The Life Cycle of Firms and the Productivity Advantages of Large Cities

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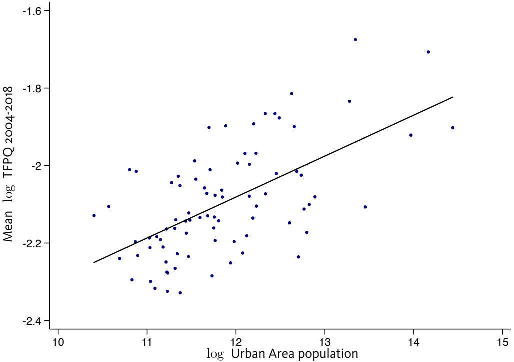
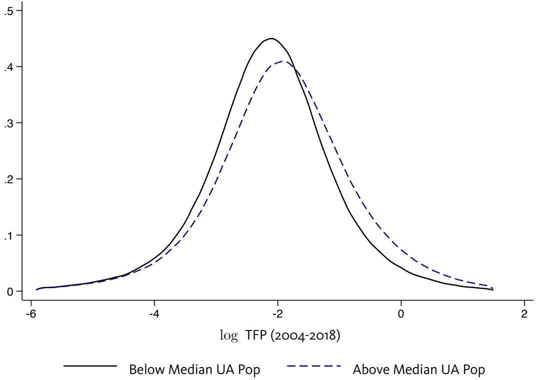
Motivation

Firms are, on average, more productive in larger cities



(a) Relationship between Urban Area population and firm TFPQ in Spain



(b) Distribution of logTFPQ across Spanish Urban Areas

Motivation

Firms are, on average, more productive in larger cities

- Different mechanisms

  1. Agglomeration (Rosenthal and Strange 2004, Combes et al 2012, Behrens et al 2014, Gaubert 2018)
  2. Sorting (Behrens et al 2014, Gaubert 2018)
  3. Selection (Melitz and Ottaviano 2008, Combes et al 2012, Behrens et al 2014)

- So far, the importance of 1.–3. for the urban productivity premium disciplined with static models

  → This paper: a dynamic perspective

  – Goals:

    (a) Quantify 1.–3. using theory and data on firm growth and firm dynamics across the city-size distribution

    (b) Revisit the implications of place-based policies for aggregate productivity

What I am doing

- Facts on firms' life-cycle growth, firm entry and firm exit across the city-size distribution in Spain
  - Firm growth over the life-cycle is higher in larger cities
  - No relevant differences in entry and exit rates across cities of different size
  - Firm reallocation is negligible ($\sim$0.01% of firms per year reallocate)

- Canonical model of firm dynamics (Hopenhayn 1992) augmented with
  + Agglomeration externality
  + Ex-ante (*productivity type*) and ex-post (*productivity shocks*) firm heterogeneity

  $\rightarrow$ captures the mechanisms that generate the urban productivity premium

- Model-based identification strategy to quantify the extent of sorting *vs* agglom *vs* selection in the UPP

  $\rightarrow$ *Today:* comparative statics exercise to discuss the identification of some key parameters

Related Literature

1. Productivity advantages of large cities and firm sorting, selection, and agglomeration
   Rosenthal and Strange (2004), Combes, Duranton, Gobillon, Puga, and Roux (2012)
   Behrens, Duranton, and Robert-Nicoud (2014), Gaubert (2018), Ziv (2019)

   $\longrightarrow$ A new identification strategy based on data and theory of firm dynamics

2. Firm dynamics across regions
   Brinkman, Coen-Pirani, and Siegel (2016), Walsh (2019), Brandt, Kambourov, and Storesletten (2019), Klenow and Li (2022)

   $\longrightarrow$ A different question: revising why firms located in large cities are more productive

3. Firm growth over the life cycle
   Haltiwanger, Jarmin, and Miranda (2013), Hsieh and Klenow (2014), Arkolakis (2016), Sterk, Sedláçek, Pugsley (2021)

   $\longrightarrow$ A look at its geographical dimension

Facts

Data

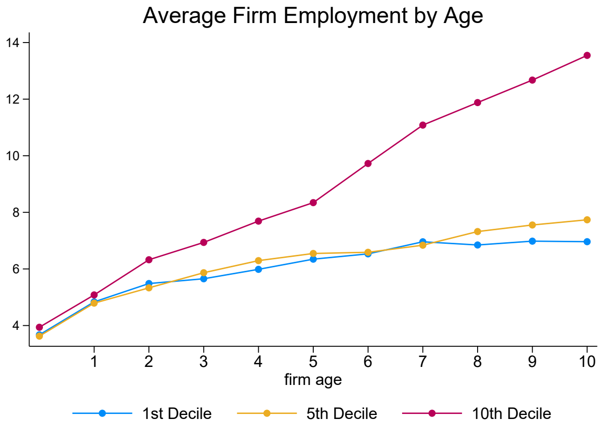
- Balance sheet information of non-financial Spanish firms, collected by the Bank of Spain
  - Annual frequency 2004-2018
  - Around 1.2 million firms, each one observed an average of 5 years
  - Information on firm sector, employment, capital, wage bill and **location** of headquarters

  - Drawbacks:
    - Data at the firm level rather than at the establishment-level
    - Imperfect to study firm exit, as firms stop showing up in the sample but continue operating

- Geography: 83 Urban Areas (UA) defined by Ministry of Transports and Mobility map
  - Notion of local labor market (68% of population, 73% of firms in full sample)
    - Final sample with 5 million firm-year observations, 915 thousand firms

  - Compute UA size as the number of people within 10km of the average person in UA (De La Roca, Puga 2017)

1. Firm growth over the life cycle is higher in large cities



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  - Holds within sector SEE
  - Also in terms of VA per worker SEE

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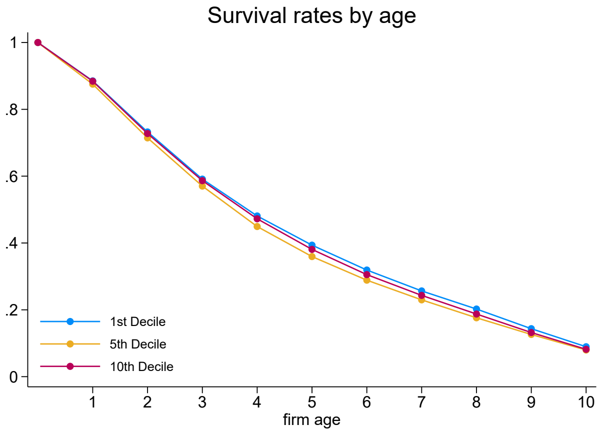

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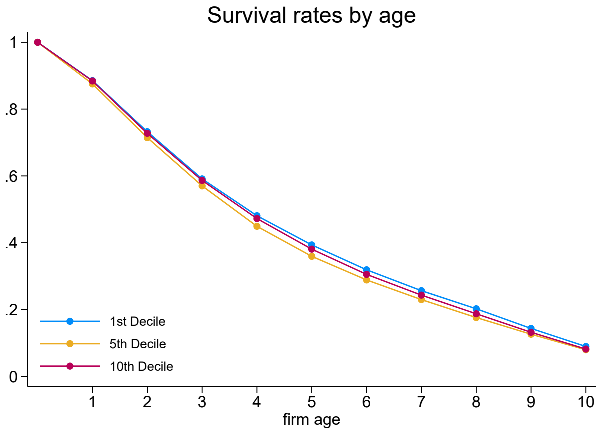


- Firms grow much more as they age in large cities
  - Holds within sector SEE
  - Also in terms of VA per worker SEE
- Not explained by survival bias
  - No relevant differences in exit rates by age across cities
- Mainly driven by a small group of high-growth firms SEE
- Not associated to some of the common drivers of misallocation

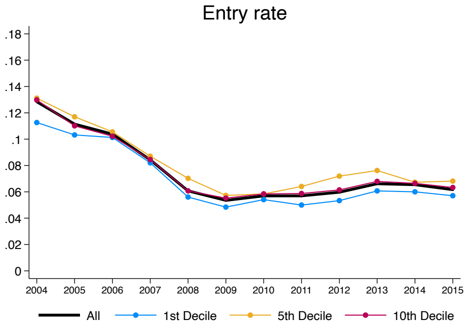
  (e.g. different labor regulation, tax regime or contract law)

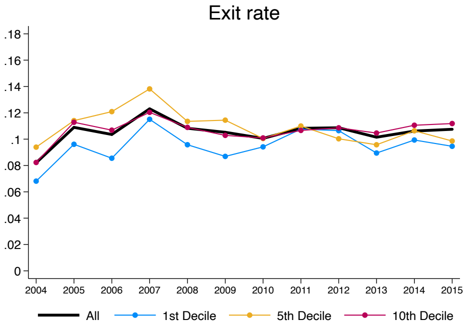
2. Entry and exit rates are similar for cities of different size

- Compute the entry and exit rates in Urban Area (UA) u in year t as

$$\text{entry rate}_{ut} = \frac{\text{number of firms with age } 0_{ut}}{\text{total number of firms}_{ut}}$$

$$\text{exit rate}_{ut} = \frac{\text{n of firms } \textit{not} \text{ present at } t+1 \text{ and present at } t_{ut}}{\text{total number of firms}_{ut}}$$





- **Entrants** are more productive in large cities, yet not larger in terms of employment or capital SEE
- **Exiters** are more productive *and* larger in big cities SEE

From the Facts to the Model

- In larger cities
  1. Firms grow more over the life-cycle, both in terms of employment and value added
  2. The entry and the exit rates are not different than in smaller cities
  3. Firms are larger and more productive

- A model relating the facts to the mechanisms of the urban productivity premium
  - Firm dynamics as in Hopenhayn (1992) $\rightarrow$ endogenous exit (selection)
  - Agglomeration externality: city size (population) increases firm TFP, more so for high productivity firms
    - $\rightarrow$ Induces sorting of ex-ante more productive firms into large cities

Model

Environment

- A city economy: agents operate in a single-city world of exogenous size L
  or a world of isolated city-islands

- Representative household: continuum of identical members (of size L)
  - Static problem, no savings

- Production
  - Heterogeneous firms in both ex-ante profiles and ex-post shocks that determine efficiency z
  - Production requires only labor ℓ, hired every period, and shows decreasing returns

$$y = \varphi(z, L)\ell^{\gamma} \quad \text{with} \quad \gamma < 1$$

$\rightarrow$ firm TFP $\varphi(z, L)$ affected by city size L

- Firm dynamics: endogenous entry and exit
  - Endogenous exit due to fixed cost of operation c_f
  - Free entry condition as entry is costly c_e

Incumbent firms

Production and exit

- Static production problem $\rightarrow$ solve for labor demand, ouput and profits (final good is the numeraire)

$$\ell(z, L, w) = \frac{\gamma}{w} \frac{\varphi(z, L)^{\frac{1}{1-\gamma}}}{c(w)}, \qquad y(z, L, w) = \frac{\varphi(z, L)^{\frac{1}{1-\gamma}}}{c(w)}, \qquad \pi(z, L, w) = (1-\gamma)\frac{\varphi(z, L)^{\frac{1}{1-\gamma}}}{c(w)}$$

where $c(w) = \left(\frac{w}{\gamma}\right)^{\frac{\gamma}{1-\gamma}}$

- Realized firm efficiency z is a function of an exogenous Markovian state vector $\mathbf{s}$ (to be discussed later)

- Before $z(\mathbf{s})$ is realized, a firm may exit and avoid paying the fixed cost of operation c_f

$\rightarrow$ The value of a firm with state vector $\mathbf{s}$ in a city of size L at time t

$$V(\mathbf{s}, L, w_t) = \max\left\{\mathbb{E}\left[\pi(\mathbf{s}', L, w_t) - c_f + \beta V(\mathbf{s}', L, w_{t+1}) \mid \mathbf{s}\right], 0\right\}$$

where $\mathbf{s}'$ is the value of the state realized after the continuation decision

Entry, Aggregation, and Market clearing

Firm entry

- After paying entry cost c_e, entrants observe their initial level of $\mathbf{s}$
  - $\rightarrow$ Depending on $V(\mathbf{s}, L, w_t)$ decide to operate and pay c_f or exit immediately and never produce
- Free entry condition (all potential entrants are indiferent between entry or not)

$$\int_{\mathbf{s}} V\left(\mathbf{s}, L, w_t\right) d\hat{G}\left(\mathbf{s}\right) \leq c_e \qquad \text{with equality if the mass of entrants } m_t > 0$$

Aggregation

- The distribution of incumbent firms μ_t follows the law of motion

$$\mu_{t+1}(\mathbf{s}') = \int_{\mathbf{s}} \underbrace{(1 - x(\mathbf{s}))}_{\text{exit policy}} G(\mathbf{s}' \mid \mathbf{s}) d\mu_t + m_{t+1} \int_{\mathbf{s}} (1 - x(\mathbf{s})) d\hat{G}(\mathbf{s})$$

Market clearing: labor

$$L = (1 - x(\mathbf{s})) \left[\int_{\mathbf{s}} \ell(\mathbf{s}, L, w) d\mu_t + m_{t+1} \int_{\mathbf{s}} \ell(\mathbf{s}, L, w_t) d\hat{G}(\mathbf{s}) \right]$$

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Market clearing: goods

$$C = (1 - x(\mathbf{s})) \left[\int_{\mathbf{s}} \left(y(\mathbf{s}, L, w) - c_f\right) d\mu_t + m_{t+1} \int_{\mathbf{s}} \left(y(\mathbf{s}, L, w) - c_f\right) d\hat{G}(\mathbf{s}) \right] - c_e m_{t+1}$$

Productivity externality: agglomeration economies

- So far, no stance on how city size affects firm TFP (model in general form with $\varphi(z, L)$)

- Evidence that more productive firms are disproportionately more productive in larger cities
  Combes et al 2012

  $\rightarrow$ Complementarity between L and z

  – Follow Gaubert (2018) and assume $\varphi(z, L) = \exp\left(\alpha \log L + \log z \left(1 + \log L\right)^{\eta}\right)^{1-\gamma}$

  $\rightarrow$ log-supermodularity of profits i.e. $\frac{\partial^2 \log \pi(z,L,w)}{\partial \log L \partial \log z} > 0$, most productive firms are better-off in large cities

  $\rightarrow$ α is the traditional agglomeration elasticity, while η controls the extent of complementarity between z and L

Productivity process

- Urban productivity premium may reflect the sorting of ex-ante more productive firms (Gaubert, 2018)

→ Allow for productivity process in which firms are ex-ante heterogeneous (Sterk, Sedláçek, Pugsley, 2021)

  - try to identify mean of ex-ante component across cities

$$\log z_{i,a} = \underbrace{u_{i,a}}_{\text{ex-ante het}} + \underbrace{v_{i,a} + \varepsilon_{i,a}}_{\text{ex-post het}}$$

(where $z_{i,a}$ is the efficiency of firm i at age a)

$$u_{i,a} = \rho_u u_{i,a-1} + \theta_i, \qquad u_{i,-1} \sim iid(0, \sigma_u^2), \qquad \theta_i \sim iid(\mu_\theta, \sigma_\theta^2), \qquad |\rho_u| \leq 1$$

$$v_{i,a} = \rho_v v_{i,a-1} + \zeta_{i,a}, \qquad v_{i,-1} = 0, \qquad \zeta_{i,a} \sim iid(0, \sigma_\varepsilon^2), \qquad |\rho_v| \leq 1$$

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differs across cities if sorting

→ Heterogeneity in long-run productivity level determined by $\frac{\theta_i}{1-\rho_u}$

→ Heterogeneity in convergence to long-run level determined by $u_{i,-1}$

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$$v_{i,a} = \underbrace{\rho_v v_{i,a-1} + \zeta_{i,a}}_{\text{standard AR(1) process}}, \qquad v_{i,-1} = 0, \qquad \zeta_{i,a} \sim iid(0, \sigma_\varepsilon^2), \qquad |\, \rho_v \,| \leq 1$$

$$\underbrace{\varepsilon_{i,a}}_{\text{noise shock}} \sim iid(0, \sigma_z^2)$$

Identification I

- Problem: higher ex-ante firm productivity μ_θ or city size L have the same implication for empl *levels*

$$\log \ell_{i,a} = \log \gamma - \log w - \log c(w) + \alpha \log L + (1 + \log L)^\eta \log z_{i,a}$$

- Employment *growth* (in Steady State) can be informative

$$\log \ell_{i,a+1} - \log \ell_{i,a} = (1 + \log L)^\eta (\log z_{i,a+1} - \log z_{i,a})$$

  - Differences in employment growth between
    - old firms in same city $\rightarrow$ only from ex-post shocks (as ex-ante type is differenced away and L is common)
    - young firms in same city $\rightarrow$ from differences in ex-ante profiles and ex-post shocks
    - old firms in different cities $\rightarrow$ from differences in L and ex-post shocks
    - young firms in different cities $\rightarrow$ from differences in L, ex-ante profiles and ex-post shocks

$\rightarrow$ Comparing employment growth of old *vs* young firms in same *vs* different cities is informative about the importance of **sorting** *vs* **agglomeration** for the city productivity premium

Identification II

- Identification argument holds conditional on exit rates being the same across space

$$\Delta \log \ell_{i,a} = (1 + \log L)^{\eta} \Delta \log z_{i,a}$$

$\rightarrow$ $\Delta \log \ell_{i,a}$ for old firms in the same city depends on ex-post shocks but *also* on endogenous exit (selection), which in turn depends on ex-ante heterogeneity

- One way of dealing with this is assuming that exit is exogenous, but unappealing to study possibly stronger selection in citites

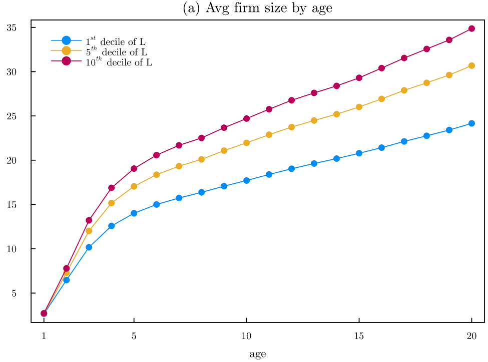
- An alternative is to allow entry costs to vary by city size $c_e(L) = c_0 L^{\chi}$
  - With higher c_e, the free entry condition is satisfied at a lower w, affecting incumbents productivity and as a result exit rates
  - Empirically, it could be justified as a reduced-form counterpart of the higher price of land in large cities

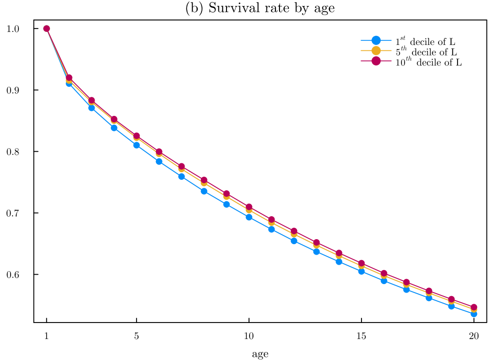
Comparative statics

- Borrow productivity process calibrated by Sterk, Sedláçek, Pugsley (2021) for US firms
- Set structural parameters arbitrarily/to standard values
- Solve model for different values of city size L and compare outcomes
  1) Same productivity process in all cities
  2) Ex-ante better firms in large cities
  3) Ex-ante better firms *and* higher entry costs in large cities
- Show identification strategy *at work*

Employment levels and Survival rates by age

1. Same productivity process in all city-sizes

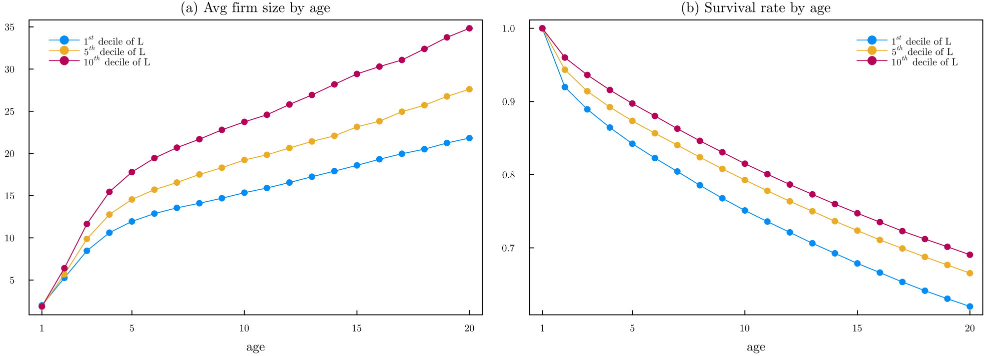




- Firms are more productive in cities due to the agglomeration externality, and so larger
  - This is partly compensated by higher wages in large L, specially for young firms
- Firms grow following good productivity shocks, which are amplified by city size $\Delta \log \ell_{i,a} = (1 + \log L)^{\eta} \Delta \log z_{i,a}$
- Survival rates similar across L sizes because higher productivity in large cities is compensated by higher w

Employment levels and Survival rates by age

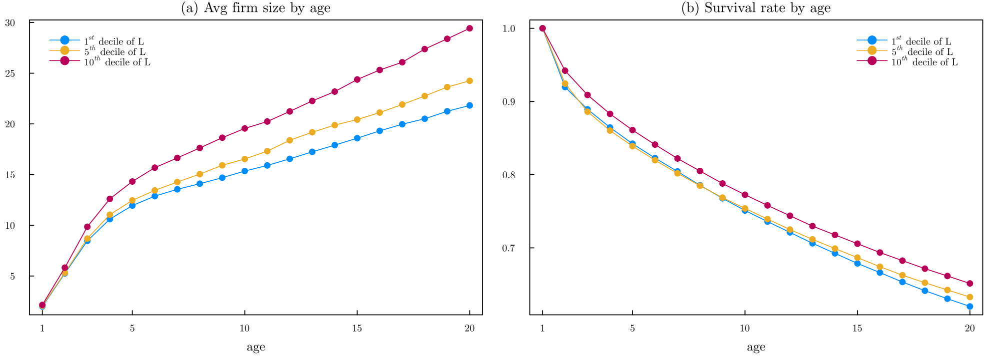
2. Ex-ante better firms in large cities (higher μ_θ)



- Firms in large cities are now *exogenously* more productive
  - For given c_e, equilibrium w increases to satisfy the free-entry condition (making operation more costly)
  - $\rightarrow$ Extra selection on entry in large cities (i.e. entrants must be *ex-ante* very productive)
  - $\rightarrow$ Highly-productive firms cope better with shocks and exit less

Employment levels and Survival rates by age

3. Ex-ante better firms in large cities (higher μ_θ) and higher entry costs c_e

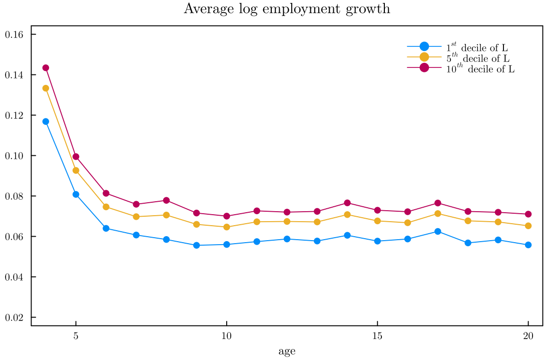


- Entrants in large cities are also *exogenously* more productive, however
  - As c_e also increases, the w that satisfies the free-entry condition is not that high
  - $\rightarrow$ Selection of ex-ante types on entry not that demanding
  - $\rightarrow$ Exit rates increase, as less *ex-ante* highly-productive incumbents

Employment growth: identification of sorting parameter

1. Same productivity process in all city-sizes

- Plot mean employment growth by age since age $= 4$



- Gap in employment growth in $\log$ terms explained by city size and different exit profiles, not by differences in μ_θ
  $\longrightarrow$ the elasticity of this gap to city-size identifies η

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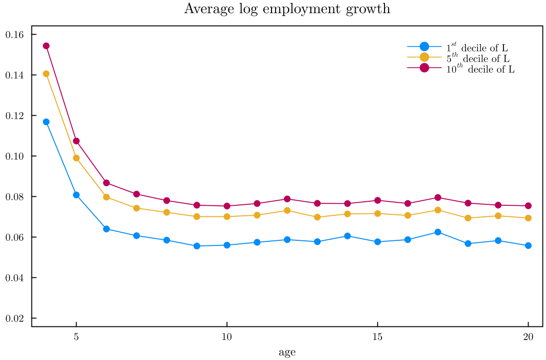

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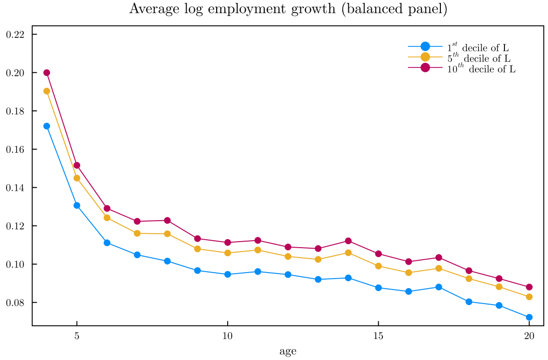

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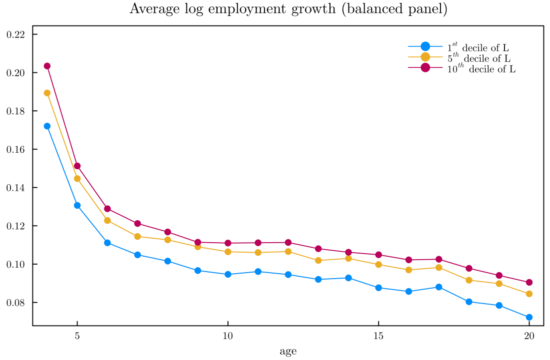

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Final remarks and Next steps

- Firm growth over the life cycle is higher in large cities, allowing firms to become larger
  - → This can be the result of agglomeration economies or differences in firms productivity across cities
- Using the predictions for firm growth of a standard firm dynamics model with agglomeration externalities, I propose a way to disentangle productivity differences from city-size advantages
- Next steps
  - Empirical implementation
    GMM with moment conditions arising from the model
  - Model extension
    - Model at this point unsuited for interesting place-based policy counterfactuals
      Entry subsidy does not change fundamental productivity of firms entering in each location
    - Firms may know their ex-ante productivity and then choose where to operate

Appendix

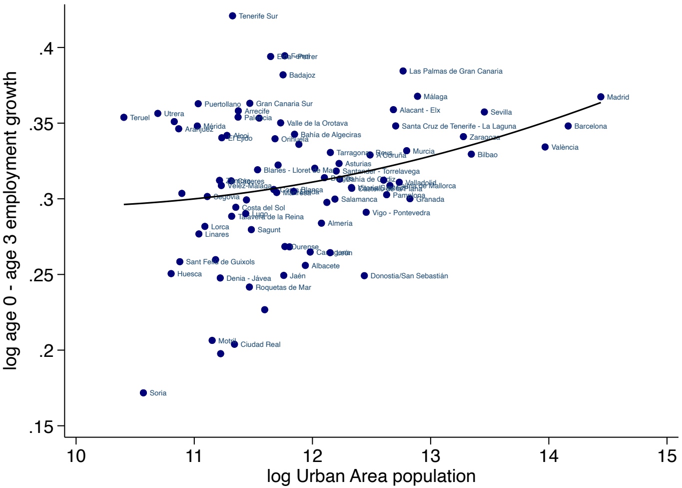
Urban Areas in Spain

- Spain has 85 Urban Areas defined by the Ministry of Transports and Mobility

  Smallest is Teruel with 32,500 people in 2004; largest is Madrid with 5,472,387 people in 2004

BACK

1'. Firm growth across the city-size distribution



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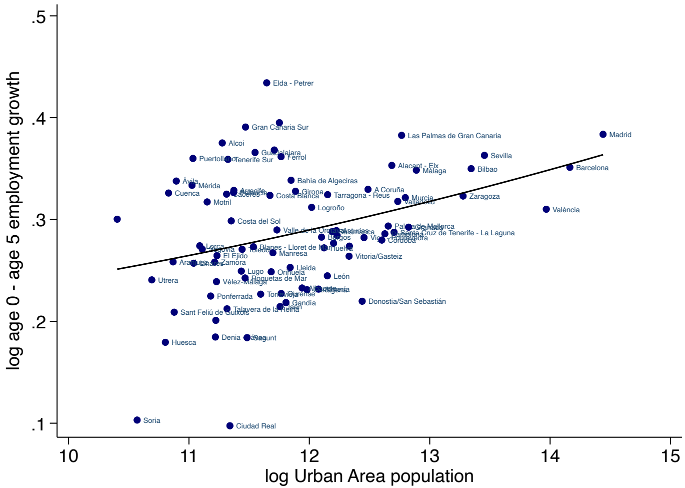

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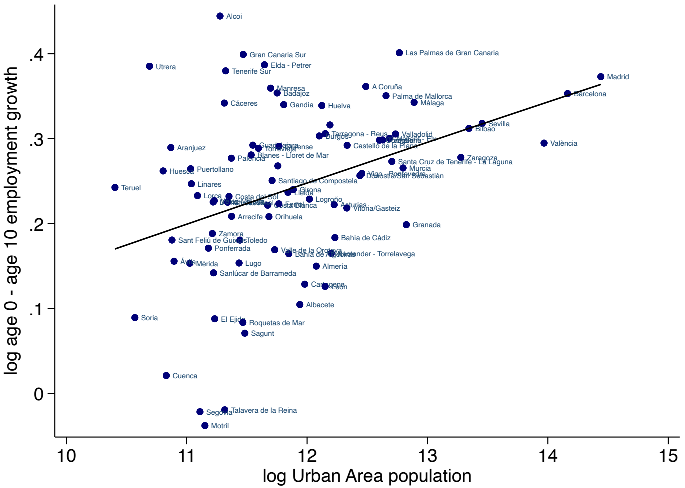

BACK

1'. Firm growth over the life cycle is higher in large cities

- Allow local population to have a different effect along the firm life cycle

$$\log \text{firm growth}_{iust} = \alpha_{st} + \sum_{a}^{A} \gamma_a \mathbf{1}_{\{\text{Age}_{iust}=a\}} + \sum_{a}^{A} \beta_a \log \text{population}_{ut} \times \mathbf{1}_{\{\text{Age}_{iust}=a\}} + \epsilon_{iust}$$

	log firm growth
Age=1 × log population	0.0009
Age=2 × log population	0.0107***
Age=3 × log population	0.0083***
Age=4 × log population	0.0050***
Age=5 × log population	0.0057***
Age=6 × log population	0.0045***
Age=7 × log population	0.0046***
Age=8 × log population	0.0012
Age=9 × log population	0.0023***
Age=10 × log population	0.0021***
Age=11 × log population	0.0019**
Age=12 × log population	0.0011
Age=13 × log population	0.0004
Age=14 × log population	0.0005
Age=15 × log population	0.0004
Observations	4232072
R^2	0.051

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

→ Firms grow more in large cities over their life-cycle (controlling by sector and age)

BACK

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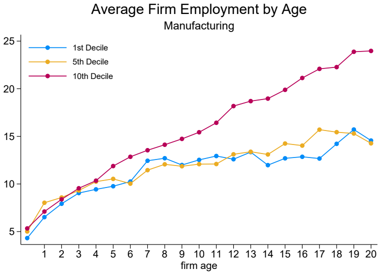
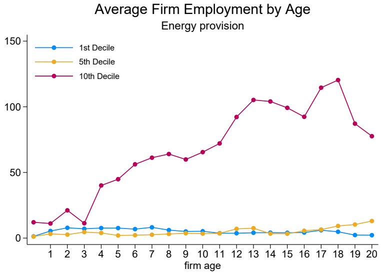
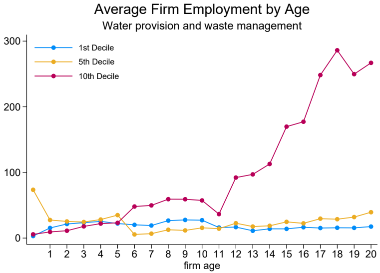
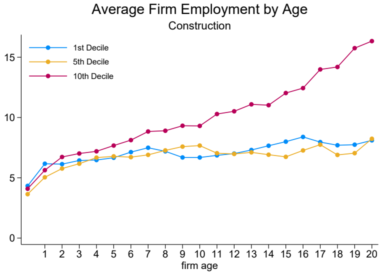
BACK



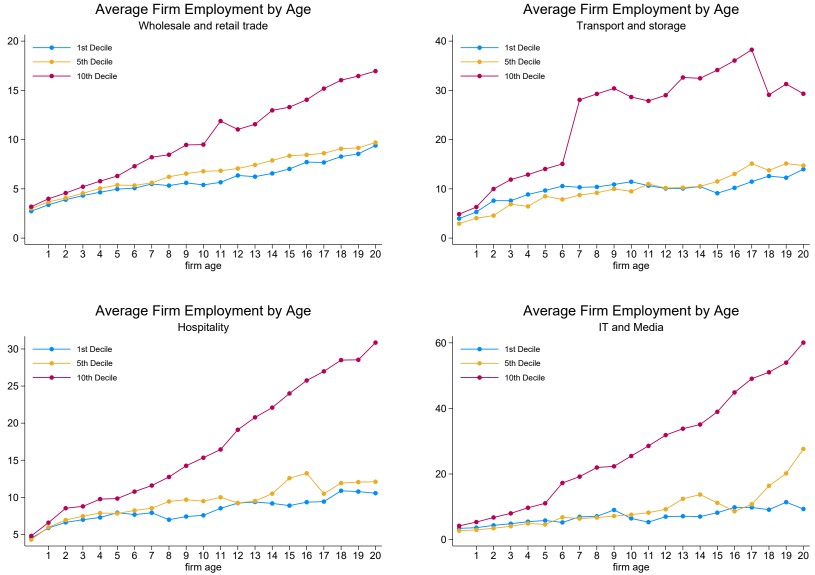






1'. Firm growth over the life cycle is higher in large cities

BACK



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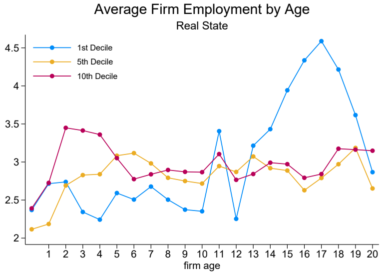
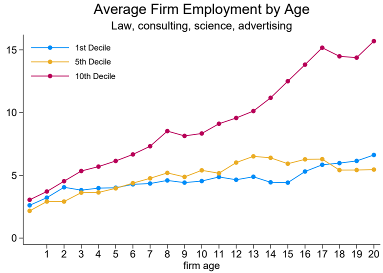
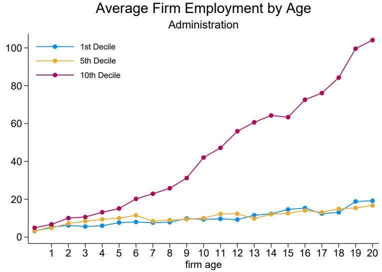
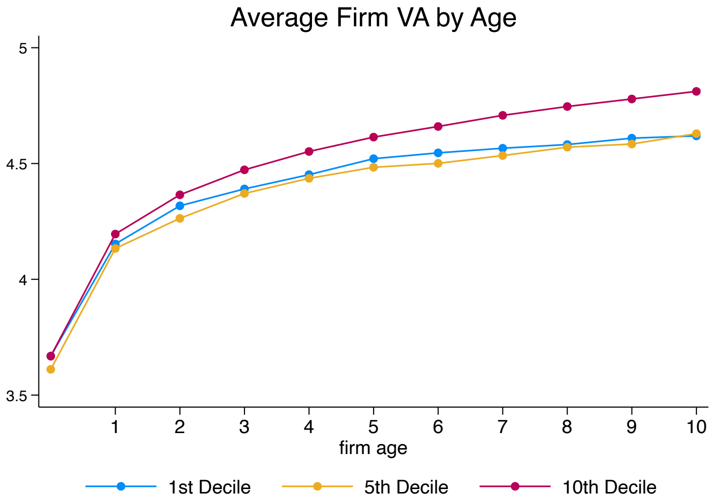




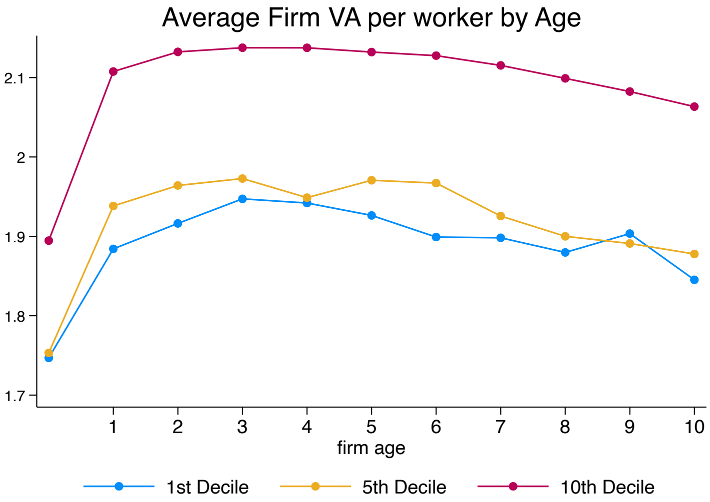


1′. VA growth over the life cycle is higher in large cities



BACK

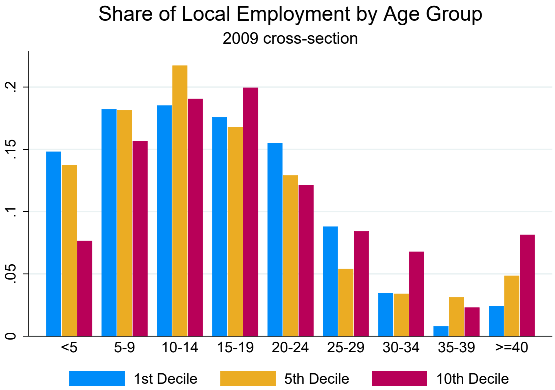
1'. VA growth over the life cycle is higher in large cities



BACK

1. Firm growth over the life cycle is higher in large cities

Corollary



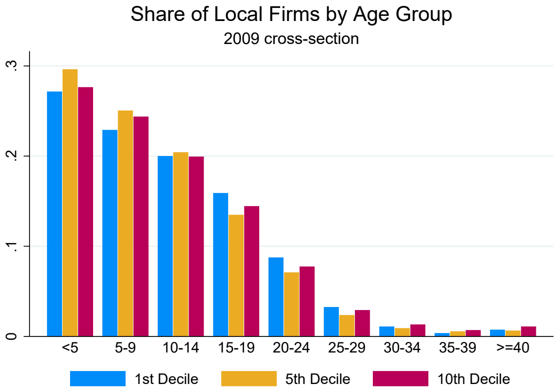
→ The share of local employment accounted for by old firms is larger in big cities

→ The firm age distribution is similar across the city-size distribution

BACK

1. Firm growth over the life cycle is higher in large cities

Corollary



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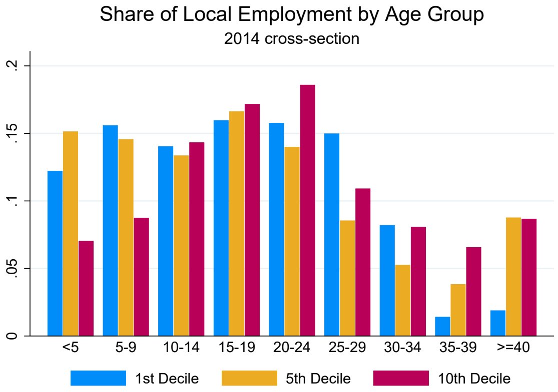

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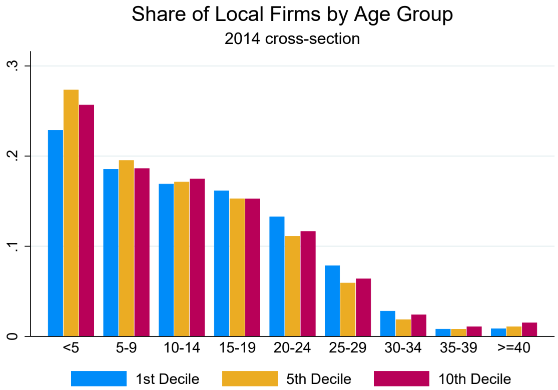
Corollary



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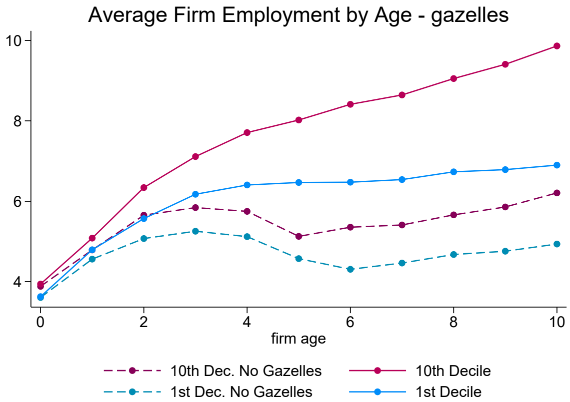
BACK

1′. Higher firm growth in large cities is driven by small group of high-growth firms

- The literature has emphasized that a small group of young firms (*gazelles*) account for a large share of employment growth (Haltiwanger et al. (2016), Sterk et al. (2021)) → define gazelles as firms that
  - (a) Grow at an annualized rate of 20% for their first 5 years of operation
  - (b) Reach at least 10 employees at some point during their life-cycle

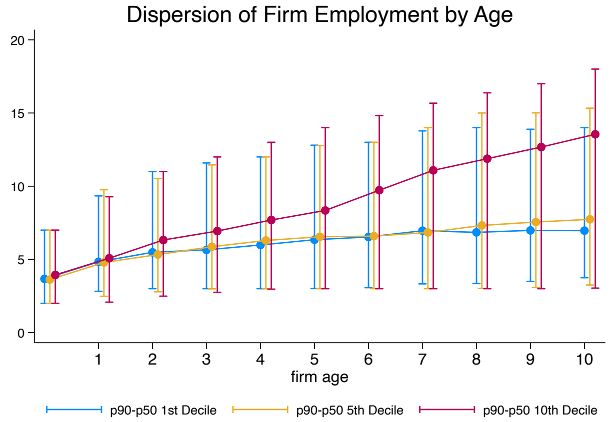


- Only 4.1% of all startups in the economy
  - In smallest cities 3.9%, in largest 4.3%
  - Similar exit profiles across cities
  - → Gazelles manage to scale up in large cities

BACK

1'. Large firms drive the higher average life cycle growth in cities

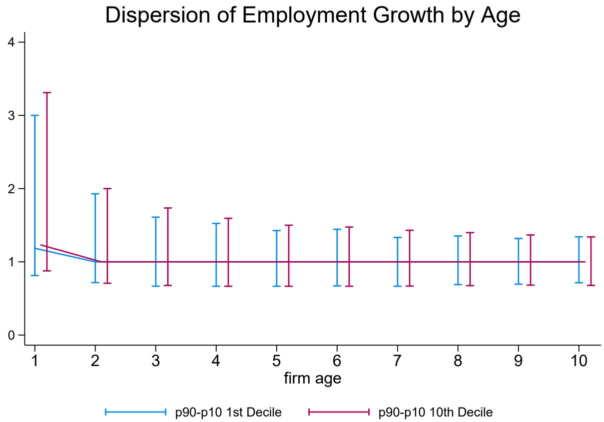
- Compute the 90th and 50th percentile of the employment distribution at each age, for each UA size-decile



BACK

1'. Dispersion of firm growth is higher in large cities

- Compute the 90th and 10th percentile of the employment growth distribution at each age, for each UA size-decile



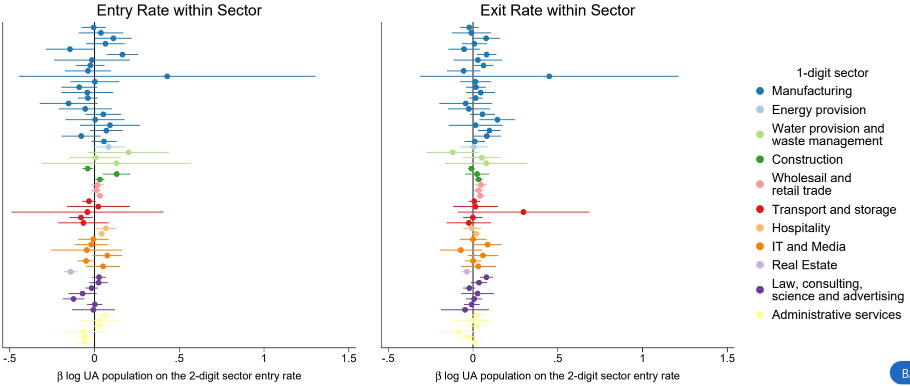
BACK

2'. Entry and exit rates (at the sector level) are similar for cities of different size

- Some sectors may be characterized by higher entry and exit rates, and may be differenty present in large and small cities

  $\rightarrow$ Define a market as UA – 2-digit-sector combination and compute entry and exit rates as before

  - Keep sectors that are large enough (200 firms) and do not consider UA – sectors with less than 10 firms
  - Still, several zeros, as in some markets no single firm enters or exits in some years $\rightarrow$ run Poisson regression at the sector level $y_{ust} = \exp\{\alpha_t + \beta \log \text{population}_{ut} + \epsilon_{ust}\}$



BACK

2'. Entrants in larger cities are more productive, yet not larger

- Regress firm K, L and TFPQ on city size, controlling by year or year-sector FE

	log TFPQ	log TFPQ	log K	log K	log L	log L
log population	0.0649***	0.0529***	-0.0171***	0.0094***	-0.0211***	-0.0045***
	(0.0025)	(0.0024)	(0.0036)	(0.0035)	(0.0014)	(0.0013)
Year FE	Yes	–	Yes	–	Yes	–
2-dig sector–year FE	No	Yes	No	Yes	No	Yes
Observations	215740	215726	250059	250047	329755	329746
R^2	0.006	0.084	0.006	0.101	0.004	0.082

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

BACK

2'. Exiters in larger cities are larger and more productive

- Regress firm K, L and TFPQ on city size, controlling by year or year-sector FE

	log TFPQ	log TFPQ	log K	log K	log L	log L
log population	0.0960***	0.0870***	0.0030	0.0080***	-0.0035***	0.0120***
	(0.0017)	(0.0017)	(0.0028)	(0.0027)	(0.0012)	(0.0011)
Year FE	Yes	–	Yes	–	Yes	–
2-dig sector–year FE	No	Yes	No	Yes	No	Yes
Observations	510486	510475	603936	603926	723037	723030
R^2	0.028	0.111	0.007	0.108	0.027	0.117

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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