

Labor market informality, risk, and insurance

Lucas Finamor

(Sao Paulo School of Economics)

Disclaimer

*"This research uses information from the Chilean Social Protection Survey (Encuesta de Protección Social). I thank the Undersecretary of Social Protection, the intellectual owner of the survey, for the authorization to use the de-identified dataset. **All the results from this research are the responsibility of the author and do not implicate the Chilean Undersecretary of Social Protection.**"*

Widespread labor market informality in developing countries

- ▶ South America: high informality rates (for 2019, ILO):
 - Lowest: Uruguay (24.5%); Highest: Bolivia (81.5%)
 - Brazil (40.1%), Colombia (62.1%), Argentina (49.7%), Peru (68.4%), **Chile (29.3%)**

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 - Brazil (40.1%), Colombia (62.1%), Argentina (49.7%), Peru (68.4%), **Chile (29.3%)**
- ▶ Informal workers: employment status cannot be verified by the government

Informal workers and insurance

- ▶ Informal workers have limited access to public insurance programs
 - Unemployment insurance & employment protection
 - Pensions
 - Paid leaves, Disability insurance
- * **Formal** jobs are valuable because they offer insurance

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- * **Formal** jobs are valuable because they offer insurance
- ▶ Informal jobs can be (usually) quickly found
- * **Informal** jobs are valuable because they are an easy way out of unemployment

Research Questions

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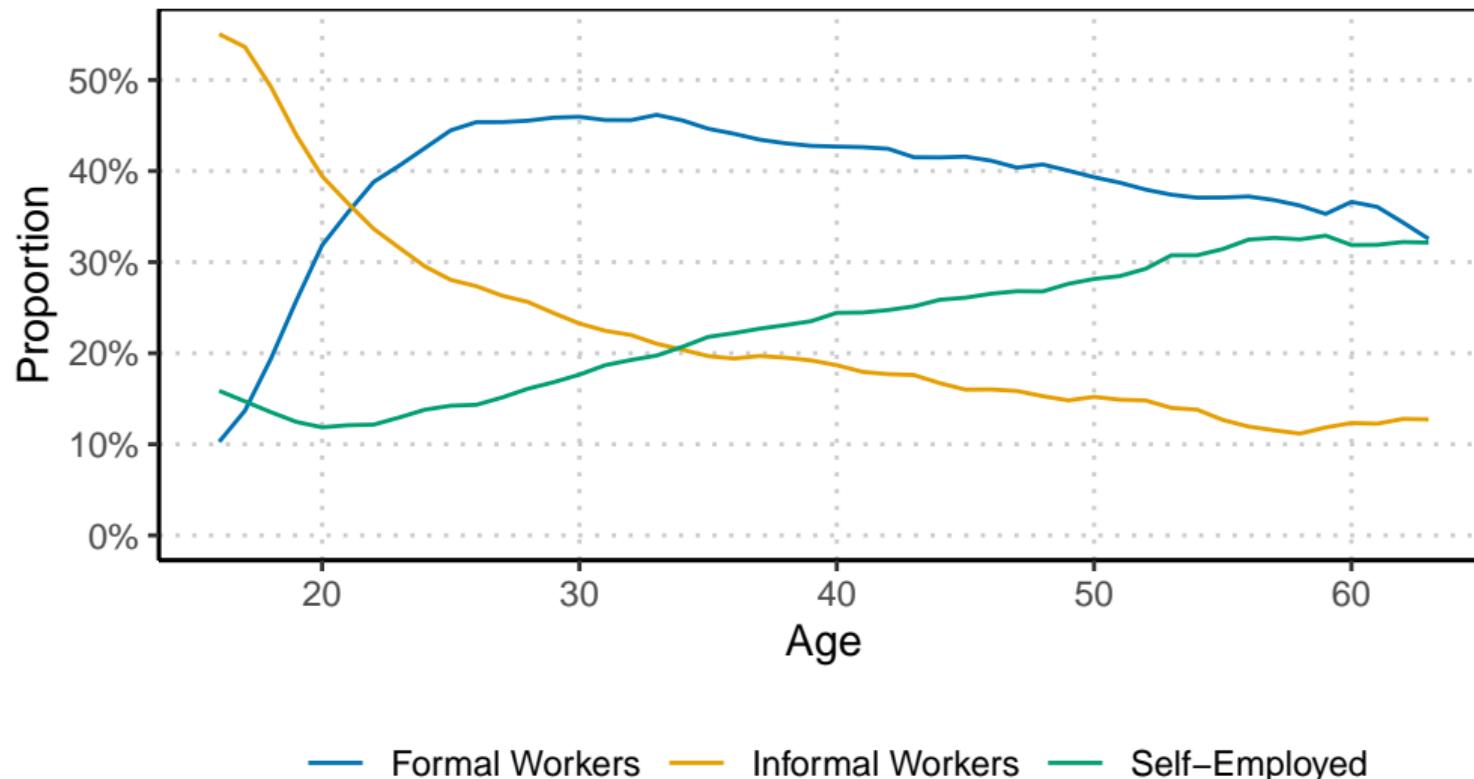
- Q1) How much workers value the insurance tied to the formal sector?
- Q2) How valuable is the informal sector for workers?
- Q3) What are the drivers of life-cycle labor market choices?

Informality over the life-cycle – Chile

Cohorts

Gender/Educ

Other Countries



This paper

1. Develop a model with employment and savings decisions, risk, and social insurance

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 - Risk-aversion, Search Frictions, and Income Shocks
 - Social Insurance (UI and Pensions) and Savings

Insurance x Incentives

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⇒ Wealth-dependent labor market decisions

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1. Develop a model with employment and savings decisions, risk, and social insurance
2. Rich characterization of informality: informal workers & self-employed
 - Self-employment requires physical capital
 - Different job characteristics (amenities, hours of work)

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2. Rich characterization of informality: informal workers & self-employed
3. Estimate the model with rich microdata & exploiting pension reforms
 - Chilean microdata: longitudinal survey + administrative data
 - Estimate the causal effects of early retirement restrictions

This paper

1. Develop a model with employment and savings decisions, risk, and social insurance
2. Rich characterization of informality: informal workers & self-employed
3. Estimate the model with rich microdata & exploiting pension reforms
4. Use the model:
 - Learn drivers of employment decisions
 - Compute the value of a formal job
 - Compute the value of the informal sector
 - Analyze counterfactuals

Main findings

1. Important drivers for the life-cycle allocation:
 - Savings influence job search (different reservation wages)
 - Amenities, physical capital and borrowing constraints

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4. Summary measures of attractiveness of formal/informal opportunities

Literature

- A. Firms' and workers' formality decision
- B. Social Insurance and Informality
- C. Self-employment in developing countries

Literature

A. Firms' and workers' formality decision

Zenou (2008), Albrecht, Navarro and Vroman (2009), Ulyssea (2010), Bosch and Esteban-Pretel (2012), Lopez Garcia (2015), Meghir, Narita and Robin (2015), Pardo and Ruiz-Tagle (2016), Ulyssea (2018), Albertini and Terriaud (2019), Narita (2020), Haanwinckel and Soares (2021), Herreño and Ocampo (2021), Bobba, Flabbi, Levy and Tejada (2021), Bobba, Flabbi and Levy (2022), Conti, Ginja and Narita (2022), da Costa and Lobel (2022)

Risk-aversion, savings, and social insurance \Rightarrow Insurance Values

Savings \Rightarrow $\left\{ \begin{array}{l} \text{job search behavior} \\ \text{self-employment investment} \end{array} \right.$

- B. Social Insurance and Informality
- C. Self-employment in developing countries

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- B. Social Insurance and Informality

[Unemployment Insurance] Huneeus, Leiva and Micco (2012), Espino and Sanchez (2013), Gonzalez-Rozada and Ruffo (2016), Audoly (2018), Gerard and Gonzaga (2021), Britto (2022), de Azevedo (2022), Bloise and Santos (2022)

[Health Insurance] Calderón-Mejía and Marinescu (2012), Azuara and Marinescu (2013)

[Minimum Wage] Granda and Hamann (2015), Parente (2022), Engbom and Moser (2021)

[Pensions] Attanasio, Meghir and Otero (2011), Behrman, Calderon, Mitchell, Vasquez and Bravo (2011), Cruces and Bérgolo (2013), Todd and Vélez-Grajales (2008), Joubert (2015), McKiernan (2019), Joubert and Todd (2020), Ferreira and Parente (2020), Moreno (2022)

Causal effects of early retirement restrictions

Dynamic model combining main social insurance programs

- C. Self-employment in developing countries

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Narita (2020), Bobba, Flabbi, Levy and Tejada (2021), Herreño and Ocampo (2021), Bobba, Flabbi and Levy (2022), Moreno (2022)

Importance of start-up costs, borrowing constraints, and amenities

Institutional setting and data

Encuesta de Protección Social (EPS)

- ▶ Panel survey at the individual level
- ▶ 7 waves (2002-2020)
- ▶ + labor market history

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- ▶ Additional data: employment surveys, administrative data (UI, pension claims)

Definitions

Self-reported information from the primary occupation + administrative data

Self-reported	Administrative Data	Sector	Example
Employed by a firm	Contributing to pensions	Formal	<i>Office clerks</i>
Employed by a firm	Not contributing	Informal	<i>Construction workers</i>
Self-employed	-	Self-employed	<i>Car/Taxi/Van drivers</i>

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Self-employment is informal [more](#)

- ▶ 16% are contributing to the pensions
- ▶ 33% are registered in the Tax Authority
- ▶ 67-91% are one-worker firm

Empirical Findings

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1. Early retirement restrictions were raised in 2004 for those born after August 1949 [more](#)

- ⇒ Sharp decline on early retirement
- ⇒ Smaller increase in the probability to contribute for Pensions

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3. Self-employment

- Part-time work and flexible work locations [Hours](#) [Workplace](#)
- Entry associated with investments in physical capital [Regression](#)
- Use own savings [Source of Capital](#)

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⇒ Model estimation

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⇒ Modeling choices

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Model

The model in a nutshell

- ▶ Risk-averse individuals **consume, save** and decide **employment status**

	Formal	Informal	Self-employment
Entry	Receive offer	Receive offer	Pay up-front investment

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- If not working:
 - Unemployed or Retired (endogenous)
 - No re-entry after retirement
- Arrival/Destruction rates depend on the sector

Employment choices

A. Employment transition: choose sector that maximizes utility more

- Formal/Informal: only when receiving an offer
- Self-employment: paying start-up cost
- Retirement is an option when meeting the requirements

Employment choices

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B. Accumulate informal earnings and UI benefits [more](#)

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- Retirement is an option when meeting the requirements

B. Accumulate informal earnings and UI benefits [more](#)

C. Bequeath remaining wealth when dying [more](#)

Estimation

1. Set and estimate some parameters outside the model

- Set coefficient of risk aversion: $\gamma = 3$

Kotlikoff et al. (1999), Conesa et al. (2009), Nishiyama (2011), O'Dea (2018)

- Estimate interest rate: $r = 4.5\%$ and $r^P = 5.8\%$

- Estimate Self-Employment earnings persistence: $\rho = 0.66$ (annually)

- Policy values for social insurance, welfare programs and taxes

2. Estimate remaining parameters using SMM

[more](#)

Preferences

- Discount factor
- Consumption weight
- Amenities for Self-Employed
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Technology

- Arrival and destruction rates
- Wage offer distributions and Self-Employment earnings
- Investment to become Self-Employed
- Ability vectors

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► Choose set of moments related to these parameters

[Moments](#)

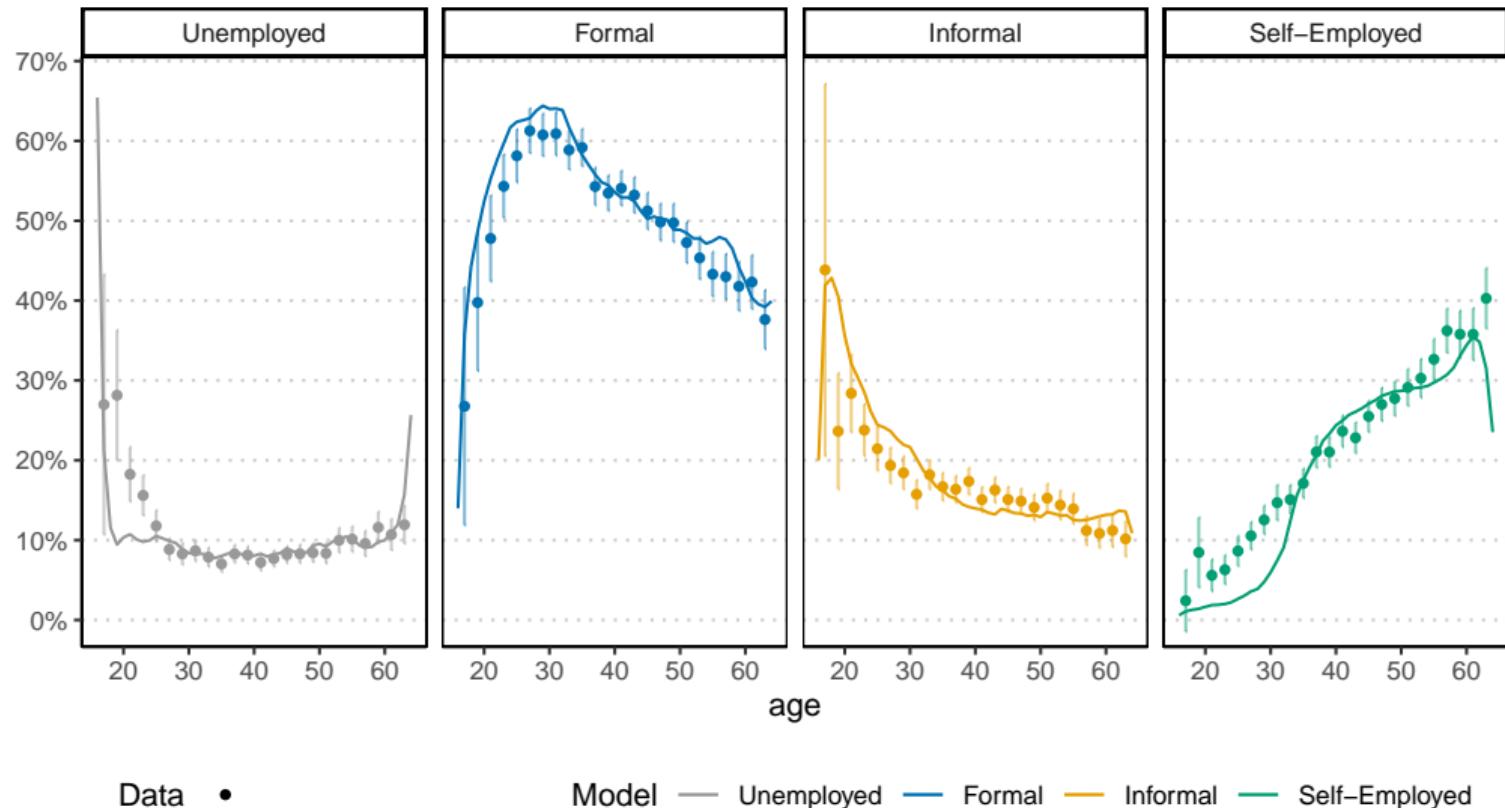
Results

Arrival and destruction rates

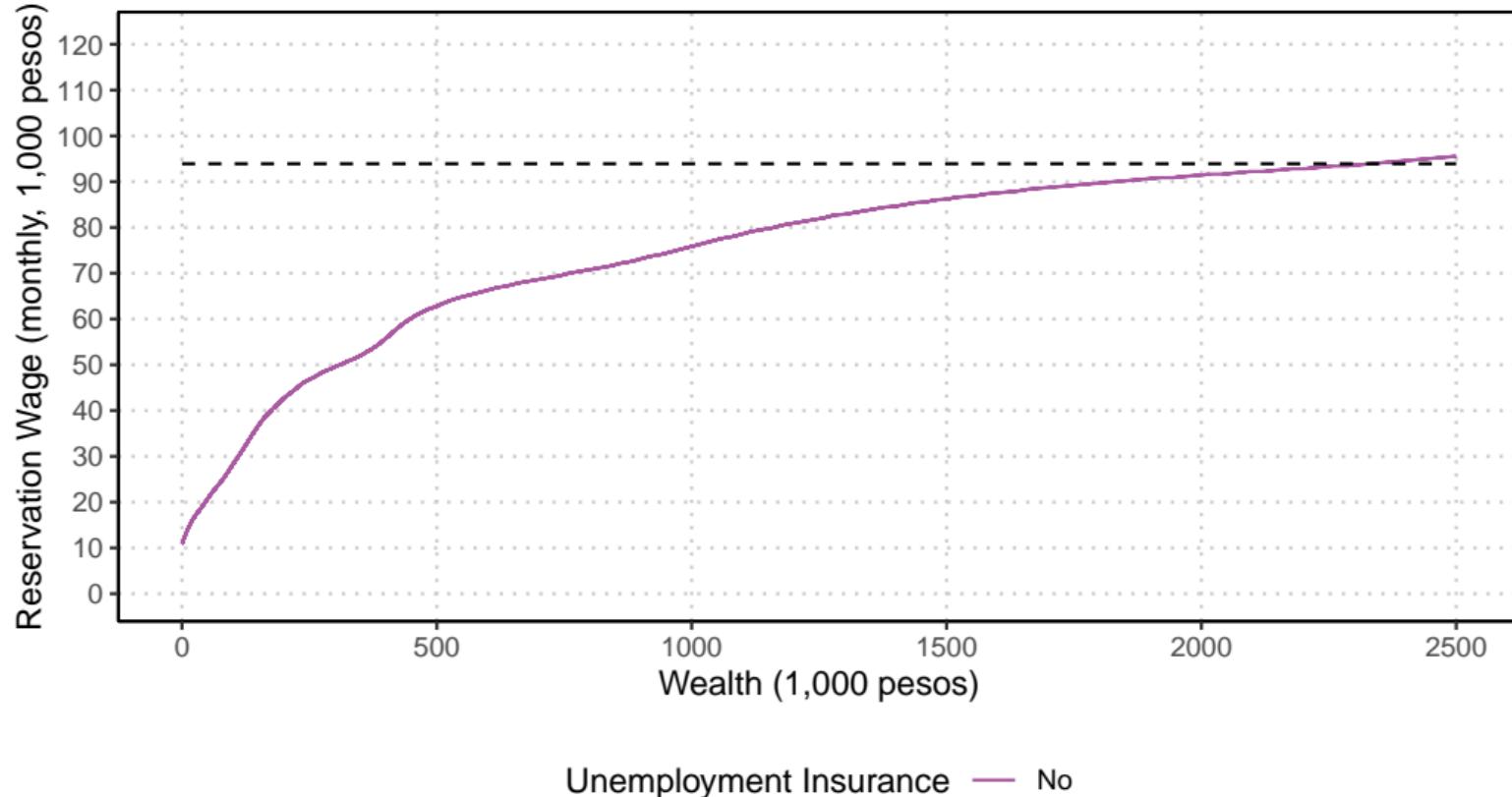
- ▶ Informal arrival rates > Formal rates

	Unemp	Formal	Informal	SelfEmp
Destruction	-	0.022	0.039	0.008
	-	-	-	(0.001)
Arrival Formal	0.116 (0.003)	0.207 (0.011)	0.031 (0.002)	0.653 (0.102)
Arrival Informal	0.213 (0.011)	0.976 (0.282)	0.117 (0.010)	0.957 (1.136)

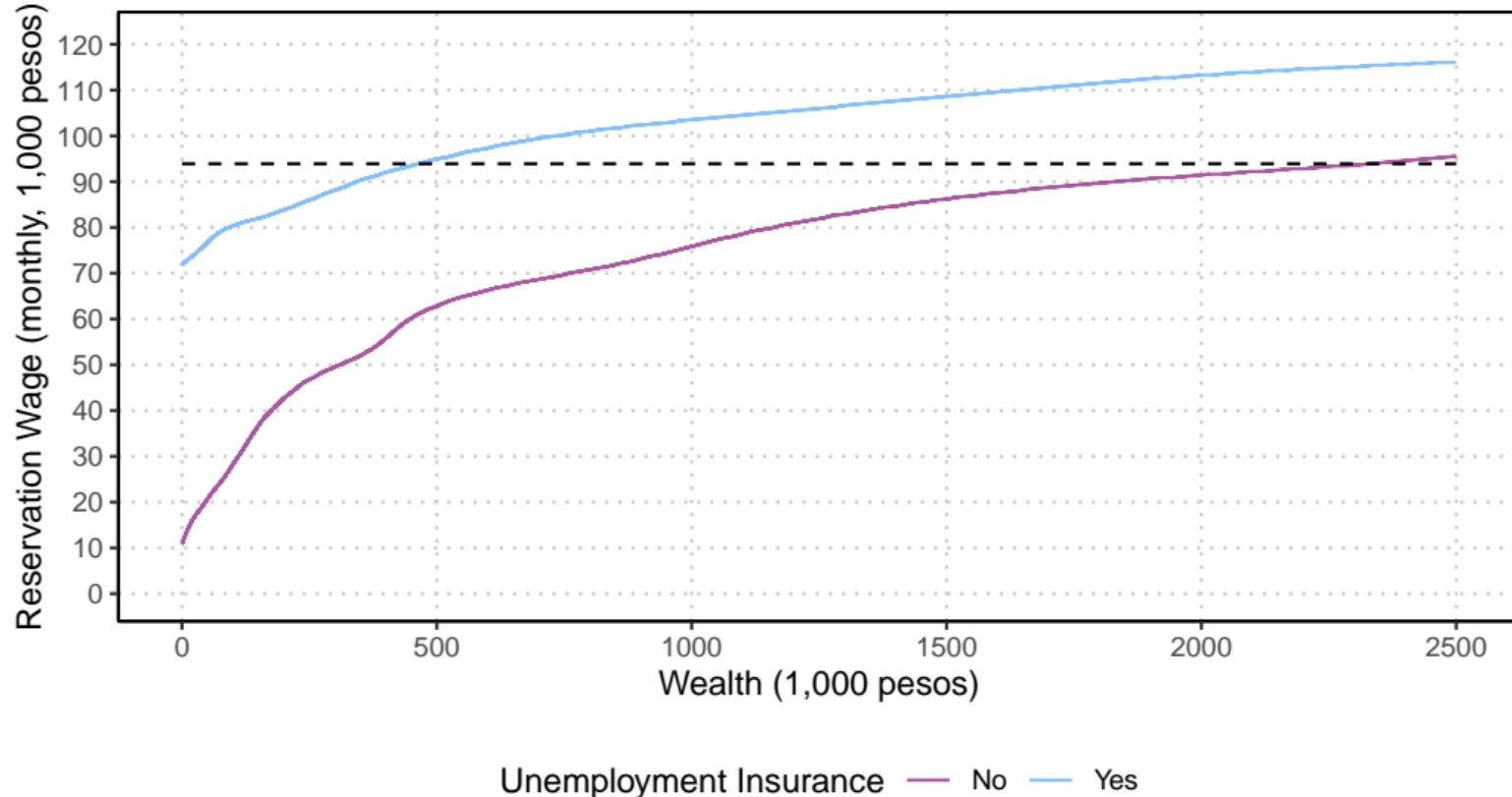
Sector allocation over the life-cycle



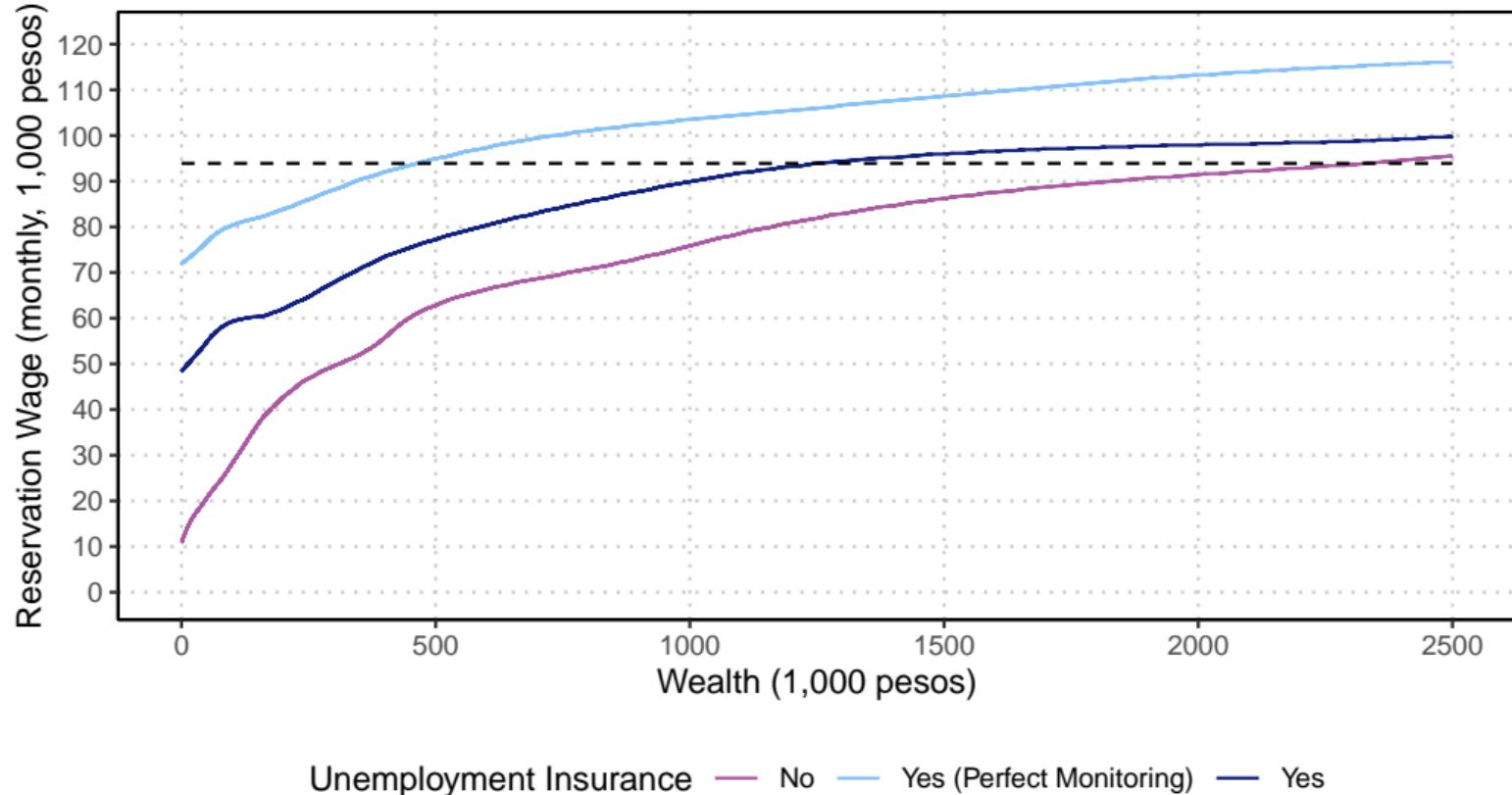
Reservation wages for the informal sector



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Willingness to pay for a formal job

- ▶ Compute their WTP to “formalize” informal jobs (all in net earnings)

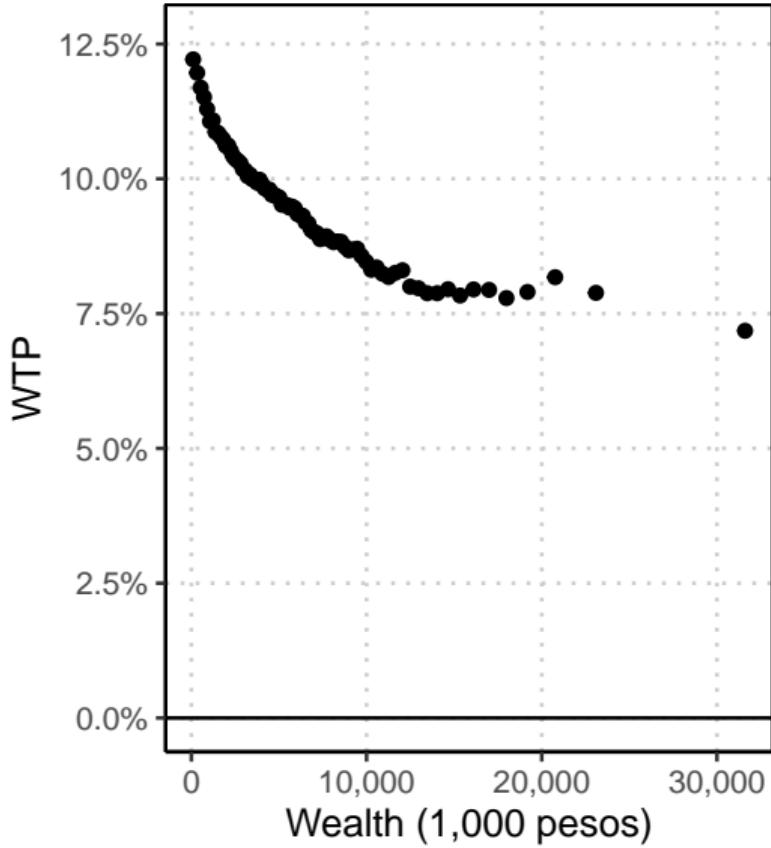
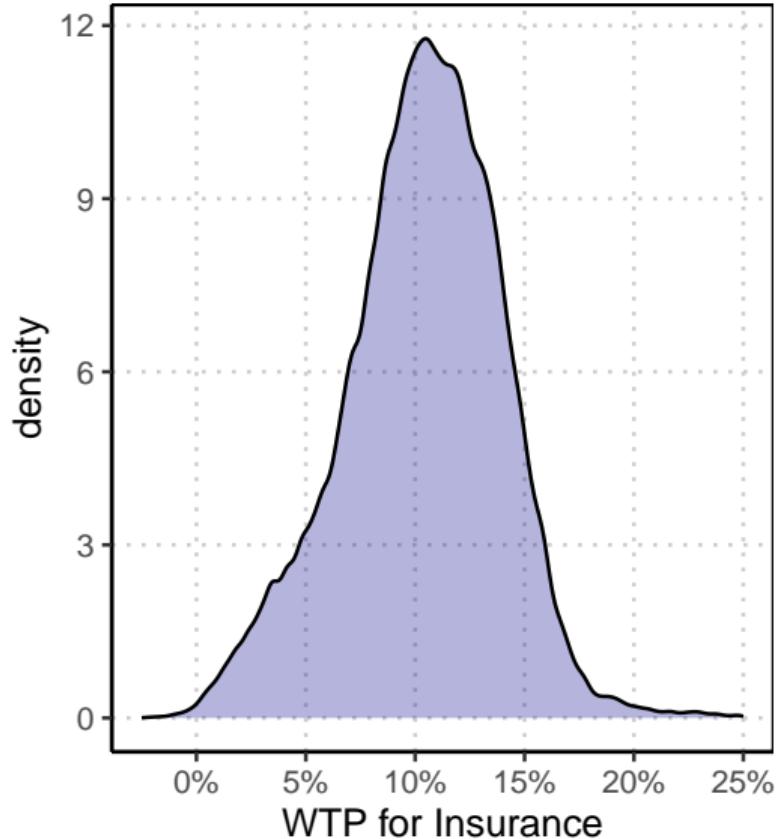
Sector	WTP	Unconstrained WTP	Job stability & Search	Insurance	Self-Emp Specific
Informal employees	18.7%	25.1%	15.6%	9.6%	-

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Informal employees	18.7%	25.1%	15.6%	9.6%	-
Self-employed	-9.9%	5.0%	-10.3%	10.7%	4.6%

Willingness to pay for a formal job



Insurance value of the Informal sector

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- ▶ What is the welfare cost of shutting access to the informal sector for one individual?

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 - Heterogeneous by wealth and age [more](#)

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 - Employment effects: \downarrow formal employment [\(more\)](#)

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 - Employment effects: \downarrow formal employment [\(more\)](#)
3. **Improving Search Frictions:** \uparrow arrival rate $U \rightarrow F$ by 25%
 - Employment effects: \uparrow formal employment [\(more\)](#)

Counterfactuals and Sectoral Insurance

Counterfactual	Δ Formal Employment	Δ Informal & Self-Emp	Δ WTP Formal	Δ Welfare Closing Informal & Self-Emp
2008 Pension Reform	0.1%	-0.1%	0.2%	0.9%
2022 Pension Reform	-10.8%	17.2%	-3.7%	4.5%
Improving Search	6.7%	-9.2%	-2.8%	-49.3%

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Conclusions

- ▶ Dynamic model with risk, savings, and insurance
 - Drivers of life-cycle labor decisions: **savings**
 - Compute the WTP to become a formal worker
 - (Insurance) value of the informal sector
 - How these values relate to formal employment in counterfactuals

Thank you

Lucas Finamor
lucas.finamor@fgv.br

Appendix

Presentation

- ▶ Introduction
- ▶ Institutional setting and data
- ▶ (Institutional setting)
- ▶ Empirical Findings
- ▶ Model
- ▶ Estimation
- ▶ Results
- ▶ Counterfactuals
- ▶ Conclusions
- ▶ Appendix
- ▶ Additional Results
- ▶ Why Chile
- ▶ Risk and Insurance in the model
- ▶ Wage growth
- ▶ Earnings variance
- ▶ Minimum Wage
- ▶ Family and Spouse
- ▶ Education and Cohorts
- ▶ Pension returns risk
- ▶ Risk Aversion and Self-Employment
- ▶ Value Functions (formulae)
- ▶ Reordering

Additional results

- ▶ All parameters
- ▶ Transitions
- ▶ Accepted wages
- ▶ Average wages
- ▶ Ability types
- ▶ Self-Employment earnings
- ▶ Wealth
- ▶ Retirement
- ▶ Part-time work
- ▶ Wage correlation
- ▶ Amenities
- ▶ Decision to be self-employed
- ▶ Value Functions
- ▶ No amenities
- ▶ (Andrews, Gentzkow and Shapiro 2017)
Sensitivity analysis
- ▶ Untargeted moments pension wealth and contributions

Setting: Chile

1. Social insurance programs co-existing with labor market informality

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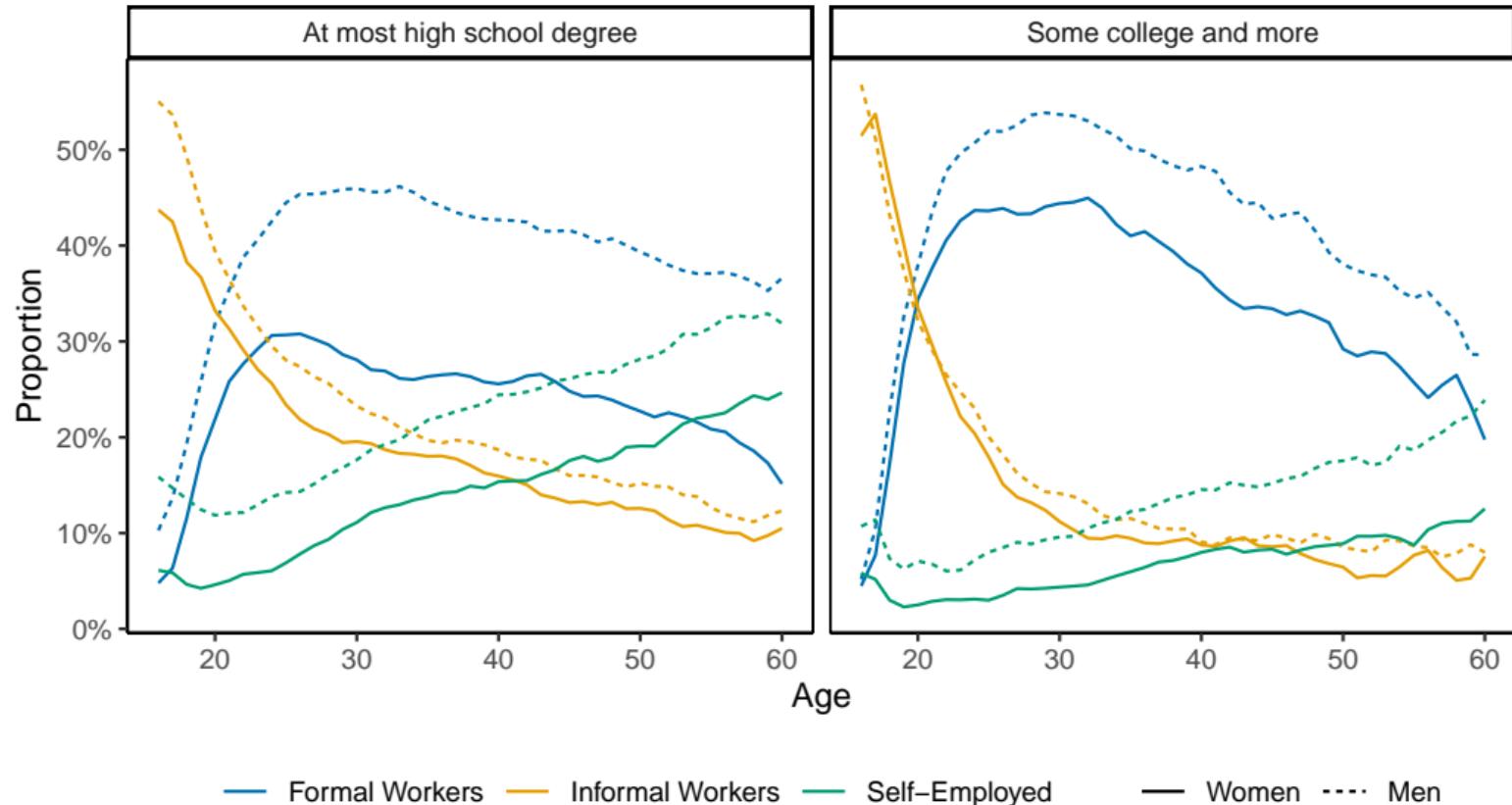
1. Social insurance programs co-existing with labor market informality
2. Country implemented several reforms in those programs
3. Data
 - Long longitudinal survey
 - Disaggregated wealth
 - Administrative data on the pension system

Risk and Social Insurance in the paper

	In the model	Not in the model
Risk		
Separation shocks	All sectors	-
Earnings shocks (within job)	Self-employment	Formal and informal jobs
Uncertain prospects job-search	All sectors	-
Longevity risk	✓	-
Returns risk	-	Pension returns, liquid savings returns
Health risk	-	Health shocks
Social Insurance		
Unemployment insurance	When fired	When quitting
Severance payment	Yes	-
Pensions	Yes	-
Welfare programs	Yes	-
Minimum wage	Yes	-
Health insurance	-	No
Disability insurance	-	No

Earnings variance

- ▶ Using the employment survey, I compute the (de-trended) 1-year log-wage growth
- ▶ Compute the variance for those formal, informal, and self-employed (and remaining in that state)
- ▶ Variance of log-wage increase
 - Formal: 0.100
 - Informal: 0.286
 - Self-employed: 0.631



Life Cycle - Cohorts

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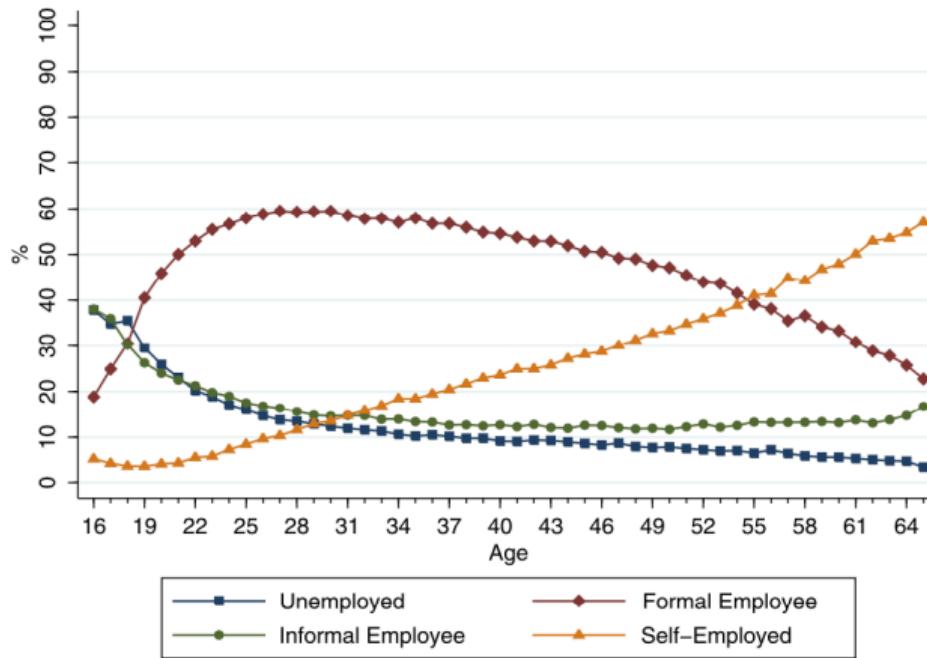
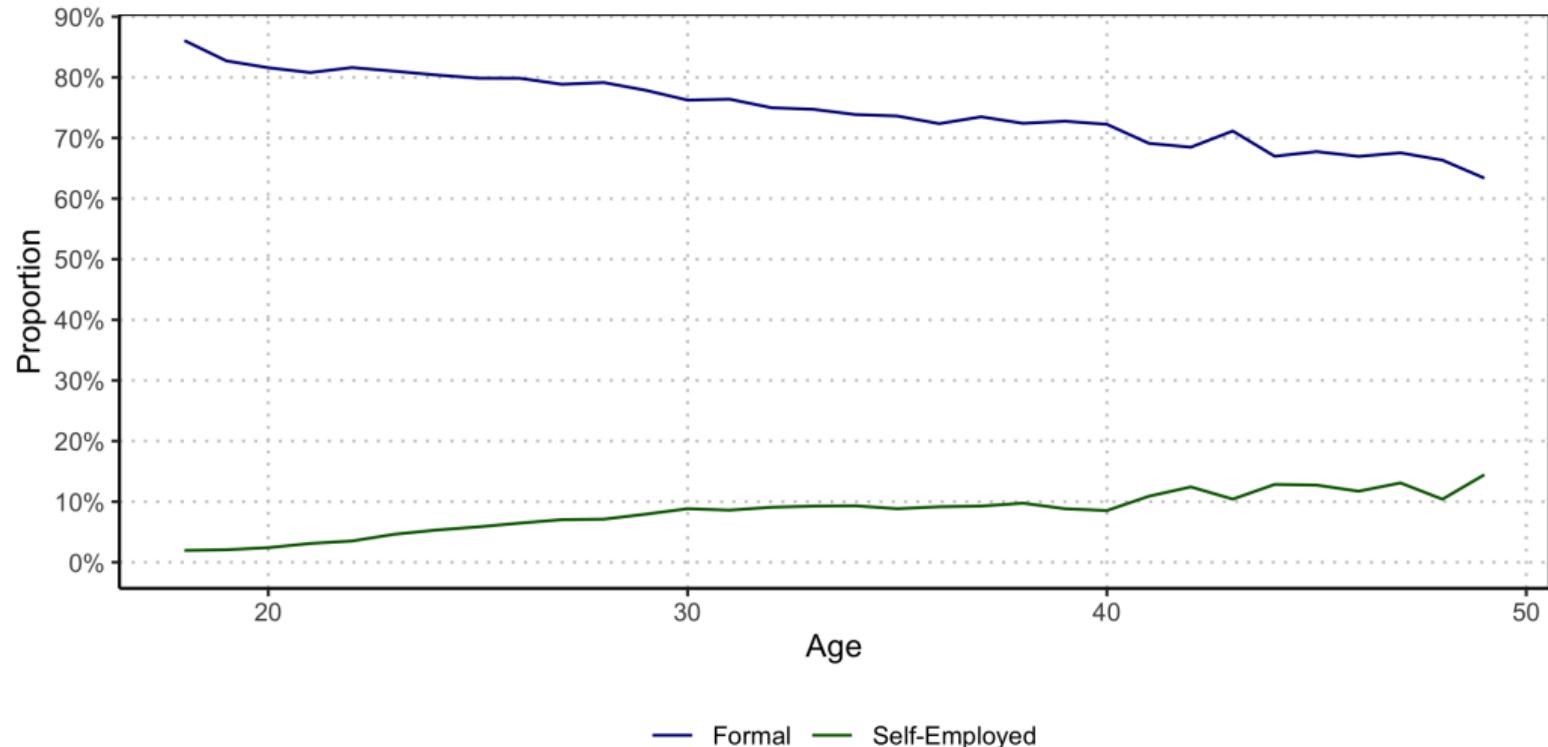


Fig. 1. Composition of workforce by age.

Extracted from Narita (2020)

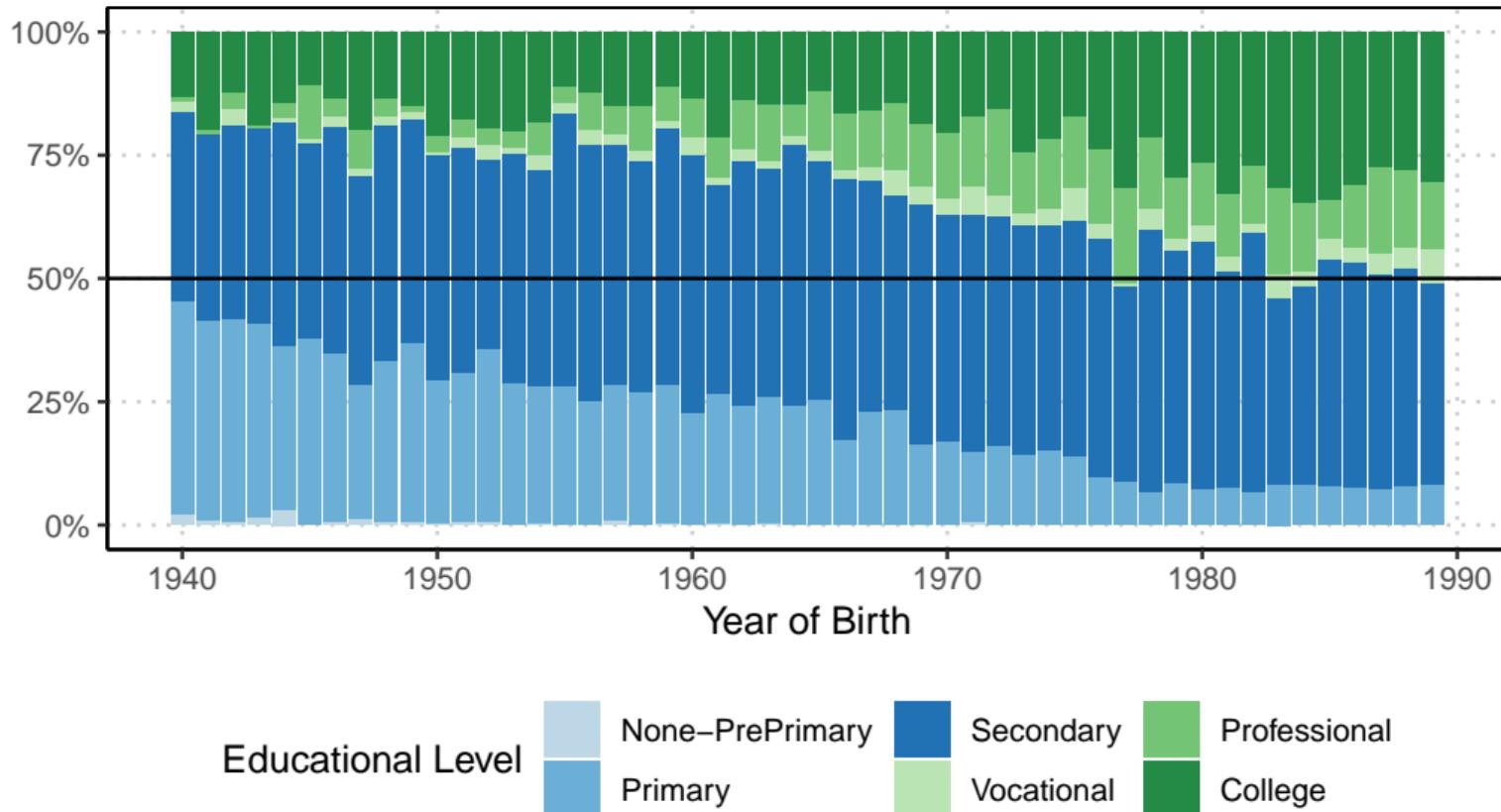
USA



NOTES: NLSY-79. Displayed as % of employed population.

Education over time

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1. **Unemployment Insurance**

[more](#)[payments](#)

- 3% of wages:
$$\underbrace{(\text{individual account})}_{\text{forced savings}} + \underbrace{(\text{collective account})}_{\text{insurance/redistribution}}$$
- Withdrawal schedule (50%,45%,40%,...)
- Limit of 5 months from the collective account

2. **Severance Payment**

- One monthly wage for every year on the job

3. **Pension system**

- Individual capitalization with privately managed accounts
- 10% of wages
- Normal retirement age for men is 65
- Early retirement is possible
- Minimum pension policies

4. **Welfare Programs** and **Income Tax**

1. **Unemployment Insurance**

[more](#)[payments](#)

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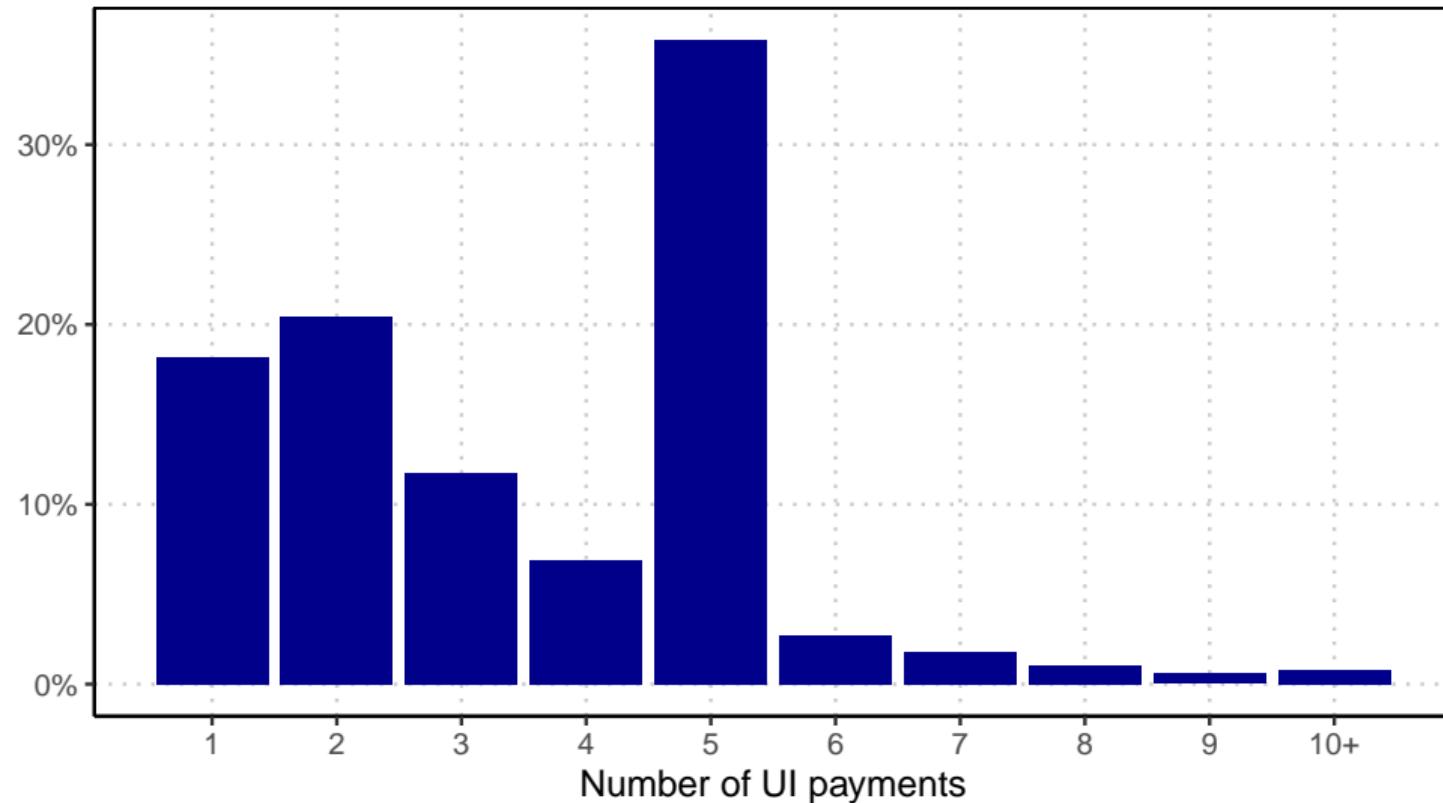
Social Security

<u>Formal Workers Pay:</u>					<u>Formal Firms Pay:</u>		
7%	0.6%	10%		≈2%	2.4%		
Health System	+	Unemp Insurance	+	Pension Contributions	+	Commissions & Disab. Insurance	Unemp Insurance

- ▶ Using data from a 20% sample of the UI system
- ▶ Among those involuntarily separated in my sample:
 - 72.7% were eligible to use the common funds
 - 43.9% used it

UI number of payments

[Back](#)



- ▶ Men born between 1941–1989, with at most high school degree
- ▶ Discard individuals who did not switch to the new pension system in 1980
- ▶ Monetary values are in 2004 values (de-trended). 1,000 Chilean pesos \approx 1.50 USD
Use the information that was reported within 18 months
- ▶ Restricted monetary values from (2002-2008). Labor market information from (2002-2015)
- ▶ Recent data for retirement patterns (up to 2019) and older cohorts to get wealth accumulation at old ages (up to 89 years)

Table: Proportion among self-employed

Variable	Value
Formal Accounting	22.0%
Separate Accounting (from HH)	32.4%
Registered in the Tax Authority	32.7%
Only 1 worker	91.7%
Contributing to Pension	15.7%

Note: EME 2009/2011 and EPS 2002-2016

- ▶ Normal retirement age: 65
- ▶ **Early Retirement** allowed if resulting pension (y_p) meets the two requirements

$$y_p > \alpha \times \text{Avg Wage} \quad \text{and} \quad y_p > A$$

\uparrow
fraction \uparrow
threshold

- ▶ Normal retirement age: 65
- ▶ **Early Retirement** allowed if resulting pension (y_p) meets the two requirements

$$y_p > \alpha \times \text{Avg Wage}$$

\uparrow
fraction

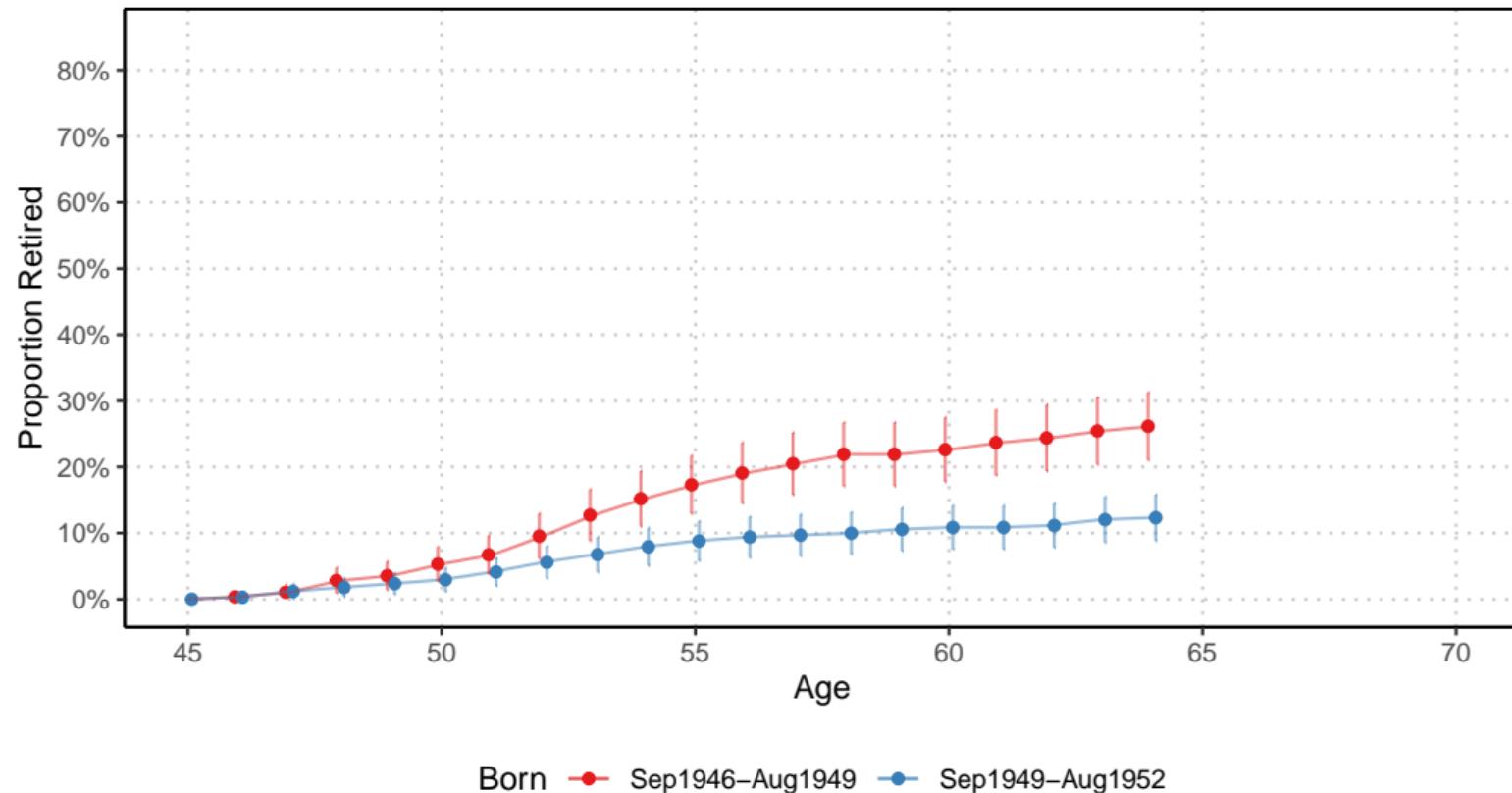
and

$$y_p > A$$

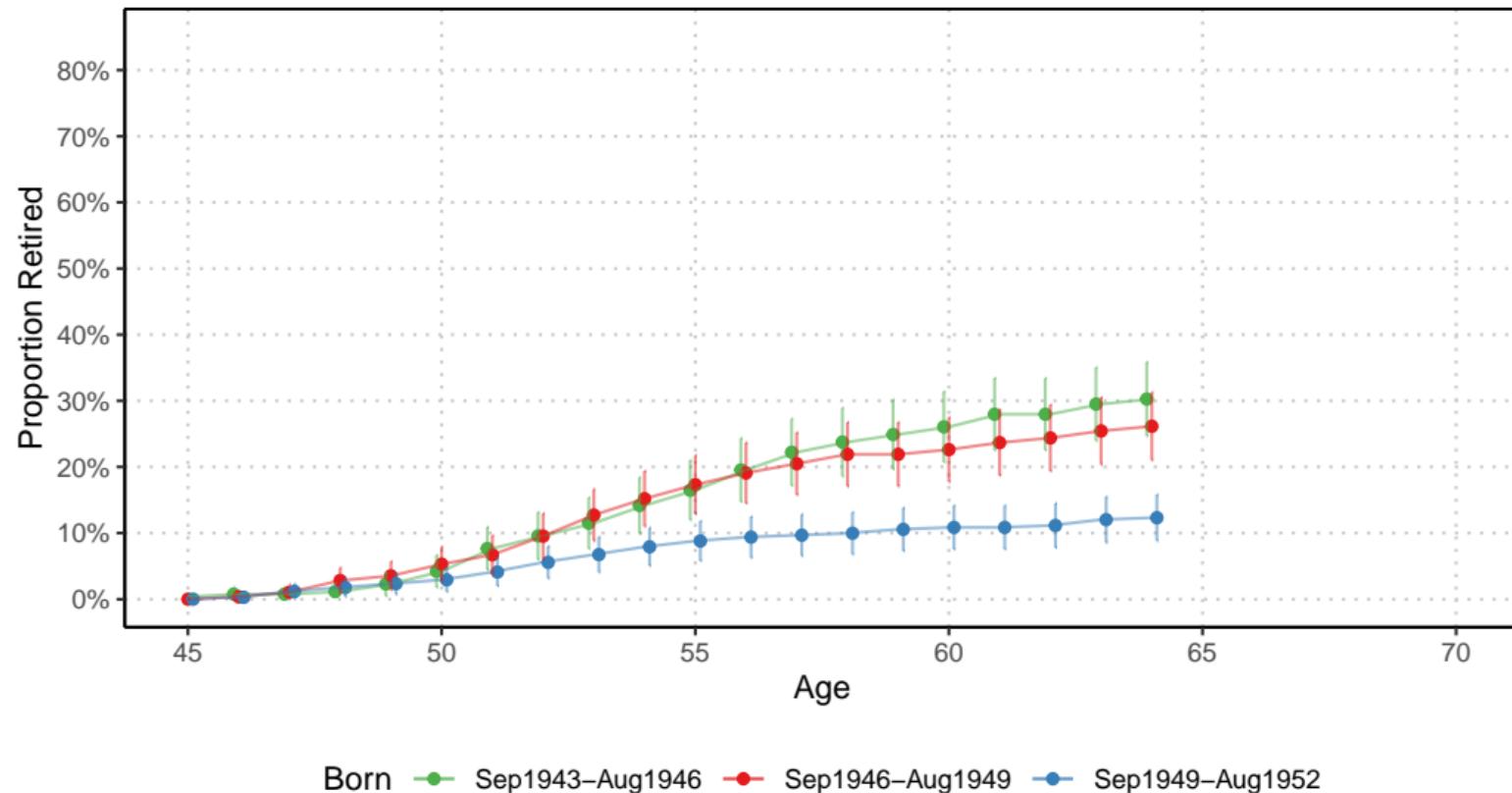
\uparrow
threshold

- ▶ 2004 Reform:
 - Raised α and A (gradually)
 - Individuals born before August 1949 were exempted

2004 Reform - Delayed Retirement

[Regression](#)[Age 55](#)[back](#)

2004 Reform - Delayed Retirement

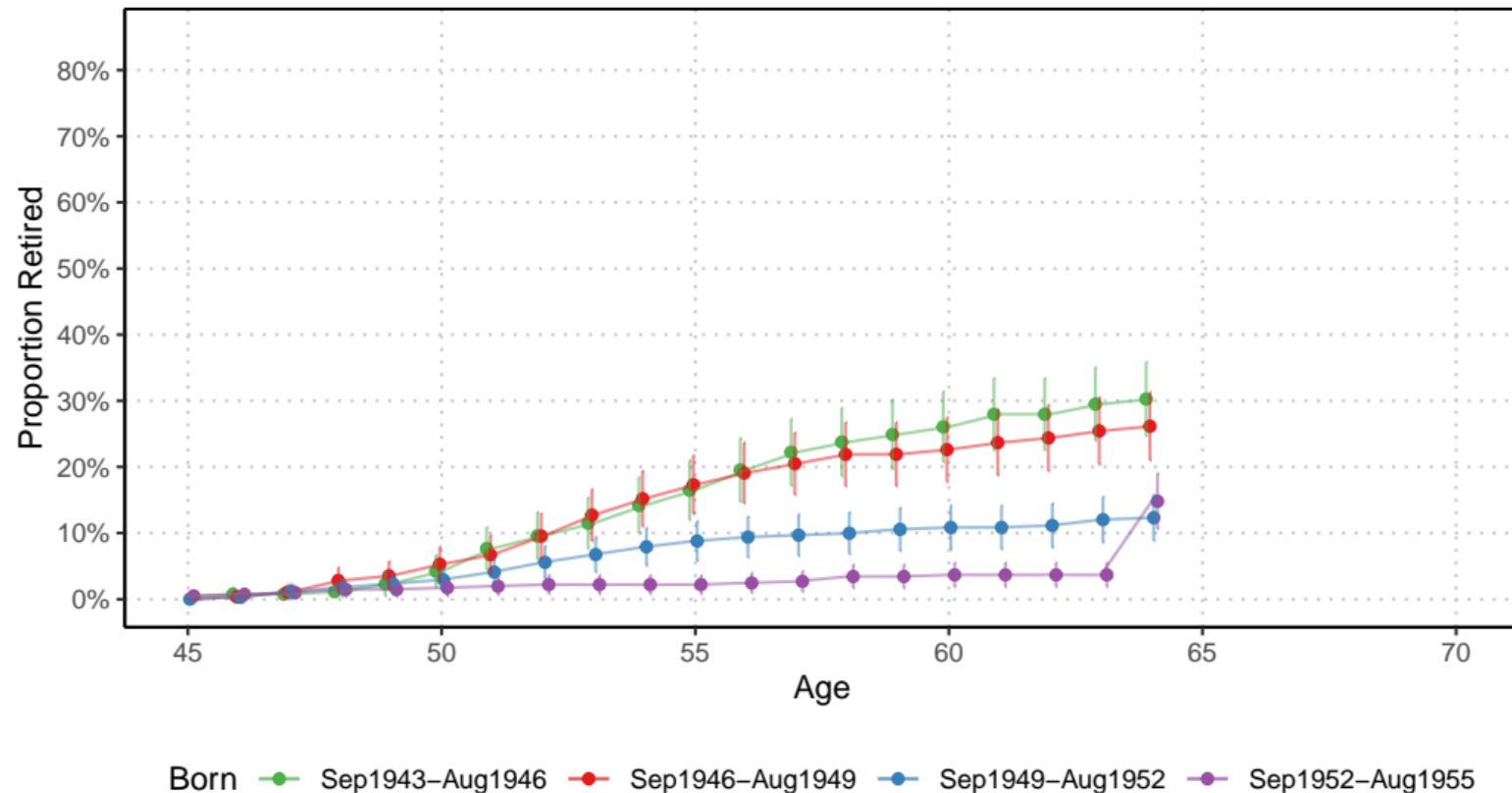
[Regression](#)[Age 55](#)[back](#)

2004 Reform - Delayed Retirement

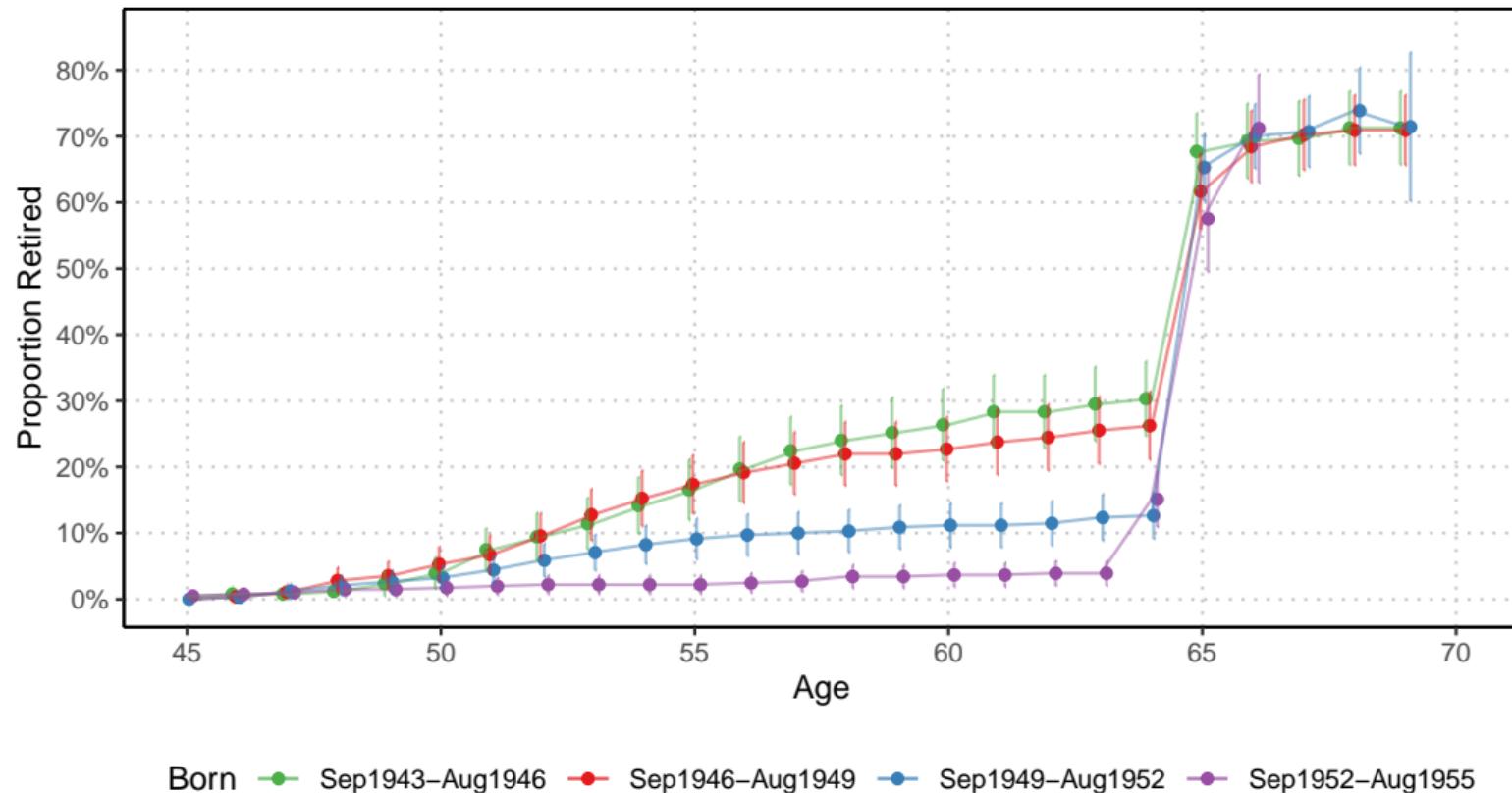
Regression

Age 55

back

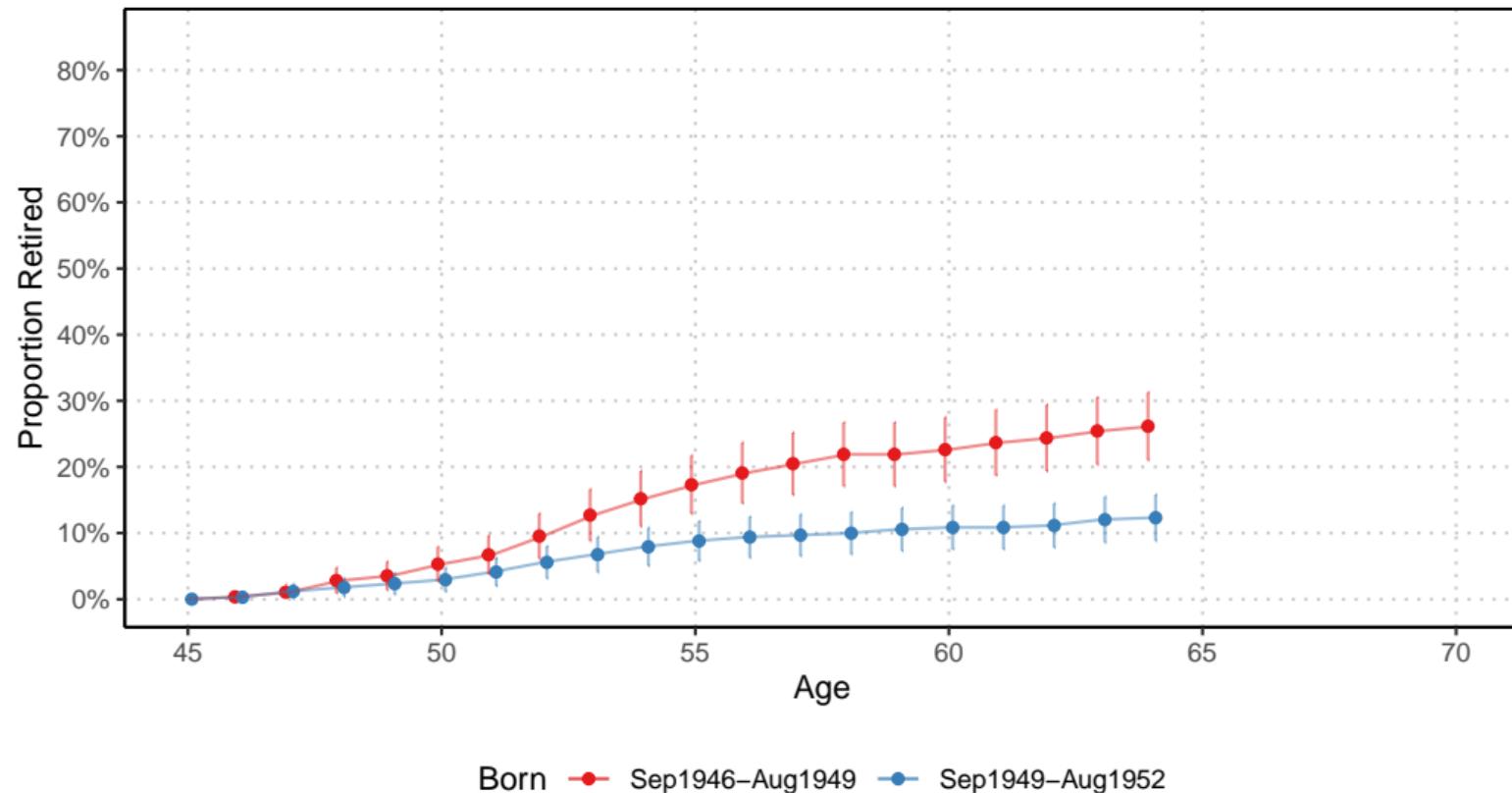


2004 Reform - Delayed Retirement

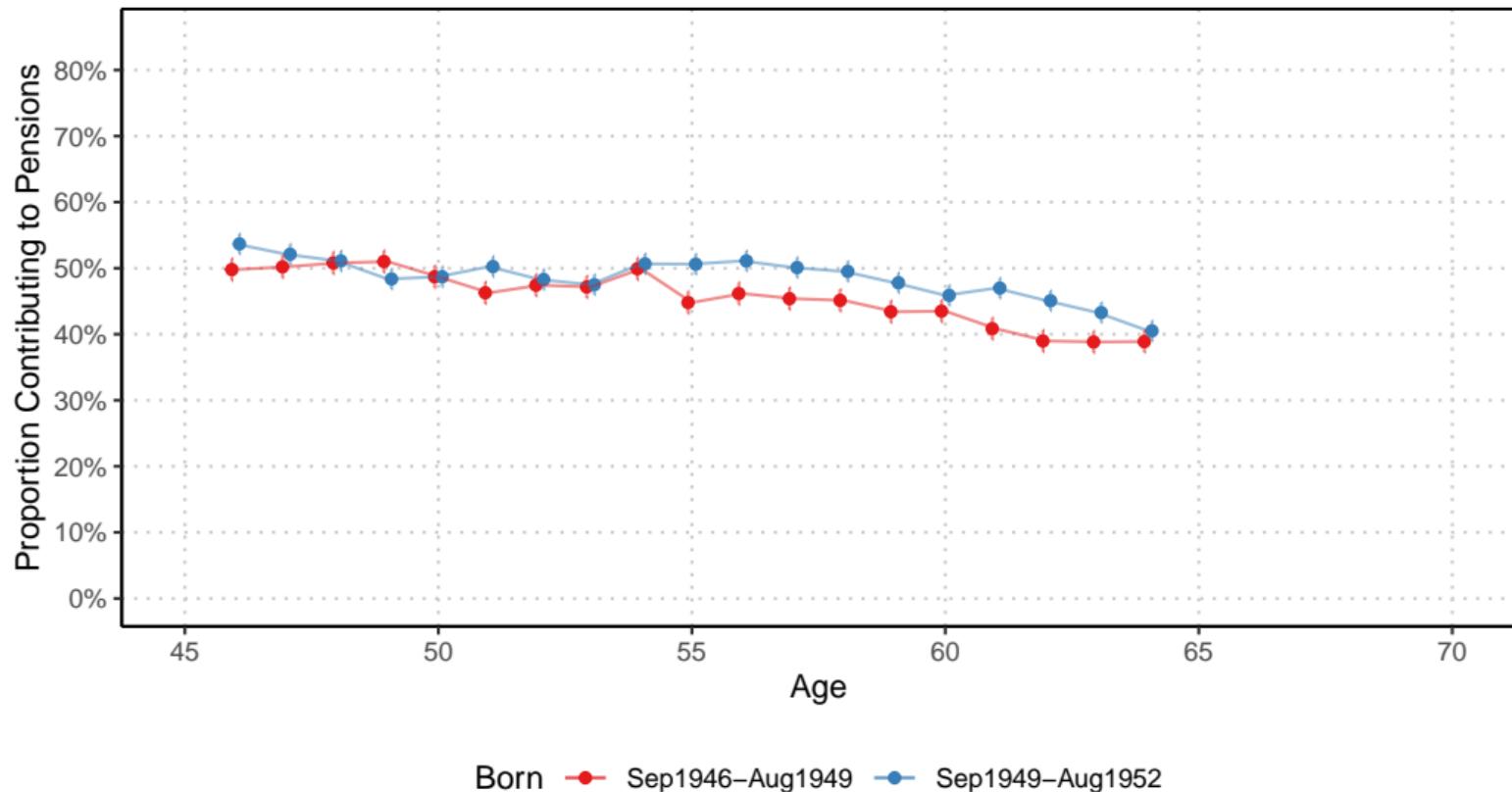
[Regression](#)[Age 55](#)[back](#)

Born ● Sep1943–Aug1946 ● Sep1946–Aug1949 ● Sep1949–Aug1952 ● Sep1952–Aug1955

2004 Reform - Delayed Retirement

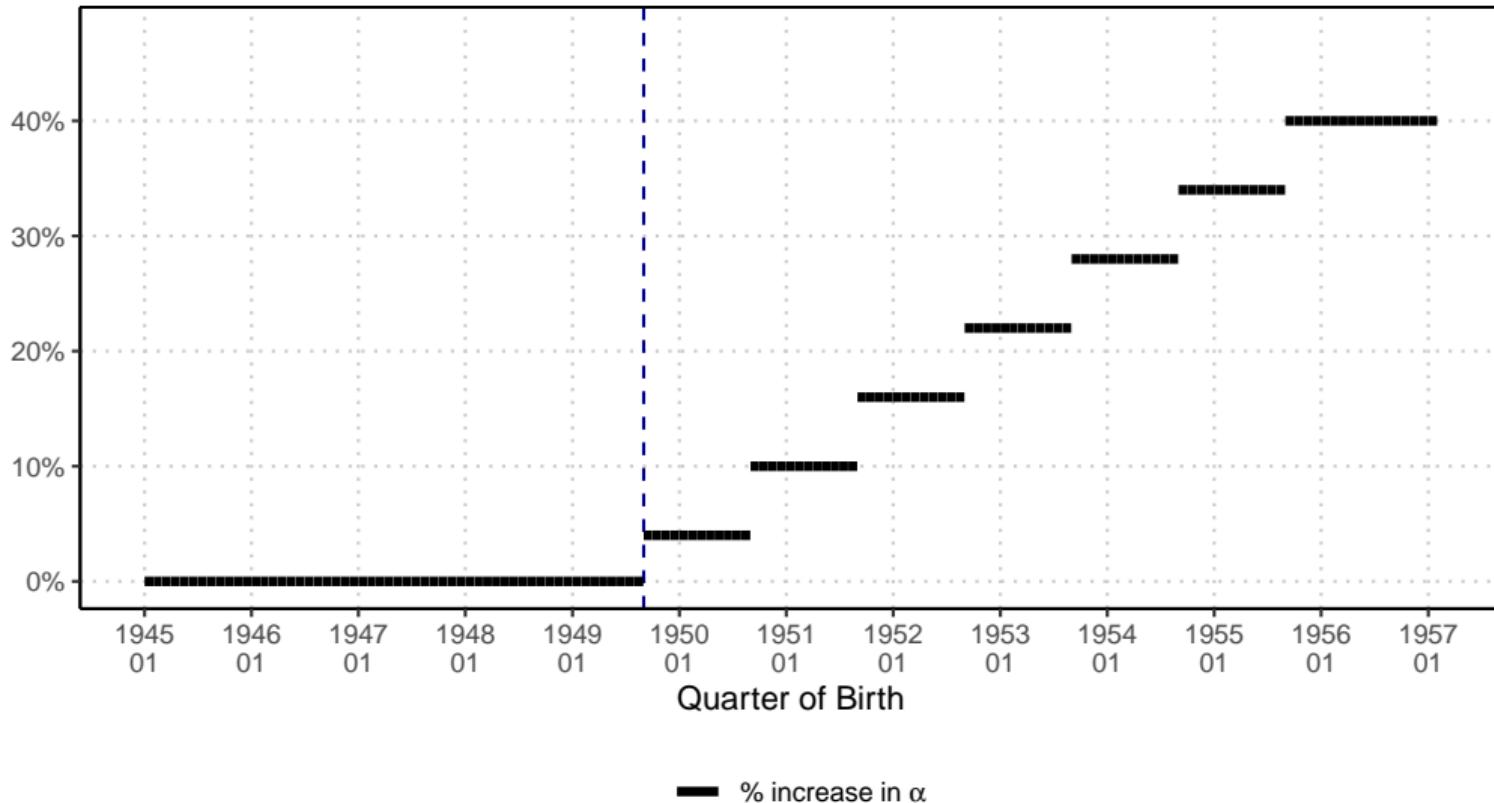
[Regression](#)[Age 55](#)[back](#)

2004 Reform - Delayed Retirement

[Regression](#)[Age 55](#)[back](#)

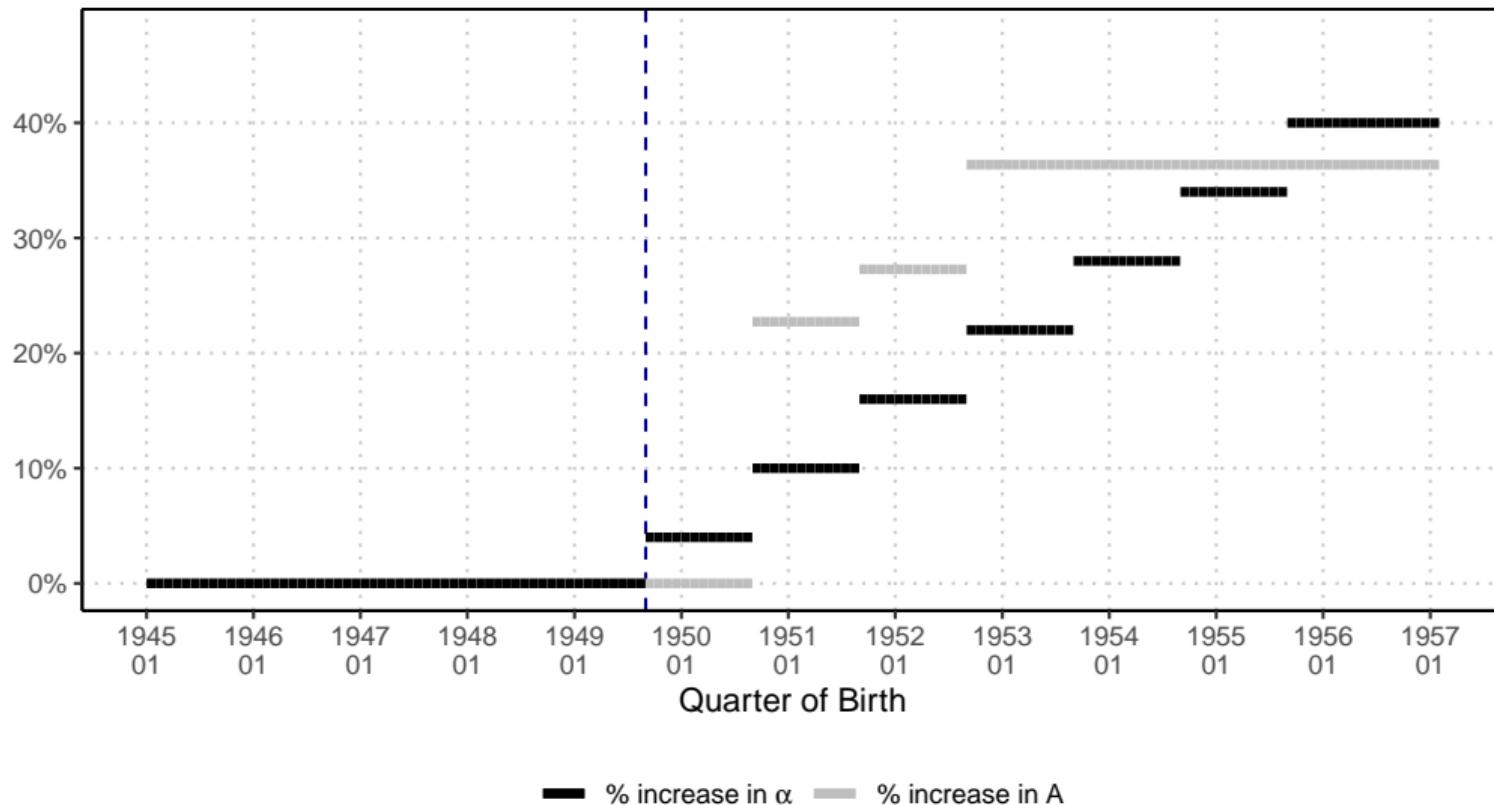
2004 Reform – Retirement at age 55

[Back](#)



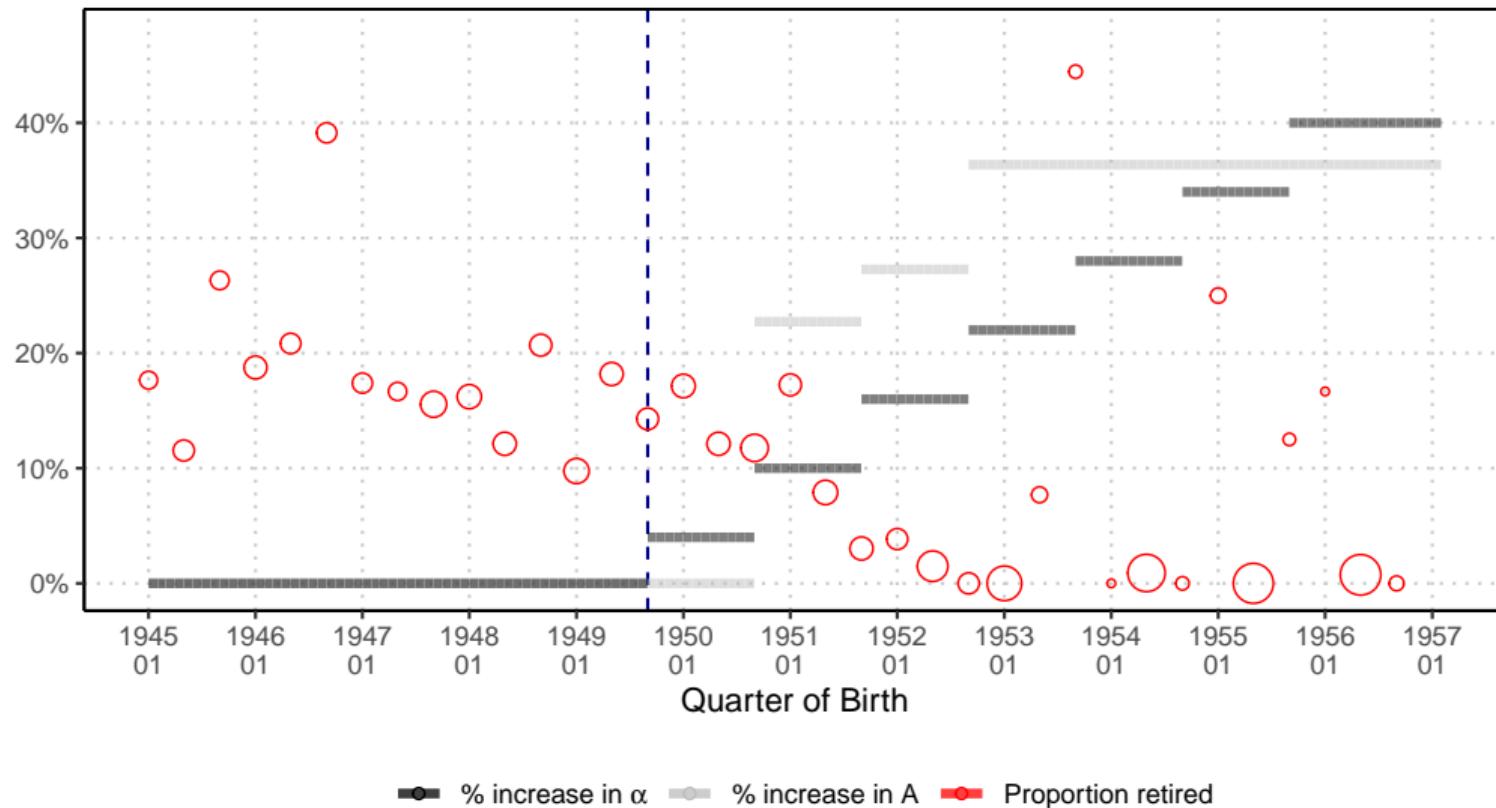
2004 Reform – Retirement at age 55

[Back](#)



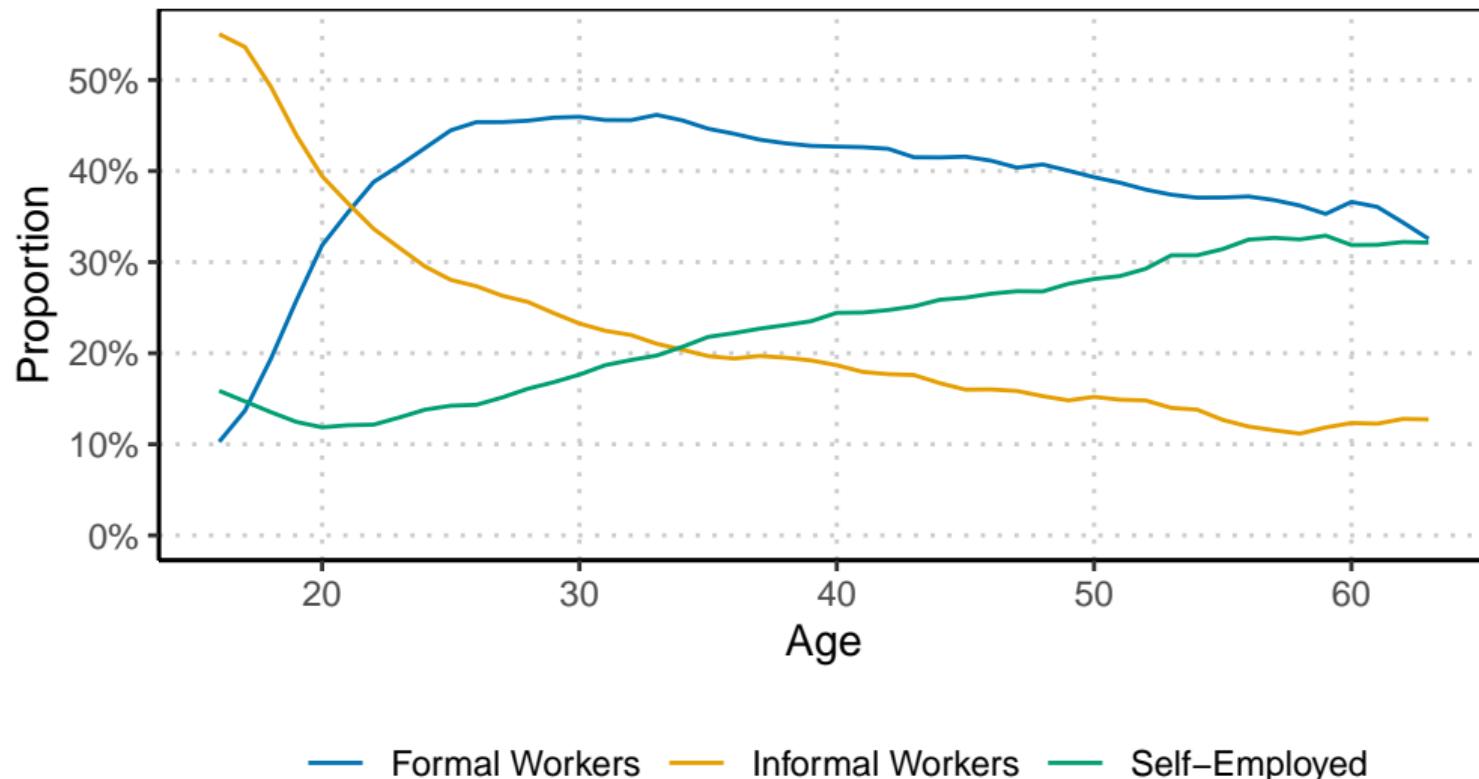
2004 Reform – Retirement at age 55

[Back](#)



Empirical Findings II: Sector heterogeneity

[back](#)



► Working part-time [more](#)

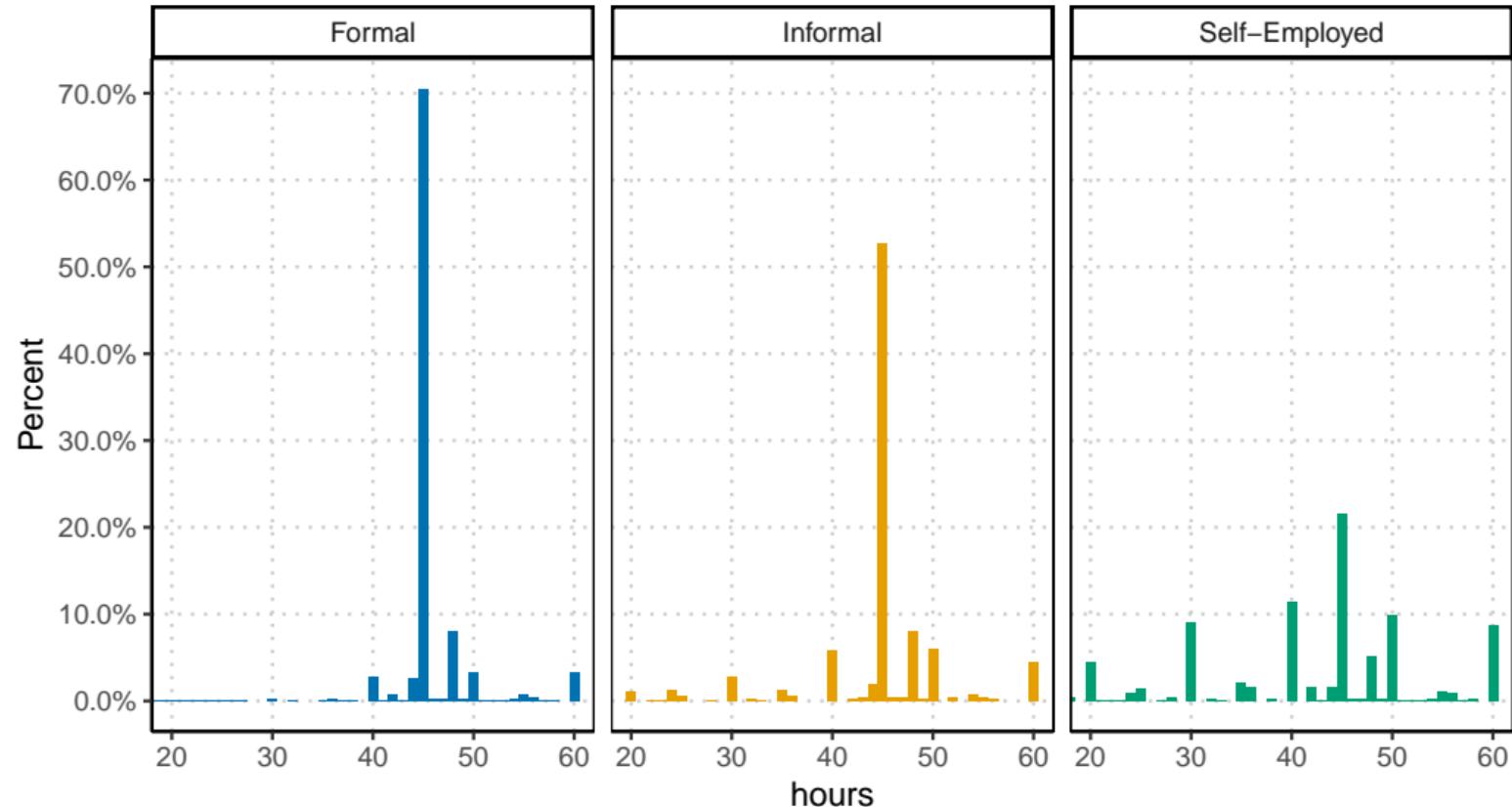
- Self-employed: 24%
- Informal employees: 8%
- Formal employees: 2%

► Working at the firm site [more](#)

- Self-employed: 14%
- Informal employees: 56%
- Formal employees: 70%

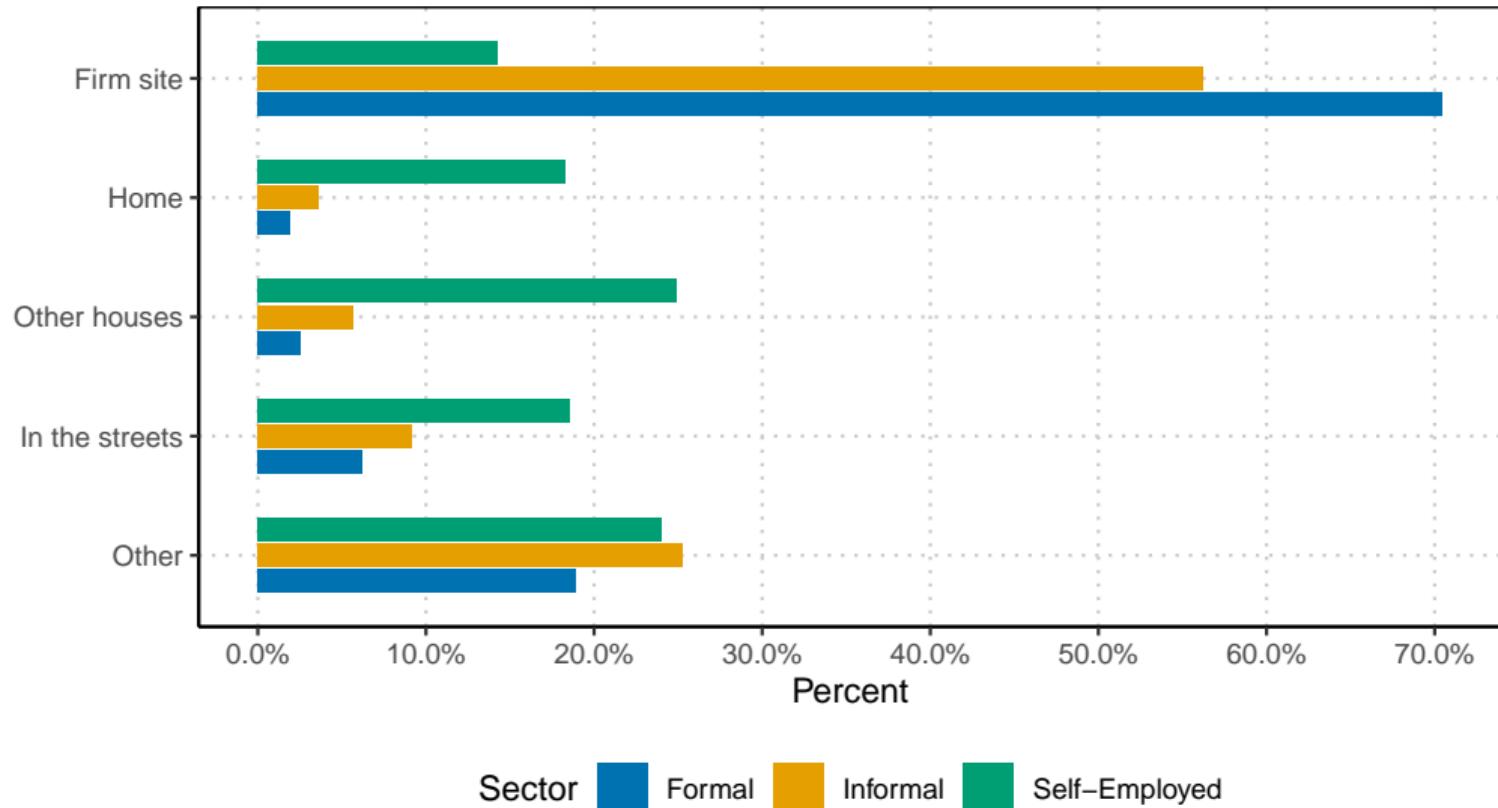
Hours distribution by sector

Back



Work place by sector

[Back](#)



2004 Reform – Delayed Retirement

Back

Outcome:	Retired (1)	Contributing (2)
(Intercept)	0.246 (0.031)	0.382 (0.027)
T1 (Sep1949–Aug1950)	-0.062 (0.052)	0.018 (0.050)
T2 (Sep1950–Aug1952)	-0.155 (0.037)	0.064 (0.046)
Age Range	63	63
Age fixed-effects	-	-
Observations	7,584	7,584

2004 Reform – Delayed Retirement

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Outcome:	Retired (1)	Contributing (2)	Retired (3)	Contributing (4)
(Intercept)	0.246 (0.031)	0.382 (0.027)		
T1 (Sep1949–Aug1950)	-0.062 (0.052)	0.018 (0.050)	-0.040 (0.038)	0.028 (0.048)
T2 (Sep1950–Aug1952)	-0.155 (0.037)	0.064 (0.046)	-0.105 (0.032)	0.044 (0.037)
Age Range	63	63	[50–63]	[50–63]
Age fixed-effects	-	-	Yes	Yes
Observations	7,584	7,584	56,105	56,105

2004 Reform – Delayed Retirement

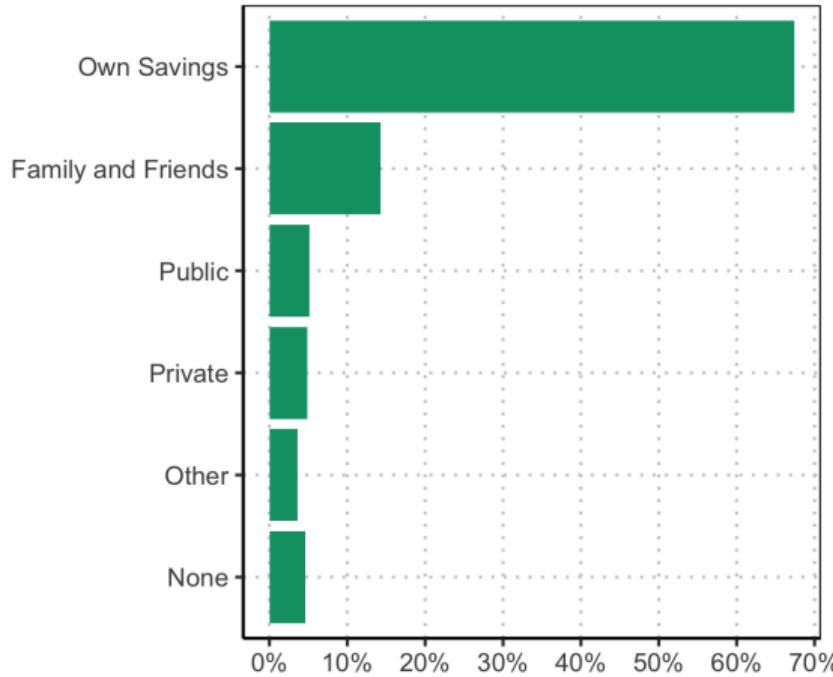
[Back](#)

Outcome:	Retired (1)	Contributing (2)	Retired (3)	Contributing (4)	Formal (5)	Informal (6)	Self-Employed (7)
(Intercept)	0.246 (0.031)	0.382 (0.027)					
T1 (Sep1949–Aug1950)	-0.062 (0.052)	0.018 (0.050)	-0.040 (0.038)	0.028 (0.048)	0.005 (0.042)	-0.007 (0.019)	-0.003 (0.032)
T2 (Sep1950–Aug1952)	-0.155 (0.037)	0.064 (0.046)	-0.105 (0.032)	0.044 (0.037)	0.052 (0.039)	0.003 (0.016)	0.045 (0.030)
Age Range	63	63	[50–63]	[50–63]	[50–63]	[50–63]	[50–63]
Age fixed-effects	-	-	Yes	Yes	Yes	Yes	Yes
Observations	7,584	7,584	56,105	56,105	56,105	56,105	56,105

Empirical Findings III: Physical capital for self-employment

Back

What was the main source of funding to start self-employment activity?



- ▶ Use panel dimension to investigate wealth held as physical capital
- ▶ 4 groups based on the self-employment status in t and $t + 1$

Empirical Findings III: Physical capital for self-employment

[back](#)

- ▶ Use panel dimension to investigate wealth held as physical capital
- ▶ 4 groups based on the self-employment status in t and $t + 1$
- ▶ $Y_i = \beta_g G_i \times Post_t + G_i$
- ▶ [CDF](#) [survey](#)

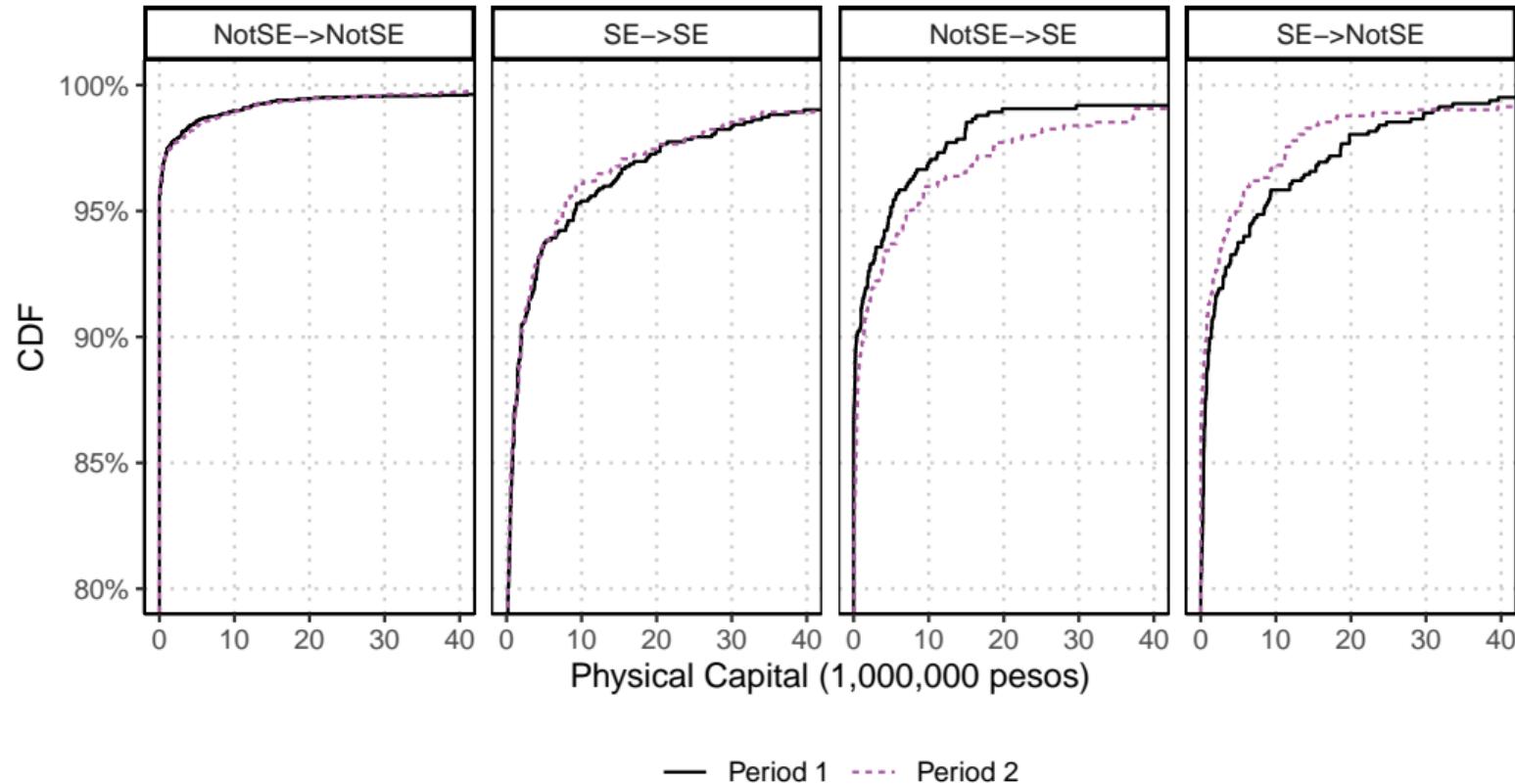
Outcome variable: Indicator for physical capital > 0

Group	Coeff
Group 00 (NotSE→NotSE)	-0.0002 (0.0017)
Group 11 (SE→SE)	0.0021 (0.0100)
Group 01 (NotSE→SE)	0.0335*** (0.0117)
Group 10 (SE→NotSE)	-0.0451*** (0.0121)

N Obs 27,926

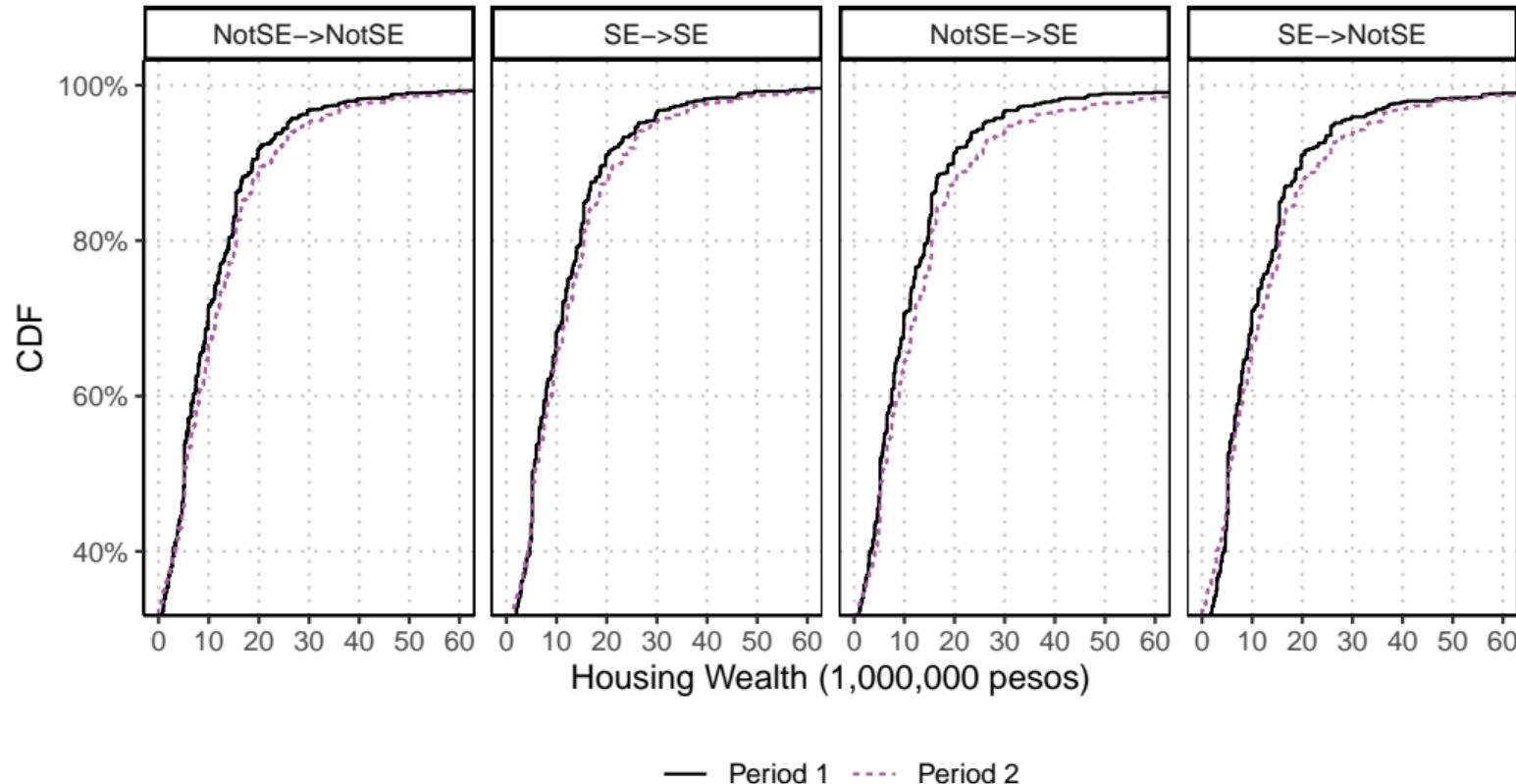
Self-Employment and start-up costs

Back



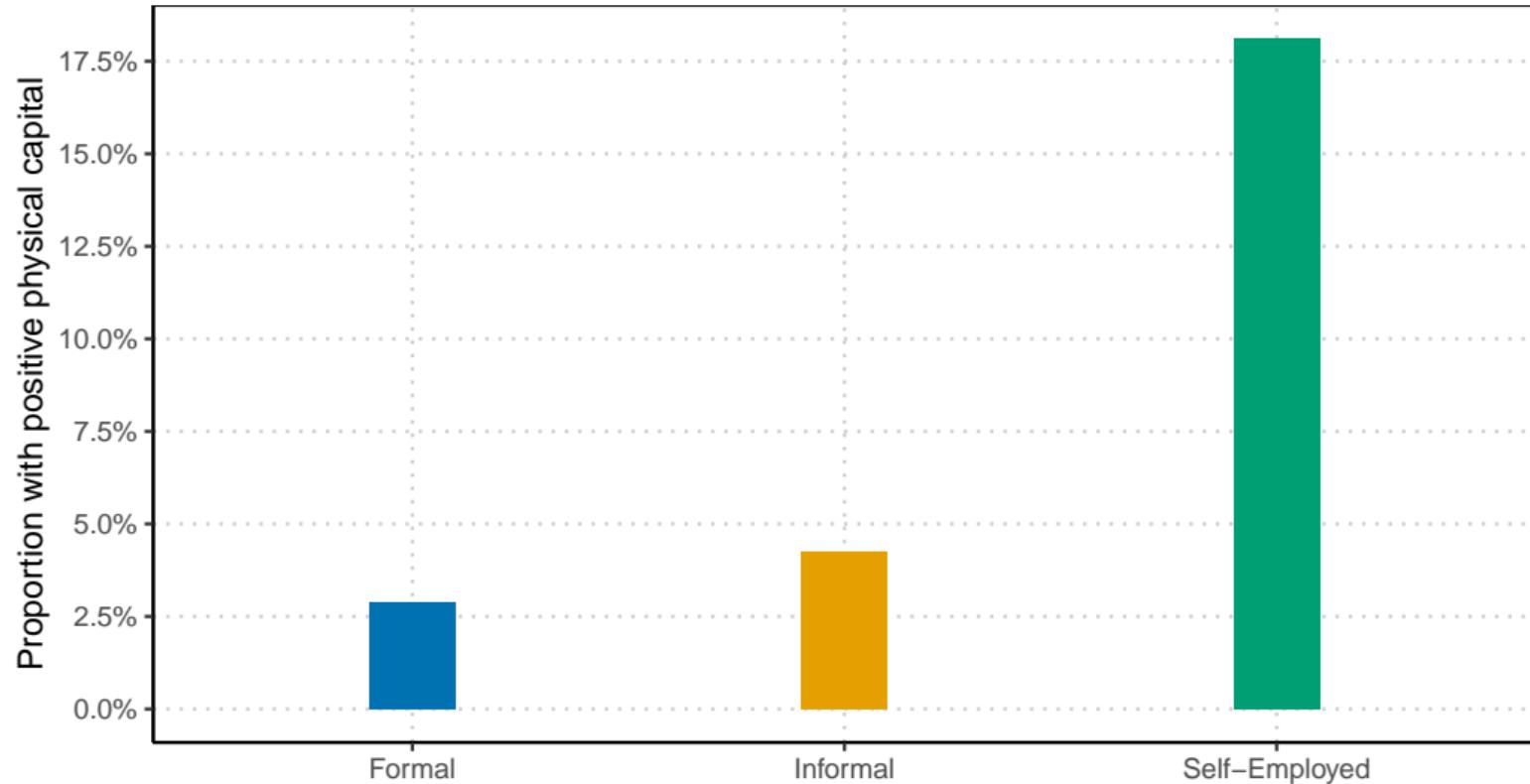
Self-Employment and start-up costs

[Back](#)



Physical capital

Back



$$\tilde{V}_{a+1}^F := \max \left\{ \overbrace{V_{a+1}(b', p', \tilde{k}, F, w),}^{\text{stay}} \right.$$

$$\tilde{V}_{a+1}^F := \max \left\{ \overbrace{V_{a+1}(b', p', \tilde{k}, F, w)}^{\text{stay}}, \overbrace{V_{a+1}(b', p', \tilde{k}, U, 0)}^{\text{quit}}, \right.$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w)}_{\text{stay}}, \underbrace{V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{quit}}, \right. \\ \left. \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w})}_{\text{move SE}} \right\},$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w)}_{\text{stay}}, \underbrace{V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{quit}}, \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w})}_{\text{move SE}}, \underbrace{V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q)}_{\text{retire}} \right\}$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w)}_{\text{stay}}, \underbrace{V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{quit}}, \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w})}_{\text{move SE}}, \underbrace{V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q)}_{\text{retire}} \right\}$$

$$\mathbb{E}_F[V_{a+1}(b', p', k', j', w')] =$$

$$\delta_F$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w), V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{stay}}, \underbrace{V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{quit}}, \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w})}_{\text{move SE}}, \underbrace{V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q)}_{\text{retire}} \right\}$$

$$\mathbb{E}_F[V_{a+1}(b', p', k', j', w')] =$$

$$\delta_F \max \left\{ V_{a+1}(b', p', \tilde{k} + SP(w), U, 0), \right.$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w), V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{stay}}, \underbrace{V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{quit}}, \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w})}_{\text{move SE}}, \underbrace{V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q)}_{\text{retire}} \right\}$$

$$\mathbb{E}_F[V_{a+1}(b', p', k', j', w')] =$$

$$\delta_F \max \left\{ V_{a+1}(b', p', \tilde{k} + SP(w), U, 0), \int V_{a+1}(b', p', \tilde{k} + SP(w) - X, S, \tilde{w}) dW^S(\tilde{w}), \right.$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w), V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{stay}}, \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w}), V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q)}_{\text{move SE}} \right\}$$

$$\mathbb{E}_F[V_{a+1}(b', p', k', j', w')] =$$

$$\delta_F \max \left\{ V_{a+1}(b', p', \tilde{k} + SP(w), U, 0), \int V_{a+1}(b', p', \tilde{k} + SP(w) - X, S, \tilde{w}) dW^S(\tilde{w}), V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q) \right\} +$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w), V_{a+1}(b', p', \tilde{k}, U, 0),}_{\text{move SE}} \right. \\ \left. \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w}), V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q)}_{\text{retire}} \right\}$$

$$\mathbb{E}_F[V_{a+1}(b', p', k', j', w')] =$$

$$\delta_F \max \left\{ V_{a+1}(b', p', \tilde{k} + SP(w), U, 0), \int V_{a+1}(b', p', \tilde{k} + SP(w) - X, S, \tilde{w}) dW^S(\tilde{w}), \right. \\ \left. V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q) \right\} + (1 - \delta_F) \left[(1 - \lambda_F^F)(1 - \lambda_F^I) \tilde{V}_{a+1}^F + \right]$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w), V_{a+1}(b', p', \tilde{k}, U, 0),}_{\text{move SE}} \right. \\ \left. \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w}), V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q)}_{\text{retire}} \right\}$$

$$\mathbb{E}_F[V_{a+1}(b', p', k', j', w')] =$$

$$\delta_F \max \left\{ V_{a+1}(b', p', \tilde{k} + SP(w), U, 0), \int V_{a+1}(b', p', \tilde{k} + SP(w) - X, S, \tilde{w}) dW^S(\tilde{w}), \right. \\ \left. V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q) \right\} + (1 - \delta_F) \left[(1 - \lambda_F^F)(1 - \lambda_F^I) \tilde{V}_{a+1}^F + \right. \\ \left. \tilde{\lambda}_F^F \int \max \left\{ \tilde{V}_{a+1}^F, V_{a+1}(b', p', \tilde{k}, F, \tilde{w}) \right\} dW^F(\tilde{w}) \right]$$

$$\tilde{V}_{a+1}^F := \max \left\{ \underbrace{V_{a+1}(b', p', \tilde{k}, F, w)}_{\text{stay}}, \underbrace{V_{a+1}(b', p', \tilde{k}, U, 0)}_{\text{quit}}, \right. \\ \left. \underbrace{\int V_{a+1}(b', p', \tilde{k} - X, S, \tilde{w}) dW^S(\tilde{w})}_{\text{move SE}}, \underbrace{V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q)}_{\text{retire}} \right\}$$

$$\mathbb{E}_F[V_{a+1}(b', p', k', j', w')] =$$

$$\delta_F \max \left\{ V_{a+1}(b', p', \tilde{k} + SP(w), U, 0), \int V_{a+1}(b', p', \tilde{k} + SP(w) - X, S, \tilde{w}) dW^S(\tilde{w}), \right. \\ \left. V_{a+1}^{\text{Ret}}(\tilde{k}, y^P, q) \right\} + (1 - \delta_F) \left[(1 - \lambda_F^F)(1 - \lambda_F^I) \tilde{V}_{a+1}^F + \right. \\ \left. \tilde{\lambda}_F^F \int \max \left\{ \tilde{V}_{a+1}^F, V_{a+1}(b', p', \tilde{k}, F, \tilde{w}) \right\} dW^F(\tilde{w}) + \right. \\ \left. \tilde{\lambda}_F^I \int \max \left\{ \tilde{V}_{a+1}^F, V_{a+1}(b', p', \tilde{k}, I, \tilde{w}) \right\} dW^I(\tilde{w}) \right]$$

1. Age: discrete from 16 to 100 y.o. (quarterly)
2. Type I: Reform 2004 and 2008 (3)
3. Type II: Ability type (2)
4. Wealth: continuous 13 points
5. Pension Wealth: continuous / 10 points
6. Sector: 4
7. Wage: continuous 12 points
8. Hours: discrete part-time x full-time (2 points)
9. UI status: discrete (3 points)

⇒ State space: $\sim 15.2 \text{mi}$ points

- i. Model is quarterly from age 16-100
- ii. Pension reforms come as surprises
- iii. Solved numerically
- iv. Weighting matrix: inverse of the diagonal of the var-cov matrix
- v. Global (Controlled Random Search) + local (Brent's algorithm) – derivative free
- vi. Continuous variables are discretized in grid points: capital (12), pension wealth (10) and wage/earnings (11)
- vii. Numerical integration using Gauss-Legendre (for Normal and Beta distributions)
- viii. Interpolation: linear interpolation for 1D,2D,3D
- ix. Numerical derivatives using two symmetrical deviations with a step size of 2.5%

- ▶ GMM estimation with moments computed by simulated data
 1. Given a vector of parameters: ξ
 2. Obtain the solution of the model: policy functions $P^*(\xi)$
 3. Simulate individuals that behave according to $P^*(\xi)$
 4. Compute moments from the simulated individuals: $M(P^*(\xi))$
 5. Choose ξ^* that minimizes:

weighting matrix

$$\left(M(P^*(\xi)) - M_d \right)' \underset{\substack{\downarrow \\ \text{moments in the data}}}{\Sigma_{M_d}} \left(M(P^*(\xi)) - M_d \right)$$

Estimated Parameters (22)

Discount factor (β)	1	(A)
Bequest (ψ, \bar{K})	2	(A)

Moments (212)

(A)	39	Median Wealth \times age groups
-----	----	-----------------------------------

2nd stage parameters

Back

Estimated Parameters (22)

Discount factor (β)	1	(A)
Bequest (ψ, \bar{K})	2	(A)
Consumption weight (ν)	1	(B),(C)

Moments (212)

(A)	39	Median Wealth \times age groups
(B)	33	Prop Retired \times age \times cohort
(C)	11	Prop Part-time \times age groups

2nd stage parameters

Back

Estimated Parameters (22)

Discount factor (β)	1	(A)
Bequest (ψ, \bar{K})	2	(A)
Consumption weight (ν)	1	(B),(C)
Amenities (ϕ_j)	1	(D)

Moments (212)

(A)	39	Median Wealth \times age groups
(B)	33	Prop Retired \times age \times cohort
(C)	11	Prop Part-time \times age groups
(D)	81	Emp-Sector \times age groups

2nd stage parameters

[Back](#)

Estimated Parameters (22)

Discount factor (β)	1	(A)
Bequest (ψ, \bar{K})	2	(A)
Consumption weight (ν)	1	(B),(C)
Amenities (ϕ_j)	1	(D)
Destruction rates (δ^j)	1	(E)
Arrival rates ($\lambda^{j,j}$)	8	(E)

Moments (212)

(A)	39	Median Wealth \times age groups
(B)	33	Prop Retired \times age \times cohort
(C)	11	Prop Part-time \times age groups
(D)	81	Emp-Sector \times age groups
(E)	14	Transitions

2nd stage parameters

Back

Estimated Parameters (22)

Discount factor (β)	1	(A)
Bequest (ψ, \bar{K})	2	(A)
Consumption weight (ν)	1	(B),(C)
Amenities (ϕ_j)	1	(D)
Destruction rates (δ^j)	1	(E)
Arrival rates ($\lambda^{j,j}$)	8	(E)
Formal Wage (ξ_1^F, ξ_2^F)	2	(F)
Informal Wage (ξ_1^I, ξ_2^I)	2	(G)

Moments (212)

(A)	39	Median Wealth \times age groups
(B)	33	Prop Retired \times age \times cohort
(C)	11	Prop Part-time \times age groups
(D)	81	Emp-Sector \times age groups
(E)	14	Transitions
(F)	13	Formal Wage Percentiles
(G)	13	Informal Wage Percentiles

2nd stage parameters

[Back](#)

Estimated Parameters (22)

Discount factor (β)	1	(A)
Bequest (ψ, \bar{K})	2	(A)
Consumption weight (ν)	1	(B),(C)
Amenities (ϕ_j)	1	(D)
Destruction rates (δ^j)	1	(E)
Arrival rates ($\lambda^{j,j}$)	8	(E)
Formal Wage (ξ_1^F, ξ_2^F)	2	(F)
Informal Wage (ξ_1^I, ξ_2^I)	2	(G)
Self-Emp Earnings (σ)	1	(H)

Moments (212)

(A)	39	Median Wealth \times age groups
(B)	33	Prop Retired \times age \times cohort
(C)	11	Prop Part-time \times age groups
(D)	81	Emp-Sector \times age groups
(E)	14	Transitions
(F)	13	Formal Wage Percentiles
(G)	13	Informal Wage Percentiles
(H)	7	Self-Emp Earnings

2nd stage parameters

[Back](#)

Estimated Parameters (22)

Discount factor (β)	1	(A)
Bequest (ψ, \bar{K})	2	(A)
Consumption weight (ν)	1	(B),(C)
Amenities (ϕ_j)	1	(D)
Destruction rates (δ^j)	1	(E)
Arrival rates ($\lambda^{j,j}$)	8	(E)
Formal Wage (ξ_1^F, ξ_2^F)	2	(F)
Informal Wage (ξ_1^I, ξ_2^I)	2	(G)
Self-Emp Earnings (σ)	1	(H)
Self-Emp Fixed Cost (x)	1	(I)

Moments (212)

(A)	39	Median Wealth \times age groups
(B)	33	Prop Retired \times age \times cohort
(C)	11	Prop Part-time \times age groups
(D)	81	Emp-Sector \times age groups
(E)	14	Transitions
(F)	13	Formal Wage Percentiles
(G)	13	Informal Wage Percentiles
(H)	7	Self-Emp Earnings
(I)	1	Physical Capital

2nd stage parameters

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Estimated Parameters (22)

Discount factor (β)	1	(A)
Bequest (ψ, \bar{K})	2	(A)
Consumption weight (ν)	1	(B),(C)
Amenities (ϕ_j)	1	(D)
Destruction rates (δ^j)	1	(E)
Arrival rates ($\lambda^{j,j}$)	8	(E)
Formal Wage (ξ_1^F, ξ_2^F)	2	(F)
Informal Wage (ξ_1^I, ξ_2^I)	2	(G)
Self-Emp Earnings (σ)	1	(H)
Self-Emp Fixed Cost (x)	1	(I)
Abilities types	2	(J),(F-H)

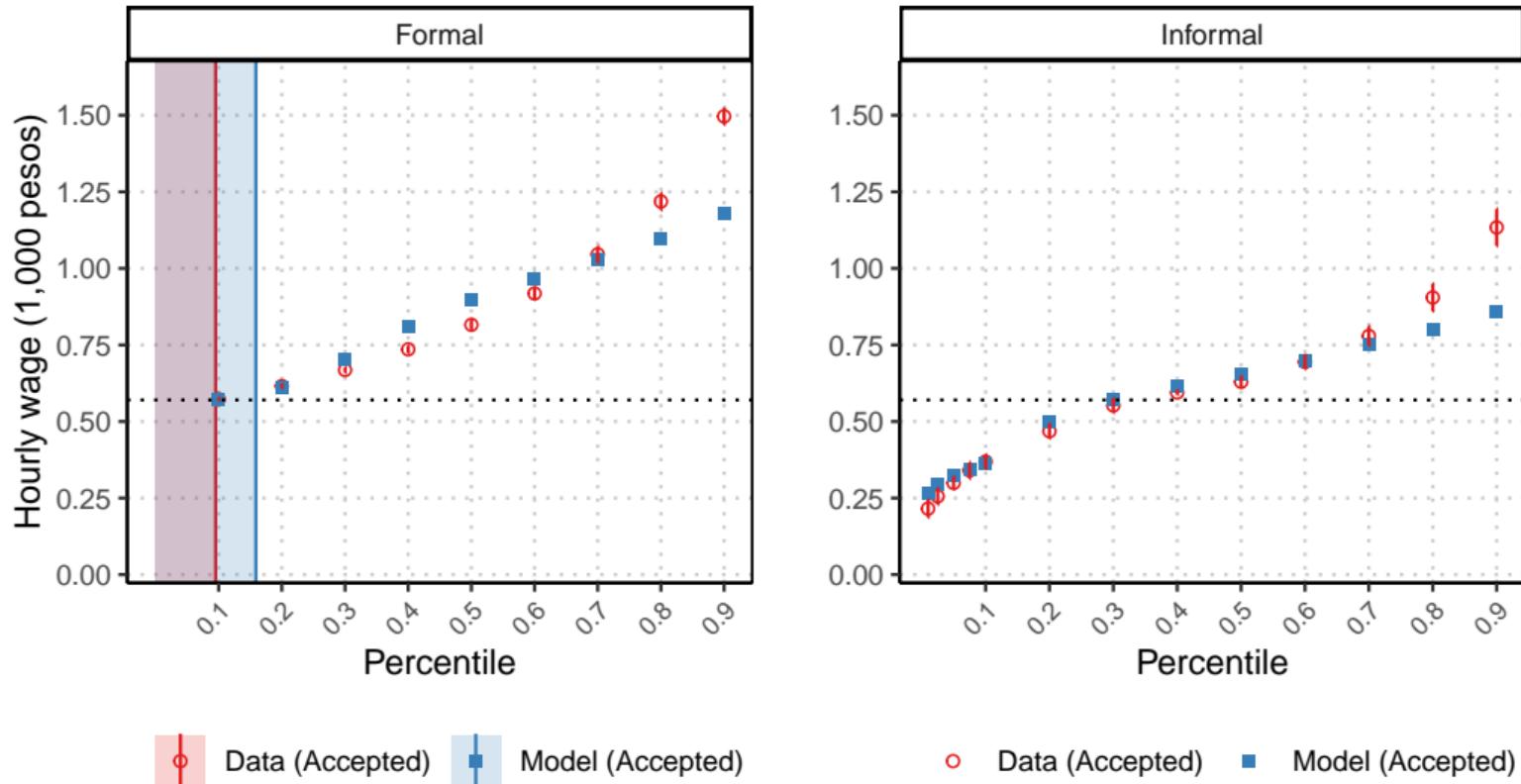
Moments (212)

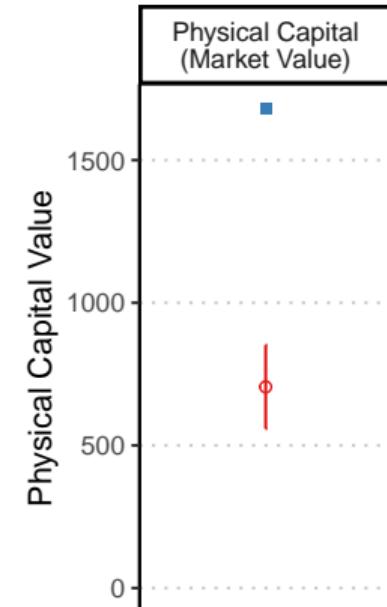
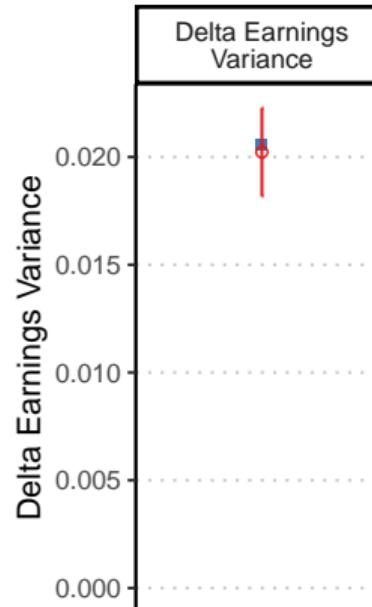
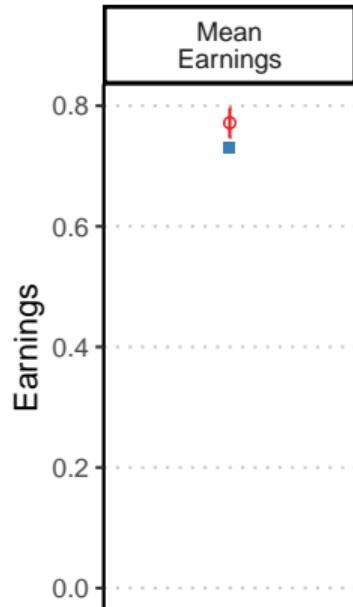
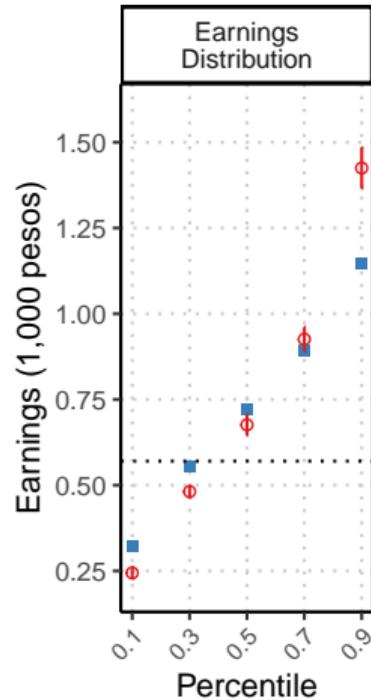
(A)	39	Median Wealth \times age groups
(B)	33	Prop Retired \times age \times cohort
(C)	11	Prop Part-time \times age groups
(D)	81	Emp-Sector \times age groups
(E)	14	Transitions
(F)	13	Formal Wage Percentiles
(G)	13	Informal Wage Percentiles
(H)	7	Self-Emp Earnings
(I)	1	Physical Capital
(J)	1	Wage correlation

Preference	β	ν	ψ	\bar{K}	ϕ_S
estimate	0.944	0.390	141.946	8375.0	1.126
(s.e.)	(0.001)	(0.002)	(50.166)	(2911.1)	(0.016)
Formal Arrival Rates	$\lambda_{U,F}$	$\lambda_{F,F}$	$\lambda_{I,F}$	$\lambda_{S,F}$	
estimate	0.116	0.207	0.031	0.653	
(s.e.)	(0.003)	(0.011)	(0.002)	(0.102)	
Informal Arrival Rates	$\lambda_{U,I}$	$\lambda_{F,I}$	$\lambda_{I,I}$	$\lambda_{S,I}$	
estimate	0.213	0.976	0.117	0.957	
(s.e.)	(0.011)	(0.282)	(0.010)	(1.136)	
Wage (Shape)	ζ_1^F	ζ_2^F	ζ_1^I	ζ_2^I	
estimate	6.086	16.942	11.304	48.887	
(s.e.)	(0.453)	(1.028)	(1.330)	(4.736)	
Self-Employment	δ_S	σ	X	g_2	e_2
estimate	0.008	0.051	3365.3	0.559	0.684
(s.e.)	(0.001)	(0.002)	(76.2)	(0.005)	(0.010)

Accepted wages

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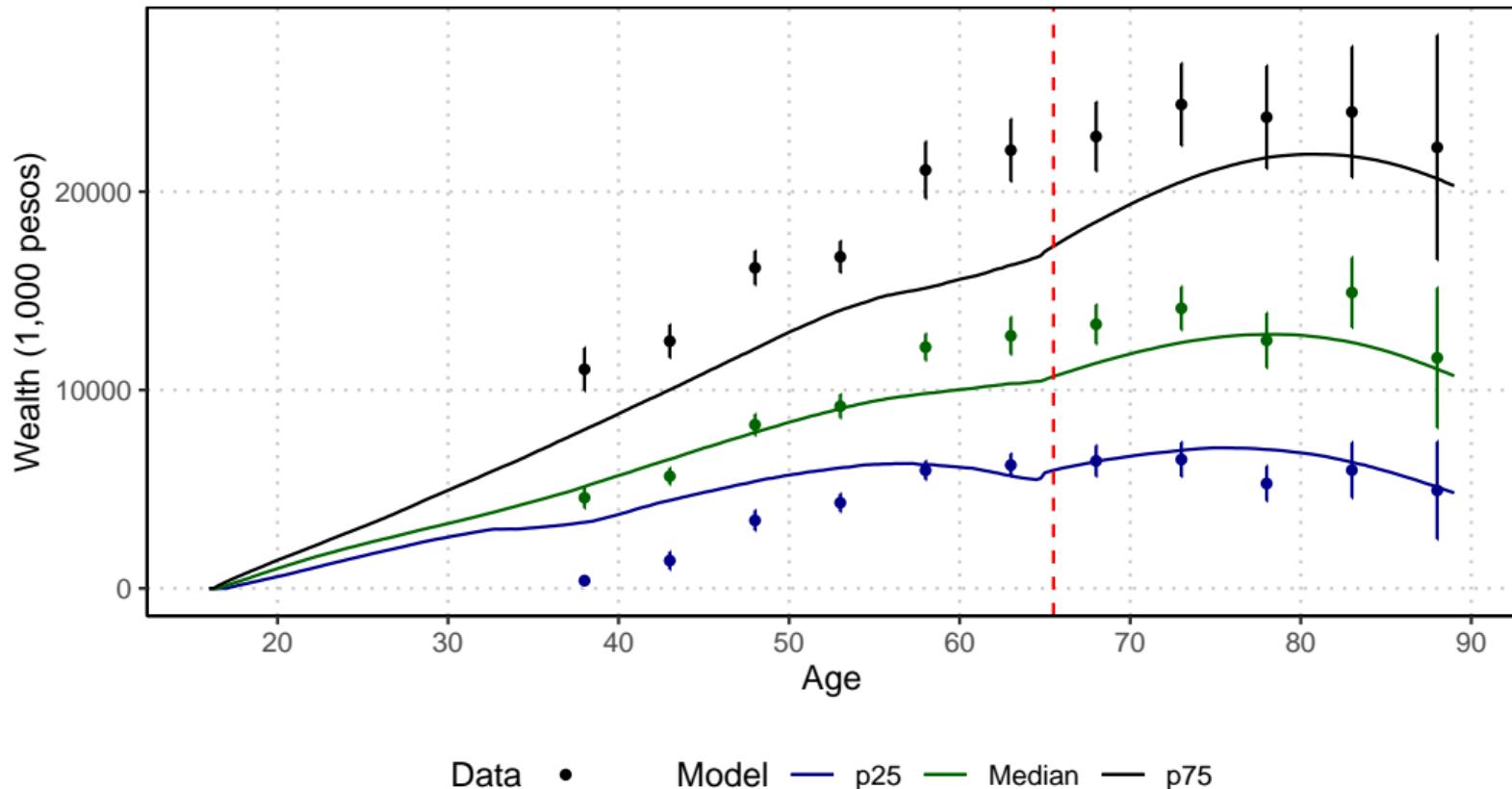


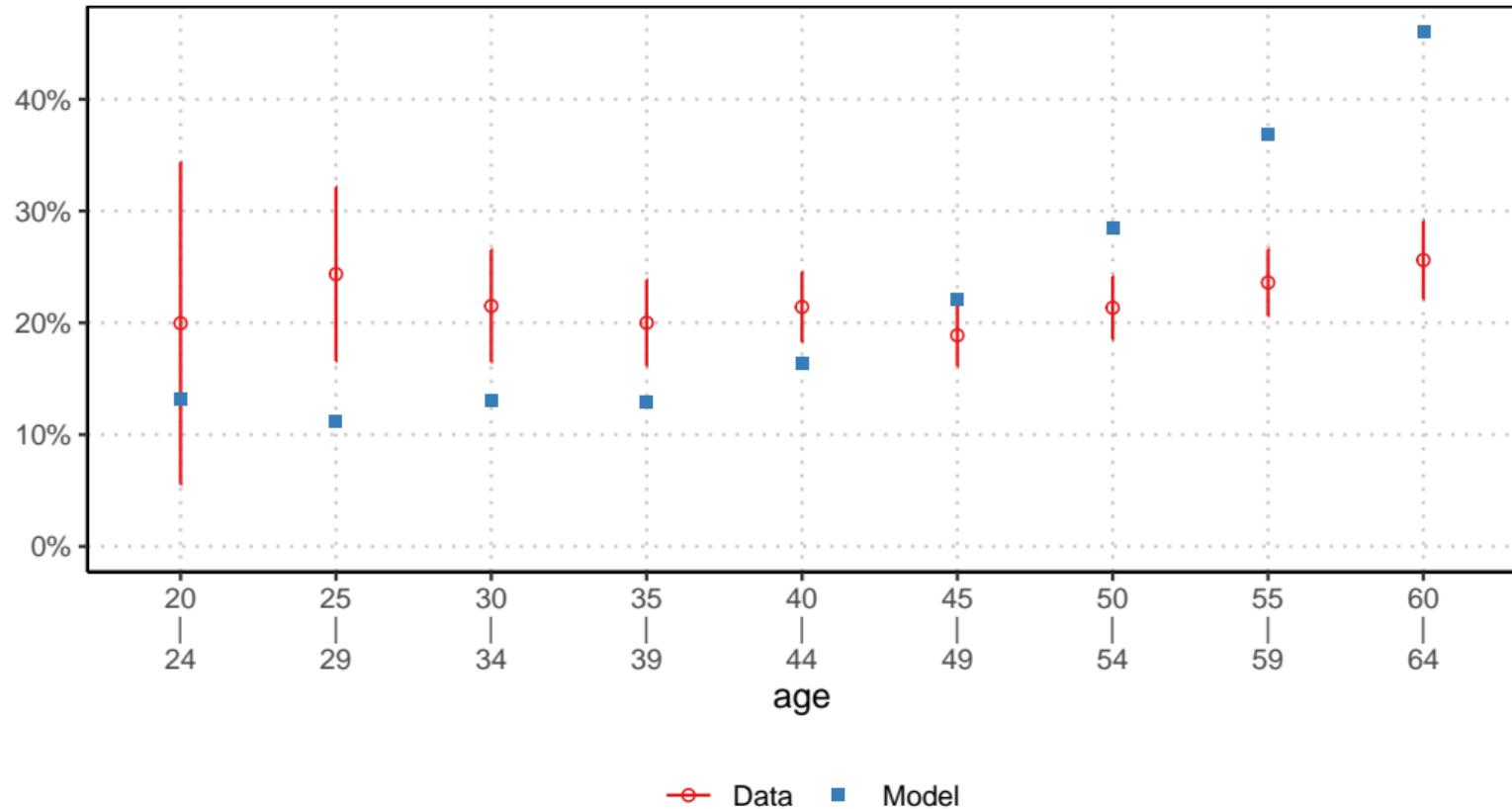
○ Data

■ Model

○ Data

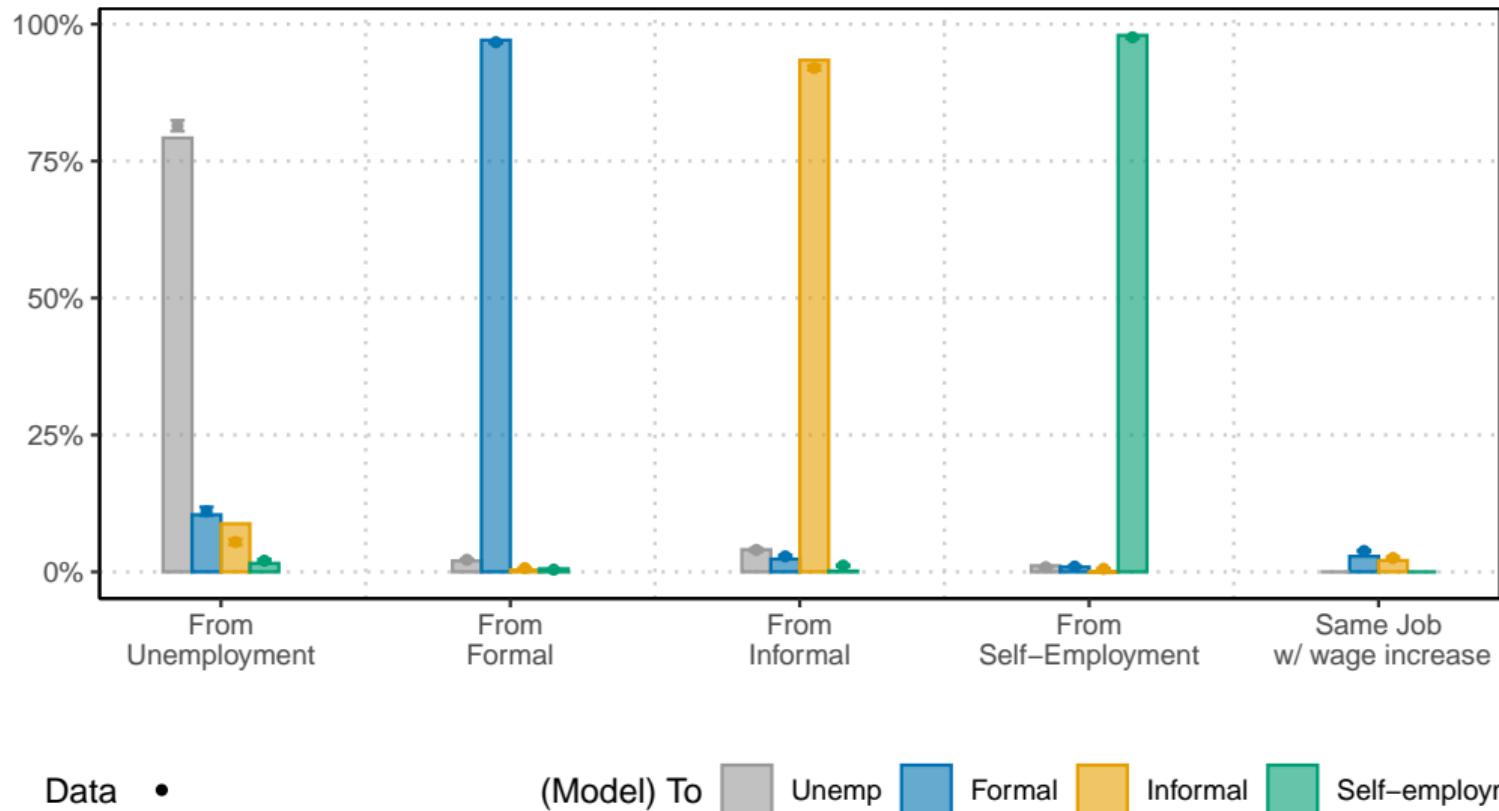
■ Model





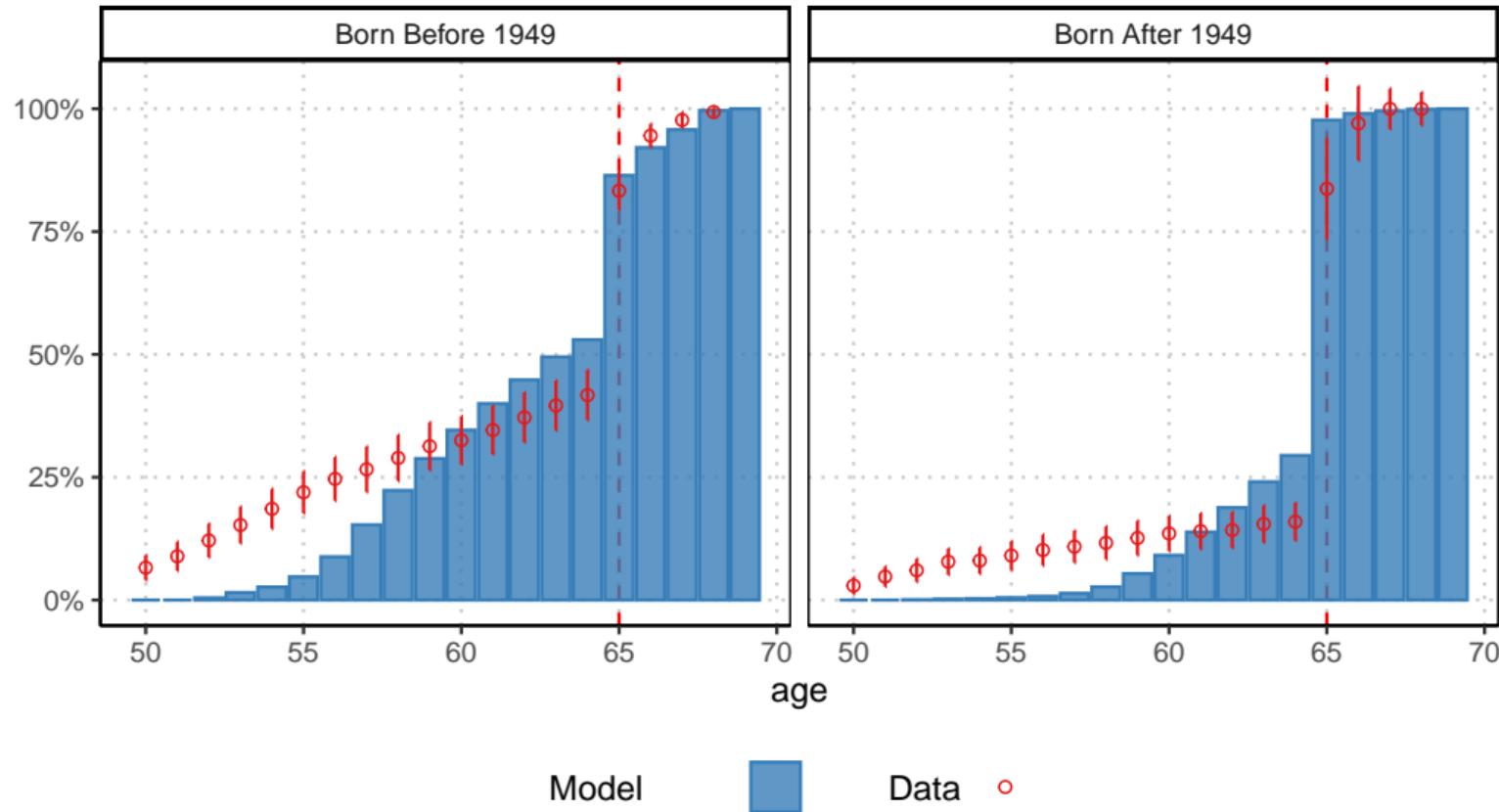
Transitions

Back



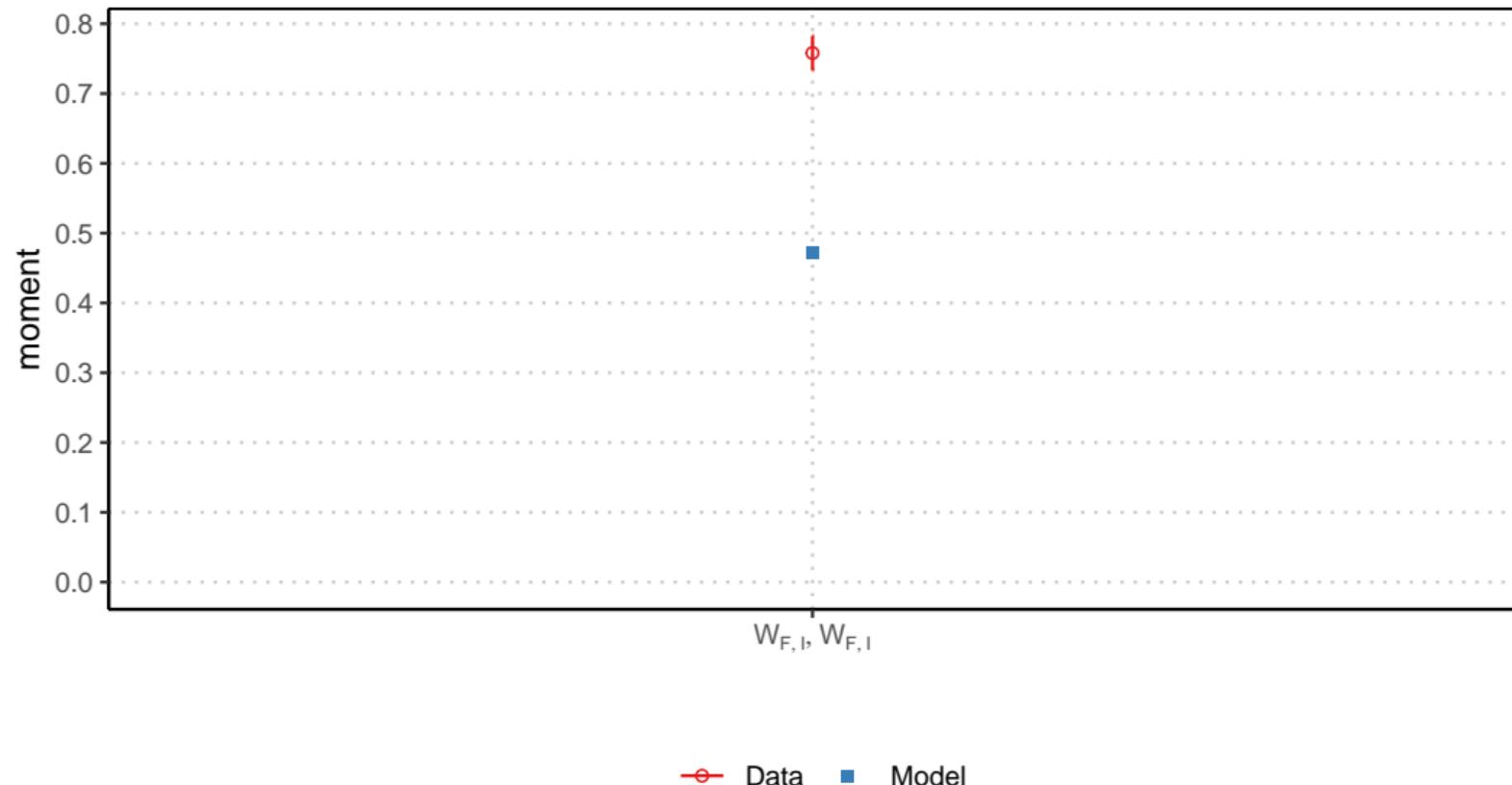
Retirement age

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Wage correlation age

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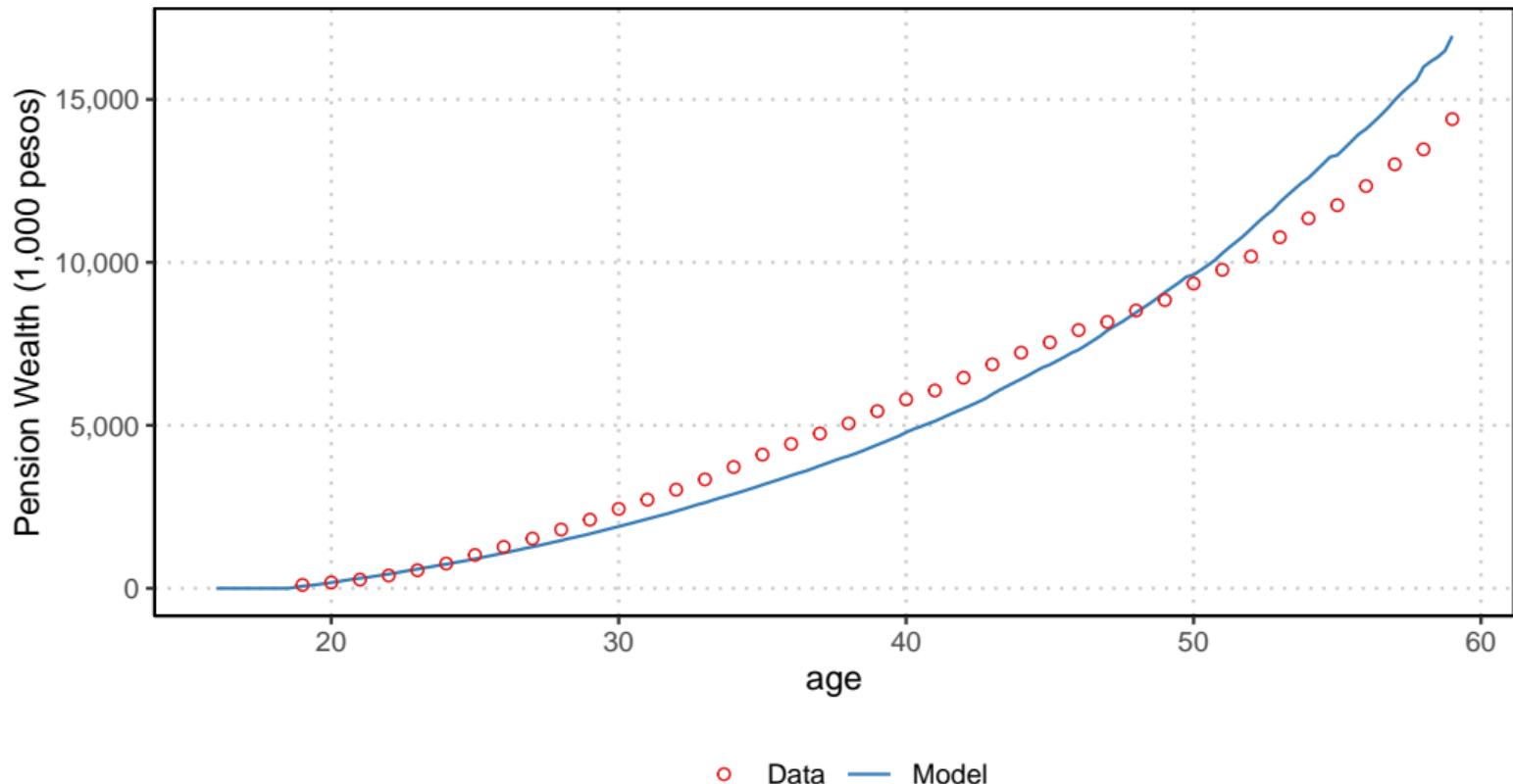
Amenities

- ▶ Consumption equivalent (intra-period) to yield the same utility as working formally full-time

Sector	Formal	Unemployed	Informal	Self-employed
Consumption Equivalent <i>(baseline)</i>	1.000	0.476	1.000	0.888

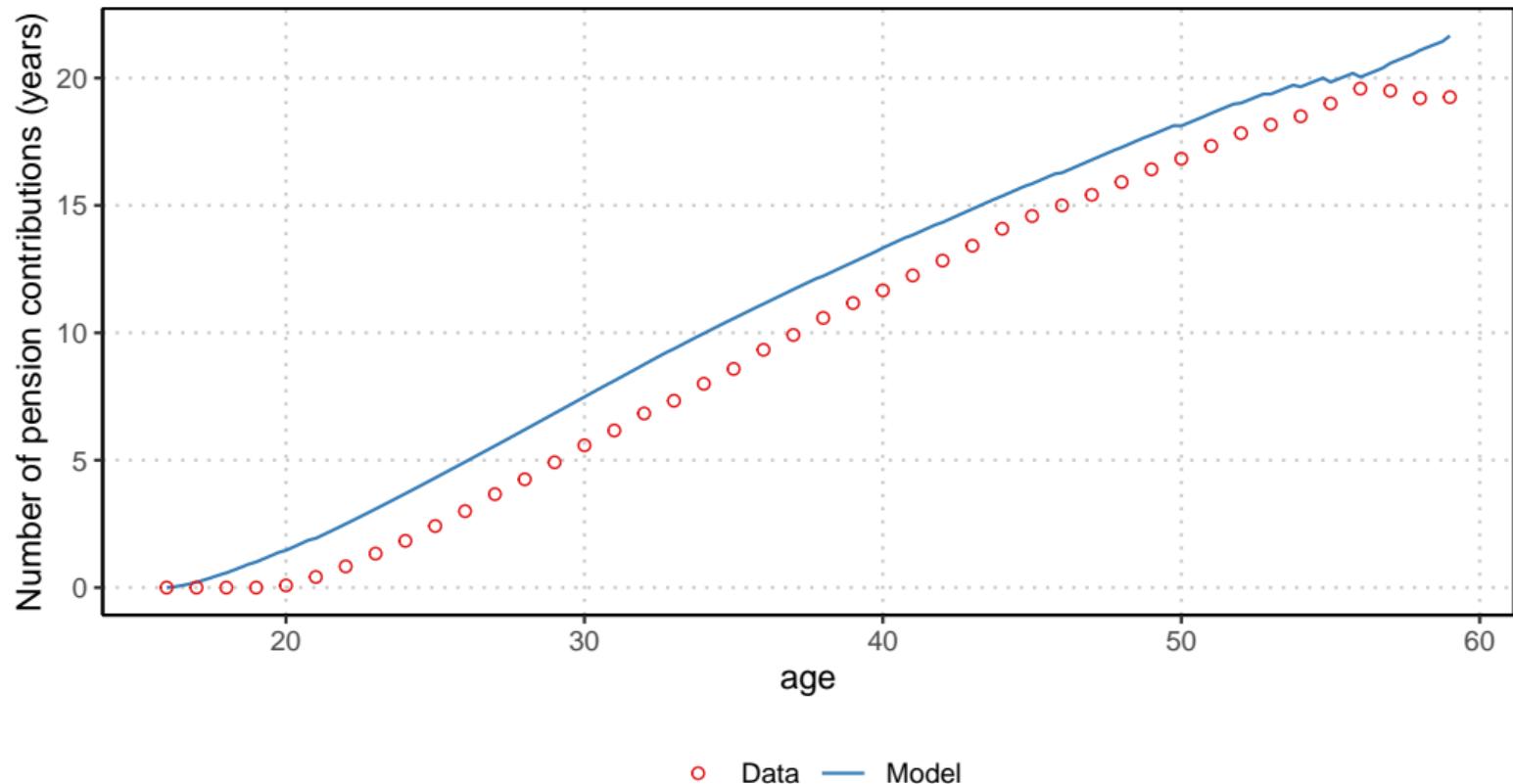
Untargetted moments: pension wealth

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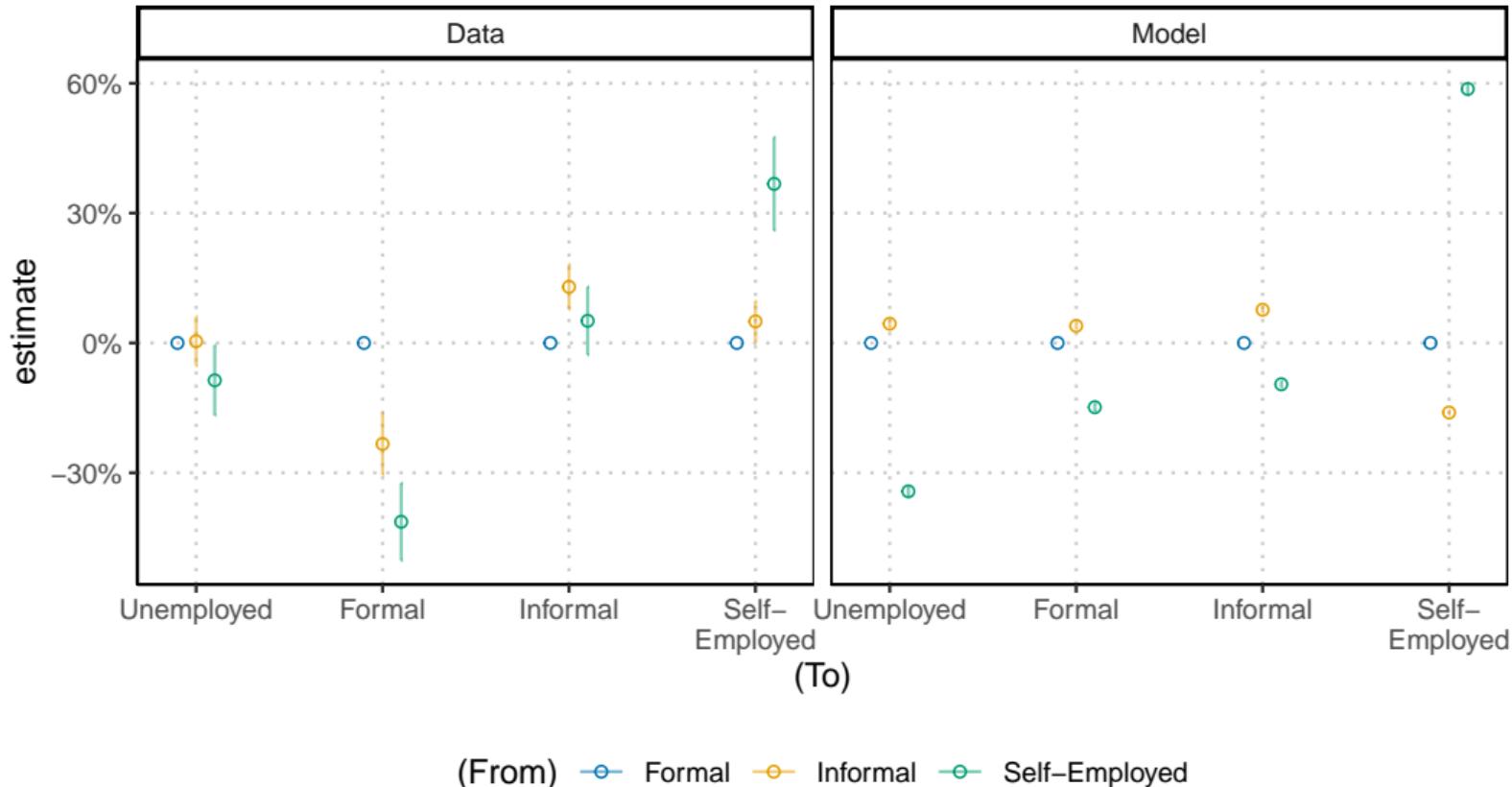
Untargetted moments: pension contributions

[Back](#)

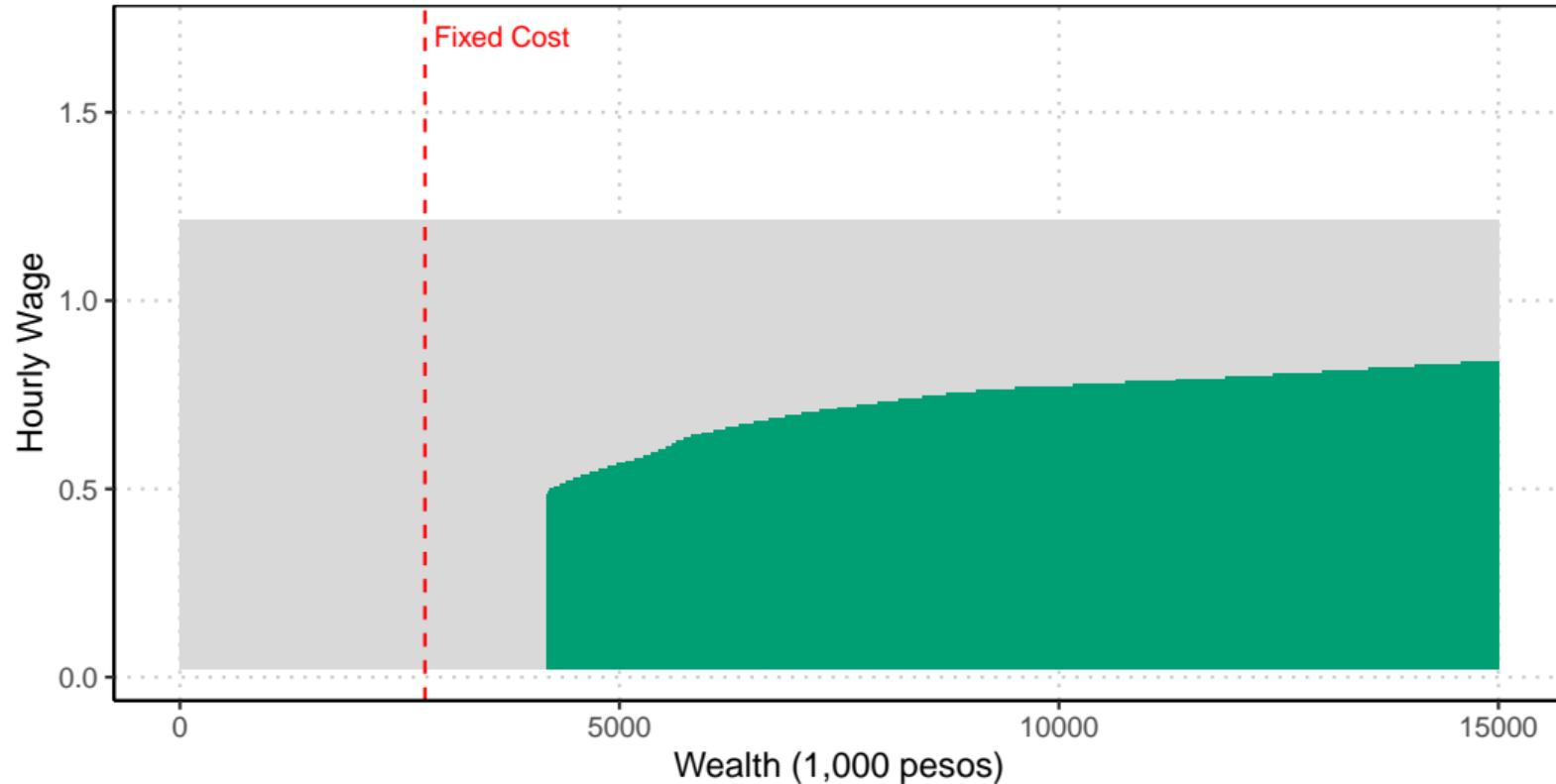


Involuntary transitions

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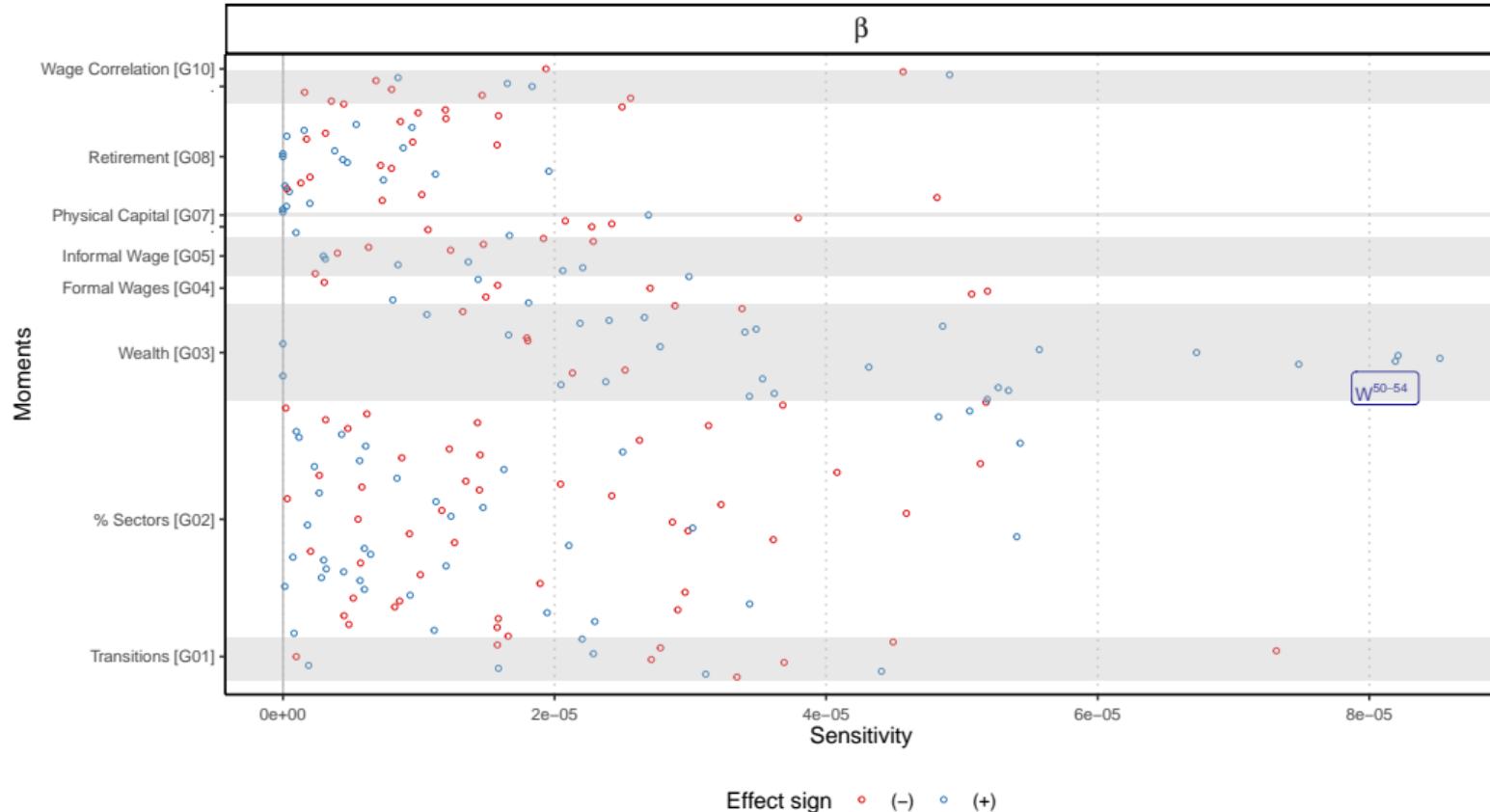


Formal



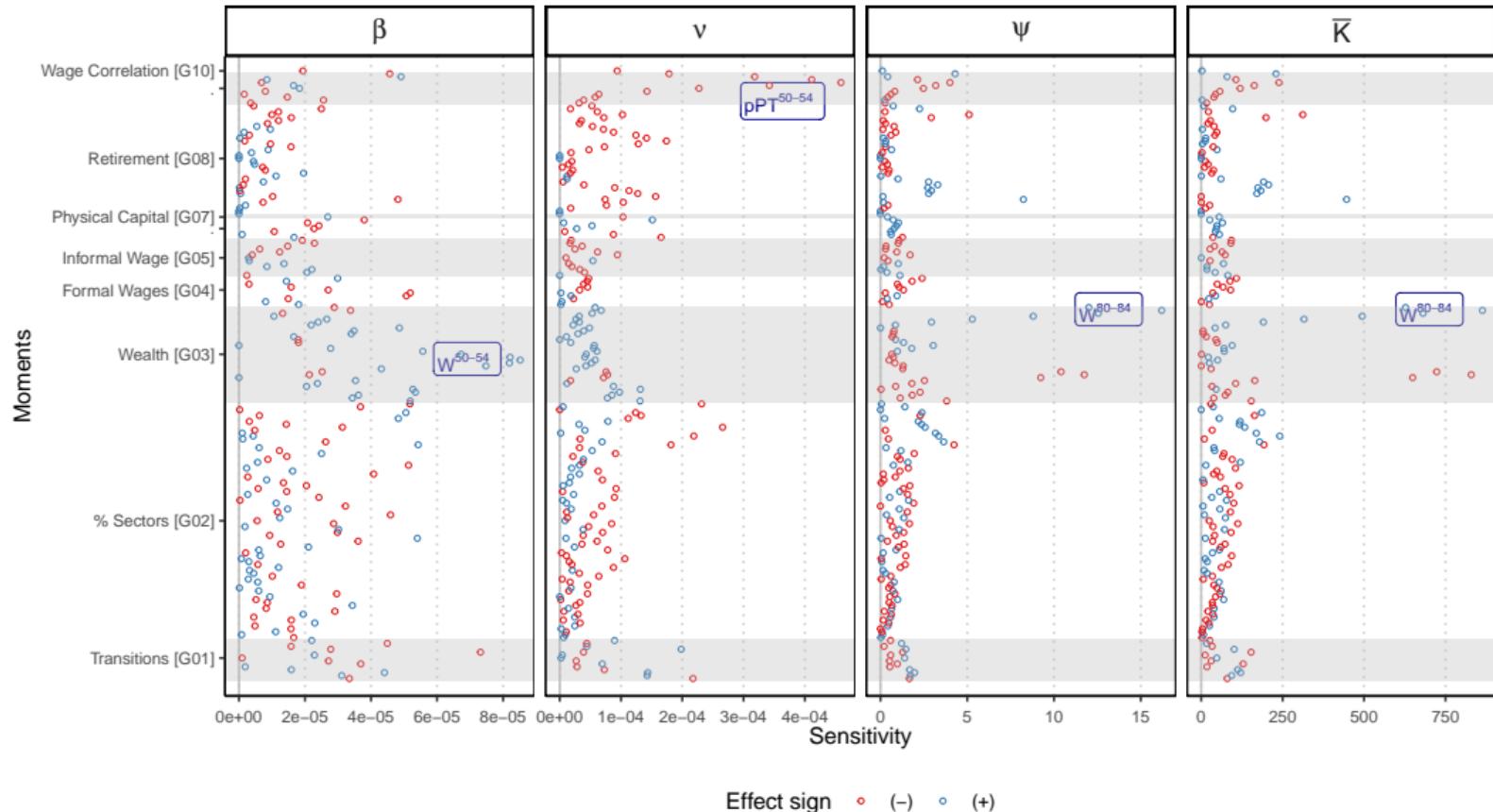
Sensitivity Matrix

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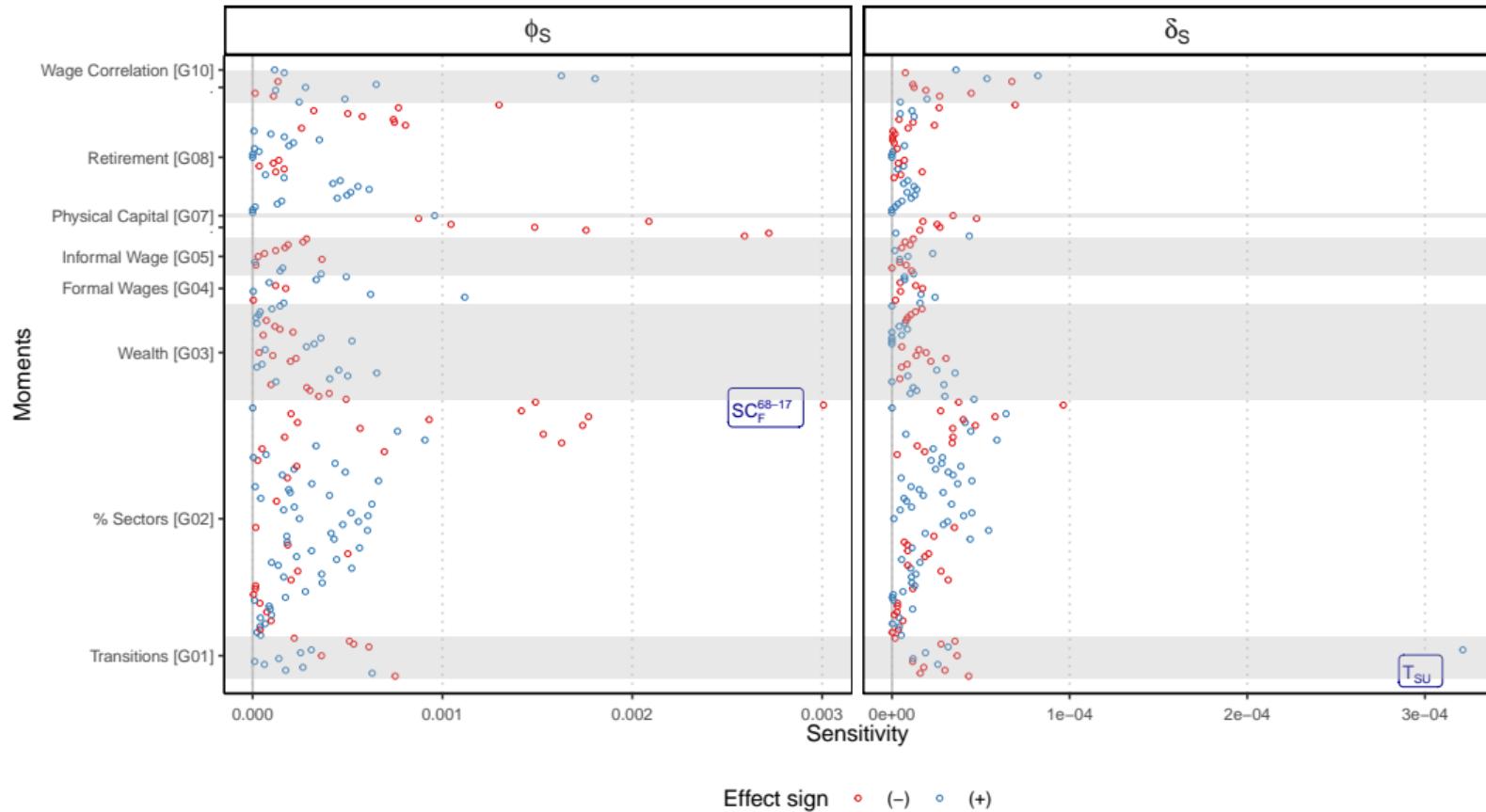
Sensitivity Matrix

[Back](#)



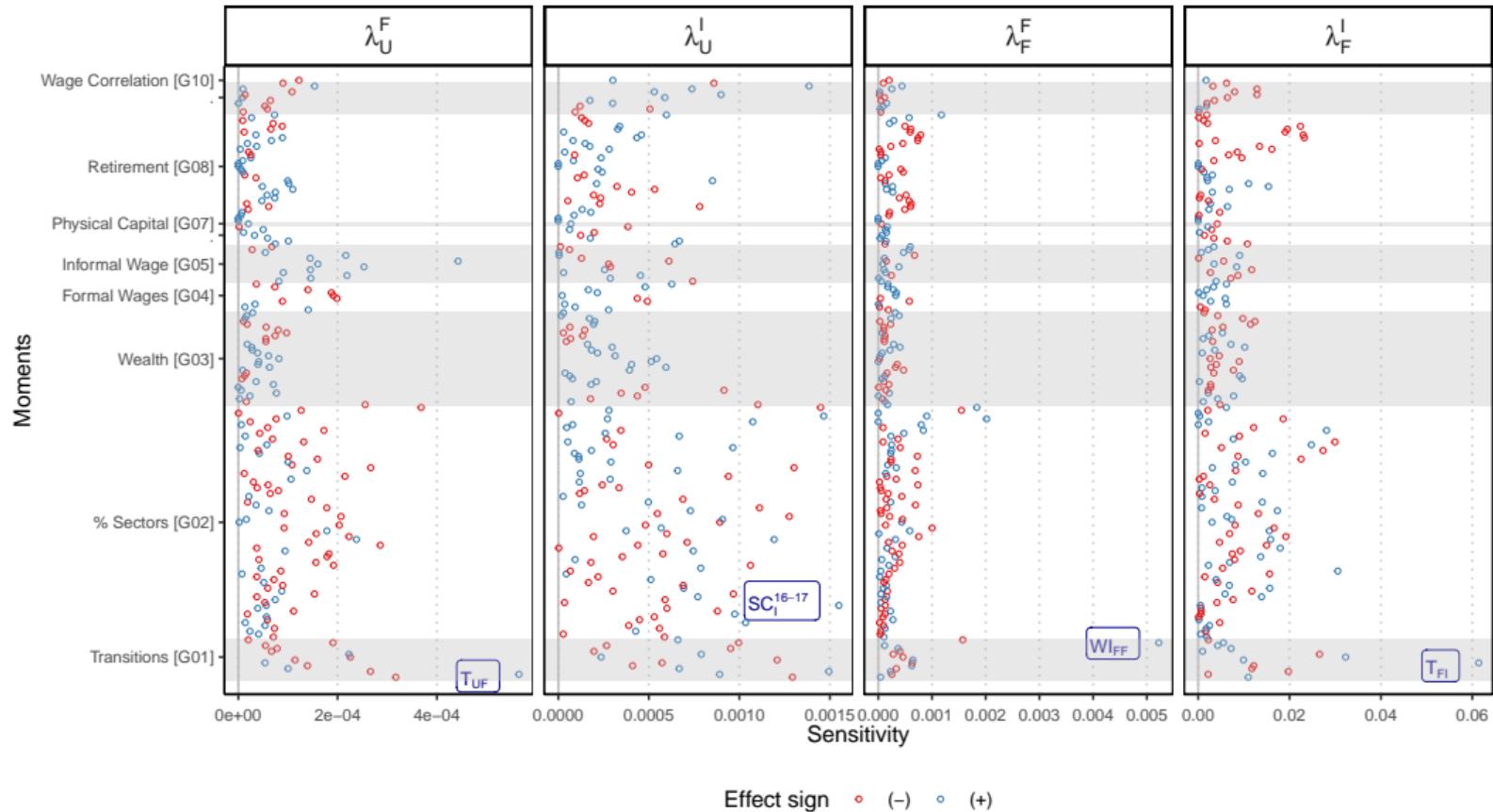
Sensitivity Matrix

[Back](#)



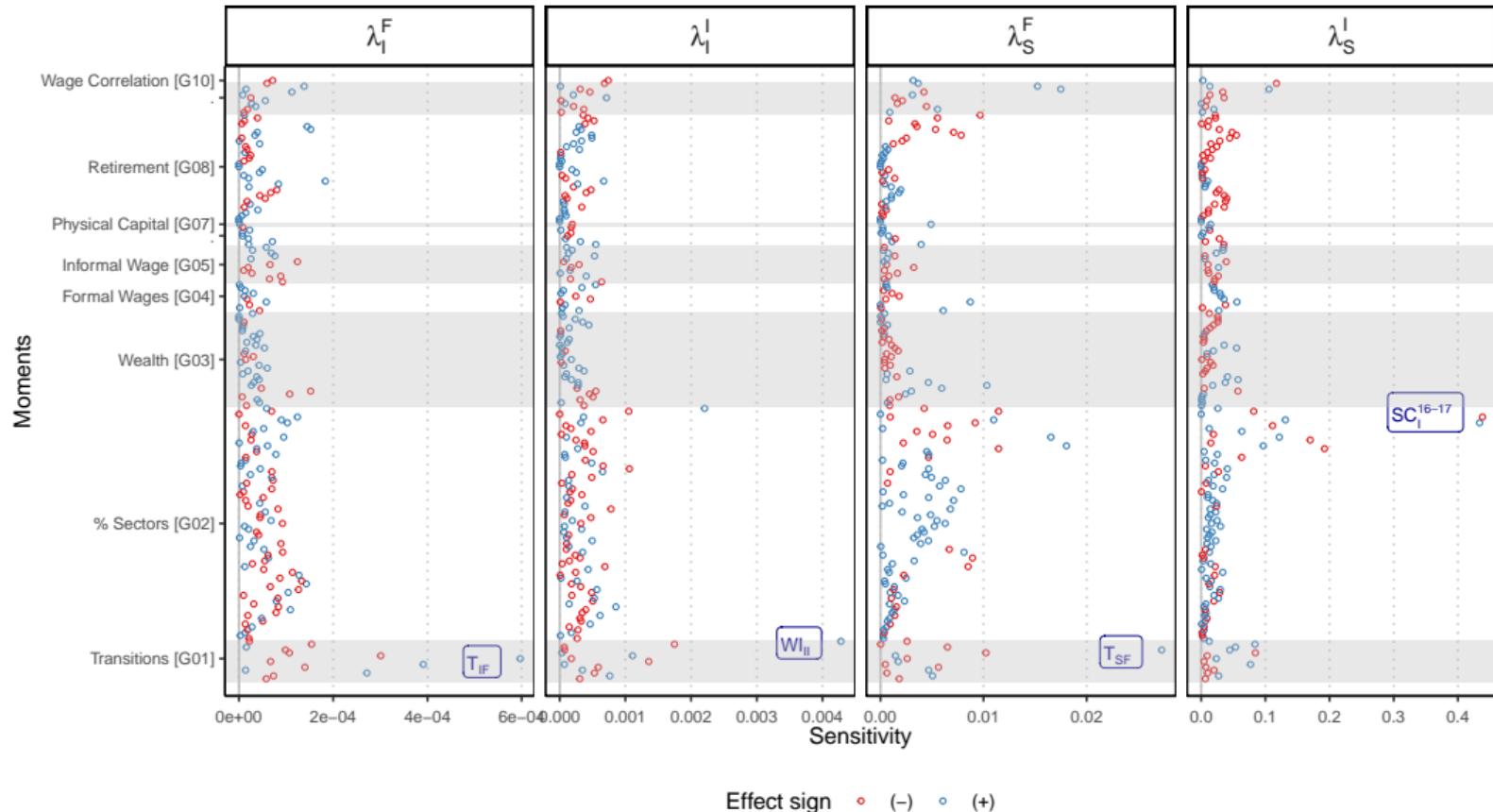
Sensitivity Matrix

[Back](#)



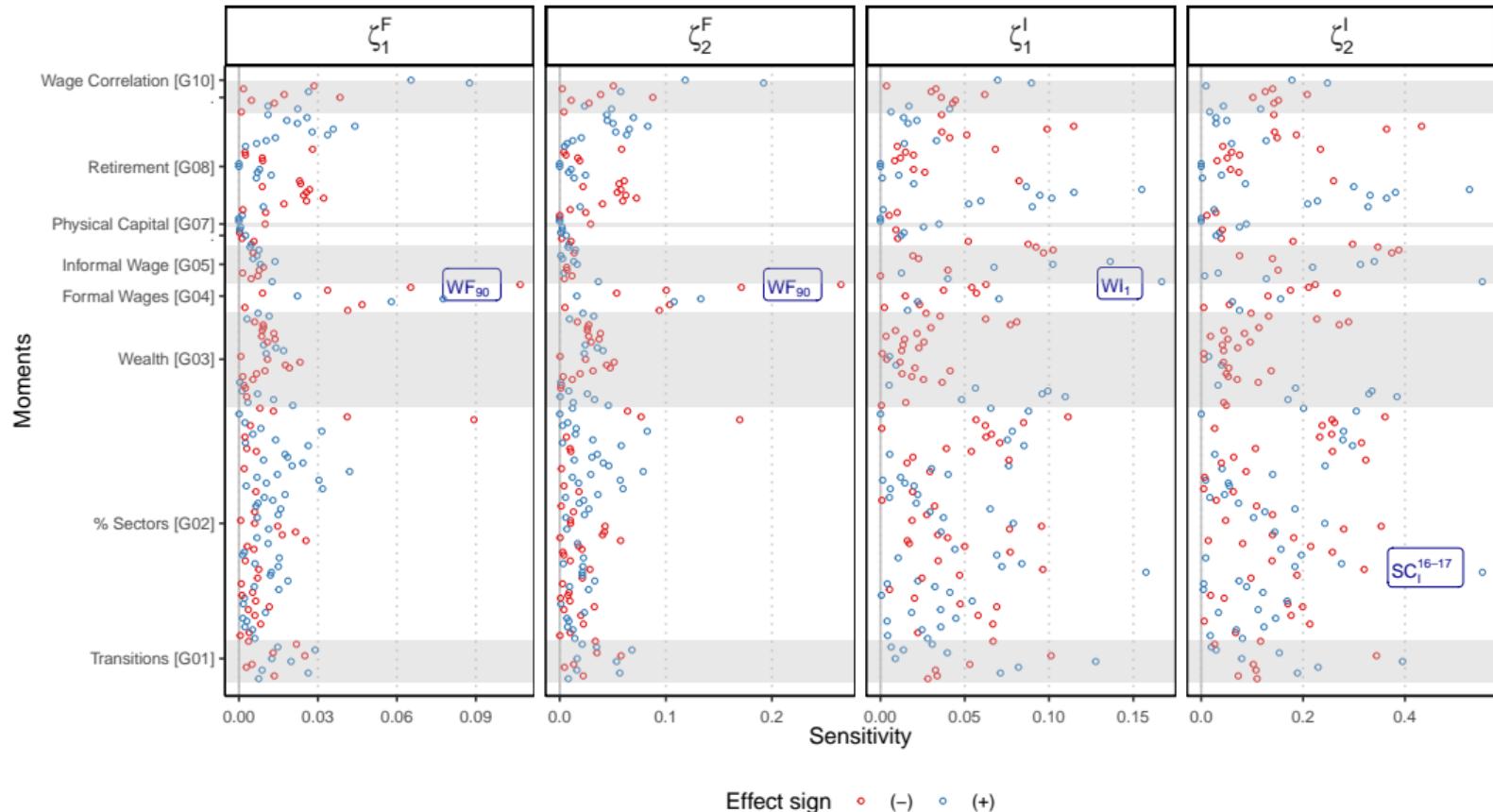
Sensitivity Matrix

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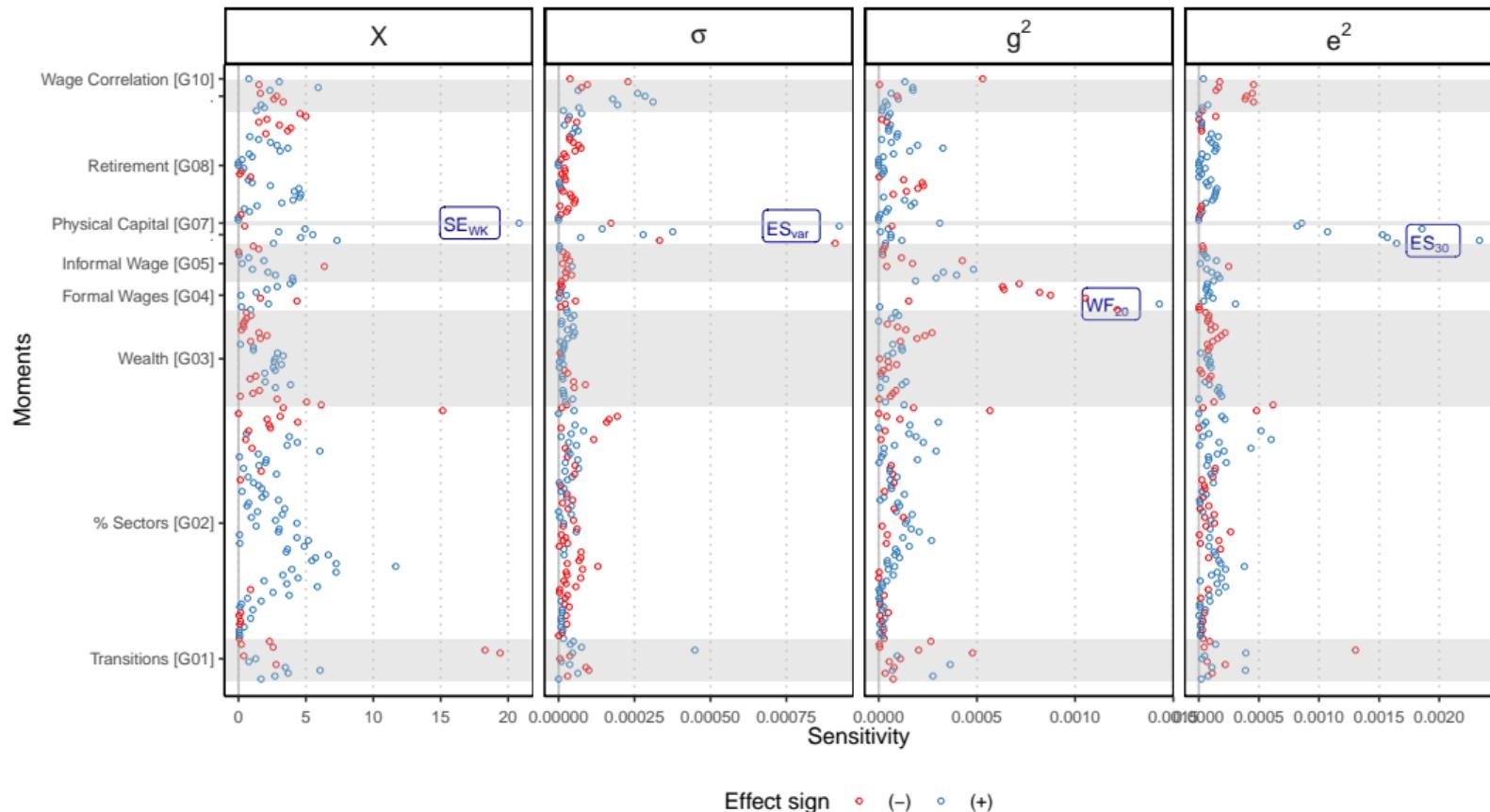
Sensitivity Matrix

[Back](#)



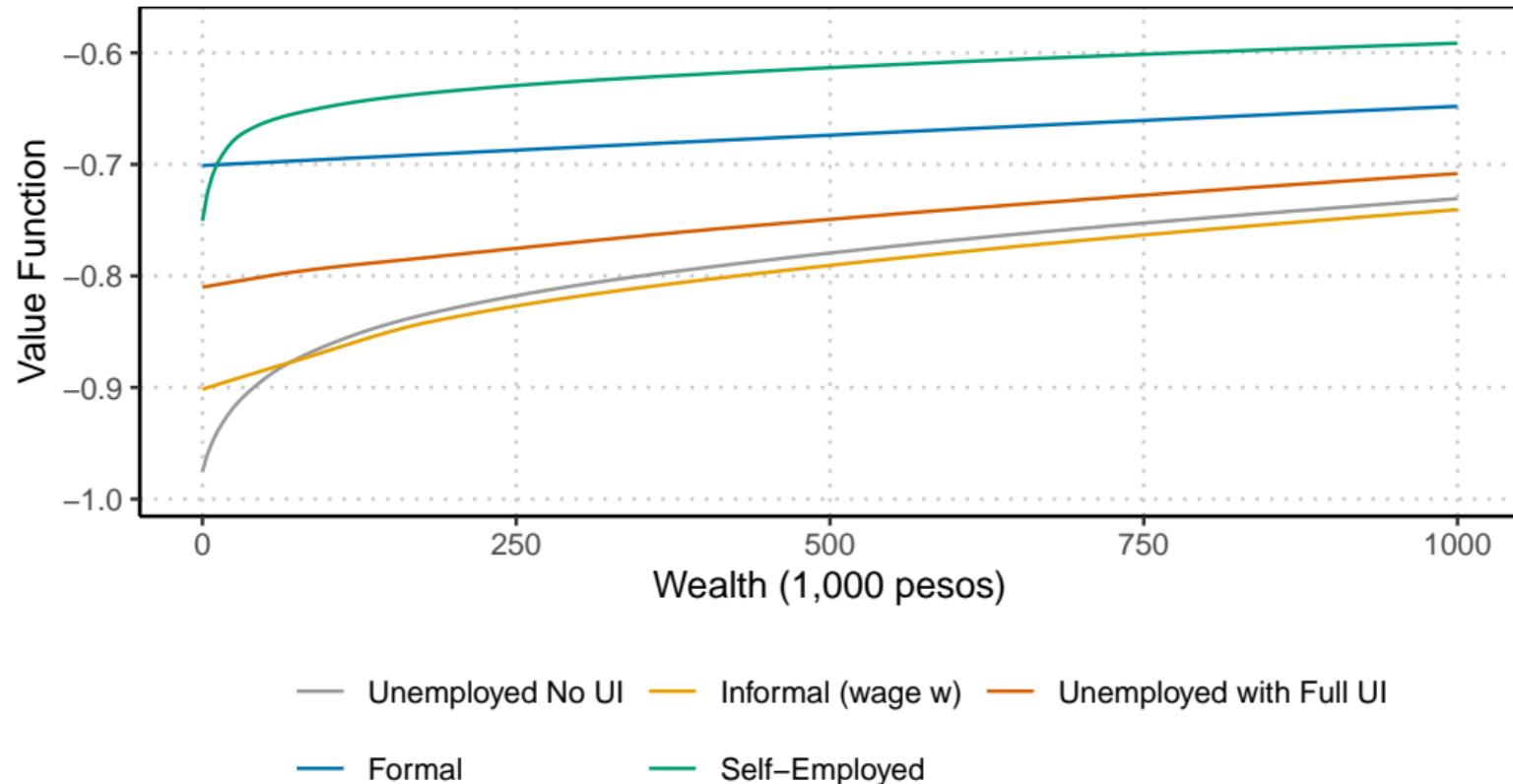
Sensitivity Matrix

[Back](#)



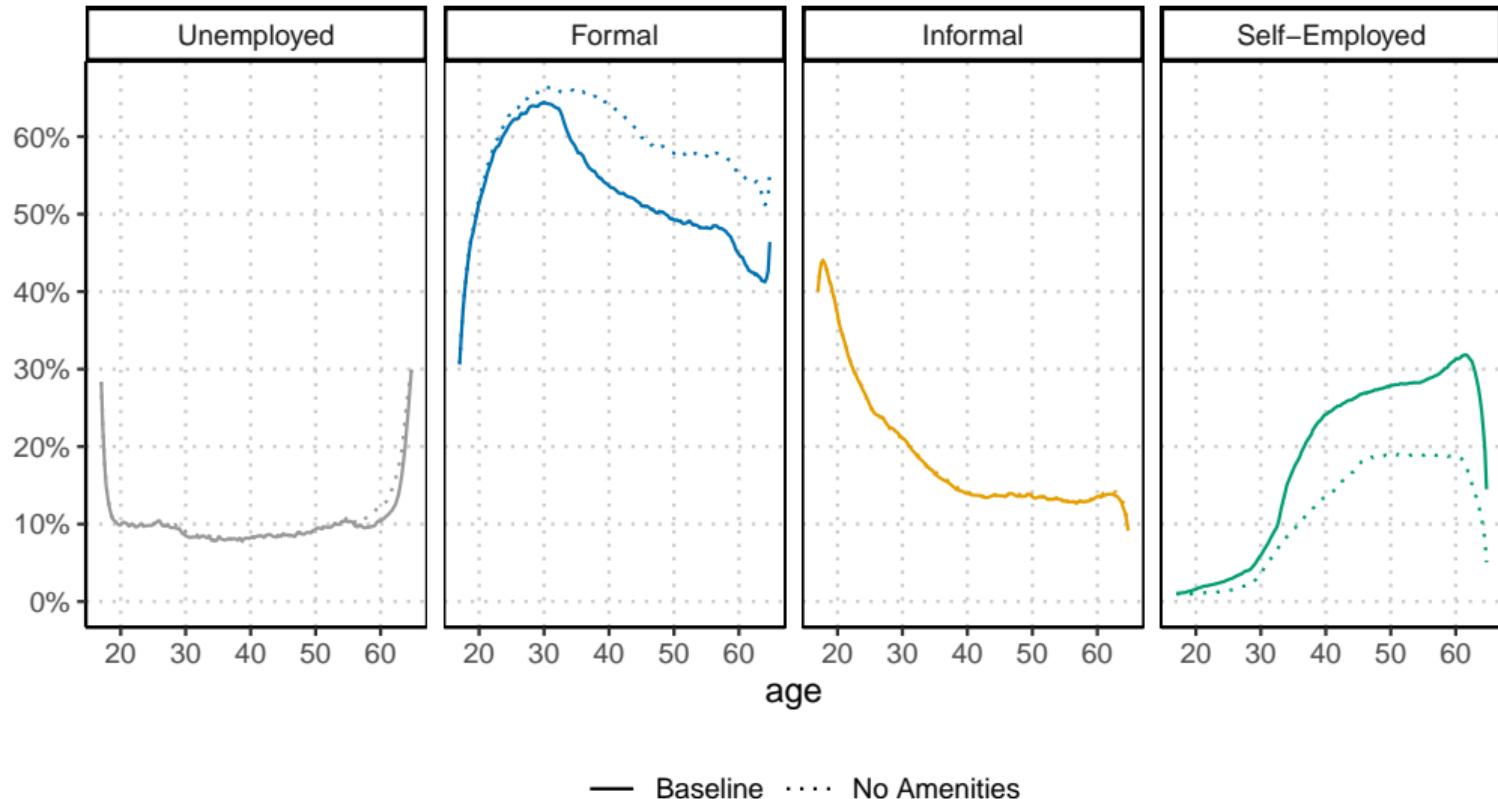
Value Function

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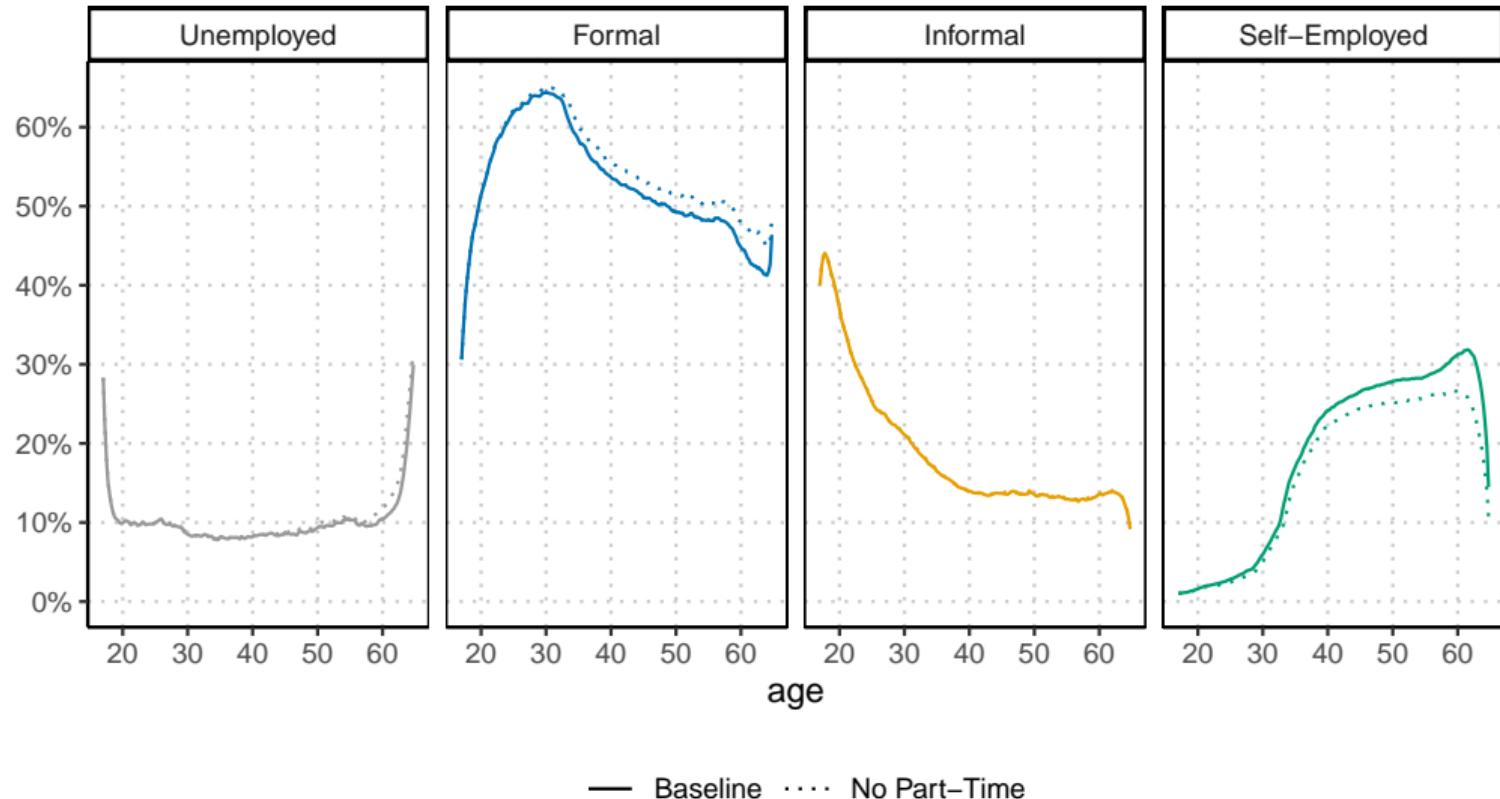
No amenities

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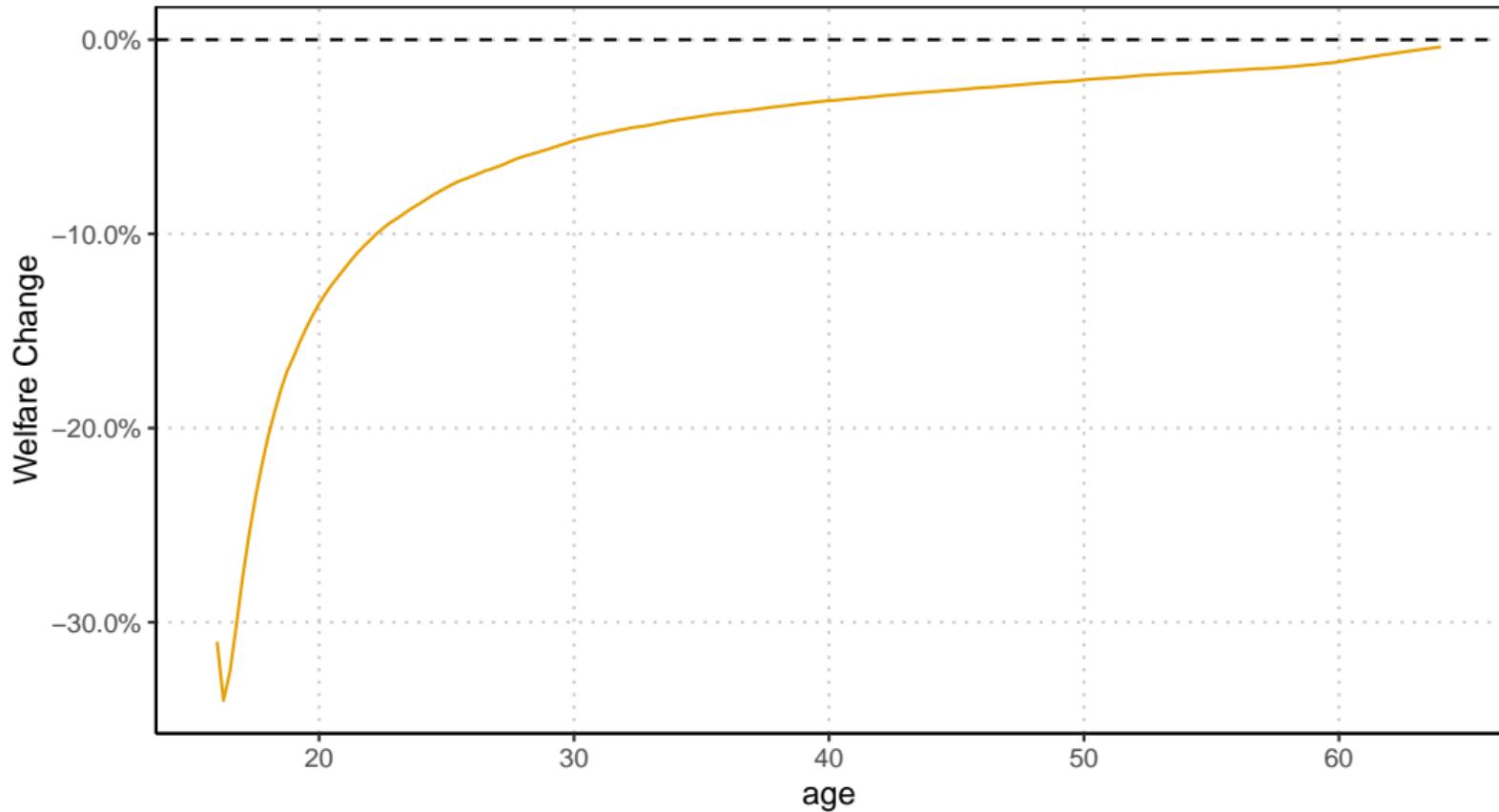
No Part-time

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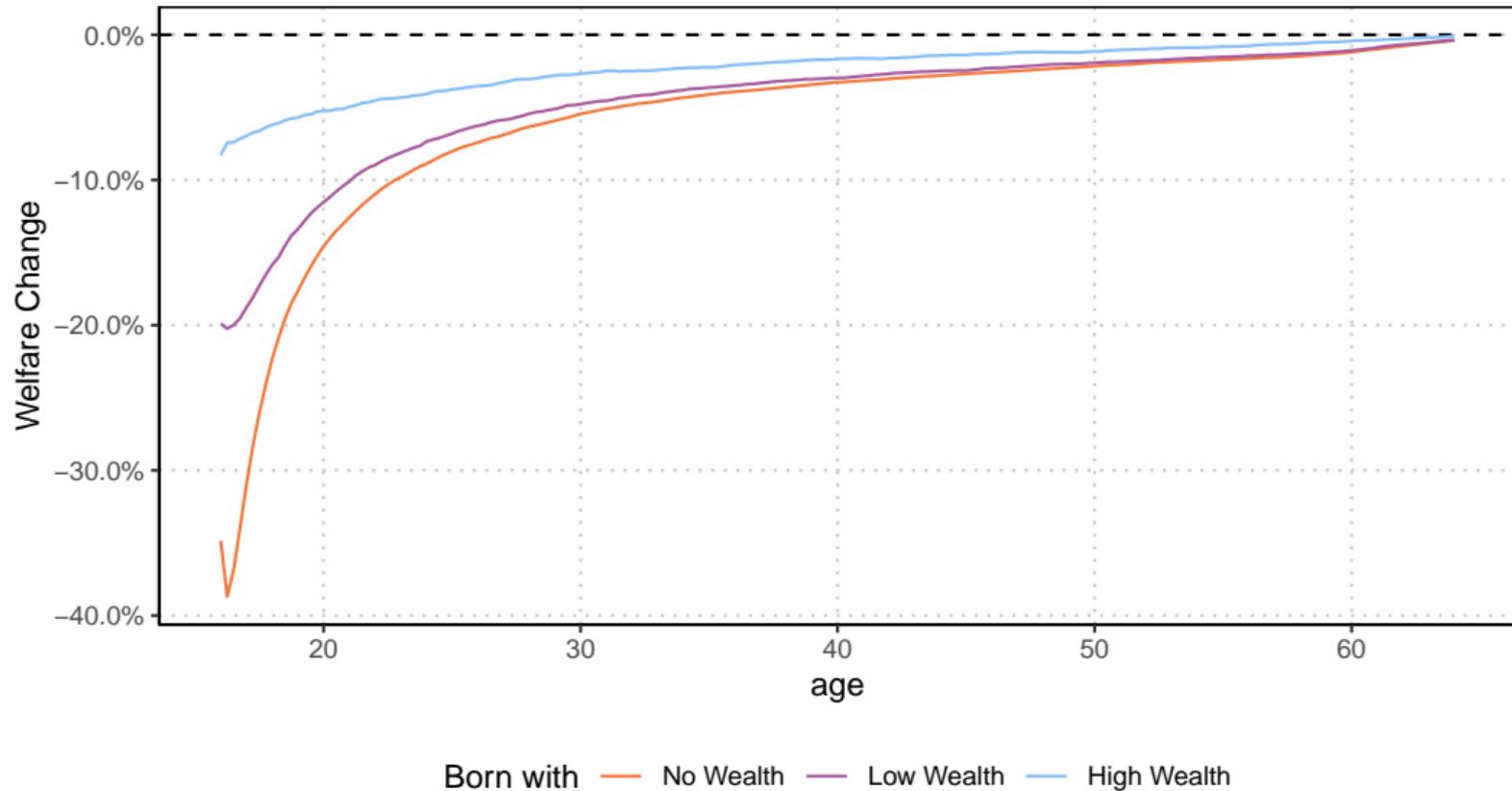
Closing Informal Sector

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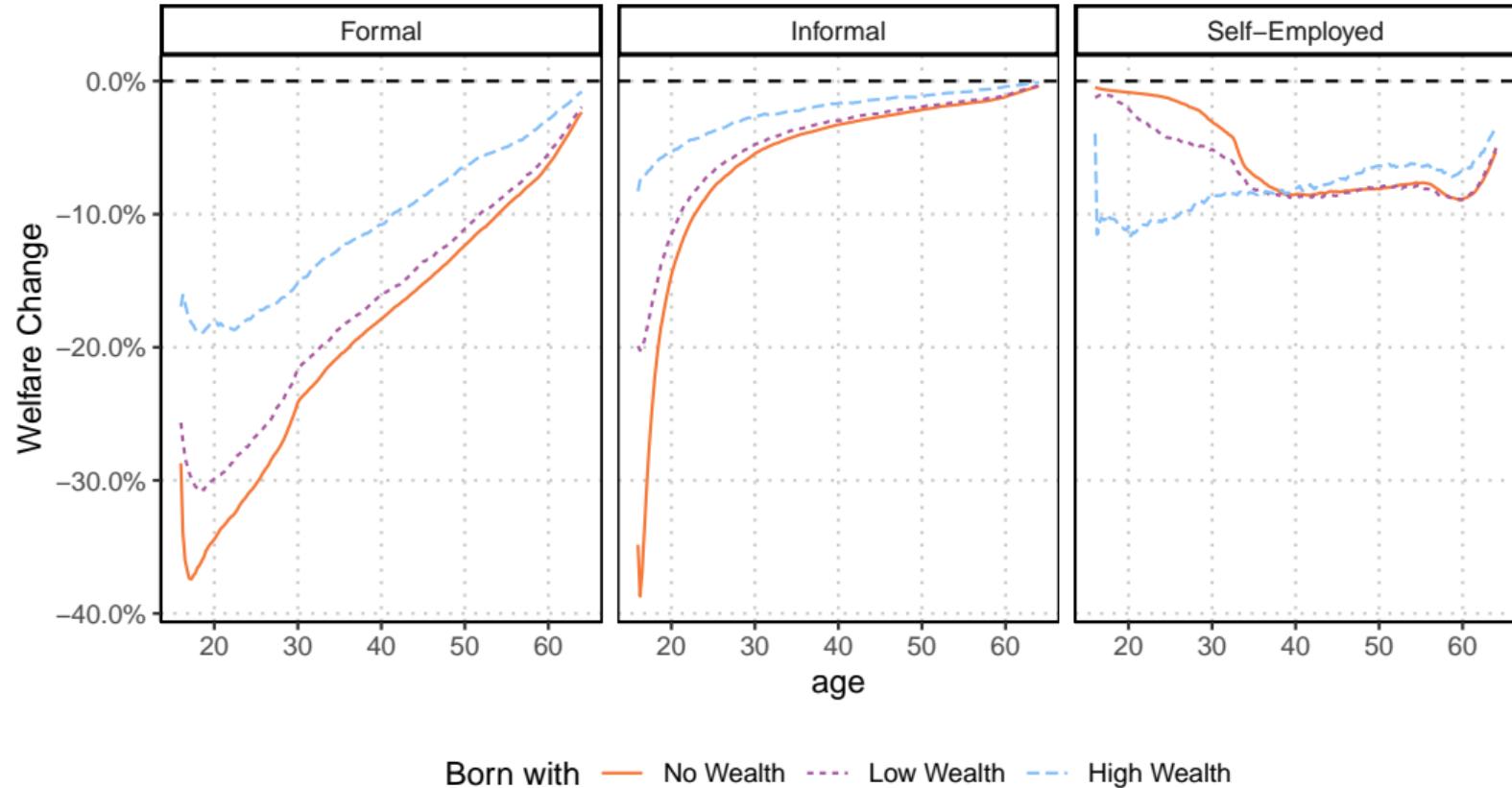
Closing Informal Sector

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Closing Informal Sector

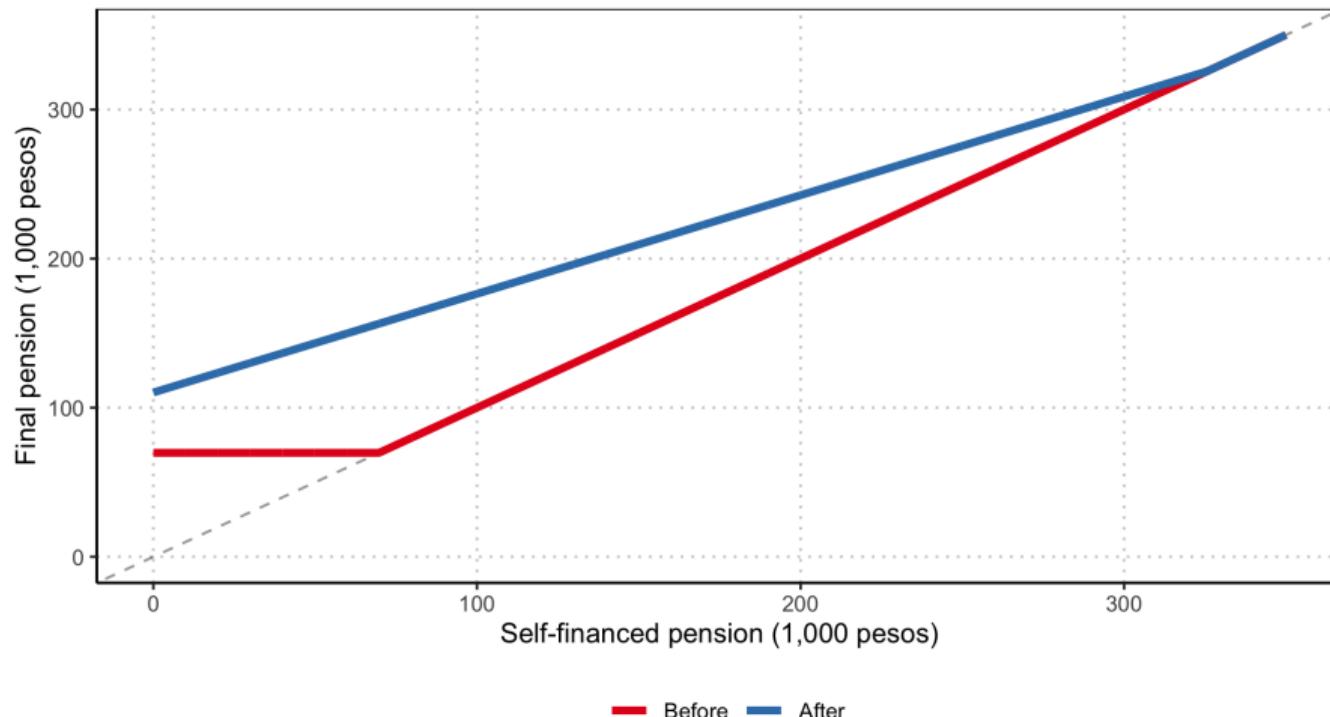
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2008 Pension Reform

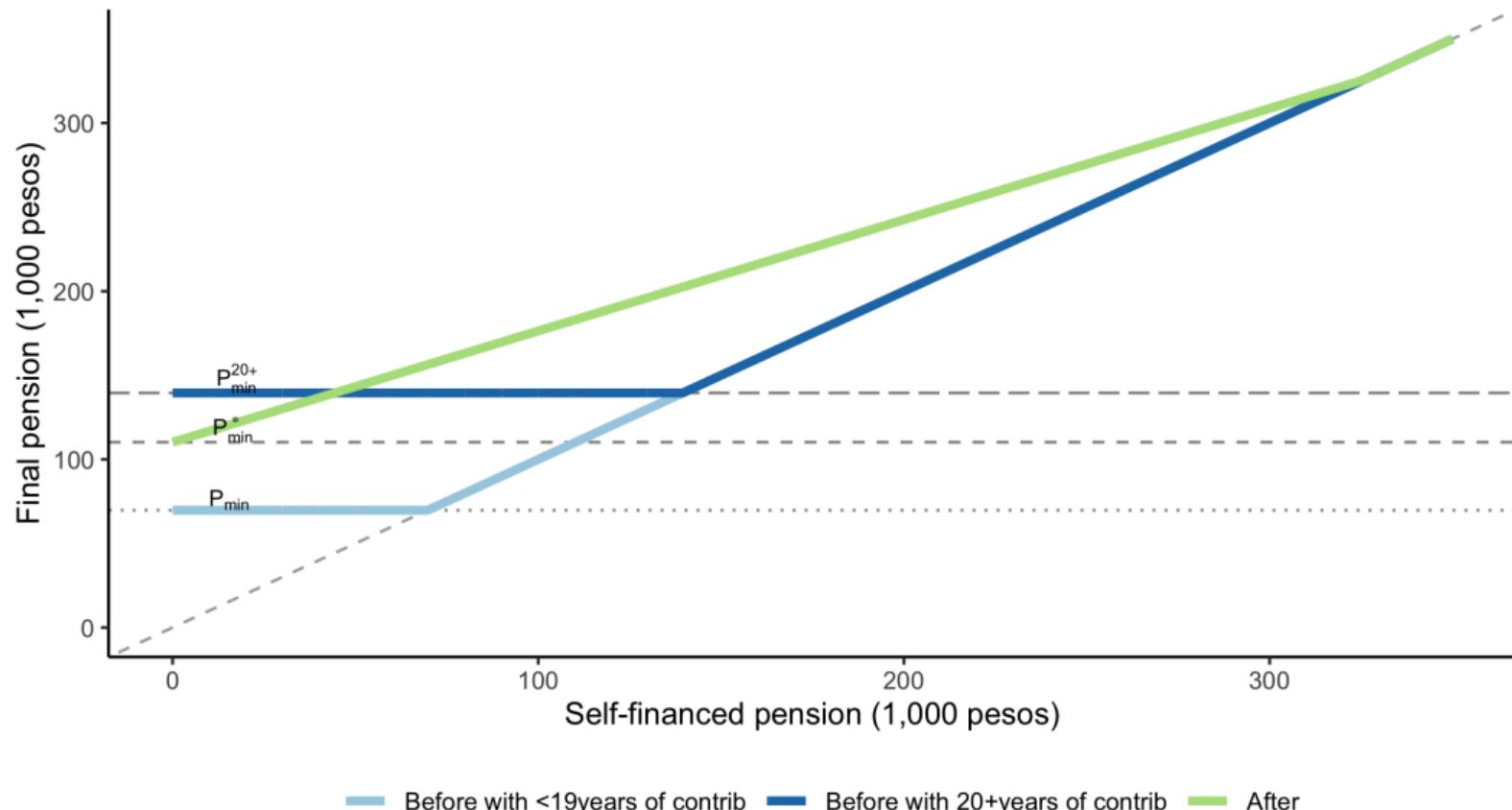
[Full BC](#)[Back](#)

- ▶ ↑ floor/bonus pension benefits
- ▶ ↑ requirements for early retirement



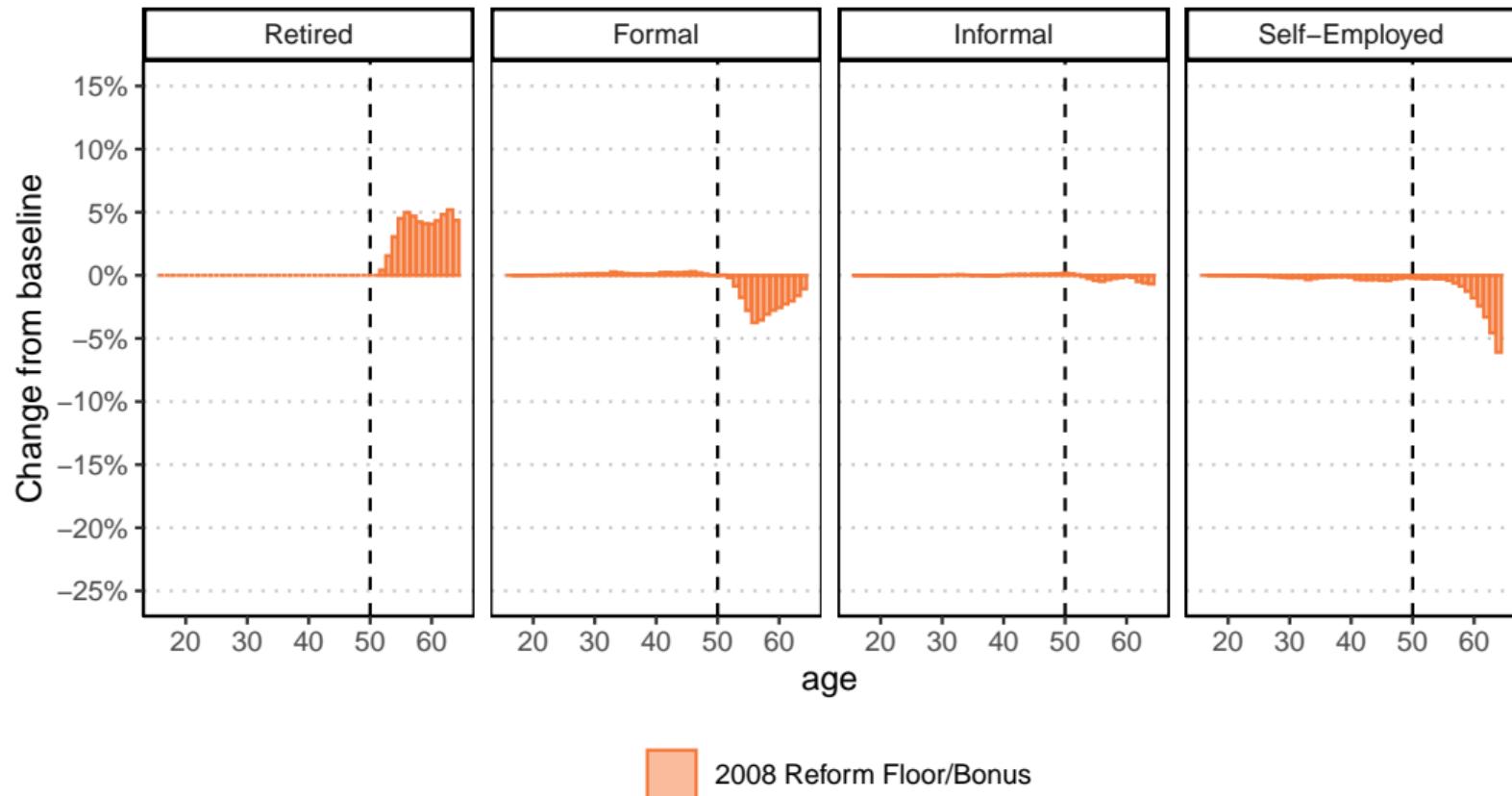
2008 Reform - New Budget Constraint

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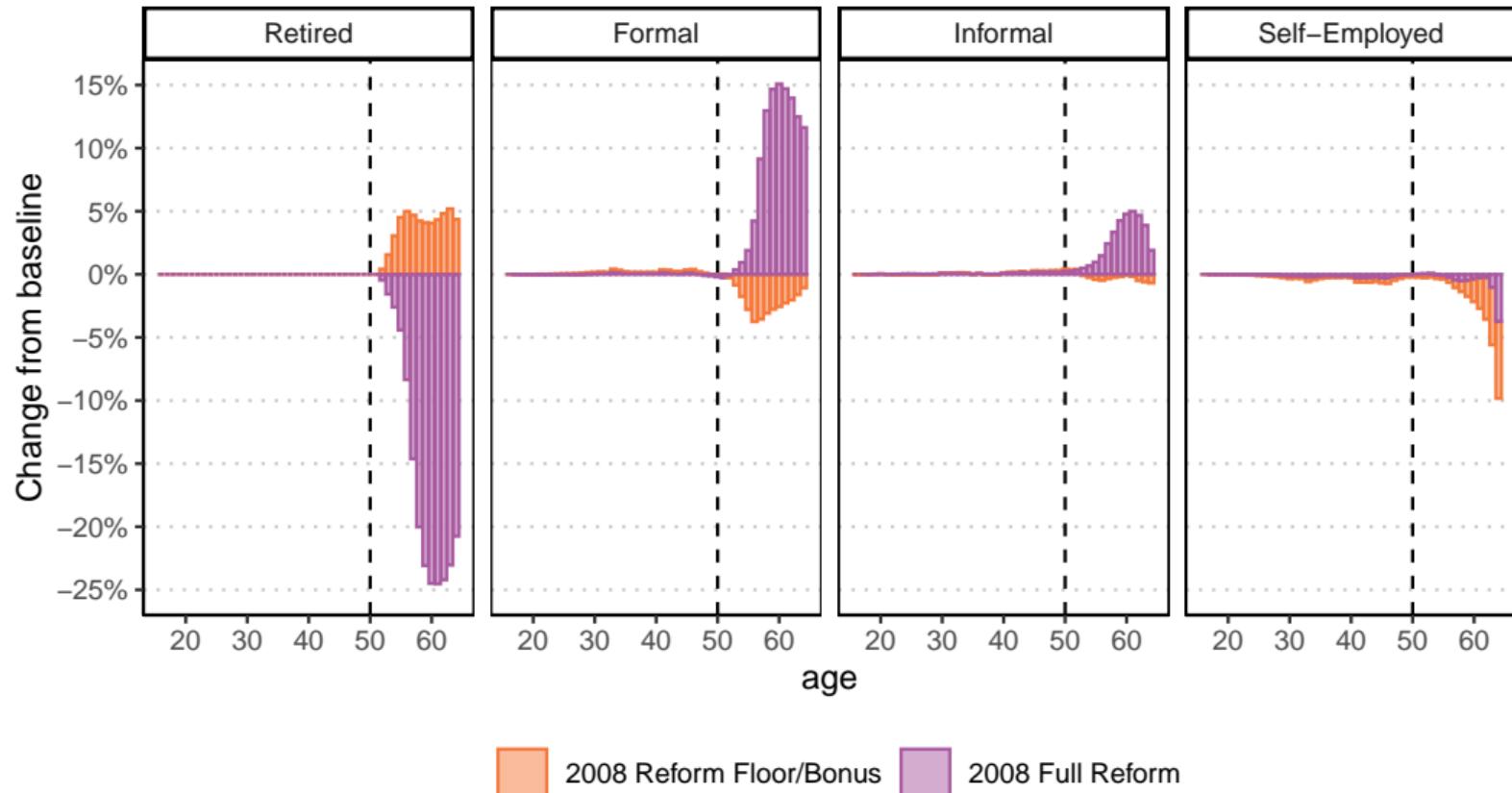
2008 Pension Reform

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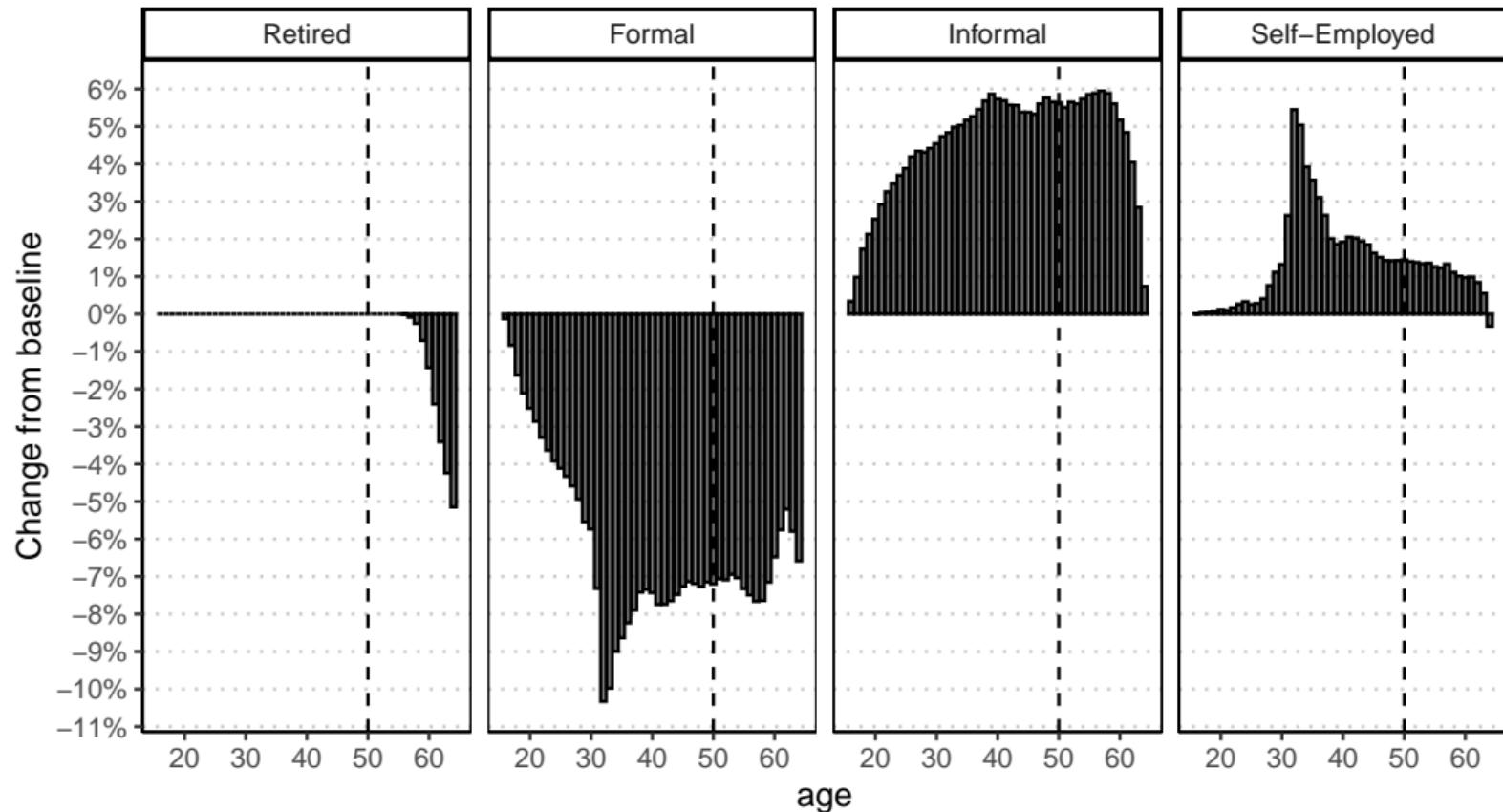
2008 Pension Reform

[Back](#)



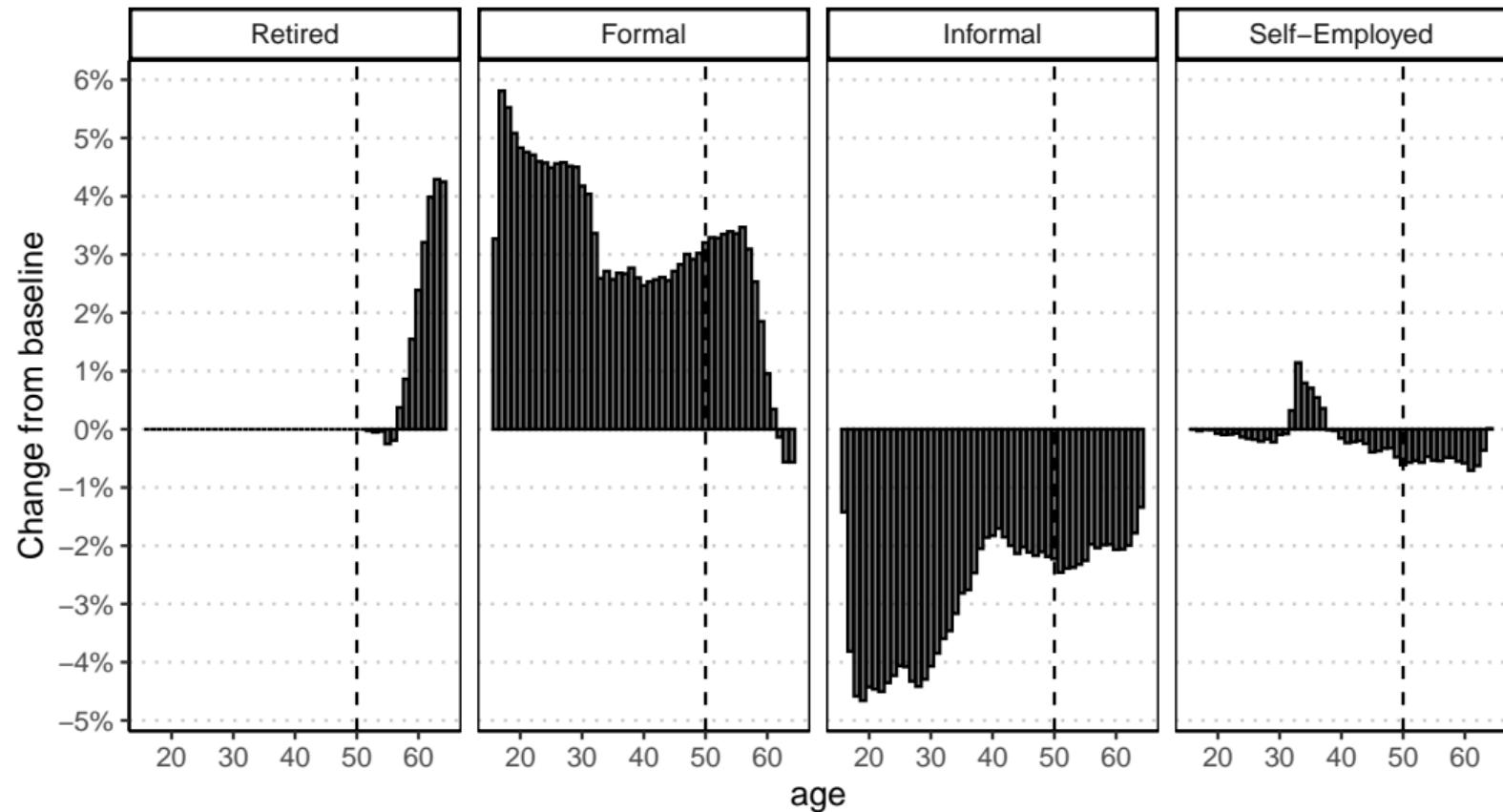
2022 Pension Reform

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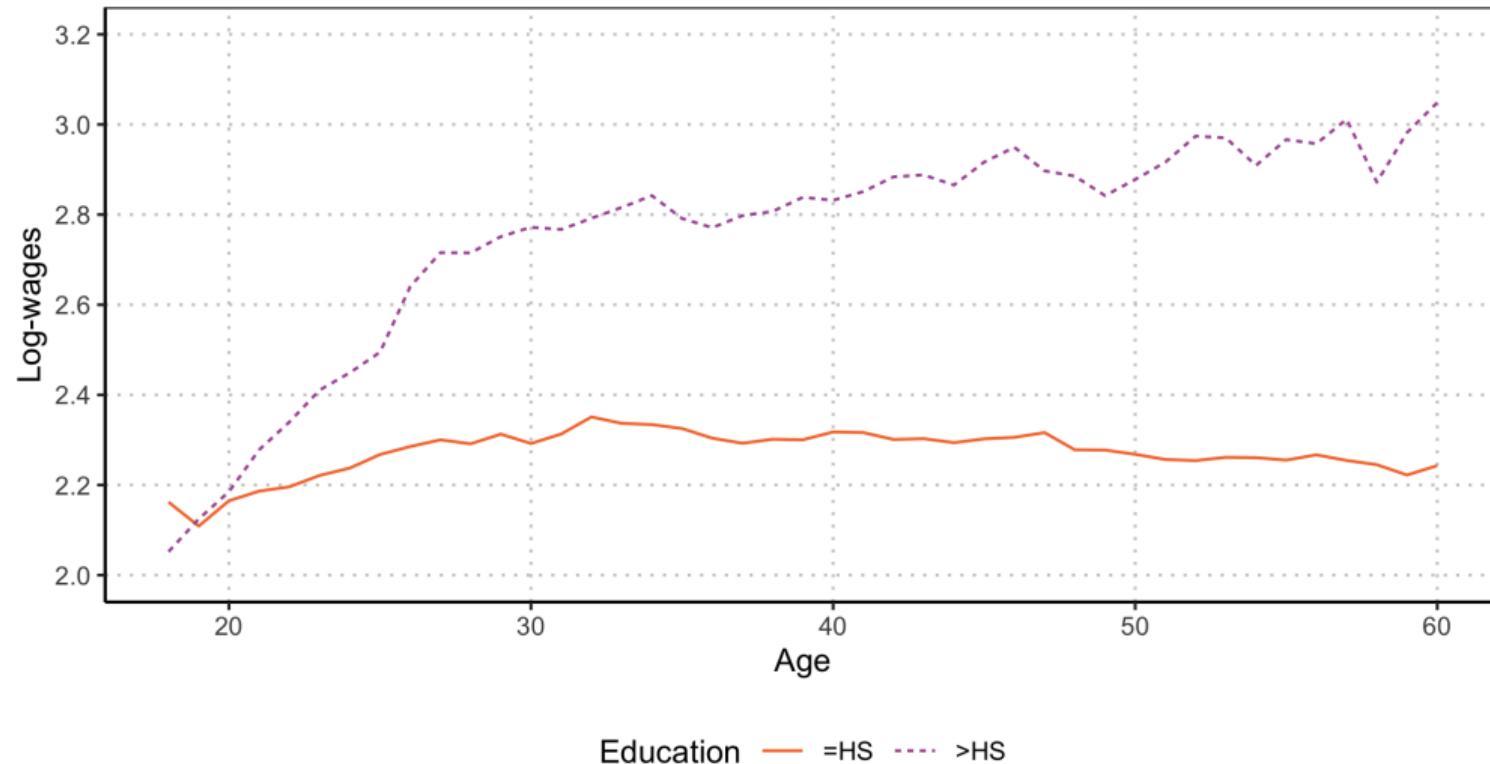
Improving Search

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Additional

Modest wage growth for High School or less



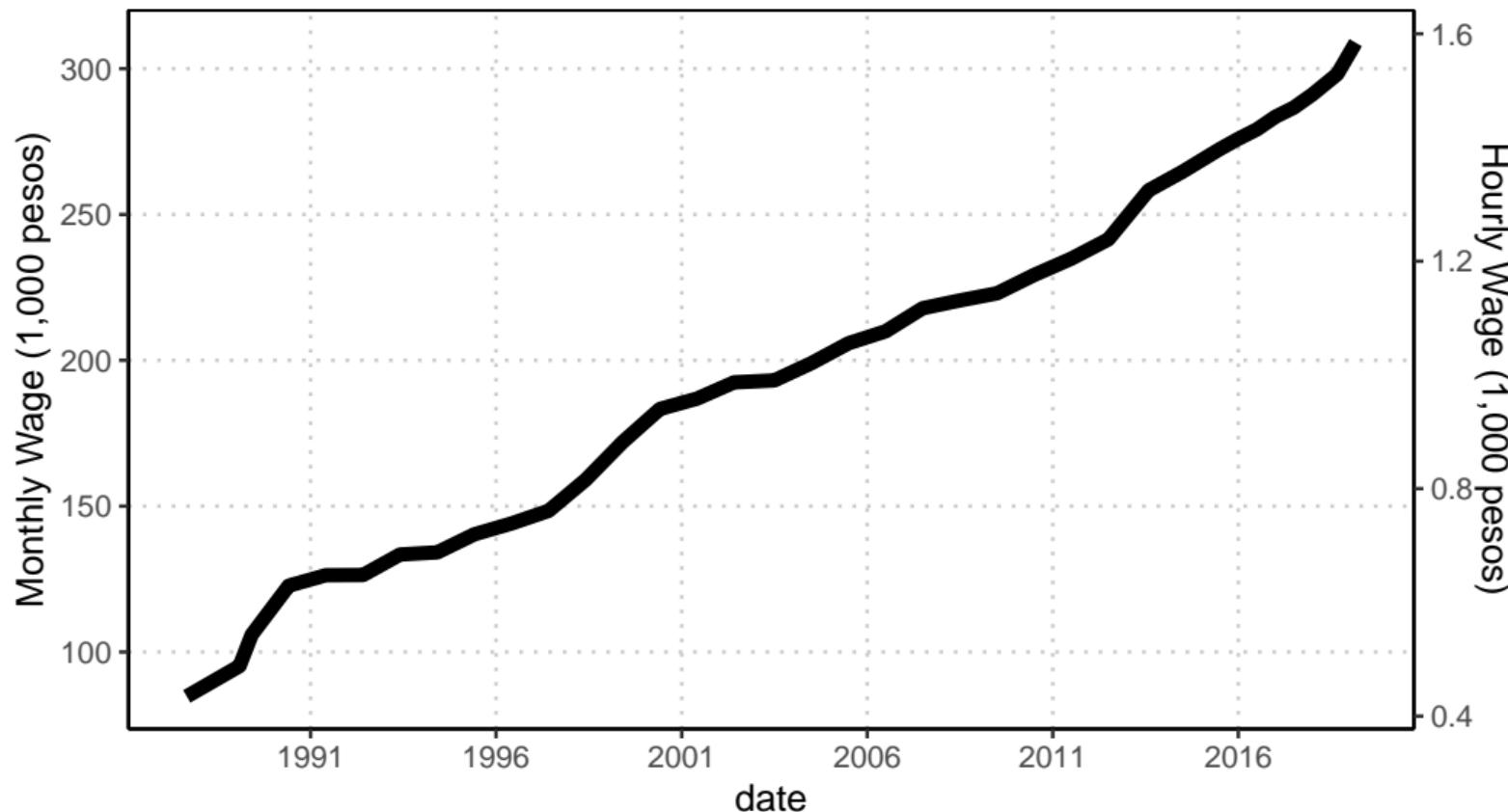
Log-Monthly Wages, for those working full time, de-trended using a linear trend.

Modest wage growth for High School or less



Log-Monthly Wages, for those working full time, de-trended using a linear trend.

Minimum Wage



Spouses' working sector

Own sector ↓	Spouse's sector:				
	Out Labor Force	Unemployed	Formal	Informal	Self-Employed
Informal	-0.0026 (0.0227)	0.0419*** (0.0132)	-0.0429*** (0.0152)	0.0013 (0.0082)	0.0003 (0.0096)
Self-Employed	-0.0857*** (0.0218)	0.0114 (0.0095)	-0.0300** (0.0142)	-0.0051 (0.0071)	0.1068*** (0.0146)
Observations	2,771	2,771	2,771	2,771	2,771
Age FE	✓	✓	✓	✓	✓

Family composition

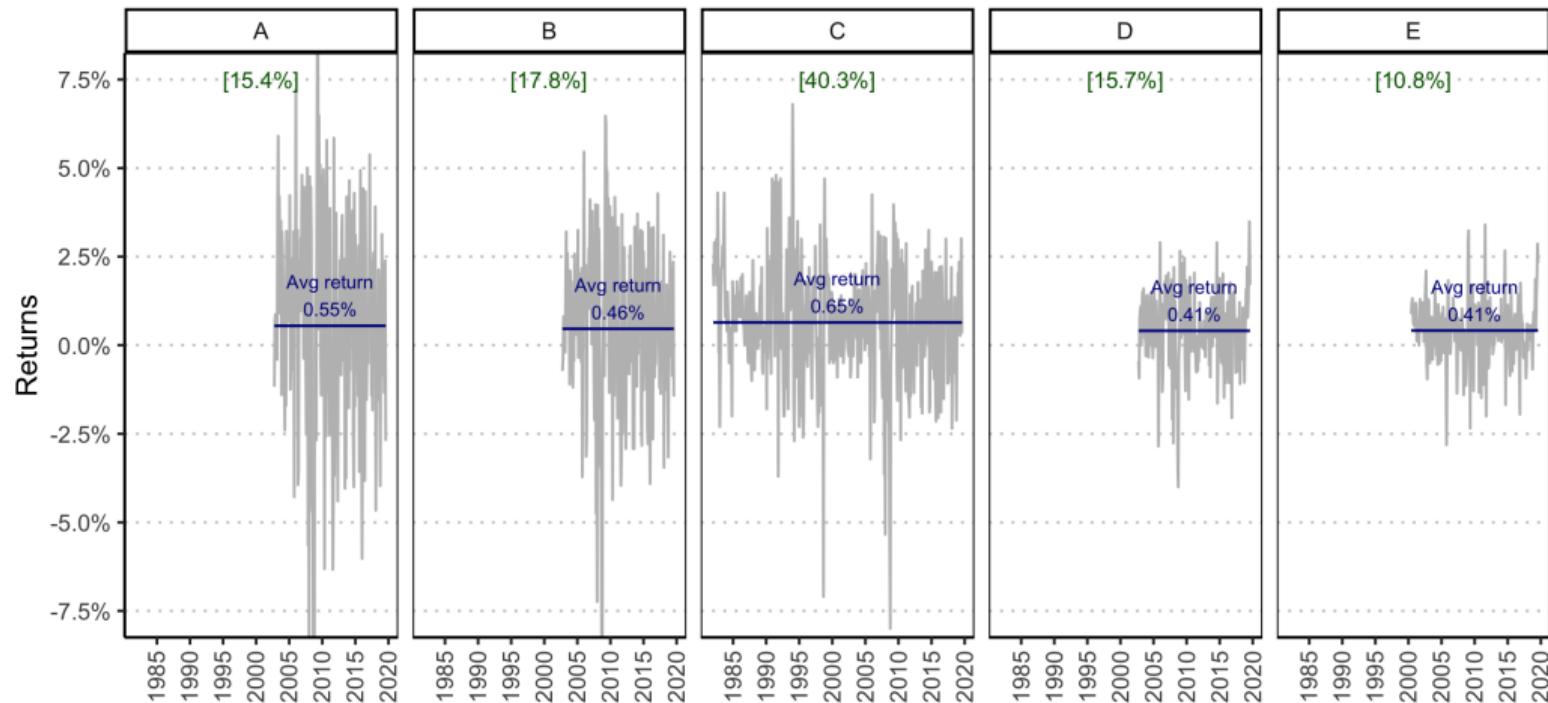
Sector:						
	Out Labor Force	Unemployed	Formal	Informal	Self-Employed	Retired
Married	-0.0473*** (0.0060)	-0.0289*** (0.0046)	0.0973*** (0.0092)	-0.0254*** (0.0056)	-0.0101 (0.0080)	0.0019 (0.0031)
Children 0–6	-0.0343*** (0.0053)	-0.0146** (0.0063)	0.0382*** (0.0124)	-0.0077 (0.0072)	0.0172* (0.0096)	-0.0083*** (0.0025)
Children 7–18	-0.0287*** (0.0053)	-0.0176*** (0.0051)	0.0377*** (0.0100)	-0.0025 (0.0058)	0.0104 (0.0081)	-0.0081*** (0.0026)
Observations	28,010	28,010	28,010	28,010	28,010	28,010
Age FE	✓	✓	✓	✓	✓	✓

Pension returns risk

- ▶ Pension returns' risk:
 - Estimate an AR(1) model with the monthly pension returns
 - Simulate accrued pension wealth for a fixed wage profile
 - Ratio of 10%-90% is 2.56
- ▶ Longevity risk:
 - Mortality tables imply that the 10%-90% survival gap for those alive at age 50 is 26 years

Pension returns risk

Monthly Return by Pension Funds Risk



Note: HPA. A is the riskiest fund and E the safest one. The blue lines and blue numbers represent the average monthly return for each fund. The green numbers in brackets are the proportion of pension wealth allocated in each fund.

Risk aversion and sector of employment

	Formal	Informal	Self-employed
(Intercept)	0.417 (0.006)	0.123 (0.004)	0.189 (0.005)
Risk 1	0.035 (0.017)	0.013 (0.012)	0.013 (0.014)
Risk 2	0.0007 (0.015)	-0.005 (0.010)	0.010 (0.012)
Risk 3	-0.041 (0.010)	0.008 (0.007)	0.054 (0.009)
Observations	15,885	15,885	15,885

Reordering

1. Unemployment Insurance

- 3% of wages:
$$\underbrace{(\text{individual account})}_{\text{forced savings}} + \underbrace{(\text{collective account})}_{\text{insurance/redistribution}}$$
- Withdrawal schedule (50%,45%,40%,...)
- Limit of 5 months from the collective account

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- One monthly wage for every year on the job

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3. **Pension system**

- Individual capitalization with privately managed accounts
- 10% of wages
- Minimum pension policies

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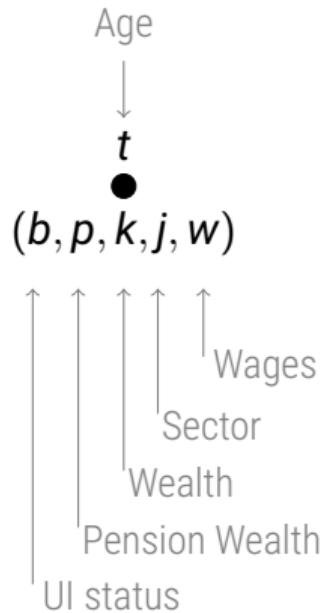
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3. **Pension system**

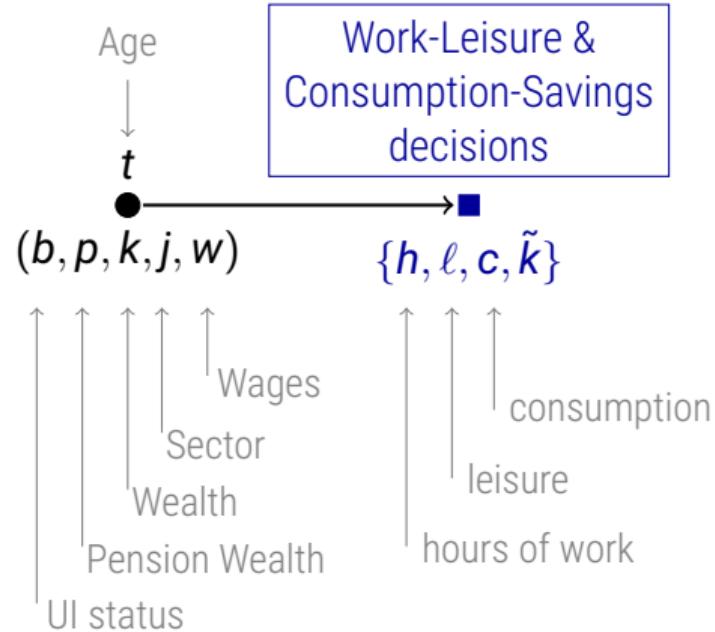
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4. **Welfare Programs** and **Income Tax**

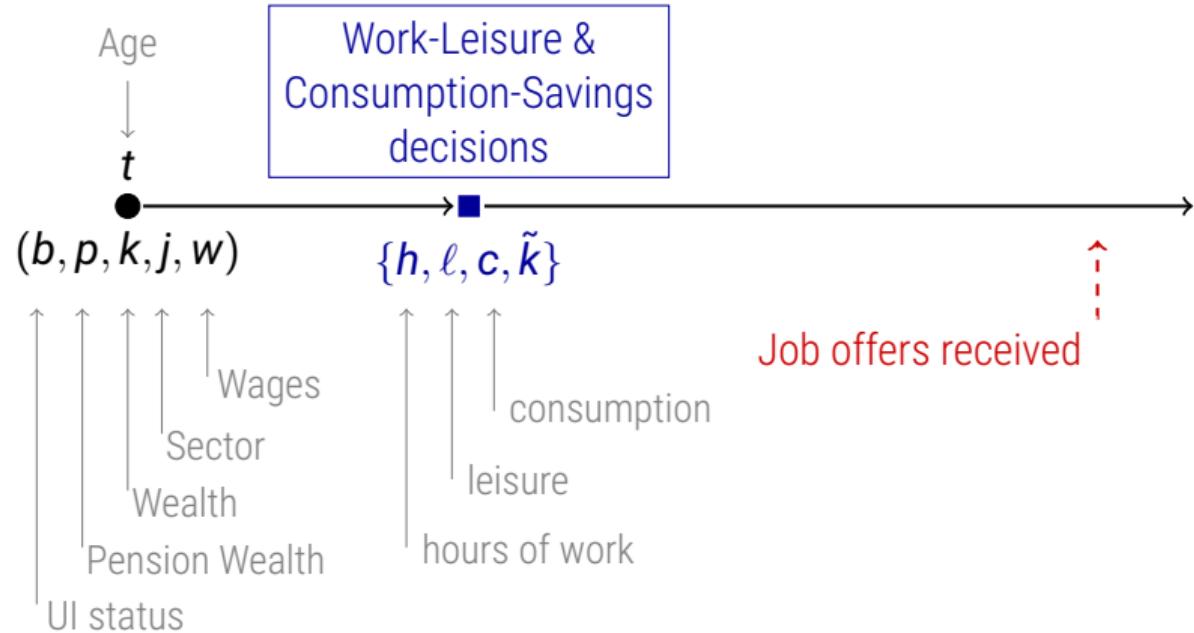
Model



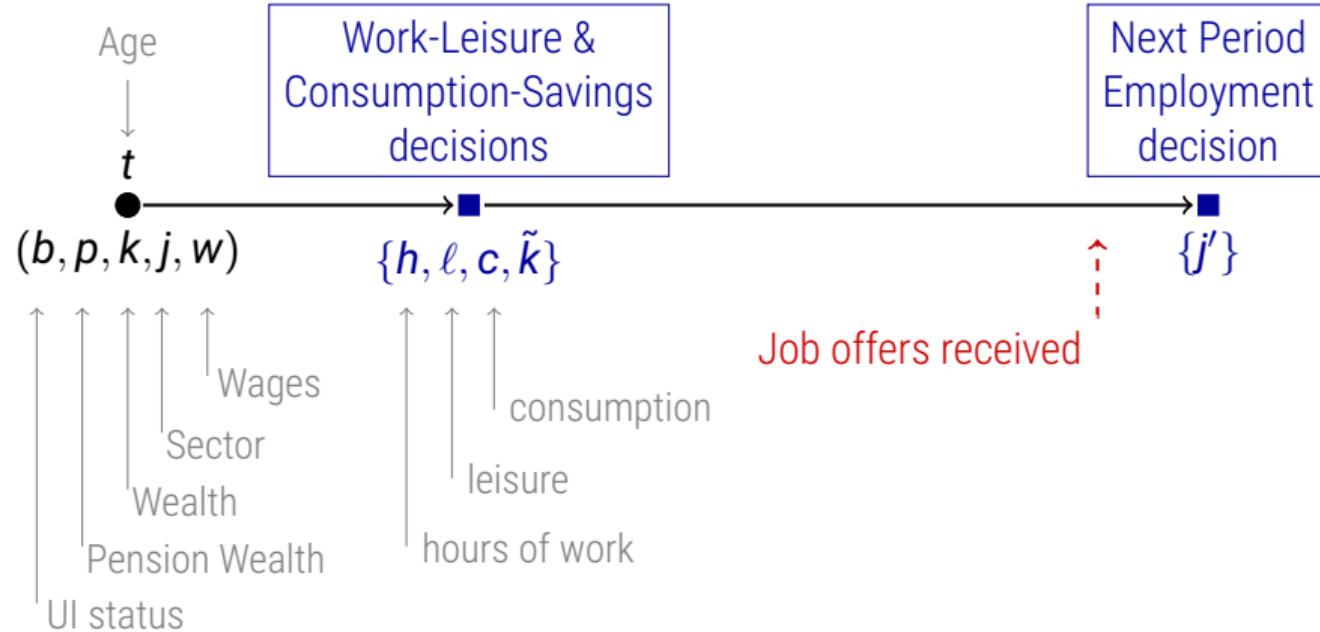
Model



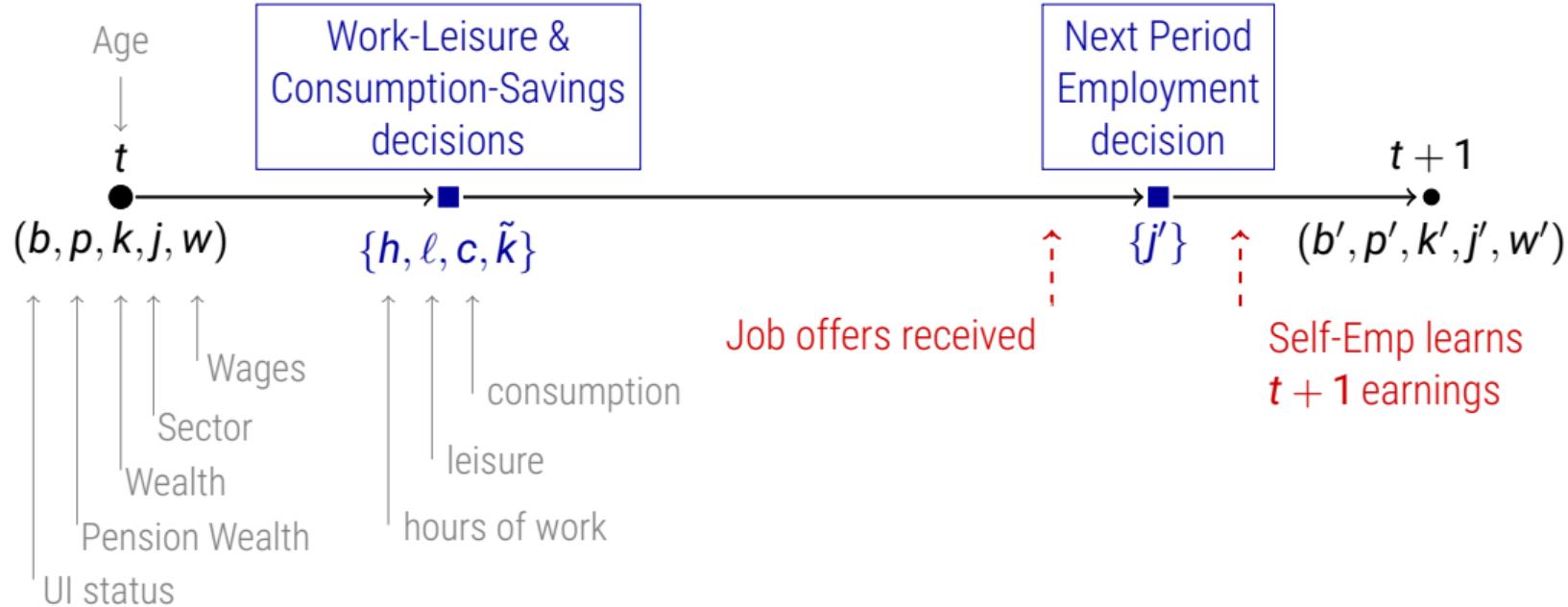
Model



Model



Model



Model



Consumption/savings choice

$$V_t(\chi) = \max_{\substack{h, \ell, c, \tilde{k} \\ \text{state space}}} \left\{ \frac{\phi_j(c^\nu \ell^{1-\nu})^{1-\gamma}}{1-\gamma} + \beta \underbrace{\mathbb{E}}_{\downarrow} [V_{t+1}(\chi')] \right\}$$

Job Destruction, Arrival Offers, Self-Emp Earnings, Survival,...

Consumption/savings choice

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Job Destruction, Arrival Offers, Self-Emp Earnings, Survival,...

(budget constraint)

$$c + \tilde{k} = (1 + r)k + y^j \left(\begin{array}{c} wh \\ \uparrow \\ \text{labor earnings} \end{array} \right)$$

(leisure)

$$\ell = \overline{L} - h \left(\begin{array}{c} \uparrow \\ \text{stock of hours} \end{array} \right)$$

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$$\tilde{k} \geq \underline{B}$$

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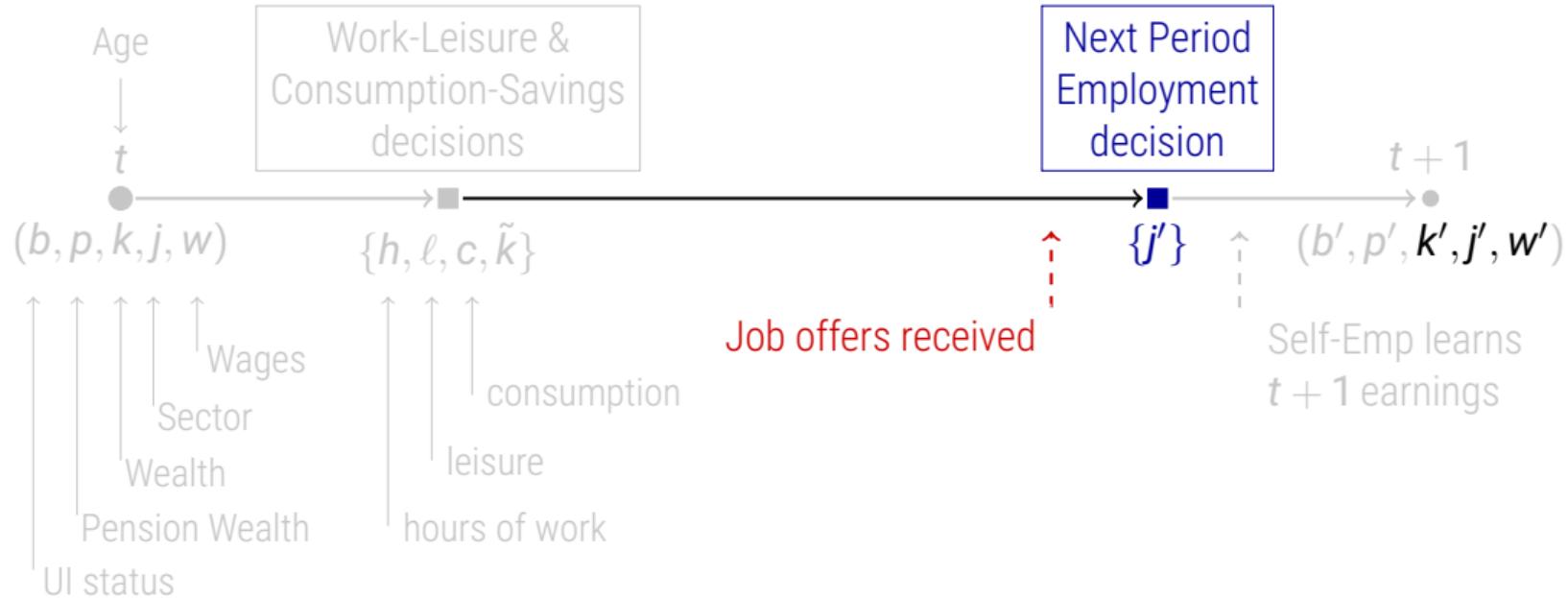
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ϕ_j : amenities from each sector

Model



Employment choice

Formal

Legend

- random
- choice if offered
- choice

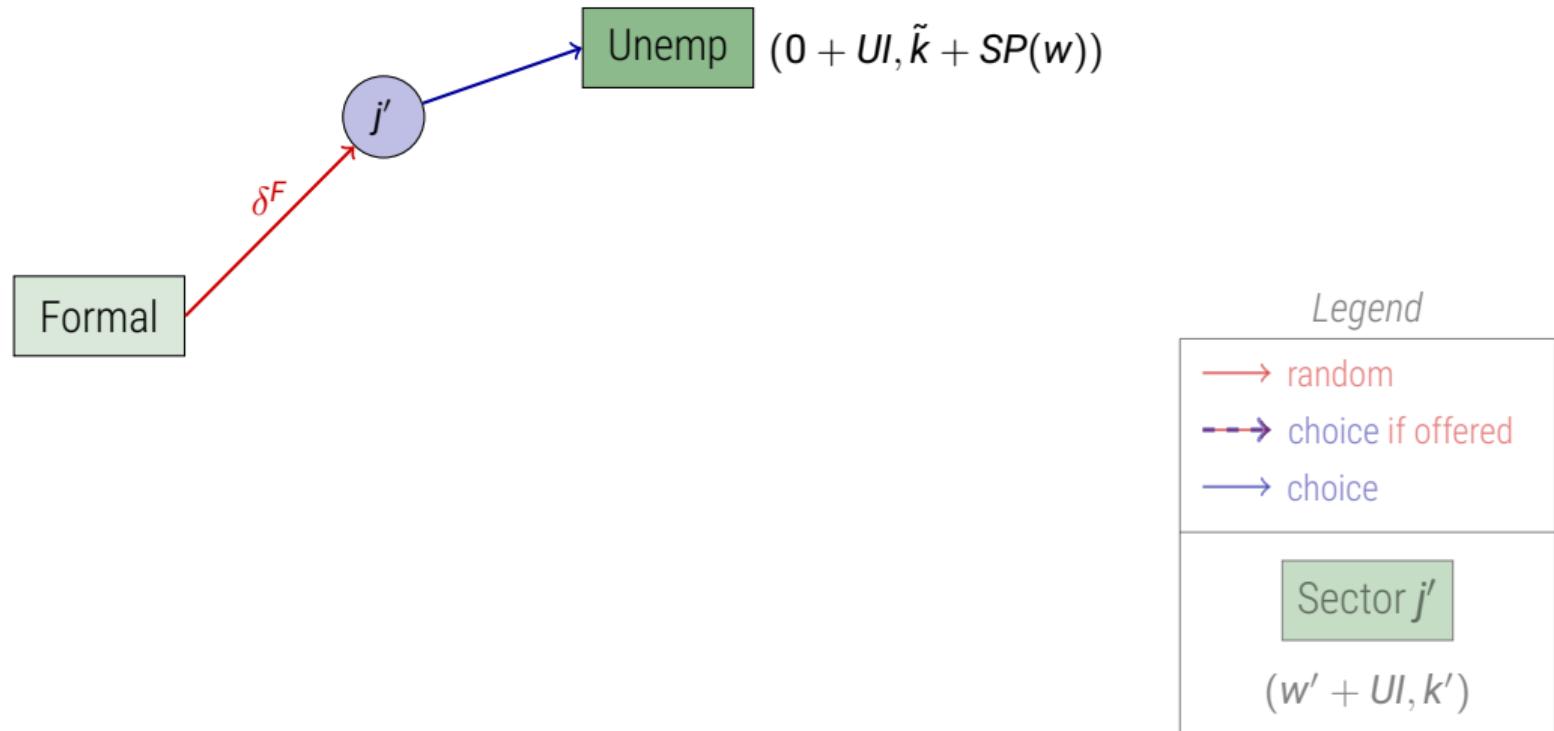
Sector j'

$(w' + UI, k')$

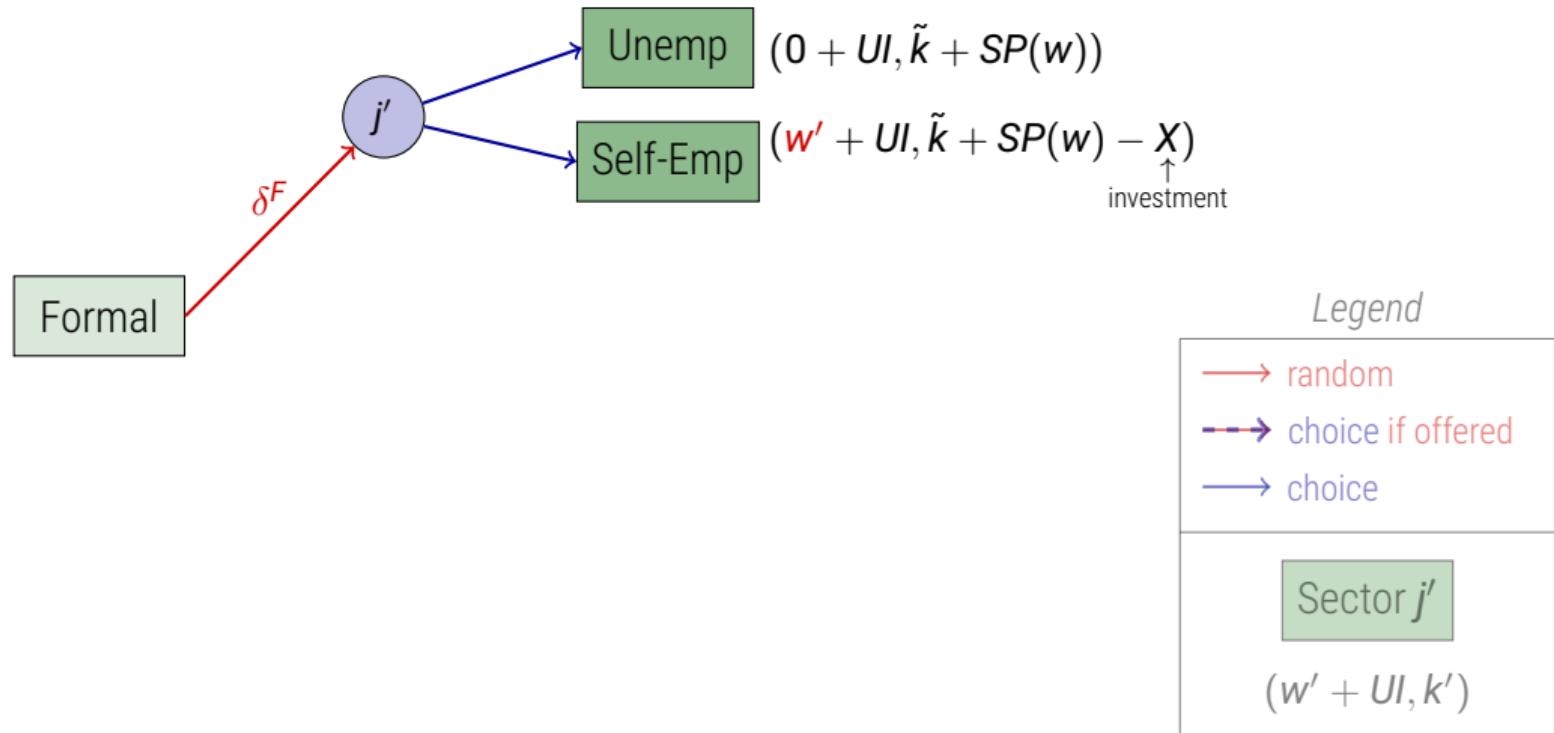
Employment choice



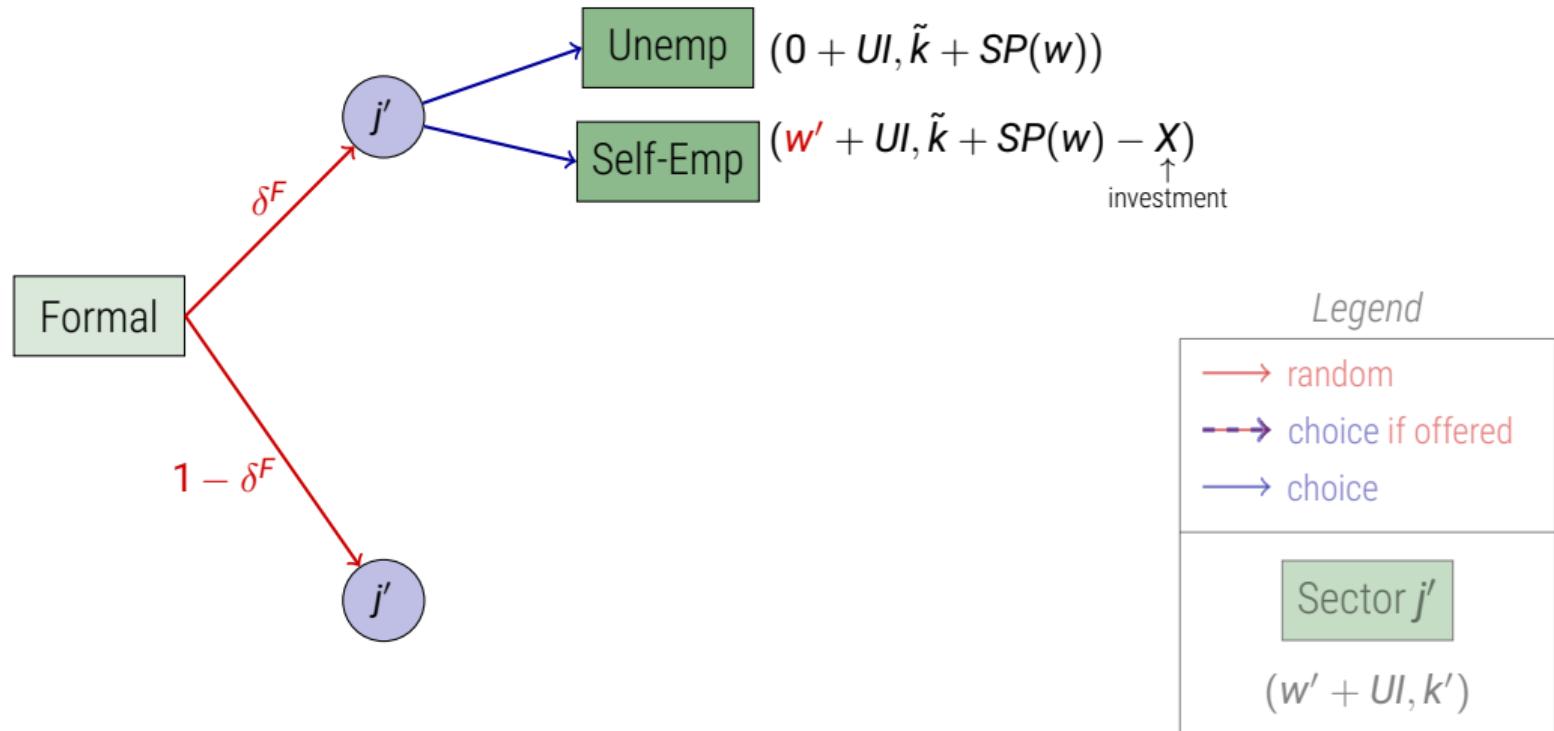
Employment choice



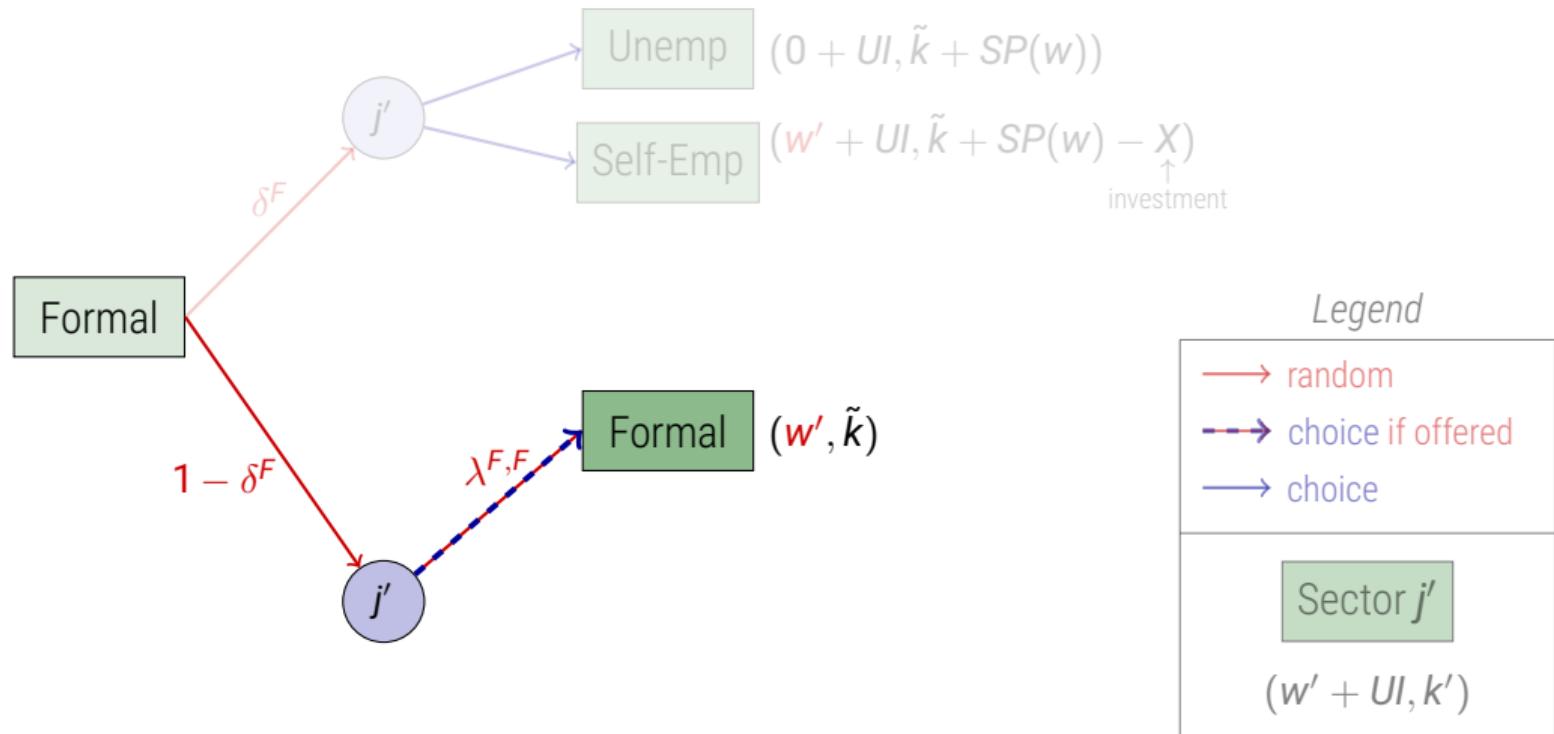
Employment choice



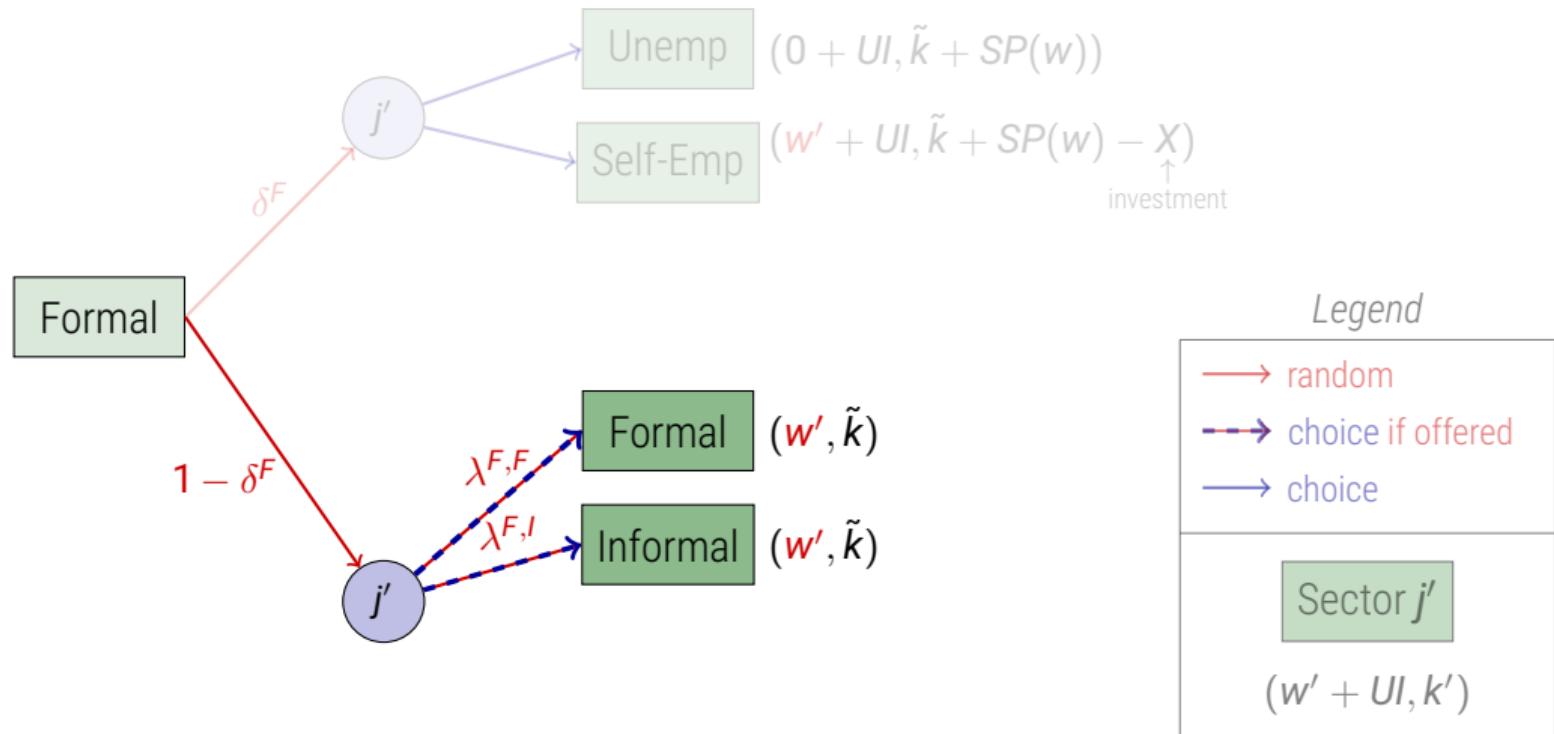
Employment choice



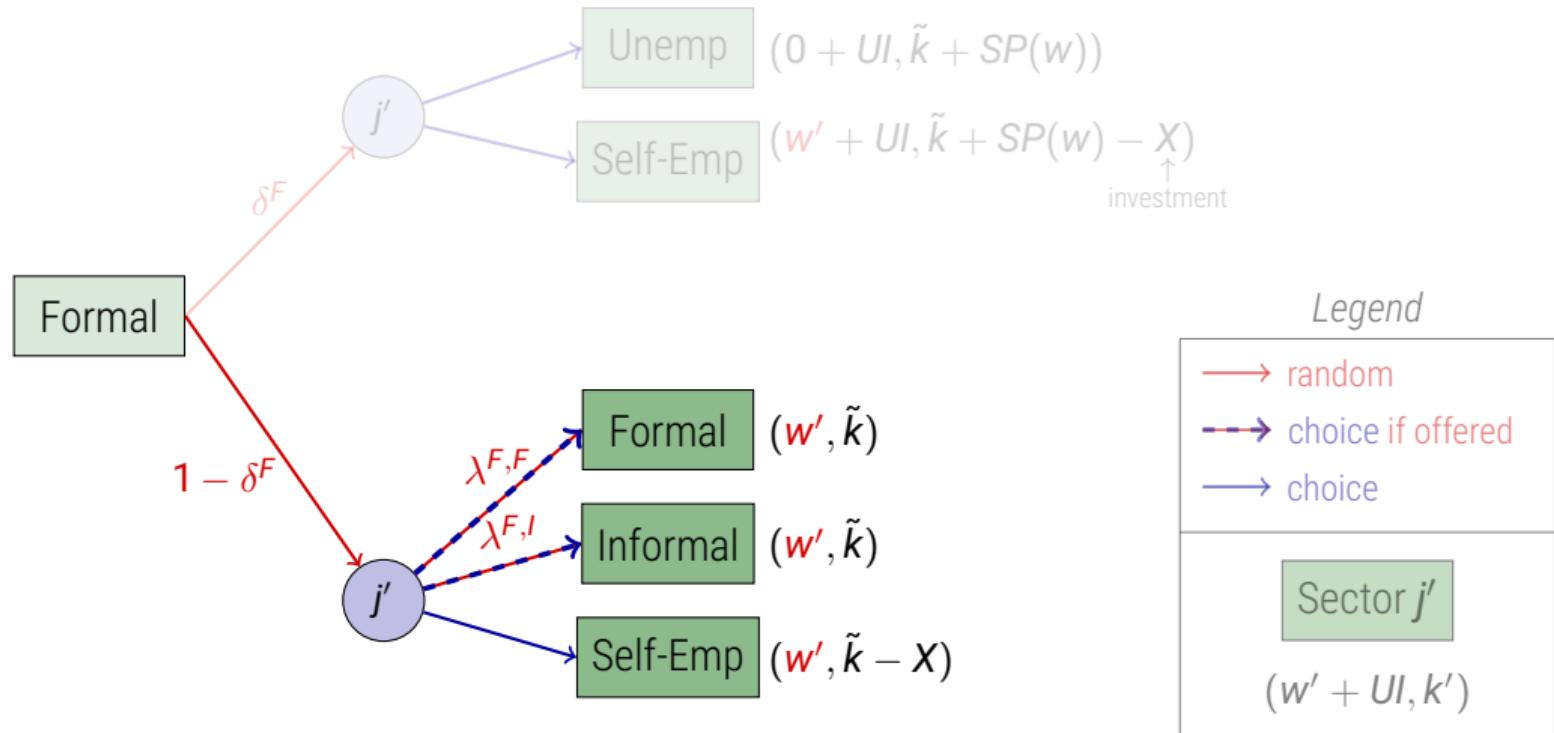
Employment choice



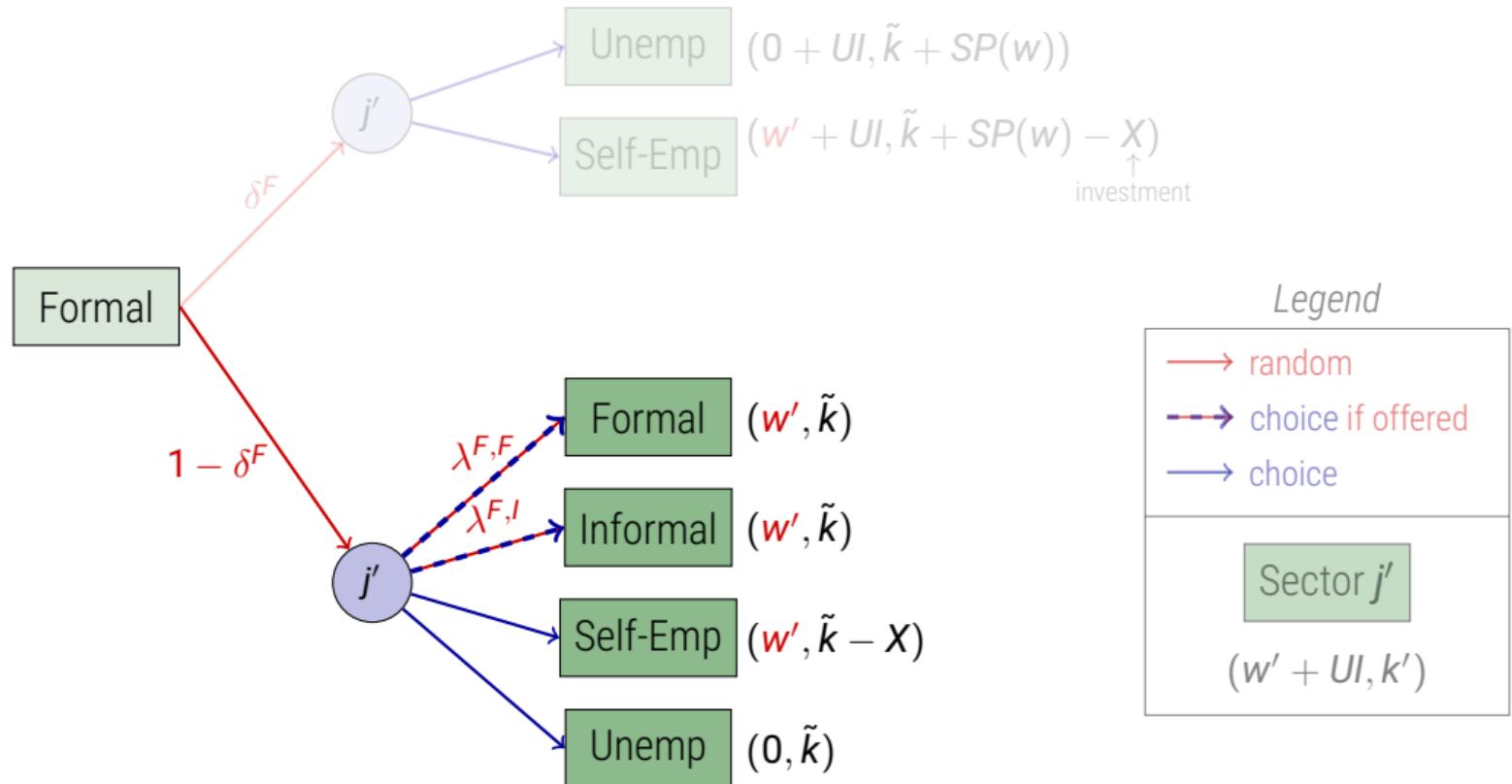
Employment choice



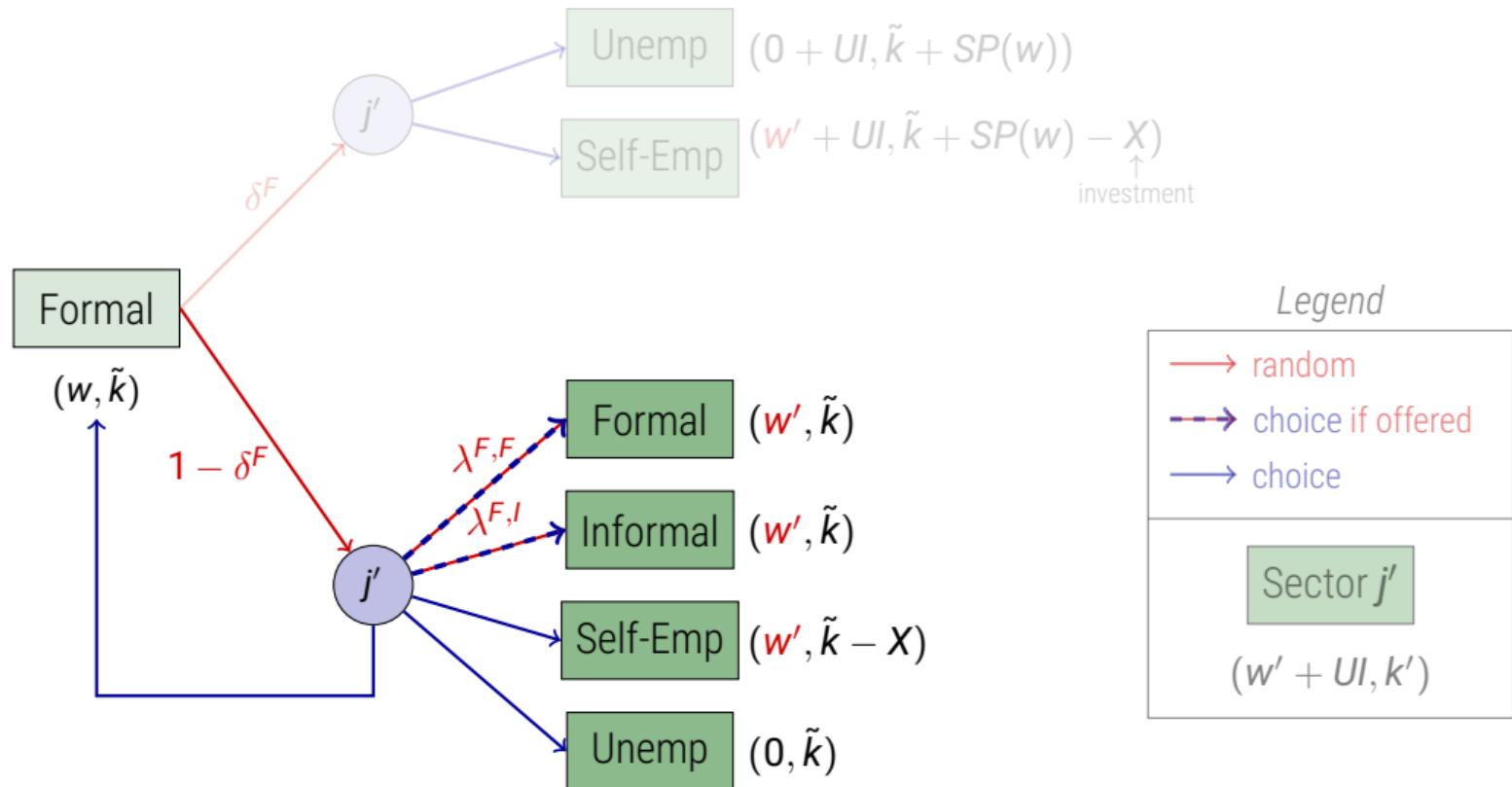
Employment choice



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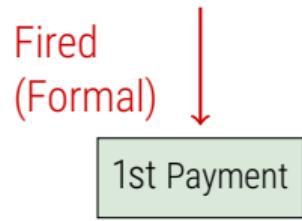
Employment choice



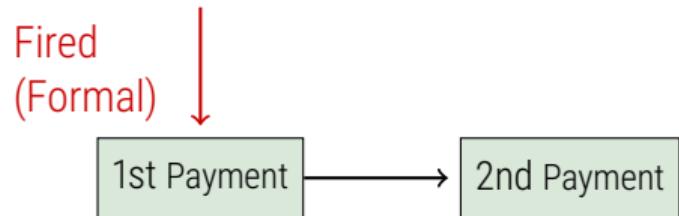
Model



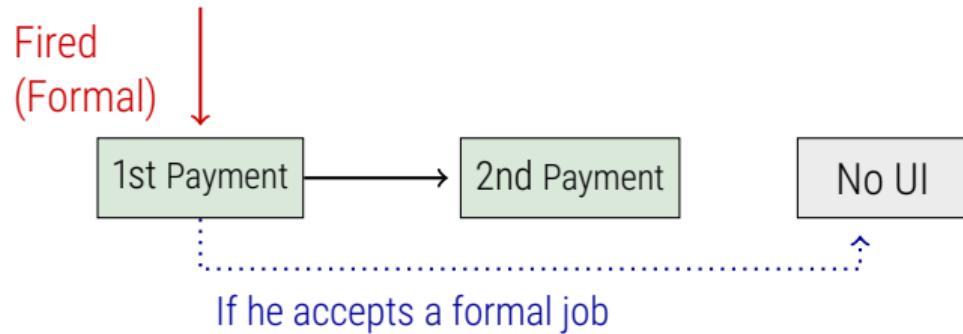
Unemployment insurance



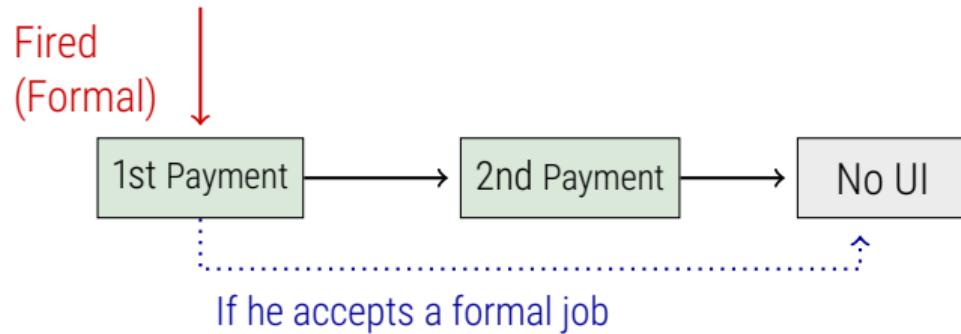
Unemployment insurance



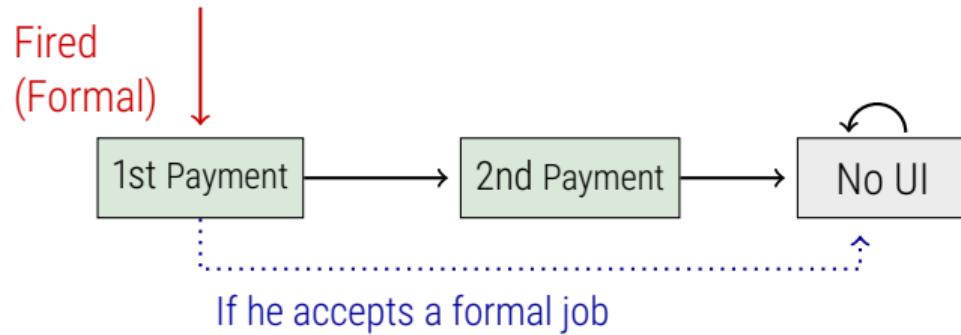
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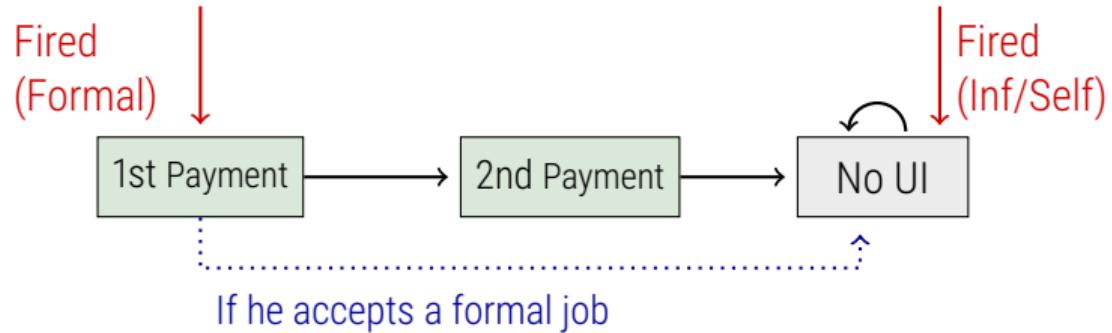
Unemployment insurance



Unemployment insurance



Unemployment insurance



The pension system

Pension wealth

$$p' = p(1 + r^P) + \begin{cases} 0.10w & \text{if formal} \\ 0 & \text{otherwise} \end{cases}$$

The pension system

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- ▶ Pension benefits: $y^R(t_R, p)$
- ▶ Early retirement is possible if $y^R(t_R, p) \geq \max\{A, \alpha\bar{w}\}$

The pension system

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- ▶ Pension benefits: $y^R(t_R, p)$
- ▶ Early retirement is possible if $y^R(t_R, p) \geq \max\{A, \alpha\bar{w}\}$
- ▶ Bequeath remaining wealth

$$B(k) = \psi \left[\frac{(\bar{K} + k)^{\nu(1-\gamma)}}{1 - \gamma} \right]$$

Types

- ▶ Individuals differ in three dimensions:
 - **Cohort**: age they will face the pension reforms (unexpected)

Types

- ▶ Individuals differ in three dimensions:
 - **Cohort**: age they will face the pension reforms (unexpected)
 - **Initial wealth**: amount of capital at time 0

Types

- ▶ Individuals differ in three dimensions:
 - **Cohort**: age they will face the pension reforms (unexpected)
 - **Initial wealth**: amount of capital at time 0
 - **Ability**: general and entrepreneurial ability
 - (g, e)
 - Affect earnings
- ▶ Three dimensions are independent

Wages

- ▶ Average Wages

Sector	Hourly	(%)	Monthly	(%)
Formal	0.870	(100.0%)	169.670	(100.0%)
Informal	0.617	(70.9%)	120.305	(70.9%)
Self-Employed	0.735	(84.5%)	133.797	(78.9%)

- ▶ Self-employment start-up cost: 3365.3 (~ 24 monthly earnings)
50% can be recouped

Ability types

- ▶ Sub-types (g, e)

Type 1: (1.000, 0.000)

Type 2: (0.559, 0.684)