Productivity and Wealth Dynamics under Financial Frictions: An Empirical Investigation of the Self-financing Channel

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[1] The views expressed are those of the authors and do not necessarily represent the views of the Central Bank of Chile (CBC) or its board members. This study was developed within the scope of the research agenda conducted by the CBC. The CBC has access to anonymized information from various public and private entities by virtue of collaboration agreements signed with these institutions.

Motivation

- Financial frictions can prevent poor firms from investing at their optimal scale
- If distributions of productivity and wealth are not aligned
  - Financial frictions can lead to misallocation, low aggregate investment, TFP and income.
- Joint distribution of productivity and wealth drives quantitative results
- Self-financing channel: over time, productive firms accumulate wealth and build collateral
  - Mitigate the effects of financial frictions on TFP and income (Moll 2014, Midrigan & Xu 2014)

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- Strength of self-financing depends on the productivity process and is reflected in the response of policy functions to productivity shocks
- Two observations on previous literature
  1. Scarce micro evidence on the behavior of policy functions and their response to productivity
  2. Prevalent methods to identify productivity can fail if financial constraints exist

This Paper

- Characterizes and estimates the investment and wealth accumulation policy functions under financial fictions using firm-level data.

  → Examines the transmission of productivity shocks to investment and wealth accumulation and explore the self-financing channel using micro data.

- **Uses rich micro data on firms' balance sheet to**
  1. Consistently estimate the firm productivity process
     - How persistent and volatile are productivity shocks?
  2. Document the transmission of productivity shocks to firm decisions
     - How do these responses vary along the wealth distribution?
  3. Empirically explores the strength of the self-financing channel
     - How fast the MPKs of two firms with different levels of wealth converge?

From Micro to Macro Development (Buera, Kaboski Townsend, 2021)

- Buera, Kaboski Townsend (JEL 2021) Ã¢ÂÂOver the same period of time, a macro economic literature has made advances in building and solving models incorporating rich micro-structure, that is, with well-defined agent problems, with heterogeneity, and with contracting and market frictions. However this line of work has tended to rely on strong structural assumptions, e.g., assumptions on functional forms and distributions of unobservables, and on somewhat stylized calibration strategies, and thus economists often view it as disconnected from micro empirical research.Ã¢ÂÂ

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New empirical approach

- Recover productivity from firm production function and estimate nonlinear policies that depends on key state variables
  - Consistent with heterogeneous-firm models with collateral constraints
    - (Moll 2014; Midrigan Xu 2014; Buera Kaboski Shin 2015, etc)
  - Not require specifying functional forms for preference and productivity

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→ Challenge: productivity is not observable
  - Literature recovers productivity by estimating the production function
    - Proxy Variable: Olley & Pakes 96; Levinsohn & Petrin 2003; etc
  - OP delivers biased estimates under financial frictions
  - Not well-suited to estimate policy functions

- Combine the insights of the self-financing channel with developments in nonlinear panel data to show non-parametric identification of the empirical model
  - (Hu & Schennach 2008, Arellano, Blundell & Bonhomme 2017)

Literature Review

Financial Frictions, Self-financing and Firms' Dynamics:

- Banerjee Moll (2010); Buera Shin (2011); Buera Shin (2013); Buera Kaboski Shin (2013); Moll (2014); Midrigan Xu (2014); Buera Kaboski Shin (2015); Buera Kaboski Townsend (2021); Kaboski (2021) Drechsel (2022); di Giovanni Garcia-Santana Jeenas, Moral-Benito Pijoan-Mas (2022) ; Cavalcanti, Kaboski, Martin, Santos (2022)
- Banerjee Duflo (2005); Hall Jones (1999); Caggese (2007); Caggese Cunat (2008); Restuccia Rogerson (2008); Alburquerque Hoppenhayn (2004); Hsieh and Klenow (2009)

Production Function Estimation and Nonparametric Identification:

- Olley-Pakes (1996); Levinsohn Petrin (2003); Ackerberg, Caves, Frazer (2015); Gandhi, Navarro, Rivers (2020); Shenoy (2020)
- Hu Schennach (2008); Hu Shum (2012); Arellano, Blundell, Bonhomme (2017); Arellano Bonhomme (2017); Hu, Huang, Sasaki (2020), Cunha, Heckman, Schennach (2010)

Outline

- ✓ Introduction
- ▶ A simple model with Financial Frictions and potential biases in Olley Pakes

3. Empirical framework
4. Results
5. Concluusion

A simple model (Buera, Kaboski & Shin 2015)

- Heterogenous entrepreneurs with initial net worth/wealth A_{it} and prod Z_{it}

$$\max_{A_{it+1},K_{it+1},L_{it},C_{it}} \sum_{t=1}^{\infty} \beta^t E\left[u(C_{it})\right]$$

$$\begin{aligned} \text{s.t.} \qquad C_{it} + K_{it+1} - (1-\delta)K_{it} &= Y_{it} - W_t L_{it} + B_{it+1} - (1+r_t)B_{it}, \\ Y_{it} &= Z_{it} K_{it}^{\beta_k} L_{it}^{\beta_l} \\ Z_{it} &= \rho Z_{it-1} + \eta_{it} \\ A_{it} &= K_{it} - B_{it} \end{aligned}$$

- Financial friction: $B_{it} \leq \kappa(K_{it}, Z_{it}) \Rightarrow K_{it} \leq \tilde{\kappa}(A_{it}, Z_{it})$

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- Investment FOC

$$C_k E(Z_{it+1}|Z_{it})^{\frac{1}{1-\beta_l}} K_{it+1}^{\frac{\beta_k}{1-\beta_l}-1} = \beta(r+\delta) + \mu(A_{it}, Z_{it})$$

$\Rightarrow$ $I_{i,t} = h_t\left(Z_{it}, A_{it}\right)$

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$\Rightarrow \; I_{i,t} = h_t\left(Z_{it}, A_{it}\right)$

- Self-financing (Euler):

$$u'(C_t) = \beta\left[(1+r_{t+1}) + E_t\left[\kappa_A \widehat{\mu}(A_{t+1}, Z_{t+1})\right]\right] u'(C_{t+1})$$

$\Rightarrow \; A_{t+1} = g_{t+1}\left(Z_{it}, A_{it}\right)$

Olley-Pakes under financial frictions

- Goal: Estimate the (log) production function:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + z_{it} + \varepsilon_{it}$$

  - endogeneity problem: $cov(k_{i,t}, z_{i,t}) \neq 0$, $cov(l_{i,t}, z_{i,t}) \neq 0$

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- With financial constraints: $i_{i,t} = h\left(z_{it}, a_{it}\right)$
  - In our simple model:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \frac{1}{\rho}(1 - \beta_k - \beta_l) i_{it} + (1 - \beta_l)\tilde{\mu}(a_{it}) + \varepsilon_{it}$$

    - $\text{Cov}(k_{it}\tilde{\mu}(a_{it})) < 0 \rightarrow \beta_k^{OP} < \beta_k$
    - High $\tilde{\mu}(a_t) \rightarrow z^{OP} < z$;
    - $\text{Cov}(l_{it}\tilde{\mu}(a_{it})) > 0 \rightarrow \beta_l^{OP} > \beta_l$

Outline

- ✓ Introduction
- ✓ A simple model of financial frictions and Olley-Pakes
- ▶ Empirical Framework
- 4. Results
- 5. Conclusion

Empirical model under financial frictions

- Value added (log) production function for firms $i = 1 \cdots N$, $t = 1 \cdots T$

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + z_{it} + \varepsilon_{it}$$

$$z_{it} = \varphi\left(z_{it-1}\right) + \eta_{it}$$

  - The innovation η_{it} is independent of z_{it-1}
  - k_{it} is dynamic but predetermined: $k_{it} = (1-\delta)k_{t-1} + i_{it-1}$

- **Non-linear policy functions**

$$i_{it} = h_t\left(z_{it}, k_{it}, a_{it}, \mu_{it}\right)$$

$$a_{it+1} = g_t\left(z_{it}, k_{it}, a_{it}, \nu_{it+1}\right)$$

  - $h(.)$ and $g(.)$ allow for rich interactions between a_{it} (wealth) and z_{it}
  - μ_{it} and ν_{it+1} are scalar i.i.d shocks independent of state variables at t
  - The joint distribution of z_{i1}, k_{i1} and a_{i1} is left unrestricted

Objects of interest: marginal derivative effects

- Investment propensity in response to productivity shocks:

$$\Phi_t^h(a,k,z) = E_\mu\left[\frac{\partial h_t(z,k,a,\mu)}{\partial z}\right]$$

- Wealth accumulation propensity in response to productivity shocks:

$$\Phi_t^g(a,k,z) = E_\nu\left[\frac{\partial g_t(z,k,a,\nu_{t+1})}{\partial z}\right]$$

- Propensities reflect how firms reacts to productivity shocks

- Propensities are heterogenous and vary with a_{it} and z_{it}
  - Evidence on collateral constraint: $\Phi_t^h(a,k,z)$ increasing in a
  - Evidence on self-financing: $\Phi_t^g(a,k,z) > 0$ and decreasing in a

Nonparametric Identification

- Sequential identification scheme
  - Identification of β_k and β_l
  - Given β_k and β_l we identify the productivity process and the policy functions
  - Procedure based on Hu and Schennach (2008)

Intuition in linear model

- If $f\left(a_{t+1} \mid z_t, X_t\right)$. and $f\left(i_t \mid z_t, X_t\right)$ are normal distributed

$$a_{it+1} = g_z z_{it} + g_a a_{it} + \nu_{it+1}$$
$$i_{it} = h_z z_{it} + h_a a_{it} + \mu_{it}$$

  - Self-financing $\Rightarrow g_z \neq 0$
  - Proxy variable: $z_{it} = \pi_1 i_{it} + \pi_2 a_{it} + \pi_3 \mu_{it}$
- Replacing the proxy variable in the prod function:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \pi_1 i_{it} + \pi_2 a_{it} + \varepsilon_{it} + \pi_3 \mu_{it}$$

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- Use a_{it+1} as an instrument for i_{it} in an IV estimation
  - Relevance: a_{it+1} is correlated with i_{it} through z_{it} if $g_z \neq 0$ (self-financing)
  - Exogeneity: $E(i_{it}\mu_{it+1}) = 0$ since $E(\nu_{it+1}\mu_{it}) = 0$
- If a firm experiences a positive productivity shock it increases **simultaneously** investment and wealth accumulation

Outline

✓ Introduction

✓ Brief example: Olley-Pakes under financial frictions

✓ Empirical framework

▶ Results

5. Concluusion

Data

- Chilean tax annual administrative data from 2005-2016.
- Approx. 4800 firms (manufacturing), 13500 obs.
- Form 22 (income tax/ reflect dividend policies, balance sheet):
  - y_{it}: *value added* .
  - k_{it}: *physical capital.*
  - a_{it}: *wealth/ net worth.*
- Form 29 (monthly report of expenditures/flows):

- i_{it} : *investment*

- DJ 1887:
  - l_{it}: Number of workers

Results: Production Function Estimates with Chilean data

	OP	LP	Proxy-IV	SEM
β_l	0.67	0.81	0.44	0.46
	0.008	*0.007*	*0.01*	*0.003*
β_k	0.35	0.33	0.42	0.43
	0.05	*0.04*	*0.01*	*0.007*
σ_ϵ	0.68	0.62	0.22	0.20
Observations	13516	13516	13516	13516
Firms	4867	4867	4867	4867

Table: Production Function Estimates from Microdata

Note: The table shows the production function estimates from administrative data for Chile, using alternative methodologies: OP (Olley and Pakes, 1996), LP (Levinsohn and Petrin, 2003) and two estimators that control for financial frictions, Proxy-IV and SEM.

Results: Production Function Estimates with simulated data

	OP	Proxy-IV	SEM
β_l	0.505	0.443	0.442
β_k	0.397	0.424	0.431

Table: Production Function Estimates from Simulated Data

Note: The table shows the production function estimates from data generated a macro model, using alternative methodologies: OP (Olley and Pakes, 1996), LP (Levinsohn and Petrin, 2003) and two estimators that control for financial frictions, Proxy-IV and SEM.

Results: Productivity Process

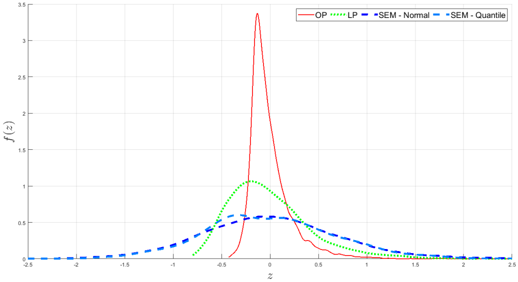


Figure: Estimated distribution of productivities

Notes: The figure shows the estimated distribution of firm-level productivities using administrative microdata for Chile, under alternative methodologies: OP , LP, the SEM algorithm using Normal shocks and the SEM algorithm using a quantile model (ABB) .

Results: Estimated Parameters of the Productivity Process

	OP	Proxy-IV	SEM
ρ_z	0.53	0.87	0.85
	0.01	*0.01*	*0.01*
σ_η	0.18	0.30	0.39
Observations	13516	13516	13516
Firms	4867	4867	4867

Table: Estimated Productivity Process with Microdata, Linear model

Note: The table shows the estimated parameters for the firm-level productivity process from administrative microdata for Chile, using alternative methodologies: OP - and two estimators that control for financial frictions, Proxy-IV and SEM.

Results: Productivity Process

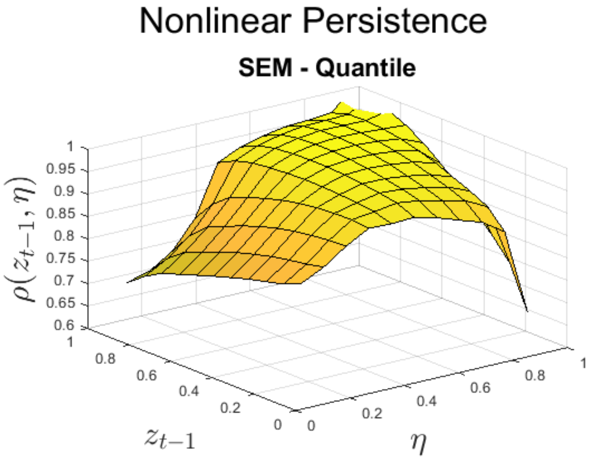
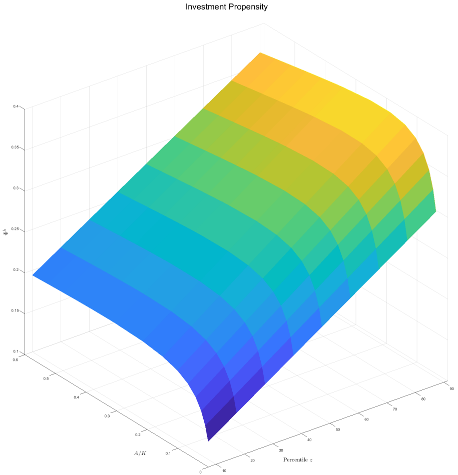


Figure: Estimated distribution of productivities

Notes: The figure shows the estimated persistence of firm-level productivities using administrative microdata for Chile, using Normal shocks and the SEM algorithm using a quantile model (ABB) .

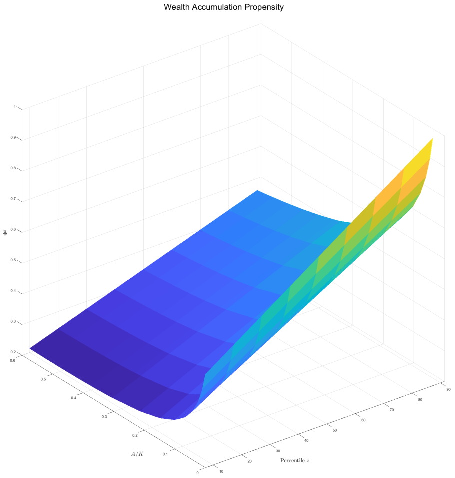
Investment Policy Rule: Nonlinear effects

- Investment propensity evaluated at different quantiles of a and z
  - High heterogeneity in propensities (0.08-0.6)
  - Increasing in a and z
  - Sensitivity to a depends on z



Wealth Accumulation Policy Rule: Nonlinear

- Wealth accumulation propensity evaluated at different quantiles of a and z
  - High heterogeneity in propensities (0.2 - 0.98)
  - Decreasing in a and increasing z
  - Low a - high z firms benefit the most from an additional unit of wealth



Estimated propensities

- The figure exhibits how the investment propensity and the wealth accumulation propensity vary along the distribution of $\frac{A}{K}$ in the micro data.
- Each point represents the propensity of each particular firm evaluated at its actual value of a, k and z.

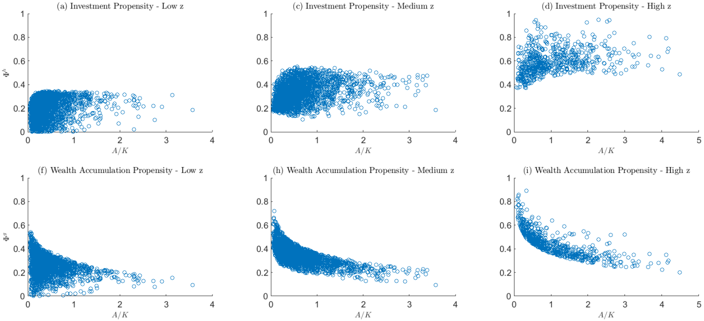


Figure: Estimated propensities

How strong is self-financing?

- Simulate MPKs for two firms with the same z but different a
- MPK of low a firm is 3 times larger than MPK of high a (same as Banerjee and Moll 2010)
- Convergence takes more than 50 years! (7 years in Banerjee and Moll 2010)

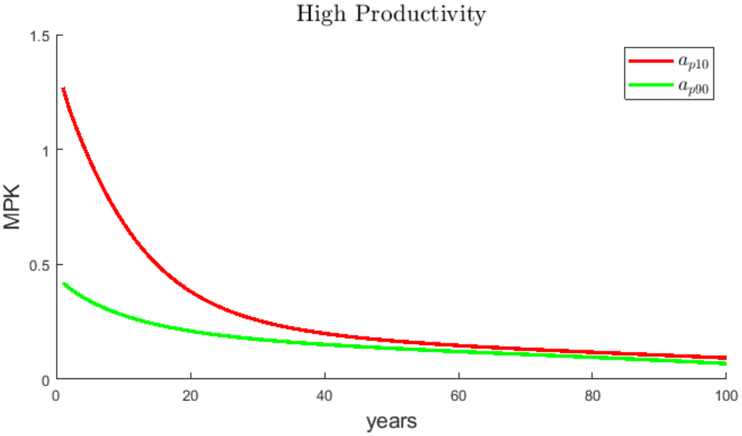


Figure: Convergence in MPKs

Conclusions

- Flexible non-linear framework to jointly model and estimate the firm wealth accumulation dynamics and the unobservable productivity process under collateral constraints.
- Reduce bias of prevalent strategies to estimate production functions and productivity.
- New results on policy functions: heterogeneous responses of investment and wealth
  - Investment propensity is increasing in wealth and productivity
  - Wealth accumulation propensity is increasing in productivity and decreasing in wealth
- Self-financing is active in the data but its impact is limited
- Our estimates might inform structural models
  - Direct estimates of production parameters
  - new elasticities to indirectly estimate key deep parameters