Working and Saving Informally

The Link between Labor Market Informality and Financial Exclusion

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Introduction

Motivation

Developing countries are characterized by high informal employment and by low saving rates.

- High Informal employment:
  - In the Latin America and the Caribbean region (LAC), about half of the labor force is informal.
  - Informality:
    - may introduce some useful flexibility
    - but lowers workers' protections, increases employment risks, hinders productivity growth.

[Jessen and Kluve, 2021; La Porta and Shleifer, 2014; World Bank, 2013; Perry et al., 2007]

- Low Saving rate:
  - In LAC, savings are 17% of GDP compared to 30% in High-Income regions.
  - Low savings:
    - make individuals more vulnerable to shocks;
    - make economies less resilient;
    - but they are not simply due to many individuals "too poor to save".

[Cavallo et al., 2016; Bond et al. 2015; Dupas and Robinson 2013; Karlan and Morduch, 2010.]

This Paper: Why

If both high levels of informality and low levels of saving are problems in themselves, this paper studies how they feed each other to generate even worse outcomes.

- The informality status causes:
  - higher employment risk, which in turn increases the need for precautionary savings
  - significant financial exclusion, which in turn increases the cost of saving
- leading to a situation where workers with a history of informality:
  - need savings the most, but they end up with sub-optimal saving levels
  - low savings do not allow an effective labor market search, so they are more likely to accept informal jobs.
- In conclusion: low savings and high informality reinforce each other, becoming persistent.

This Paper: How

Since these deep linkages prevents from studying each problem in isolation, we develop a model that integrates all the crucial elements giving rise to both phenomena:

- Agents search on- and off-the-job for both formal and informal work;
- save through both formal financial institutions and informal ones.
- But informal workers face higher costs of accessing formal financial institutions (financial exclusion).

To provide a quantitative assessment and evaluate policy interventions, we estimate the model on Colombia:

- It belongs to a region where both issues are particularly acute (Colombia is the fourth economy in LAC).
- It collects good quality data on both saving and labor market behavior (rare among developing countries).

Preview of Preliminary Results

1. The link labor market informality and financial exclusion is confirmed:
   - Informal workers face higher costs to access formal financial institutions.
   - Granting full financial access to informal workers would increase monthly savings by 3% and formal assets by 21%. It would also decrease inequality in assets and consumption.

2. Specific policy experiment for Colombia:
   - The 2012 reform that lowered the payroll contribution from 29.5% to 16% may be responsible for increasing monthly saving by 10%.

3. Methodological contributions in the search literature:
   - First estimated search and saving model allowing for two assets: Not only a saving decision, but also a portfolio allocation decision.
     [Rendon (2006); Lentz (2009); Lise (2013); Garcia-Perez and Rendon (2020); Abrahams (2022]
   - First search and informality paper allowing for saving and borrowing: Not only labor market search decisions, but also saving decisions.
     [Bobba et al. 2022, 2021; Megir et al. 2015; Bosch and Esteban-Pretel 2012; Charlot et al. 2013; Albrecht et al 2009]

Our paper in Context

1. Large literature on savings in developing countries shows that low savings are not only due to too-poor-to-save individuals but also to institutions.

   Lack of a safe place to save [Dupas and Robinson 2013]; Capital market segmentation [Batini et al. 2010]; Not-working financial intermediation [Ogbuabor et. 2013]; Labor market informality [Lorenzo and Osimani (2001); Granda and Hamann (2015)]

   - Our contribution provides:
     - A joint model of both financial exclusion and labor market informality that can rationalize previous seemingly contradictory results.
     - Novel estimates of the importance of these institutions.

2. Growing literature using models with frictions to explain labor market informality is able to study a variety of issues but ignores the link with saving behavior and financial access which our contribution is the first to provide in this context.

   Firm productivity [Megir et al. 2015]; human capital accumulation [Bobba et al. 2022, 2021]; cyclical reallocations [Bosch and Esteban-Pretel (2012)]; different contracts in equilibrium [Albrecht et al 2009; Charlot et al. 2013]

Our paper in Context

3. Small but established literature analyzing saving with idiosyncratic risk in search models of the labor market

   Early and seminal [Danforth (1979); Acemoglu and Shimer (1999)] ; macro literature [Krusell et al. (2010); Bils et al. (2011); Ji (2021)] ; closer to us because estimate model's parameters on microdata [Rendon (2006); Lentz (2009); Lise (2013)]

   - Our contribution:
     - New application on developing countries with high informality.
     - New extension which allows for two assets and therefore for a portfolio allocation decision.

4. Tiny literature analyzing labor market informality and saving behavior

   [Esteban-Pretel and Kitao, 2021; Granda and Hamann, 2015]

   - Our contribution:
     - This literature cannot study financial exclusion: we can by introducing two assets and estimating portfolio costs.

Model

Model: General Environment

- Stationary, continuous time.
- Individuals discount the future at ρ and face a death shock with Poisson rate θ
  $\implies$ effective discount rate $\tilde{\rho} = \rho + \theta$
- They consume, search for jobs and can save and borrow.
- Objective function:
$$E_0 \int_0^{\infty} e^{-\tilde{\rho} t} \left[u(c) + \epsilon f \right]$$
  where c is consumption, $f = 1$ if formal, $\epsilon > 0$ is the additional utility of being hired formally.
- We assume risk aversion of the form: Constant Relative Risk Aversion (CRRA)
$$u(c) = \frac{c^{\delta}}{\delta}$$

Model: Labor Market Environment

- Three labor market states:
  1. Unemployed
     - Flow income b (social protection benefits, transfers, others)
     - Job offers at rate λ^u
  2. Employment in an informal job.
     - Flow income w
     - Job offers at rate $\lambda^e(0)$
     - Termination shock at rate $\eta(0)$
  3. Employment in a formal job.
     - Receive flow income $w(1-\tau)$
     - Receive job offers at rate $\lambda^e(1)$
     - Termination shock at rate $\eta(1)$

- Job offer is a pair $\{w, f\}$ where:
  - $f \in \{0, 1\}$, $f = 1$ if formal status
  - $w \sim F(w|f)$
  - $p(f) =$ proportion of f-status offers in the population

Model: Financial Market Environment

- Markets are incomplete:
  - individuals cannot fully insure against labor income risk (but they can save and borrow up to a limit).

- There are two assets:
  1. Risk-less asset a_1 (formal asset):
     - Constant return r_1.
  2. Risky asset a_2 (informal asset):
     - Variable return r_2 with dynamics $dr_2 = \kappa(\bar{r}_2 - r_2)dt + \sigma dz$
     - In steady state $r_2 \sim \mathcal{N}\left(\bar{r}_2, \frac{\sigma^2}{2\kappa}\right)$

- Wealth: $a = a_1 + a_2$
  - Share of formal assets $\phi = \frac{a_1}{a}$.
  - Convex costs to maintain portfolio ϕ:
    - $\frac{\psi^e(f)}{2}\phi^2 \implies \psi^e(0) > \psi^e(1)$ captures financial exclusion.
  - Self-imposed borrowing limit [Aiyagari 1994]: $\underline{a} = -\frac{b}{\bar{r}_2(1+\nu)}$

The steady state value of unemployment is:

$$\begin{aligned}\tilde{\rho}U(a,r_2) &= \max_{0\leq c\leq\bar{c},0\leq\phi\leq 1}\{u(c) \\ &+ \lambda^u\sum_{f=0}^{1}\int_w \max\{W(a,r_2,w,f)-U(a,r_2),0\}dF(w|f)p(f)\} \\ &+ \partial_a U(a,r_2)\left[(r_1\phi+r_2(1-\phi))(1+\nu I_{a^-})a+b-c-\frac{\psi^u}{2}\phi^2\right] \\ &+ \partial_{r_2}U(a,r_2)\kappa(\bar{r}_2-r_2)+\frac{1}{2}\partial^2_{r_2}U(a,r_2)\sigma_z^2\}\end{aligned}$$

where ν is the markup over the savings rate that financial institutions charge and $I_{a^-}=1$ if $a<0$ (borrowing).

Notice conditioning on both a and r_2.

Model: Value functions

The steady state value of employment is:

$$\begin{aligned}
\tilde{\rho} W(a, r_2, w, f) &= \max_{0 \leq c \leq \bar{c}, 0 \leq \phi \leq 1} \{u(c) + \epsilon f \\
&+ \lambda^e(f) \sum_{f=0}^{1} \int_{w'} \max\{W(a, r_2, w', f') - W(a, r_2, w, f), 0\} dF(w'|f') p(f') \\
&+ \eta(f) \left[U(a, r_2) - W(a, r_2, w, f)\right] \\
&+ \partial_a W(a, r_2, w, f) \left[(r_1 \phi + r_2(1-\phi))(1 + \nu I_{a^-})a + w(1-\tau f) - c - \frac{\psi^e(f)}{2}\phi^2\right] \\
&+ \partial_{r_2} W(a, r_2, w, f) \kappa(\bar{r}_2 - r_2) + \frac{1}{2}\partial^2_{r_2} W(a, r_2, w, f) \sigma_z^2\}
\end{aligned}$$

Model: Decisions rules

- Optimal decisions on job offers are derived by pairwise value function comparisons.

$$\begin{cases} \text{accept an offer } \{w, f\} \text{ if } W(a, r_2, w, f) \geq U(a, r_2) & \text{unemployed} \\ \text{accept an offer } \{w', f'\} \text{ if } W(a, r_2, w', f') \geq W(a, r_2, w, f) & \text{employed with } \{w, f\} \end{cases}$$

- Optimal decision rules on $\{c, \phi\}$ are derived from the first order conditions of the value functions:
  - Unemployment:

$$\begin{aligned} u'(c) &= \partial_a U(a, r_2) \\ (r_1 - r_2)(1 + \nu I_{a^-})a &= \psi^u \phi \end{aligned}$$

  - Employment:

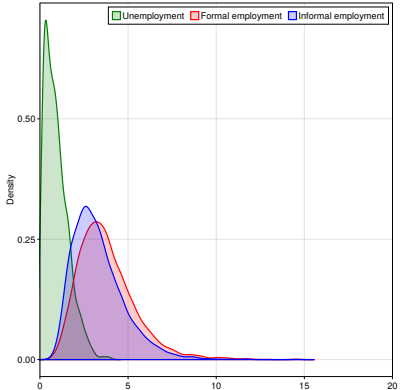
$$\begin{aligned} u'(c) &= \partial_a W(a, r_2, w, f) \\ (r_1 - r_2)(1 + \nu I_{a^-})a &= \psi^e(f)\phi \end{aligned}$$

  Note: Corner solutions at $\phi = 0, \phi = 1$ are possible.

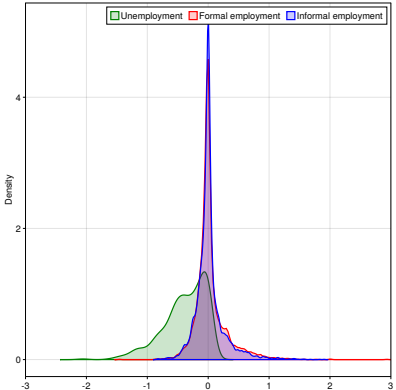
Definition
Given the primitive parameters $\{\rho, \theta, \lambda^u, \lambda^e(1), \lambda^e(0), \eta(1), \eta(0), \psi^u, \psi^e(1), \psi^e(0), b\}$, the instantaneous utility function $u(c)$, the distributions of wage offers $F(w|1)$, $F(w|0)$, $p(1)$ the *steady state equilibrium* is a set of values $U(a, r_2)$ and $W(a, r_2, w, f)$ that satisfy the value functions equations, together with the invariant distributions of individuals across labor market states and the invariant distributions of total assets $\Lambda(a)$.

- Endogenous:
  - hazard rates
  - accepted wages distributions
  - distribution over labor market states
  - assets distribution
- Exogenous
  - wage offers distributions
  - utility function and institutional parameters
  - Poisson rates (mobility parameters, risky asset)
  - effective discount rate

Steady State Distributions: Consumption and Savings

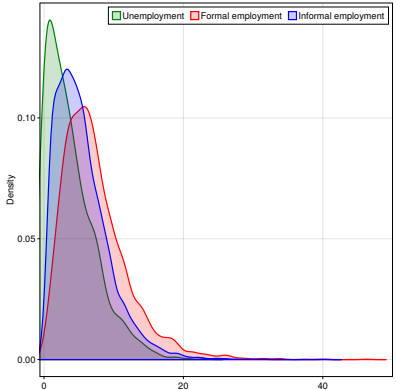


(a) Consumption (100s of $ a month)

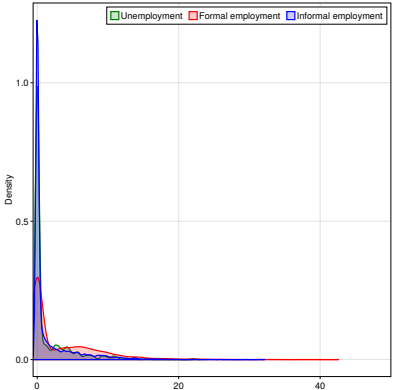


(b) Savings (100s of $ a month)

Steady state distributions: Assets



(c) Total Assets (100s of $)



(d) Formal Assets (100s of $)

Data

Data: Sources

We combine information from two data sources: GEIH and ELCA.

1. **Gran Encuesta Integrada de Hogares (GEIH)**: Monthly household survey focusing on labor market outcomes.
   - Individual characteristics (gender, age, years of schooling)
   - Labor market status:
     - Formal employment: employed individuals who contribute to social security.
     - Informal employment: employed individuals who do not contribute to social security.
     - Unemployment: individuals who are not employed.
   - Durations:
     - On-going
     - In both unemployment and employment
   - Labor income:
     - Monthly wages and salaries
     - Weekly hours worked

2. **Encuesta Longitudinal Colombiana (ELCA)**: Longitudinal survey focusing on saving behavior.
   - Individual characteristics (gender, age, years of schooling)
   - Labor market outcomes similar to GEIH with the exception of durations.
   - Savings:
     - Average monthly savings.
     - Amount of saving through formal financial institutions such as as banks, employee funds, credit unions.
     - Amount of saving through informal financial institutions such as cash, informal group savings (RoSCA funds).

Estimation Sample:

- Unskilled urban men (male, 25 and 55 years old, living in urban areas, at most secondary education)
- Observed in 2016 (most recent year for which both surveys available; we wages and salaries in December 2016 US dollars)

Descriptive statistics

Descriptive Statistics on Labor Market Outcomes

	Formal Employment	Informal Employment	Unemployment
	Labor Market States		
Proportion	0.395	0.527	0.077
	Wages (hundred of US$ per month)		
Mean	3.284	2.429	–
Standard Deviation	1.395	1.126	–
Ratio of Average Wages	1.352	1.000	–
	Ongoing Duration (months)		
Mean	67.535	89.507	4.034
Standard Deviation	78.689	100.191	6.858
	Sample		
Number Obs.	31709	42307	6195

Descriptive statistics

Descriptive Statistics on Saving Behavior

	Formal Employment	Informal Employment	Unemployment
Proportion of Individuals who save			
At all	0.271	0.211	0.036
Mainly in formal institutions	0.493	0.185	0.333
Savings amount among savers (hundred of US$)			
Mean	0.601	0.508	0.443
Standard Deviation	0.721	0.748	0.480
Saving rate among savers (savings/labor income)			
Mean	0.133	0.151	-
Standard Deviation	0.123	0.122	-
Sample Size			
Number Obs.	517	589	83

Identification

Identification

1. Wage offers distributions:
   - We need a distributional assumption [Flinn and Heckman 1982].
   - We follow the literature by assuming lognormality: $\log(w)|f \sim \mathcal{N}(\mu(f), \sigma(f))$, with $f = 0, 1$.
   - Under the assumption and the model, we can identify the primitive distribution by observing their truncations.

2. Mobility parameters:
   - Unemployment durations identify (main contribution to the identification of) λ^u
   - Employment durations jointly identify $\{\eta(f), \lambda^e(f)\}$
   - Steady state proportions in each labor market state separately identify $\eta(f)$ from $\lambda^e(f)$

3. Rate of returns:
   - Formal assets:
     - We set $r_1 = 0.075$ based on the 7.5% yearly return of the 10-year Colombian Government Bond.
   - Informal assets:
     - We assume 99% of the returns should fall between upper bound $\bar{\bar{r}}_2 = 2.1 r_1$ (Eeckhout and Munshi (2010)) and 0.
     - This condition and the steady state normal distribution lead to: $\mu_{r_2} = 0.079$ and $\sigma_{r_2} = 0.031$
     - κ is then identified by information on the savings and portfolio allocations.

4. Portfolio cost functions:
   - Monthly savings and portfolio allocations, conditional on labor market states, identify ψ^u and $\psi^e(f)$.

5. Effective discount rate and unemployed flow income:
   - They are jointly identified [Flinn and Heckman 1982]: we fix $\tilde{\rho}$ and identify b through equilibrium equations.
   - We calibrate the two components of $\tilde{\rho}$ as:
     - $\rho = 0.012$, based on the discount rate recommended for LAC by multilateral development banks;
     - $\theta = 0.013$, based on Colombia's life expectancy of 77 years.

6. Relative risk aversion parameter:
   - Notoriously difficult to identify in this class of models without additional information [Dey and Flinn 2008; Flabbi and Mabli 2018]
   - We set it at a consensus value of 1.5, implying $\delta = -0.5$. [Bond et al. 2015]

7. Institutional parameters:
   - $\tau = 0.16$ based on 2016 payroll contributions in Colombia [Fernandez and Villar 2017]
   - $\nu = 1.14$ based on the average markup that financial institutions charge when lending with respect to what they pay on (worker's) saving [IMF *International Financial Statistics*]

Estimation

Method

We estimate the model's parameters using the following Method of Simulated Moments (MSM) estimator:

$$\hat{\Xi}_{N,T}(W) = \text{argmin}_{\Xi} \frac{1}{2} \left[M_N^D - M_T(\Xi) \right]' W_N \left[M_N^D - M_T(\Xi) \right]$$

where:

- Parameter set is: $\Xi \equiv \{b, \lambda^u, \psi^u, \kappa, p(1)\} \cup \{\lambda^e(f), \eta(f), \mu(f), \sigma(f), \psi^e(f)\}_{f \in \{0,1\}}$
- M_N^D denotes the set of appropriately chosen sample statistics
- $M_T(\Xi)$ denotes the corresponding simulated statistics at Ξ from sample of size T
- W is a symmetric, positive-definite weighting matrix

and we use 41 moments to estimate 15 parameters.

Implied Values

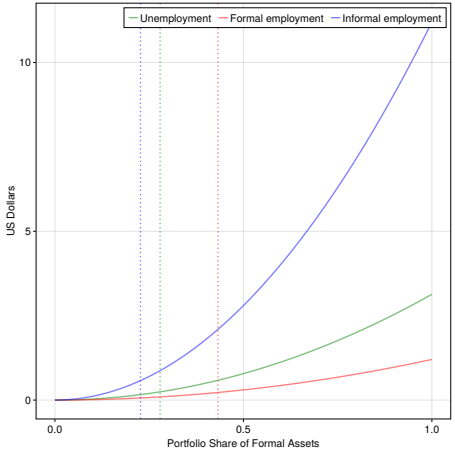
Estimated Parameters

Definition	Parameter	Est. Value	Std. Error
Mobility Shocks			
Job offer rate - unemployment	λ^u	0.178	(0.0072)
Job offer rate - formal employment	$\lambda^e(1)$	0.034	(0.0054)
Job offer rate - informal employment	$\lambda^e(0)$	0.015	(0.0040)
Job separation rate - formal employment	$\eta(1)$	0.017	(0.0039)
Job separation rate - informal employment	$\eta(0)$	0.014	(0.0027)
Job offers			
Proportion formal job offers	$p(1)$	0.455	(0.0038)
Location wages distribution - formal employment	$\mu(1)$	1.056	(0.0519)
Scale wages distribution - formal employment	$\sigma(1)$	0.394	(0.0147)
Location wages distribution - informal employment	$\mu(0)$	0.800	(0.0369)
Scale wages distribution - informal employment	$\sigma(0)$	0.408	(0.0205)

Estimated Parameters (cont...)

Definition	Parameter	Est. Value	Std. Error
Portfolio costs			
Cost function parameter - unemployment	ψ^u	0.063	(0.0045)
Cost function parameter - formal employment	$\psi^e(1)$	0.024	(0.0027)
Cost function parameter - informal employment	$\psi^e(0)$	0.224	(0.0314)
Rate of return informal assets			
Persistence	κ	0.701	(0.0218)
Std. Dev. of shock	σ_z	0.037	(0.0006)
Unemployment income			
Flow	b	0.197	(0.0230)
Utility Value of Formal Jobs			
Value	ϵ	0.026	(0.0012)

Portfolio Costs ($ per month)



NOTE: Dotted line show the average simulated portfolio allocation. Simulated samples of 10,000 individual-level observations.

Experiments

Experiments: Definitions

We perform the following counterfactual experiments by simulation:

1. **Financial inclusion**: Equal portfolio costs for formal and informal workers: $\psi^e(0) = \psi^e(1) = 0.024$.

2. **Drop in informal job offers**: Reduction that generates the same increase in savings obtained by the financial inclusion experiment: $p(0) = 0.486$ from the baseline 0.545.

3. **Increase in formal payroll contribution**: Back to the level before the influential 2012 tax reform: $\tau = 0.295$ from the baseline 0.160.

We evaluate the impact on labor market and financial outcomes and on wealth and consumption inequality taking into account the endogenous adjustment in individuals' optimal behaviors.

Results

	Benchmark	$\psi^e(0) = \psi^e(1)$		$p(0) = 0.486$		$\tau = 0.295$	
	Value	Value	Ratio	Value	Ratio	Value	Ratio
Labor market states (proportion)							
Formal emp.	0.394	0.393	0.996	0.445	1.129	0.342	0.867
Informal emp.	0.566	0.565	0.997	0.513	0.907	0.615	1.086
Unemp.	0.039	0.043	1.077	0.041	1.048	0.043	1.097
Average savings among savers (100s of $ per month)							
All workers	0.189	0.195	1.030	0.195	1.030	0.170	0.900
Formal emp.	0.221	0.225	1.019	0.226	1.020	0.176	0.797
Informal emp.	0.172	0.177	1.030	0.172	1.004	0.170	0.990
Average total assets (100s of $ per month)							
All workers	6.149	6.365	1.035	6.322	1.028	5.519	0.898
Formal workers	7.362	7.412	1.007	7.573	1.029	5.768	0.783
Informal workers	5.495	5.862	1.067	5.499	1.001	5.557	1.011
Average formal assets (100s of $ per month)							
All workers	2.241	2.705	1.207	2.305	1.028	1.921	0.857
Formal workers	3.264	3.223	0.987	3.283	1.006	2.404	0.736
Informal workers	1.598	2.461	1.540	1.566	0.980	1.704	1.066

NOTE: Benchmark's values are: $\psi^e(0) = 0.224$; $\psi^e(1) = 0.024$; $p(0) = 0.545$; $\tau = 0.160$.

Results: Inequality

General Entropy Indexes	Benchmark Value	$\psi^e(0) = \psi^e(1)$		$p(0) = 0.486$		$\tau = 0.295$	
		Value	Ratio	Value	Ratio	Value	Ratio
		Total Assets					
Mean log dev.	0.277	0.240	0.869	0.270	0.975	0.277	1.001
Theil index	0.224	0.196	0.878	0.220	0.982	0.223	0.997
Coef. of variation/2	0.247	0.216	0.872	0.242	0.979	0.241	0.975
		Formal Assets					
Mean log dev.	0.794	0.359	0.453	0.760	0.956	0.799	1.007
Theil index	0.434	0.232	0.533	0.415	0.955	0.451	1.039
Coef. of variation/2	1.625	1.135	0.699	1.556	0.958	1.678	1.033
		Consumption					
Mean log dev.	0.128	0.126	0.986	0.130	1.016	0.128	1.002
Theil index	0.110	0.107	0.971	0.111	1.007	0.109	0.990
Coef. of variation/2	0.113	0.108	0.957	0.113	1.002	0.110	0.977

NOTE: Benchmark's values are: $\psi^e(0) = 0.224$; $\psi^e(1) = 0.024$; $p(0) = 0.545$; $\tau = 0.160$.

Conclusion

Conclusion

- We develop and estimate a model able to replicate the crucial features of developing countries economies:
  1. High level of labor market informality
  2. Low level of savings
  3. High proportion of assets held in informal institutions

- Our claim that working informally is linked to saving informally is confirmed:
  - Informal workers face partial financial exclusion from formal financial institutions
  - If full financial access were guaranteed to them:
    - Savings would increase 3% a month and formal assets 21%
    - Asset inequality would decrease 13% and consumption inequality 4%

- Colombia-specific policies:
  - A recent reform reducing formal payroll contribution had the potential to increase savings by 10% a month.

Conclusion

- We also provide two methodological contributions in the labor market search literature:
  1. We add saving and borrowing to search models with informality.
     [Bobba et al. 2022, 2021; Megir et al. 2015; Bosch and Esteban-Pretel (2012)]; Charlot et al. 2013; Albrecht et al 2009]
  2. We allow for two assets and portfolio allocation decisions in an estimated search model with saving.
     [Rendon (2006); Lentz (2009); Lise (2013); Danforth (1979); Acemoglu and Shimer (1999); Krusell et al. (2010); Bils et al. (2011)]

Appendix

- Value functions iteration with a discretized state space and an upwind finite difference method to approximate the derivatives (Achdou et.al., 2017).
- Define $W_{i,j,k,f}$ and $U_{i,j}$ for the grids a_i, $r_{2,j}$, w_k.

$$\partial_a U(a, r_2) \approx \begin{cases} \frac{U_{i+1,j} - U_{i,j}}{a_{i+1} - a_i} & da > 0 \\ \frac{U_{i,j} - U_{i-1,j}}{a_i - a_{i-1}} & da < 0 \end{cases}$$

$$\partial_a W(a, r_2, w, f) \approx \begin{cases} \frac{W_{i+1,j,k,f} - W_{i,j,k,f}}{a_{i+1} - a_i} & da > 0 \\ \frac{W_{i,j,k,f} - W_{i-1,j,k,f}}{a_i - a_{i-1}} & da < 0 \end{cases}$$

- Upwind to approximation $\partial_a U(a, r_2)$ and $\partial_a W(a, r_2, w, f)$
- The upwind approximation $\partial^2_{r_2} U(a, r_2)$ and $\partial_{r_2} W(a, r_2, w, f)$ is similar, use *forward difference* when $dr_2 > 0$ and *backward difference* when $dr_2 < 0$.

- We use again finite differences to approximate the second derivative.

$$\partial^2_{r_2} U(a, r_2) \approx \frac{U_{i,j+1} - 2U_{i,j} + U_{i,j-1}}{(r_{2,j+1} - r_{2,j})^2}$$
$$\partial^2_{r_2} W(a, r_2, w, f) \approx \frac{W_{i,j+1,k,f} - 2W_{i,j,k,f} + W_{i,j-1,k,f}}{(r_{2,j+1} - r_{2,j})^2}$$

- Boundary conditions in a-dimension are needed for the backward approximation:

$$\begin{aligned}\partial_a U(\underline{a}, r_2) = u'(r_1\phi(\underline{a}, r_2, 0) + r_2(1 - \phi(\underline{a}, r_2, 0)))\underline{a} + b - c^u(\underline{a}, r_2) \\ - \frac{\psi^u}{2}\phi(\underline{a}, r_2, 0)^2)\end{aligned}$$
$$\begin{aligned}\partial_a W(\underline{a}, r_2, w, f) = u'(r_1\phi(\underline{a}, r_2, w, f) + r_2(1 - \phi(\underline{a}, r_2, w, f)))\underline{a} + w - c^u(\underline{a}, r_2, w, f) \\ - \frac{\psi^e(f)}{2}\phi(\underline{a}, r_2, w, f)^2)\end{aligned}$$

- Boundary conditions in r_2-dimension:

$$\partial_{r_2} U(a, \underline{r_2}) = 0 \Rightarrow U_{i,0} = U_{i,1}$$
$$\partial_{r_2} U(a, \bar{r}_2) = 0 \Rightarrow U_{i,J+1} = U_{i,J}$$
$$\partial_{r_2} W(a, \underline{r_2}, w, f) = 0 \Rightarrow W_{i,0,k,f} = W_{i,1,k,f}$$
$$\partial^2_{r_2} W(a, \bar{r}_2, w, f) = 0 \Rightarrow W_{i,J+1,k,f} = W_{i,J,k,f}$$

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Moments Fit

Statistic	Data	Model	Statistic	Data	Model	Statistic	Data	Model
$e(1)$	0.395	0.394	$E[I_{s>0} \times s \vert e(1)]$	0.163	0.097	$\Pr[\phi > 0.5 \vert e(1)]$	0.493	0.434
$e(2)$	0.527	0.566	$SD[I_{s>0} \times s \vert e(1)]$	0.460	0.223	$\Pr[\phi > 0.5 \vert e(1)]$	0.493	0.434
u	0.077	0.039	$E[I_{s>0} \times s \vert e(0)]$	0.107	0.080	$\Pr[\phi > 0.5 \vert e(0)]$	0.185	0.208
$E[w(1)]$	3.284	3.759	$SD[I_{s>0} \times s \vert e(0)]$	0.400	0.183	$\Pr[\phi > 0.5 \vert u]$	0.333	0.314
$SD[w(1)]$	1.395	1.465	$E[I_{s>0} \times s \vert u]$	0.016	0.001	$\Pr[\phi > 0.5 \vert e(1), Q_1]$	0.312	0.397
$E[w(0)]$	2.429	2.854	$SD[I_{s>0} \times s \vert u]$	0.112	0.003	$\Pr[\phi > 0.5 \vert e(1), Q_2]$	0.458	0.436
$SD[w(0)]$	1.126	1.153	$E[I_{s>0} \times s \vert e(1), Q_1]$	0.061	0.029	$\Pr[\phi > 0.5 \vert e(1), Q_3]$	0.368	0.450
$P5[w(1)]$	2.289	1.790	$E[I_{s>0} \times s \vert e(1), Q_2]$	0.065	0.067	$\Pr[\phi > 0.5 \vert e(1), Q_4]$	0.623	0.454
$P5[w(0)]$	0.867	1.348	$E[I_{s>0} \times s \vert e(1), Q_3]$	0.145	0.106	$\Pr[\phi > 0.5 \vert e(0), Q_1]$	0.000	0.047
$E[t \vert e(1)]$	5.628	5.950	$E[I_{s>0} \times s \vert e(1), Q_4]$	0.393	0.187	$\Pr[\phi > 0.5 \vert e(0), Q_2]$	0.107	0.176
$SD[t \vert e(1)]$	6.557	6.316	$E[I_{s>0} \times s \vert e(0), Q_1]$	0.026	0.029	$\Pr[\phi > 0.5 \vert e(0), Q_3]$	0.194	0.257
$E[t \vert e(0)]$	7.459	7.653	$E[I_{s>0} \times s \vert e(0), Q_2]$	0.056	0.051	$\Pr[\phi > 0.5 \vert e(0), Q_4]$	0.353	0.353
$SD[t \vert e(0)]$	8.349	8.107	$E[I_{s>0} \times s \vert e(0), Q_3]$	0.096	0.087			
$E[t \vert u]$	4.034	4.954	$E[I_{s>0} \times s \vert e(0), Q_4]$	0.310	0.152			
$SD[t \vert u]$	6.859	5.922						

NOTE: $s = da/dt$ is the amount saved, $I_{s>0}$ is an indicator variable that takes the value of 1 if the individual saves a positive amount and zero otherwise, and Q_i represents the quartile i in the observed wages distribution.

Implied Paramters

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Implied Parameters

Definition	Parameter	Est. Value
Job offers		
Mean of wages distribution - formal employment	$E[w(1)]$	3.106
Std.Dev. of wages distribution - formal employment	$SD[w(1)]$	1.274
Mean of wages distribution - informal employment	$E[w(0)]$	2.418
Std. Dev. of wages distribution - informal employment	$SD[w(0)]$	1.030
Distribution of the rate of return for informal assets		
Mean rate of return of informal assets	$\bar{r}_2$	0.079
Std. Dev. of the rate of return of informal assets	s_{r_2}	0.031

Informal Asset

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Returns of Informal Asset r_2