The Life-Cycle Effects of Pension Reforms: A Structural Approach

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Retirement age	Fixed	Flexible

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- Implemented reforms often imply large decrease in future replacement rates for a given retirement age (e.g., Sweden $\simeq -30\%$, OECD, 2019)

- High stakes setting:
  - Pension wealth is one of the largest component of households' wealth
  - Retirement saving key financial decision

Question

What is the effect of these reforms on **household finances** and **welfare**?

- Many studies on the offset between social security and private wealth but evidence inconclusive (e.g., Lachowska and Myck, 2018)
- Little evidence on the effects of benefit generosity on portfolio choice and retirement (Blundell et al., 2016)

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- **Challenges**:
  - Limited data on individual public pension wealth and no lung run data on retirement behavioral response
  - Empirical research design: real-world pension reforms often far from ideal experimental setting
  - Complex institutions (pension rules, role of financial markets) and dynamic setting (savings, portfolio choice, retirement, bequests,...)

Our answer

1. To inform the specification of a life-cycle model, exploit the **quasi-experimental variation** from actual pension reforms
   - Major Italian pension reforms introducing a Notional Defined Contributions (NDC) system and flexible retirement
   - Discontinuous legislation changes across cohorts and sectors of employment: reduced-form effects using a DiD strategy
2. Develop a rich **life-cycle model** of saving, portfolio choice and retirement drawing from the reduced-form evidence
3. Identify and estimate the structural parameters of the model relying on an **indirect inference approach**
   - DiD regressions as auxiliary models
4. Conduct **counterfactual pension policy experiments** and study **welfare effects** of pension reforms

Contribution

1. **Structural estimation** (Gourinchas and Parker, 2002; Blundell et al., 2016)
   - We are the first to **estimate a fully fledged life-cycle model** exploiting **quasi-experimental variation** from pension reforms
   - Model matches well households' pre-reform wealth and financial markets participation and the reduced-form effects of the reforms
2. **Life-cycle model** (Carroll, 1997; French, 2005; French and Jones, 2011; Fagereng et al., 2017)
   - We explicitly introduce the dynamic incentives individuals face in a NDC pension system to postpone retirement
3. **New insights** on the implications of pension reforms (Attanasio and Brugiavini, 2003; Bottazzi et al., 2006; Manoli and Weber, 2016; Lachowska and Myck, 2018)
   - New insights on the offset between pension and private wealth:
     - 0.65, holding retirement age constant.
     - 0.55, allowing for retirement age to change.
   - Pension wealth effects on retirement (benefits $\downarrow 10\% \implies$ retire 0.5 later)
   - Quantify the life-cycle effects of pension reforms: households would be willing to pay 2.4% of annual consumption on average to face the reform 10 years earlier in the life-cycle

Outline

1. Empirical evidence on the effects of pension reforms
   - Institutional setting
   - Empirical challenges and research design
   - Data and reduced-form results
2. A Life-cycle model (with NDC)
   - Model features and setup
   - Structural estimation
   - Goodness of fit and validation
3. Implications
4. Conclusion

The institutional setting exploited for model validation

	Pre-reform	Post-reform
***Older workers*[1]**		
Private employees	DB	
Public employees	DB	
***Middle-aged workers*[2]**		
Private employees	DB	
Public employees	DB	

[1] $\geq$ 18 years of contribution in 1995
[2] $<$ 18 years of contribution in 1995

- In the post-reform period, **DB less generous for public employees**;

The institutional setting exploited for model validation

	Pre-reform		Post-reform
***Older workers*[1]**			
Private employees	DB		DB
Public employees	DB	$\Longrightarrow$	DB (less generous)
***Middle-aged workers*[2]**			
Private employees	DB	$\Longrightarrow$	Pro-rata model
Public employees	DB	$\Longrightarrow$	Pro-rata model

[1] $\geq$ 18 years of contribution in 1995
[2] $<$ 18 years of contribution in 1995

- In the post-reform period, **DB less generous for public employees**;
- Pro-rata: **NDC gradually phased-in** for middle-aged workers (DB until 1995).

Empirical challenges

- Italian reforms brings about arguably **exogenous changes** in eligibility criteria and pension formula, which be used to deliver DiD estimates of *some* meaningful treatment effect parameter
  - Employ DiD approach with older private employees as control group

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- Irrespective of the limitations of the quasi-experimental setting, the DiD are not informative about:
  1. the offset between pension and private wealth;
  2. the long-run behavioural responses;
  3. the welfare effects;
  4. the consequences of alternative pension policies.

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  1. the offset between pension and private wealth;
  2. the long-run behavioural responses;
  3. the welfare effects;
  4. the consequences of alternative pension policies.
- We use DiD estimates to **validate a quantitative model** of savings, portfolio choice and retirement.

Research design

- Use the quasi-experimental variation from the pension reforms to identify and estimate a structural model which is then used to conduct counterfactual pension policy experiments

  1. To assign the treatment status, model households' decisions, pre- and post-reform, allowing for **heterogeneous policy variation** between cohorts:
     - 2 pension regimes: DB (pre-reform) and pro-rata (post-reform)
     - 2 sectors of employment
     - 6 year-of-birth cohorts (40-45; 45-50; 50-55; 55-60; 60-65; 65-70)
  2. Simulate (10,000) households' decisions over the life-cycle:
     - **Replicate composition** SHIW data (= # households in each group)
     - Cohort-specific timing of reform
  3. Construct **pre-reform target moments** and use the **DiD regressions as auxiliary models** in an **indirect inference** estimation approach

The data

- Bank of Italy's Survey on Household Income and Wealth (SHIW) 1986-2008
- Representative of Italian population of households
- Bi-annual information on earnings, hours of work, assets and portfolio composition

Reduced-form results

DiD regression model

$$y_{it} = \delta_0 + \delta_1 POST_t + \delta_2 D_i + \delta_3 * PUB_i + \delta_4 POST_t * PUBi + \delta_5 D_i * PUB_i + \delta_6 POST_t * D_i * PRIV_i + \delta_7 POST_t * D_i * PUB_i + \varepsilon_{it}$$

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	(1) Log Net Wealth to income ratio
Private employees, middle-aged, after the reform	0.175* (0.090)
Public employees, middle-aged, after the reform	0.324*** (0.091)
Controls	Yes
Cohort dummies	Yes
Time dummies	Yes
Observations	14,738
R-squared	0.106

Notes: OLS estimates in Columns (1), (3) and (4). Marginal effects from Probit model in Column (2). Standard errors clustered at the household level. *** p<0.001, ** p<0.05, * p<0.1. Controls: household size, age, gender and education of the household head.

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	(1) Log Net Wealth to income ratio	(2) Financial market participation
Private employees, middle-aged, after the reform	0.175*	0.049**
	(0.090)	(0.024)
Public employees, middle-aged, after the reform	0.324***	0.057**
	(0.091)	(0.028)
Controls	Yes	Yes
Cohort dummies	Yes	Yes
Time dummies	Yes	Yes
Observations	14,738	15,252
R-squared	0.106	0.113

Notes: OLS estimates in Columns (1), (3) and (4). Marginal effects from Probit model in Column (2). Standard errors clustered at the household level. *** p<0.001, ** p<0.05, * p<0.1. Controls: household size, age, gender and education of the household head.

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	(1) Log Net Wealth to income ratio	(2) Financial market participation	(3) Log Hours of work
Private employees, middle-aged, after the reform	0.175*	0.049**	0.007
	(0.090)	(0.024)	(0.009)
Public employees, middle-aged, after the reform	0.324***	0.057**	0.017
	(0.091)	(0.028)	(0.014)
Controls	Yes	Yes	Yes
Cohort dummies	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes
Observations	14,738	15,252	15,218
R-squared	0.106	0.113	0.115

Notes: OLS estimates in Columns (1), (3) and (4). Marginal effects from Probit model in Column (2). Standard errors clustered at the household level. *** p<0.001, ** p<0.05, * p<0.1. Controls: household size, age, gender and education of the household head.

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	(1) Log Net Wealth to income ratio	(2) Financial market participation	(3) Log Hours of work	(4) Expected Age of retirement
Private employees, middle-aged, after the reform	0.175*	0.049**	0.007	0.736***
	(0.090)	(0.024)	(0.009)	(0.276)
Public employees, middle-aged, after the reform	0.324***	0.057**	0.017	0.784**
	(0.091)	(0.028)	(0.014)	(0.349)
Controls	Yes	Yes	Yes	Yes
Cohort dummies	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
Observations	14,738	15,252	15,218	13,125
R-squared	0.106	0.113	0.115	0.136

Notes: OLS estimates in Columns (1), (3) and (4). Marginal effects from Probit model in Column (2). Standard errors clustered at the household level. *** p<0.001, ** p<0.05, * p<0.1. Controls: household size, age, gender and education of the household head.

The model

- The model accomodates the following key features:
  1. Saving dynamics
  2. Portfolio choice: excess-returns from risky assets, tail risk, participation cost ψ
  3. Two pension regimes: pre-reform DB and post-reform pro-rata/NDC with illiquid defined contribution wealth
  4. Endogenous retirement: under NDC, trade-off between higher PB and disutility from work
  5. Uncertainty: labor income, returns from risky assets and mortality

$\Longrightarrow$ realistic interplay between SS wealth and households' decisions

Model setup

- Life-cycle model: yearly frequency between ages 25 and 90
- Rich economic environment:
  - **Assets**: riskless savings, risky assets (share ω_t), illiquid defined contribution wealth
  - **Labor market**: two sectors of employment, sector - specific labor income risk and age-varying income growth
  - **Demography**: uncertain length of life, age-varying household composition z_t
  - **Pension rules**: carefully replicate institutional setting under DB and pro-rata/NDC

▸ Portfolio ▸ Income process ▸ Preferences

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  - **Pension rules**: carefully replicate institutional setting under DB and pro-rata/NDC
- Parsimonious parametrization of preferences:
  - CRRA instantaneous utility, non-separable consumption and leisure $u(C_t, R; z_t)$ (Attanasio et al., 2008)
  - Standard bequest function $b(A_t)$ (De Nardi, 2004)

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Pension rules in the model: DB

- Under the **DB** pension regime, **pension benefits** PB:

$$PB = \rho N H_N$$

where:

- ρ is the accrual rate (sector of employment-specific)
- N are years of contribution
- H_N is a measure of average earnings at retirement

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- Average earnings follow the dynamic equation:

$$H_{t+1} = (1 - R)\left(h_1 H_t + h_2 Y_{t+1}\right) + R H_N$$

where $R = 1$ indicates household is retired

- Parametrization (ρ, h_1, h_2) **replicates heterogeneity** in rules across sectors of employment and pre-/post-reform variation

Pension rules in the model: Pro-rata NDC

- Under the **pro-rata regime**, **pension benefits** PB given by:

$$PB = \rho N_{1995} H_N + \Gamma_N$$

where:

- N_{1995}: number of years of contribution in 1995 (cohort-specific)
- Γ_N: **contributions model component** of PB, defined as:

$$\Gamma_N = \alpha_N \Xi_N$$

  - Ξ_N: defined contribution wealth accumulated at retirement age
  - α_N: transformation coefficient, increasing with age of retirement

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- **Defined contribution wealth** evolves according to:

$$\Xi_{t+1} = (1 - R)\left(\overline{G}_t \Xi_t + \tau Y_{t+1}\right) + R\Xi_N$$

where:

- τ: non-contingent contribution rate to the retirement account ($\frac{\tau}{3}$ paid by the worker; $\frac{2\tau}{3}$ employer defined contributions)
- $\overline{G}_t$: return factor equal to the 5-years moving average of GPD growth

Household's problem and solution

$$\max \mathbb{E}_t \left\{ \sum_{s=t}^{T} \beta^{s-t} \left[q_s u(C_s, R; z_s) + (1 - q_s) b(A_s) \right] \right\}$$

- 3 choice variables:
  - Consumption C
  - Portfolio share of risky assets ω_t
  - Retirement age (under NDC, between ages 57 and 65)
- 7 state variables:
  - Age in years t
  - Retirement status R
  - Discretionary wealth A
  - Labour earnings Y
  - Average earnings H
  - Defined contribution wealth Ξ
  - Defined contribution benefits Γ
- Solution based on a modification of Endogenous Grid Method and Upper Envelope (Iskhakov et al., 2017; Druedahl and Jørgensen, 2017)

Identification and estimation

Adopt a two-steps approach (Gourinchas and Parker, 2002):

1. Exogenous parameters estimated directly from the data (e.g., parameters income process, demographics, pension parameters)
2. 7 parameters are jointly estimated exploiting the indirect inference approach:

$$\kappa = [\beta, \gamma, \widetilde{\theta}, \psi, \boldsymbol{p_{tail}}, \widetilde{\phi_1}, \phi_2]$$

- Indirect inference estimator:

$$\widehat{\kappa} = \arg\min_{\kappa} \left(\widehat{\lambda^d} - \hat{\lambda}^s(\kappa)\right)' W \left(\widehat{\lambda^d} - \widehat{\lambda^s}(\kappa)\right)$$

- $\hat{\lambda}^d$: vector of auxiliary moments/parameters estimated in the data
- $\hat{\lambda}^s(\kappa)$: model moments/parameters obtained for a given set of κ
- W: inverse of the diagonal term of the bootstrapped variance matrix

Exogenous parameters

Identification: sensitivity

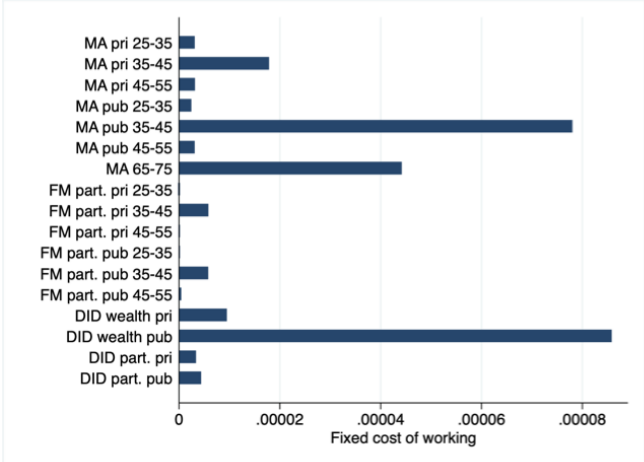


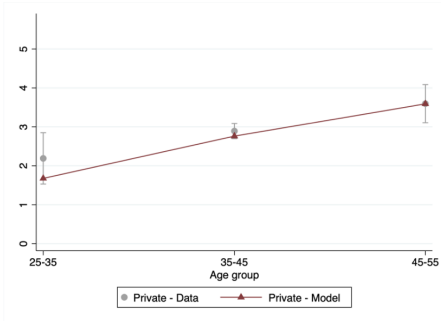
Figure: Absolute value of the scaled sensitivity matrix as defined in Andrews et al. (2017). The sensitivity measure has been rescaled to indicate the effect of a 1% increase in the moments on the parameters.

Second-step estimation results

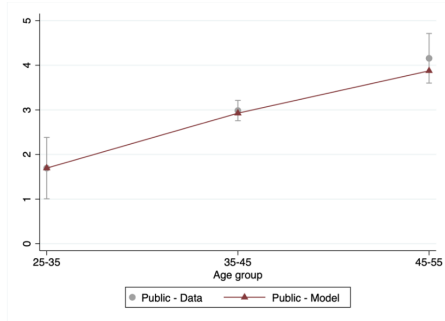
TABLE 2. Estimated structural parameters

Parameter		Value	Std. error
Time discount factor	β	0.9919	(0.0002)
Coefficient of relative risk aversion	γ	1.6103	(0.0091)
Financial markets participation cost	ψ	766.13	(1.7627)
Tail event probability	$p_{\widetilde{tail}}$	0.0205	(0.0001)
Utility cost of work	$\widetilde{\phi}_1$	0.1417	(0.0034)
	ϕ_2	0.0006	(0.0001)
Marginal propensity to bequeath	$\tilde{\theta}$	0.8761	(0.0015)

Goodness of fit: pre-reform median wealth-to-income ratio

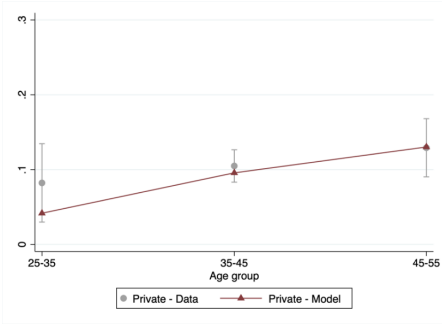


(A) Wealth-to-income ratio, private employees

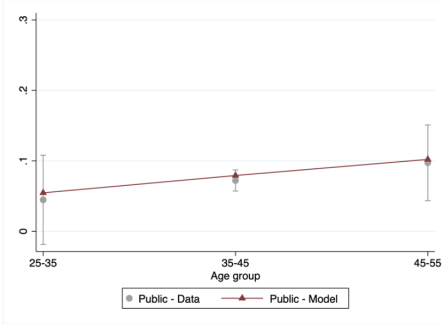


(B) Wealth-to-income ratio, public employees

Goodness of fit: financial markets participation



(C) Participation, private employees



(D) Participation, public employees

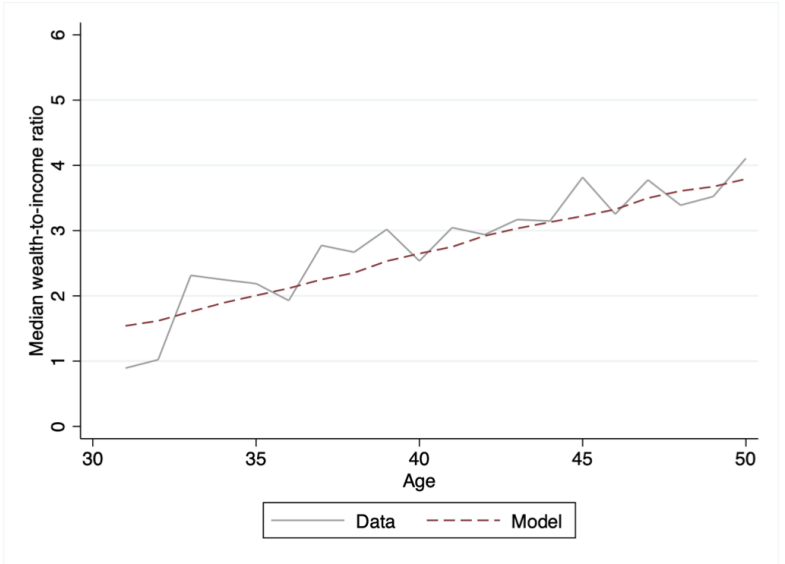
Goodness of fit: reduced form effects of the reform

DiD estimates for the effects of the reform

	Sector	Model	Data	[95% CI	Diff.]
(Log) wealth	Private	0.218*	0.199	-0.217	0.178
	Public	0.344*	0.352	-0.166	0.182
Participation	Private	0.047*	0.050	-0.036	0.044
(*Marginal effects*)	Public	0.044*	0.047	-0.040	0.045

Notes: *indicates simulated moment falls within the 95% confidence interval of the empirical moment.

Model validation: untargeted post-reform wealth of middle-aged workers

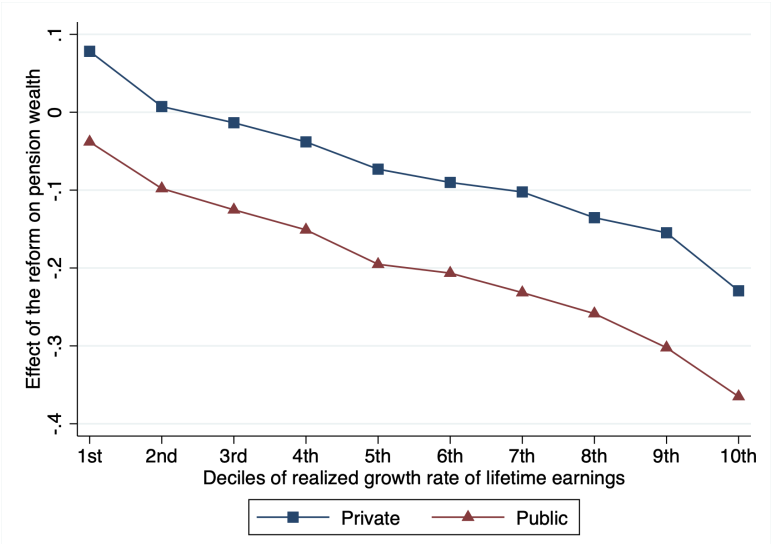


Model validation: untargeted expected retirement and model-predicted retirement age

		Data	Model
		Expected	
Sector	Private	62.35	62.26
	Public	62.25	62.29
Cohort	1955-60	62.83	62.21
	1960-65	61.95	62.25
	1965-70	62.17	62.37
All		62.31	62.27

Notes: Comparison between mean expected retirement age in the SHIW data and simulated by the economic model for middle-aged workers.

The distributional effects of the reforms on pension wealth



Implications I: Displacement effect

Q1: How much do public pensions **crowd-out** private savings?

- Simulate **long-run** behavior (age 60) using the model:
  1. Actual behavior in the *presence* of the reform:
     - Obtain $A^A_{i,60}$ and $PB^A_{i,60}$
  2. Counterfactual behavior *absent* the reform:
     - Obtain $A^C_{i,60}$ and $PB^C_{i,60}$

  $\Longrightarrow \Delta A_{i,60}$: individual level effect of the reforms on lifetime savings

- Estimate the following equation on simulated data:

$$\Delta A_{i,60} = \delta^A_0 + \delta^A_1 \Delta PB_{i,60} + \epsilon_{i,60}$$

- Repeat counterfactual simulation shutting-off retirement response

Model-predicted displacement effect

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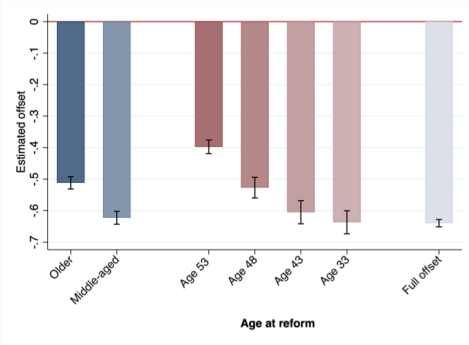
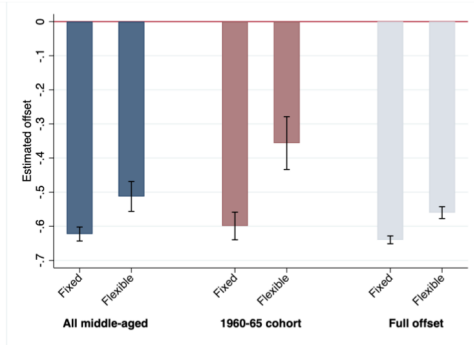


(A) By timing of reform, fixed labor supply



(B) The role of flexible retirement

Implications II: Retirement decision response

Q2: How does benefit generosity affect retirement decisions?

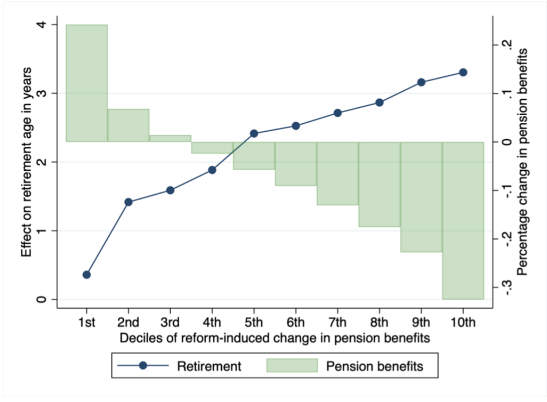


FIGURE 3. The extent of insurance through the retirement age. Each point corresponds to the model-predicted response of retirement to changes in pension wealth, in each decile of reform-induced variation in pension benefits. The response is expressed as the difference between the simulated retirement age under the post-reform NDC scheme and that under the pre-reform defined benefit regime.

Implications III: Welfare effects

Q3: What are the welfare effects of the reforms?

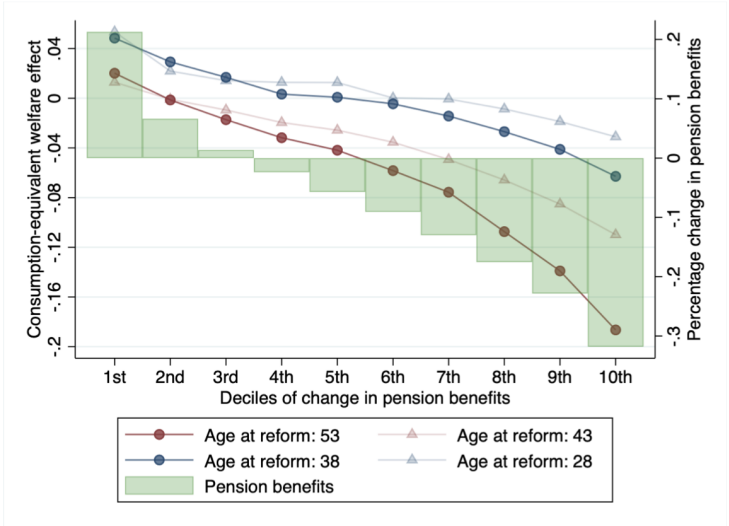
- Cohort-sector of employment groups hit differently

  $\Longrightarrow$ Focus on **distributional welfare effects**

- Compute model-predicted lifetime utility from the cohort-specific age at the time of the reform (t_{1995}):
  1. Actual lifetime utility in the presence of the reform
  2. Counterfactual lifetime utility in the absence of the reform
- Welfare metric: **consumption-equivalent** ζ_i (Low et al., 2010)

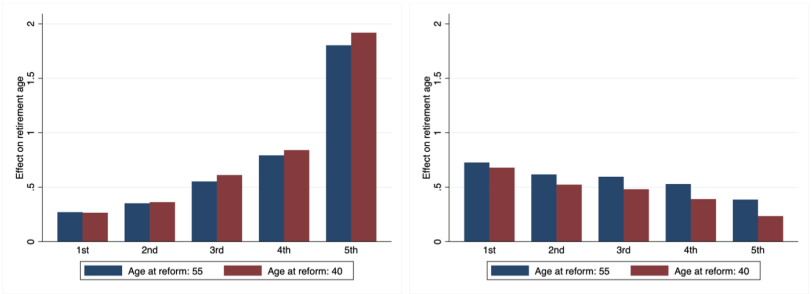
Implications III: Life-cycle welfare effects

Q3: What are the welfare effects of the reforms?



Ex-ante pension policy experiments

- Two pension policy experiments:
  1. ↑ in the early retirement age from 57 to 62
  2. 10% ↓ in benefit generosity, for a given retirement age



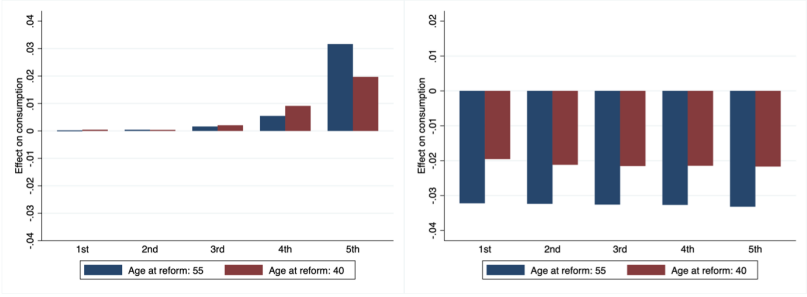
(A) Early retirement age - retirement

(B) Benefit generosity - retirement

Figure: Model-predicted effects on retirement age. Each bar corresponds to the simulated effect in each wealth quintile at the time of the reform. Baseline regime: Italian NDC 2013 rules

Ex-ante pension policy experiments

- Two pension policy experiments:
  1. ↑ in the early retirement age from 57 to 62
  2. 10% ↓ in benefit generosity, for a given retirement age



(c) Early retirement age - consumption

(d) Benefit generosity - consumption

Figure: Model-predicted effects on consumption. Each bar corresponds to the simulated effect in each wealth quintile at the time of the reform. Baseline regime: Italian NDC 2013 rules

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Bottom line: the results are robust.

Conclusions

- We provide and estimate a **dynamic life-cycle model** of savings, portfolio choice and retirement using the **reduced form effects** of a wave of major pension reforms carried out in Italy in the nineties.
- The model **fits** the data **well**, both the pre-reform wealth and participation profiles and the effects of pension reforms, predicts **substantial** social security wealth effects on retirement, and higlights the role of the **retirement choice**.
- Further, our framework allows to quantify **life-cycle effects** of the pension reforms, with older workers experiencing larger welfare losses, for any level of variation in benefit generosity.
- We use the estimated model to illustrate the substantially different consequences of **alternative pension policies** in terms of consumption and retirement wealth effects, as well as "life-cycle" welfare effects.

Supplementary material

Pre-reform pension regime: Defined benefits system

- Under the pre-reform defined benefits (DB) scheme, pension benefits PB:

$$PB = \rho N H_N$$

where:

  - ρ is the accrual rate
  - N are years of contribution
  - H_N is a measure of average earnings at retirement.

	Private employees	**Public employees**
ρ	0.02	0.023
H_N	Mean last 5 earnings	Last earning

- After the reform, DB scheme:
  - Unaltered for older private employees
  - Modified for older public employees ($\rho = 0.02$) and H_N the mean of last 10 earnings

Back

Post-reform pension regime: Pro-rata model

- Reform phased-in a Notional Defined Contribution (NDC) scheme for middle-aged workers:
  - DB until 1995
  - NDC after 1995: when retiring at age N, NDC component of pension benefits Γ_N:

$$\Gamma_N = \alpha_N \Xi_N$$

where:

- α_N: transformation coefficient, increasing with N
- Ξ_N: amount of defined contribution wealth at retirement

$$\Xi_N = \sum_{t=1}^{N} \tau Y_t \prod_{j=t+1}^{N-1} (1 + \overline{G}_j)$$

- τ: contribution rate
- $\overline{G}_t$: five-years moving average of the GPD growth factor

  - NDC gradually phased-in based on the number of years of contribution in 1995.

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Household's portfolio returns

- Total discretionary wealth A_t composed of riskless B_t (share $1-\omega_t$) and a risky S_t assets (share ω_t):
  - The return from a household's portfolio:

$$r^p_{t+1} = r_f + \omega_t(\mu_S + \eta_{t+1})$$

  - Riskless return: r_f
  - Risky assets returns: $r_f + \mu_S + \eta_{t+1}$, with $\mu_S > 0$ and η_{t+1} normal *iid* $\mathcal{N}(0, \sigma^2_S)$
  - Tail risk in the risky assets return distribution: r_{tail} with prob. p_{tail} (Fagereng et al., 2017)
- Per-period fixed cost to hold the risky assets: ψ (e.g., Vissing-Jorgensen, 2004)

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Labor income process

- During the working life, households receive gross labor earnings Y_t:

$$Y_{t+1} = g_t Y_t v_{t+1}$$

  where:

  - v_t are permanent i.i.d. shocks to earnings with constant variances
  - g_t is the age-varying earnings growth factor

- This is a standard permanent-transitory type earnings process in which the variance of the transitory shocks to zero (as in, e.g., Scholz, 2006)

- Shock variances and age-varying earnings growth allowed to vary with the sector of employment.

Back

Defined contribution benefits

Between ages 56 and 64, we can write the evolution of defined contribution benefits as:

$$\Gamma_{t+1} = \left(\frac{\overline{G}_t \Gamma_t}{\alpha_t} + \tau Y_{t+1} \right) \alpha_{t+1}$$

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Preferences

- Intertemporally separable utility, instantaneous utility (Attanasio et al., 2008):

$$u(C_t, R; z_t) = q(z_t)\frac{\left(\frac{C_t}{q(z_t)}\right)^{1-\gamma}}{1-\gamma}e^{\phi_1(1-R)} - \phi_2(1-R)$$

  where:

  - C_t: consumption
  - $q(z_t)$: function of demographics (nr. of adults and children)
  - R: indicator for retirement status

- Bequests valued as in De Nardi (2004):

$$b(A_t) = \theta\frac{(A_t + k)^{1-\gamma}}{1-\gamma}$$

  - A_t: end-of-period discretionary wealth

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Other exogenous parameters

Parameter			Value
Risk free rate		r_f	1.0302
Excess risky assets return		μ_S	0.0194
Std. deviation of risky assets returns		σ_S	0.2620
Return in the tail event		r_{tail}	-0.50
Retirement age			
	Before the reform (all)		60
	After the reform (older)		61
Evolution average earnings		h_2	
	Before the reform		
	Private-employees		0.2
	Public-employees		1.0
	After the reform		
	Private-employees		0.1
	Public-employees		0.1
GDP growth rate		g	0.015
Accrual rate		ρ	
	Private-employees		0.02
	Public-employees		0.023
Contribution rate		τ	0.33

Note: r_f and μ_S are computed as described in the main text, g is the average real GDP growth rate from Istat National Account data. The after-reform retirement age apply to older workers only. For each group and pension regime, h_1 is obtained as $1 - h_2$.

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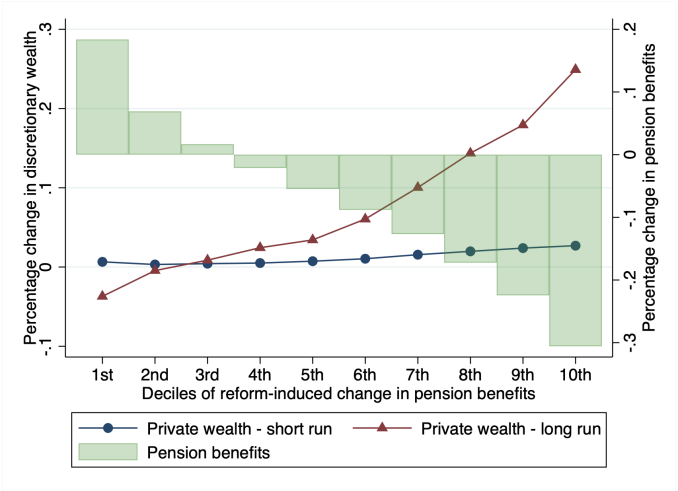
Long-run vs. Short run displacement



Welfare effects by cohort

TABLE A9. Welfare effects of the pension reforms by cohort

	Cohort	Private	Public	All
Older	1940-1945	-0.0240	-0.0979	-0.0567
	1945-1950	-0.0151	-0.0748	-0.0423
	1950-1955	-0.0126	-0.0610	-0.0351
Middle-aged	1955-1960	0.0021	-0.0346	-0.0138
	1960-1965	0.0102	-0.0201	0.0004
	1965-1970	0.0186	-0.0052	0.0127
All		-0.0035	-0.0563	-0.0250

Notes: The Table reports the average simulated consumption-equivalent welfare effect of the reform ζ, by group.