costs are even higher and where both types are offered the same contract—under the assumption that marginal variable administrative costs are higher for the bad risks. This pooling contract offers even lower coverage, premiums, and profits ("skinny plans").

Under certain conditions, when administrative costs are very high, Figure E3 shows a scenario where the entire risk group gets denied coverage. This is because the insurer cannot offer a profitable contract with positive coverage. The result is a pooling contract with (0,0), and nobody has insurance. Please see Chade and Schlee (2020) and Braun et al. (2019) for more

Figure E3: Optimal Contracts with Private Information and High Admin Costs: Denial



Source:: The dashed indifference curve shows optimal contracts for good risks at the bottom of the work disability distribution θ^b trading off premia (Π) on the y-axis and coverage levels (b) on the x-axis. The solid indifference curve shows optimal contracts for bad risks at the top of the work disability distribution θ^t. The flatter dotted linear line is the insurer's isoprofit curve for the good risks, and the steeper dotted line is the isoprofit curve for the bad risks.

details and formal proof.

E3 Extended Case II: Private Information and Social Insurance

Braun et al. (2019) introduce an extension that includes a means-tested public insurer for long-term care costs ('Medicaid'). It crowds out private insurance benefits dollar-by-dollar. This is not the case in Germany, where private ODI benefits top-up the basic WDI benefits. This implies that German private ODI also provides utility with public benefits, unlike in the U.S. case. Nevertheless, the main underlying mechanisms are the same in the German ODI case: public social insurance can lead to optimal contracts with partial coverage. Further, it can lead to the denial of coverage.

Public insurance generally increases individuals' utility in the case of no private insurance. It thus reduces the demand for private insurance and the profits of private insurers. As it increases the individual's outside option, insurers lower premiums (to satisfy the participation constraint). However, if the consumption floor is high enough, the insurer cannot offer contracts that are still profitable (and provide a sufficiently high utility for individuals). As a result, the insurer denies coverage; see Braun et al. (2019) for details. This case is relevant in Germany, where the consumption floor is relatively high. As with administrative costs, whether an insurer denies coverage to entire risk groups depends on the dispersion of private information and the population share of the good risks ρ.

In this context, uncertainty about future income shocks that may (or may not) result in eligibility for the means-tested basic income affects demand for private ODI insurance but more so for high-income populations whose income could drop more sharply. As explained, we use the representative SOEP to model the income shock distribution over the lifecycle and set the bounds for τ empirically (see Figure 8 and Table 2).

In conclusion, the equilibrium model includes multiple risk groups with observable h, w, o whereas θ^i is private information. An ODI take-up rate of less than 100% is produced via two channels. First, insurers deny coverage to entire groups. Second, some individuals are offered a profitable optimal policy, but those individuals prefer to self-insure.