Firm Sorting and Agglomeration

Gaubert (2018)

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Introduction

What is the impact of an increase in city size
in terms of firm value added and firm employment changes?

- Elasticities are positive in a great share of sectors
- For value added, it is positive for 85% of industries, corresponding to 93% of firms. Significantly negative for only one industry.
- The elasticity of employment to city size almost always lies below the elasticity of value added to city size

Introduction

Does city size impact the share of inputs used in production?

- Larger cities host more capital intensive production[1]
- Even controlling for local skill intensity and export activities.

[1] Cobb-Douglas production, with local labor, tradable and non-tradable capital.

Introduction

Who benefits from agglomeration externalities?

- Firms located in large cities benefit disproportionately from agglomeration externalities, Combes et al. (2012)
- More efficient firms self-select into larger cities (looking at the moves of mono-plant firms across cities and relying on a residual approach)
- Firm-size distribution is more fat-tailed for industries located in larger cities (lower Pareto exponent)

Motivation

The *Urban productivity premium*

- **First and Second natural advantage**,
  "Nature's unfairness is not easily remedied", Cronon (1991)
- **Agglomeration economies**: learning, matching, sharing, spillovers,
  Productivity gains from non-market interactions within cities
- **Sorting**: (self-selection of the more productive firm into larger cities)
  Spatial wage disparities remain between 'equivalent' workers,
  Combes et al. (2008)
- **Selection**: Large cities tend to select more productive agents
- **City size distribution**: Zipf, Gibrat, Stability...

Motivation

Main Takeaways of this session

- More efficient firms locate in larger cities: sorting matters!
- Ingredients and results in labor geography:
  - spatial segmentation distorts nation-wide policies through local spillovers,
  - more productive labor demand is in larger cities, with more capital intensive production
- Policy recommendation
  - Supporting the growth of cities has better welfare implication than subsidizing the implementation of firms in smaller cities
- Next Challenges: Identifying the local factors of growth
  - Beyond size composition may matters
  - as Space: City networks, Distances and Large scale commuting
  - Dynamic system of cities

Worker based proposal

Sorting, selection, and agglomeration, Behrens et al. (2014)

- Individual are characterized by their 'talent' t and 'serendipity' s, which yields their 'productivity' $\varphi \equiv t \times s$.
- Their is a continuum of *ex ante* homogeneous sites where people form *endogenous* cities i. Their size L fully characterize cities.
- Following Lucas' model (1978), there is city-specific selection cut-offs to be entrepreneur $\varphi_c(i)$.
- Goods are non-tradable and produced in varieties $x_c(i) = \varphi_c(i) l_c(i)$

Worker based proposal

Sorting, selection, and agglomeration, Behrens et al. (2014)

- People choose cities according to their talent, increasing with size L: **sorting**.
- Then they draw a random and individual level of serendipity s, which determines their own productivity φ as the local cut-off $\varphi_c(i)$, increasing in size, to establish a business: **selection**.
- Which ends up by producing more varieties in larger cities: **agglomeration economies**

Conclusion:

- Elasticity of earnings with respect to city population is 8.2%
- Explained simultaneously by sorting, selection and agglomeration

The Model

Firm Sorting and Agglomeration, Gaubert (2018)

How much of the productivity advantage of a region is shaped by the efficiency of the firms it attracts?

Objective:

- Building a theory of firm location choice, with a variety of sector
- Disentangling firm 'raw' productivity and agglomeration externalities
- Assessing the general equilibrium effect of place-based policies

The Model

Firm Sorting and Agglomeration, Gaubert (2018)

Results:

- More efficient firms locate in larger cities
- Sectoral firm size distribution is more fat-tailed for industries located in large cities.
- Sorting accounts for 1/2 of the productivity advantage of large cities; with an elasticity of observed firm productivity to city size of 2.3%, compared to a total estimated at 4%
- Supporting the growth of cities has better welfare implication than subsidizing the implementation of firms in smaller cities

The Model

Cities

- Constraint in land supply
- Fully characterized by their size
- Atomistic landowners construct housing, h^{Prod}, using land γ, with local labor l_h, according to the housing production function:

$$h^{\text{Prod}} = \gamma^b \left(\frac{l_h}{1-b}\right)^{1-b}$$

- Housing price $p_H(L)$ and local wage $w(L)$ are given in competitive local markets.

The Model

Workers

- Utility

$$U = (\frac{c}{\eta})^{\eta}(\frac{h}{1-\eta})^{1-\eta}$$

- with $c = \Pi_{j=1}^{j=S} c_j^{\xi_j}$ the Cobb-Douglas bundle of goods across S sectors
- CES bundle of varieties within sector $c_j = [\int c_j(i)^{\frac{\sigma_j - 1}{\sigma_j}} di]^{\frac{\sigma_j}{\sigma_j - 1}}$

The Model

Workers

- Workers are freely mobile, they follow firms location choice
- The budget constraint faced by workers is $Pc(L) + p_H(l)h(L) = w(L)$
- Housing consumed by each workers in equilibrium in city L is $h(L) = (1-\eta)^{1-b}L^{-b}$
- Workers wage is $w(L) = \overline{w}((1-\eta)L)^{b\frac{1-\eta}{\eta}}$

$=>$ Utility equalized across localisation in equilibrium

$=>$ Workers' wage increases with city size, but city population also increases congestion: higher housing prices

The Model

Firms

- Firms are engaged in monopolistic competition
- Heterogeneous firms with 'raw' productivity z and sector j (with capital intensity α_j and specific benefit from local externalities σ_j)
- Varieties are produced by firm from different sectors j, using (non-tradable) labor l and (tradable) capital k inputs in a Cobb-Douglas production function: $y_j(z, L) = \psi(z, L, s_j) k^{\alpha_j} l^{1-\alpha_j}$
- $\psi(z, L, s_j)$ is a firm-specific Hicks-neutral productivity shifter. A choice of a classic productivity shifter is of the form $\psi = zL^s$

$=>$ The sorting assumption lies in the complementarity between intrinsic productivity and local externalities: $\psi(z, L, s_j)$

Set up

- Firm discover their raw productivity z (draw from some distribution F_j) and chose a city size where to produce
- No *entry selection*, such as Melitz (2003), but a *selection on city size*
- Firms set constant markups over their marginal cost
- City developers built cities on an infinite set of potential sites
- The heterogeneity across cities will results from firm sorting and city size (different from Behrens et al., 2014), varying with sectors.

Firms in this set up

- Firm z's profit[2] is $\pi_j(z,L) = \kappa_{1j}(\frac{\psi(z,L,s_j)}{w(L)^{1-j}})^{\sigma_j-1} R_j P_j^{\sigma_j-1}$
- Firm employment in city size L is $l_j(z,L) = (1-\alpha_j)(\sigma_j-1)\frac{\pi_j(z,L)}{w(L)}$
- The problem of the firm is thus to choose the city size L that maximize its profits $\pi_j(z,L)$:

$$L_j^*(z) = \underset{L\in\mathcal{L}}{\operatorname{argmax}}\{\pi_j(z,L)\}$$

[2] $\kappa_{1j} = ((\sigma_j-1)\alpha_j^{\alpha_j}(1-\alpha_j)^{1-\alpha_j}(P)^{-\alpha_j})^{\sigma-1}/\sigma_j^{\sigma_j}$

Assumption and Properties (I)

- Properties of monotone comparative statics (Topkis, 1998), and assuming log-supermodularity of the productivity shifter, yields a matching scheme that is non-decreasing in z.
- and fully determined the firm maximization problem and optimal values of firm z's profit, revenues and employment; conditional on the set of city size $\mathcal{L}$.

Assumption and Properties (II)

- The *geographic distribution* (def.) is the probability for a firm from sector (α_j, σ_j) to choose to locate in a city of size smaller than L
- The *geographic distribution* of firms of a high α_j sector first-order stochastically dominates that of a lower α_k sector, all else equal.
- The same holds for high σ_j sector (benefit from agglomeration externalities) compared to a lower σ_k sector.
- In addition if $(\alpha_j, \sigma_j) \geq (\alpha_k, \sigma_k)$ the tail of the firm-size distribution from sector j is thicker than the tail of the firm-size distribution in sector k : $\zeta_j \leq \zeta_k$.

City Developers to close the model

- Equilibrium device allows to create new city, where agents may locate
- City developers subsidizing firms' profit $T_j(L)$ and perfectly compete across cities, so that they maximize:

$$\max_{\{T_j(L)\}_{j\in 1,..,S}} \Pi_L = b(1-\eta)Lw(L) - \sum_{j=1}^{S} \int_z T_j(L)\pi_j(z,L)1_L(z,j)dF_j(z)$$

- The first term corresponds to housing revenue, the second term to subsidies cost
- Solving the problem results in subsidies independent of city size

The Model

A system of Cities: Definition of the Equilibrium

- The equilibrium is a set of cities $\mathcal{L}$ characterized by a city-size distribution f_L, and for each sector $j = 1, .., S$ a location function $L_j(z)$, an employment function $l_j(z)$

  and also a wage schedule $w(L)$, a housing-price $p_H(L)$, a capital-use function $k_j(z)$, a production function $y_j(z)$, a price index P_j, and a mass of firms M_j

$=>$ The equilibrium of this economy exists and is unique

The Model

Solving the model in 4 steps:

- Equilibrium subsidy between city, with city developers zero profit condition, to find $T_j^* = \frac{b(1-\eta)(1-\alpha_j)(\sigma_j-1)}{1-(1-\eta)(a-b)}$
- Firms match with city size, $L_j^{**}(z) = \underset{L \geq 0}{\operatorname{argmax}} \pi_j^*(z, L)$
- General equilibrium quantities, R, P_j, M_j
- City-size distribution, this yields[3]

$$f_L(L) = \kappa_4 \frac{\sum_{j=1}^{S} M_j 1_L(j) l_j(z_j^*(L))(f_j(z_j^*(L)) \frac{dz_j^*(L)}{dL}}{L}$$

[3] $\kappa_4 = \frac{1}{1-(1-\eta)(1-b)}$

The Model

Theoretical conclusion

- Under reasonable hypothesis **the model yields a unique equilibrium** of the economy, that provides a system of cities and a **matching scheme between firm (j, z) and city (L)**.
- More productive firms locate in larger cities, thanks to the log-supermodularity of the firm-specific productivity shifter $\psi(z, L, s_j)$
- **Sectors that are more capital intensive (α_j) are more likely to locate in larger cities** (stochastic dominance)
- **Sectors that benefit the most from agglomeration externalities (σ_j) are more likely to locate in larger cities**
- In addition if $(\alpha_j, \sigma_j) \geq (\alpha_k, \sigma_k)$ implies thicker tail of the firm-size distribution from sector j compared to k ($\zeta_j \leq \zeta_k$).

Estimation of the Model

French firm-level **data and localization** (with the CASD)

- Information on firms comes from FICUS/FARE data set, and plant-firm information from DADS allow to localize the production.
- City are defined according to the commuting zones (*Zones d'emploi*)
- City size corresponds to the total local employment of the area
- Focus only on firms in the tradable production sectors in year 2000, 157,070 firms, covering 23 sectors, as in Combes et al. (2012)

Estimation of the Model

Structural estimation

- The model is estimated industry by industry
- The estimation is made by minimizing the distance between moments of the data and their simulated counterparts to estimate the sectoral parameters[4]: $(\alpha_j, \sigma_j, \nu_{z,j}, \nu_{R,j})$

$$||m_j - \hat{m}_j(\theta)||_{W_j^2} = (m_j - \hat{m}_j(\theta))' W_j (m_j - \hat{m}_j(\theta))$$

- Weights are, for each sectors, the generalized inverse of the estimated variance-covariance matrix Ω_j of the moments, calculated from the data m_j

[4] α_j: capital intensity; σ_j: complementarity in ψ; $\nu_{z,j}$: the variance of z and $\nu_{R,j}$ the variance of an additional parameter $\epsilon_{i,L}$ (error term), described later.

Estimation of the Model

Structural estimation

- An error structure is introduced by an idiosyncratic motive for choosing a specific location[5], $\epsilon_{i,L}$, with variance $\nu_{R,j}$
- The productivity shifter is chosen, such as to fit the criteria of the previous solving (especilly log-supermodularity)

$$log(\psi_j(z_i, L, s_j, \alpha_j)) = \alpha_j log(L) + log(z_i)(1 + log(\frac{L}{L_0}))^{s_j} + \epsilon_{i,L}$$

if $log(z_i) \geq 0, L_0$; if not $log(\psi_j(z_i, L, s_j, \alpha_j)) = 0$

[5] This will be used later to disentangle the agglomeration impact in the identification.

Estimation of the Model

Structural estimation: **two steps**

- First estimating α_j and σ_j, then $b\frac{1-\eta}{\eta}$, equal to the elasticity of wages to city size in the model and the Cobb-Douglas share of each industry ξ_j by measuring its share of value-added produced.
- Secondly, backing out the quadruple $(\alpha_j, \sigma_j, \nu_{z,j}, \nu_{R,j})$ for each sectors j, comes from the firms discrete choice of (normalized) city size:

$$log(\tilde{L}_j^*(z_i)) = \underset{log(\tilde{L})\in\mathcal{L}}{\text{argmax}} log(z_i)(1+log\tilde{L})^{s_j} + (a_j - b(1-\alpha_j)\frac{1-\eta}{\eta})log\tilde{L} + \epsilon_{i,L}$$

Estimation of the Model

Structural estimation: **Simulated Method of Moments**

- Unobserved heterogeneity across firms (larger firms benefit more from agglomeration externalities) and Non-linearity of the firm choice
- We require to use the simulated method (Gourieroux et al., 1996) to estimate the parameters of interest $(\alpha, \sigma, \nu_z, \nu_R)$, as in Eaton et al. (2011).
- Three sets of nonparametric moments:
  - Moments (quantile) of the firm value-added increase with city size, sector by sector (to pin dawn a and s)
  - Moments characterizing the firm size distribution in value added (for ν_z and ν_R): 25th, 50th, 70th and 90th (emphasizing higher quantiles, capturing most of the value added and less noisier).
  - Moments of the distribution of sectoral value-added across city sizes (25th, 50th, 75th), help to ν_z from s and a.

Estimation of the Model

Conclusion: **the Parameters**

- **Agglomeration externalities** per se:
  + Publishing and printing, Manufacturing of computers and office machinery, Business services and IT;
  - Motor vehicles, Product of wood, except furniture

  Complementarity:
  + Chemical, Manufacturing of furniture, Manufacturing of medical, precision and optical instrument;
  - Leather and footwear, Basic metal

  Both:
  + Information technology services, Manufacturing of wearing apparel
- **Limitation** to the identification of agglomeration externalities are shown when sector may also benefits from higher Market Potential in larger cities like 'Business services and IT' or 'Publishing and printing' Seminal contribution and comparable results in Combes et al., 2012

Estimation of the Model

Conclusion: **Analysis of the Parameters**

- The **importance of the sorting**: decomposition of the variance contributions of productivity due:
  - to sorting $log(z_i)(1 + log\tilde{L})^{s_j}$
  - and the idiosyncratic part ϵ_{iL}

  $=>$ On average, across sectors, the systematic component (firm sorting) explains 51% of the variance of firms productivity. The remaining part is due to random location choice.

Aggregate, Welfare and Policy Implications

Local Tax Incentives

(subsidizing firms locating in less develop cities)

- Forces at play:
  - \+ Enhancing local TFP by attracting economic activity
  - \- Larger cities lose some resources and activity
  - ▸ It depends on the overall reallocation of economic activity in space
- Local effects:
  - ▸ Increase city size by 4%, small because attracted firms are small and low productive.
- Aggregate effects:
  - ▸ Computing counterfactuals aggregate TFP and welfare (real income).
  - ▸ Subsidy by 1% of GDP leads to 1.05% loss in TFP, 1.4% in welfare.
  - ▸ More inequality: low productive firm from mid sized cities goes in small cities, while people goes in larger cities

Aggregate, Welfare and Policy Implications

Land-use regulation

(decreasing the land-use parameter b in the housing production function)

- Direct effect on (increasing) utility: less congestion
- Flattens the wage schedule, which leads firms to locate in larger cities, enhancing productivity
- An overall increase in housing supply elasticity (from the 25th to 75th percentiles) leads to a 1.6% increase of TFP plus a 1.8% indirect gain in welfare.

Conclusion on the Model

Contribution

- Firm maximizing problem depend only on city size: location choice
- Disentangling firm sorting from agglomeration externalities in the urban premium
- Place-based policy evaluation with local and aggregate impacts
- *Limits*: Static, Non-spatial, No-Unemployment and No-Composition

Research Agenda

What matters?

- Identifying the local factors of growth: Where are the new jobs?
- Understanding spatial disparities beyond size (composition, network)
- Building a dynamic model of cities (growth process, shuffling around)

Research Agenda

Zipf, Gibrat and the Dynamic of Cities

- Life cycle model of firm location (Duranton and Puga, 2001)
- Productivity shocks shuffle around spatial activity,
  with pretty stable locus (Michaels and Rauch, 2018)
  from handcraft to manufacturing to tech jobs (Harrigan et al., 2016);
  from North-East to the West Coast?
- Specialization: from sectoral to functional
  (Duranton and Puga, 2005, Charnoz et al., 2018)
- Centrality (Hsu, 2012) and City networks
- Frictional labor mobility (Schmutz and Sidibe, 2018)

Discussion

Main Takeaways

- More efficient firms locate in larger cities: **sorting matters!**
- Results in **labor geography**:
  - More productive and capital intensive jobs are in larger cities (sorting)
  - Geographic segmentation distorts nation-wide policies (local spillovers)
- **Policy recommendations**
  - Supporting the growth of cities has better welfare implication than subsidizing the implementation of firms in smaller cities
- Ideas and Challenge: Identifying the local factors of growth
  - Beyond size **composition** may matters, as..
  - **Space**: City networks, Distances and Large scale commuting
  - **Dynamic system of cities**

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