Entrepreneurship Across Cities: Uncovering Policy Implications

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Motivation I

- Entrepreneurship is relevant for economic aggregates:
  - Economic Growth and Job Creation (Glaeser, Kerr and Ponzetto (2010), Genniaoli et al. (2013), Haltiwanger, Jarmin and Miranda (2013), ...)
  - Innovation (Chatterji, Glaeser and Kerr (2013), Duranton (2007), ...)

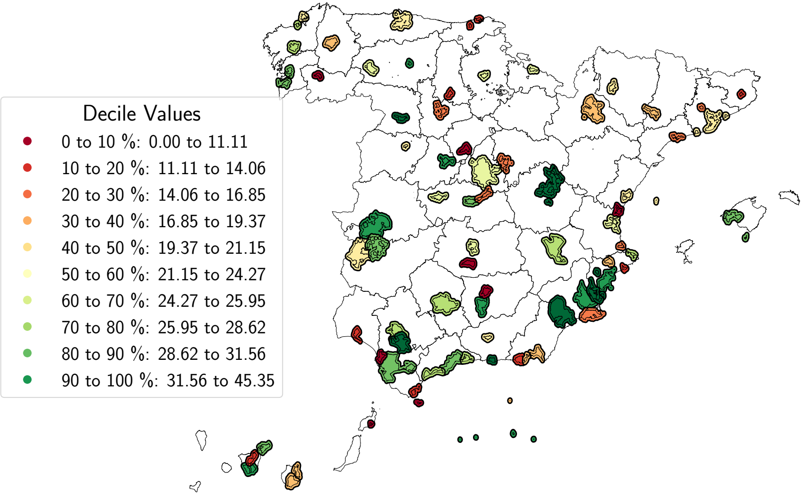
- Space matters for Entrepreneurship:
  - local agglomeration externalities ((Rossi-Hansberg, Sarte and Schwartzman (2021), Giannone (2022))
  - spatial sorting of skill ((Eeckhout, Hedtrich and Pinheiro (2021), Autor (2019)...)

- Interest by policymakers to foster Entrepreneurship
  - The Draghi report, EU expenditure of 0.1% of GDP in fostering innovation and entrepreneurship (Horizon Europe, EIC, ...)

- Is there scope for these entrepreneurial expenditures to be targeted?
  - Could space be a targeting criteria?

Motivation II, the (Substantial) Spatial Variation of Entrepreneurship

Entrepreneurial Rate: New Incorporated per 10,000 inhabitants (Working Age)
Averaged Over 2013-2018, by Urban Area (MCVL data)



In this paper

- Develop a novel Quantitative Dynamic Spatial model of Entrepreneurship:
  - Set of Urban Areas, where heterogeneous workers and entrepreneurs sort across space
  - Elements from both literatures: mobility, financial frictions, occupational choice, heterogeneous locations, agglomeration forces, housing sector...
  - Takeaway:
    - Presence of financial frictions creates heterogeneous returns to capital across space $\Longrightarrow$ space matters for policy!
  - Take model to top 20 UAs of the Spanish State (49% of population, $\sim$ 74% of GDP)

- Propose an efficient solution method (+ sample codes) that exploits the parallel nature of quantitative macro algorithms and GPUs (Graphics Processing Units)

- Long-run effects of entrepreneurial place-based policies:
  - Takeaways:
    - Targeting productive, more constrained Urban Areas and entrepreneurs leads to larger welfare gains
    - It's not all good news for the targeted location!

Relation to the literature

- Entrepreneurship and Macroeconomics: Quadrini (2000), Caggeti and De Nardi (2006), Caggeti and De Nardi (2009), Guvenen et al. (2023), Boar and Midrigan (2023), Glaeser, Kerr and Ponzetto (2010), Haltiwanger, Jarmin and Miranda (2013), Chatterji, Glaeser and Kerr (2013) ...
  - Introduce the spatial dimension of entrepreneurship and explore the policy implications
- Quantitative Spatial Economics: Giannone, Paixao and Pang (2020), Kleinman, Riu, Redding (2023), Redding, Rossi-Hansberg (2017), Desmet, Nagy and Rossi-Hansberg (2018), Caliendo, Dvorkin and Parro (2019), ...
  - Propose efficient solution algorithm and bring together entrepreneurial and spatial literatures
- Financial Frictions: Evans and Jovanovic (1989), Holtz-Eakin et al. (1994), Banerjee and Duflo (2014), Schmalz et al. (2017), ...
  - Explore spatial dimension of financial frictions
- Computational Economics with GPUs: Creel and Zubair (2012), Duarte et al. (2020), Villaverde and Valencia (2018), Aldrich (2014), ...
  - Full-fledged (calibration + policy exercises) low-level implementation in CUDA/C++ and sample codes for VFI, panel simulation, Young (2010)'s method and reduction

Plan for today

- Model
  - Setting
  - Building blocks
  - Equilibrium
- Calibration
  - Data Sources
  - Main calibrated parameters
  - Targeted and untargeted moments
- Solution Method
  - Intuition of the method
  - When does it work best?
- Results
  - More productive UAs are more constrained
  - Policy experiments

Model

Setting of the Model

- Heterogeneous agents who:
  - Have a fixed skill s and sectoral j type
  - Make occupational choices:
    - Entrepreneurs: produce intermediate goods
    - Workers: supply a unit of labour
  - Are mobile across locations
  - Receive per-period entrepreneurial productivity draws z
- J sectors:
  - Produce under heterogeneous intensity of inputs and returns to scale
  - Are subject to heterogeneous sensitivity to agglomeration forces
- L heterogeneous locations (UAs) across space with:
  - Exogenous sector-location productivity $A_{j,l}$
  - Exogenous housing supply elasticity η_l
  - Exogenous skill specific amenities $a_{s,l}$

Final and Intermediate Goods

- There exists a single costlessly tradable final good Y that is composed of intermediate sectoral goods in CES fashion:

$$Y = \left(\sum_{j}^{J} \gamma_j^{\frac{1}{\rho}} Y_j^{\frac{\rho-1}{\rho}} \right)^{\frac{\rho}{\rho-1}}$$

- Where J is the number of sectors in the economy, ρ is the elasticity of substitution and γ_j are the weight parameters for each intermediate

- Under those assumptions, the country-wide demand for a given intermediate sectoral good is given by:

$$Y_j = \left(\frac{\gamma_j P_j^{-\rho} Y^d}{P^{(1-\rho)}} \right) \forall j \in J$$

Intermediate Goods Production

- Intermediates produced by entrepreneurs who differ in their asset holdings a, productivity z, skill s, sector j and location l. They are price-takers, pay profit taxes τ_k and produce according to the following DRS production function:

$$(1-\tau_k)\pi_{a,z,s,j,l} = (1-\tau_k)\Big(\underbrace{p_j}_{\text{PRICE-TAKERS}}\ \underbrace{\Xi_{z,j,s,l}}_{\text{PRODUCTIVITY TERM (NEXT SLIDE)}}$$

$$\left(1 + \underbrace{\left(\frac{L_l}{L}\right)^{\Omega_{\text{SIZE},J}}}_{\text{SIZE AGG. FORCES}} \underbrace{\left(\frac{H_l}{U_l}\right)^{\Omega_{\text{SKILL},J}}}_{\text{SKILL AGG. FORCES}}\right)\left(\alpha_{H,j} h^{\frac{(\xi-1)}{\xi}} + \alpha_{U,j} u^{\frac{(\xi-1)}{\xi}} + \alpha_{K,j} k^{\frac{(\xi-1)}{\xi}}\right)^{\frac{\xi}{\xi-1}\underbrace{\mu_j}_{\text{DRS},\,\mu_j<1}}$$

$$-\underbrace{(W_{H,j,l}h + W_{U,j,l}u_e)}_{\text{LABOUR COSTS}} - \underbrace{(r_t+\delta)k}_{\text{CAPITAL COSTS}} - \underbrace{F_j}_{\text{FIXED COSTS}}\Big)$$

S.T.

$$\underbrace{k \leq \lambda_j a}_{\text{BORROWING CONSTRAINT}}$$

Empirical Motivation Agglomeration Forces
Empirical Motivation Financial Frictions

Details on the Productivity Term

- The productivity term is:

$$\Xi_{z,j,s,l} = (\underbrace{z}_{\text{Idiosyncratic Productivity}} + \underbrace{\phi_j}_{\text{Productivity Scaler}}) \underbrace{\Phi_{s,j}}_{\text{Multiplier High-Skilled}} \underbrace{A_{j,l}}_{\text{Exogenous Productivity}}$$

- z is the idiosyncratic productivity of the entrepreneur
- ϕ_j regulates the share of profits out of revenues per sector
- $\Phi_{s,j}$ regulates the average share of skilled entrepreneurs per sector
- $A_{j,l}$ is the exogenous UA-Sector productivity term

Financial Markets

- There exists a risk-free bond that is borrowed and lent intra-period at rate r
- Impose the following structure on the financial market:
  - (i) no borrowing for consumption is allowed, so that $a \geq 0$
  - (ii) the borrowed funds may only be employed to finance entrepreneurial capital
  - (iii) production takes place after z has been observed, so there no within period uncertainty in borrowing
  - (iv) entrepreneurs are subject to borrowing constraints, which are assumed to take the following functional form:

$$k_{con} \leq \lambda_j a$$

Housing

- Each location has an exogenous endowment of land $\bar{H}_l$
- In addition, the overall supply of housing in location l is increasing in the price $p_{h,l}^{\eta}$, with η_l being the elasticity, so that $H_l^s = p_{h,l}^{\eta_l}\bar{H}_l$ (Supply) (Ganong and Shoag, 2017)
- Agents have CB preferences over the final good and housing, so that a share (of expenditure) $(1-\alpha_c)$ is spent on housing (Demand)

$$u(c,h) = \frac{\left(c_t^{\alpha_c} h_{r,t}^{(1-\alpha_c)}\right)^{1-\sigma}}{1-\sigma}$$

Household's problem

- Agents are mobile across locations l, subject to utility moving costs $\tau_{l,l',o}$. Each period, they receive a sized L vector of $i.i.d.$ location preference shocks ϵ (distributed Extreme Value Type-I)
- At the beginning of a period once having moved to a location l, given their position on the state space (a, z, s, j, l), households choose between becoming a worker or an entrepreneur

$$V(a, z, s, j, l) = \max\{V^w(a, z, s, j, l), V^e(a, z, s, j, l)\}$$

Worker's Problem

- At time t, workers on point on state space $\{a, z, j, s, l\}$ make optimal housing, consumption, savings and location decisions.

$$V_t^w(a_t, z_t, s, j, l_t) = \max_{a_{t+1}, h_{r,t}, c_t} \frac{\left(c_t^{\alpha_c} h_{r,t}^{(1-\alpha_c)}\right)^{1-\sigma}}{1-\sigma} + \underbrace{a_{s,l}}_{\text{Amenities}}$$

$$+\beta \mathbb{E}_{z,\epsilon}\left(\max_{\{k\}_{k=1}^{L}} V_{t+1}(a_{t+1}, z_{t+1}, s, j, k) - \overbrace{\tau_{l,k,o}}^{Utility\ \ Moving\ \ Costs} + \overbrace{v\epsilon_{t+1}^{k}}^{Location\ \ Preference\ \ Shock} \right)$$

$$s.t.\ c_t = (1 + r_t)a_t + (1 - \tau_L)w_{t,s,j,l} - h_{r,t}p_{t,h,l} - a_{t+1} \qquad \text{(Budget Constraint)}$$

$$a_{t+1} \geq 0 \qquad \text{(Borrowing Constraint)}$$

Clearing the Markets

- The interest rate r clears the country-wide supply and demand for capital (1 *EQ.*):

$$r \ s.t. \int a'(a,z,s,j,l)d\lambda(a,z,s,j,l) = \int l_{occ(a,z,s,j,l)}k(a,z,s,j,l)d\lambda(a,z,s,j,l)$$

- The housing sector clears (L *EQ.*): $H_l^d \equiv \int\int\int\int h_r(a,z,s,j,l)\Lambda'(a,z,s,j,l)dadzdsdj = p_{h,l}^{\eta}\bar{H}_l$ for each l

- Local labour markets clear ($S \times J \times L$ *EQ.*):

$$w_{l,j,s} \ s.t. \quad \underbrace{LS_{s,j,l}}_{\text{Labour Supply of type } \{s,j\} \text{ in location } l} = \underbrace{\int_a\int_z\int_s LD_{s,j,l}(a,z,s,j,l)dadzds}_{\text{Labour demand in location } l \text{ and sector } j \text{ for skill } s}$$

- Overall demand for intermediate sectoral goods clears (J *EQ.*): p_j s.t. $Y_j = \left(\frac{\gamma_j P_j^{-\rho} Y}{P^{(1-\rho)}}\right) \forall j \in J$

- The Government Budget clears (1 *EQ.*):

$$\underbrace{\sum_{l=1}^{L}\sum_{j=1}^{J}\sum_{s=1}^{S}\tau_L w_{l,j,s}LS_{l,j,s}}_{\text{Labour Tax Revenue}} + \underbrace{\int \tau_K \pi(a,z,s,j,l)occ(a,z,s,j,l)d\lambda^*(a,z,s,j,l)}_{\text{Profit Tax Revenue}} = \underbrace{GY}_{\text{Exogenus Expenditure}}$$

Calibration

Taking the Model to the Data

- Main moments employed for calibration:

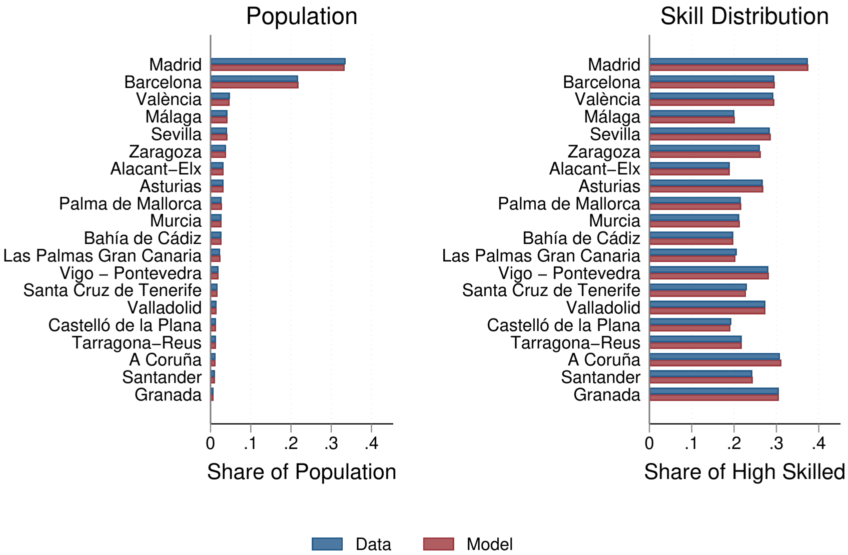
Model Ingredient	Moment / Procedure Employed	Data Source
State Space		
Number of Locations	Top 20 UA by population	MCVL
Number of Sectors	3 skill-based sectors (from 1st digit NACE)	MCVL
Number of Skills	2, following Roca and Puga (2017)	MCVL
Dimensionality ($N_a \times N_z \times N_s \times N_j \times N_l$)	$150 \times 21 \times 2 \times 3 \times 20 = 378,000$	VRAM Capacity RTX 3070 (8GB)
Housing		
Housing Supply Elasticities η_l	Follow procedure in Saiz (2010)	UA Atlas, GEBCO, CORINE
Population		
Distribution over skills and sectors $\Lambda_{s,j}$	Joint distribution over skill and sectors	MCVL
Amenities $a_{s,l}$	Distribution of Skilled and Unskilled by UA	MCVL
Moving Costs $\tau_{l,l',o}$	Out-migration probability by Occupation	MCVL
Production		
Fixed Costs F_j	Country-wide share of entrepreneurs by sector	MCVL
λ_j	Capital-weighted debt-to-assets ratio	SABI
Exogenous Productivity $A_{j,l}$	Solow approach	SABI, MCVL
Agglomeration forces $\Omega_{skill,j}$ and $\Omega_{size,j}$	Follow procedure in Giannone (2022)	MCVL, SABI, UA Atlas

Table: Summary of calibration moments and employed sources

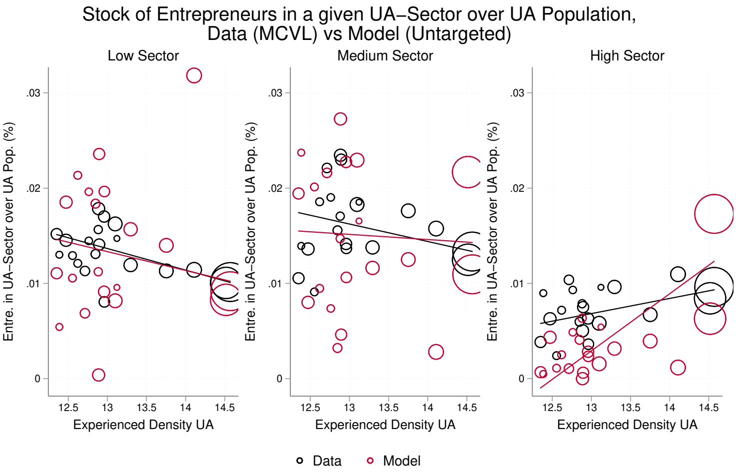
Full Calibration I | Full Calibration II | Housing Supply Elasticities | Exogenous Productivities | Agglomeration Forces | Amenities | $\Lambda_{s,j}$

Sector Composition | Skill Composition | Data Sources | Experienced Density | MPKs by UA in the data

Targeted Moments: Population and Skill Composition by UA



Untargeted Moments: Share of Entrepreneurs by UA-Sector



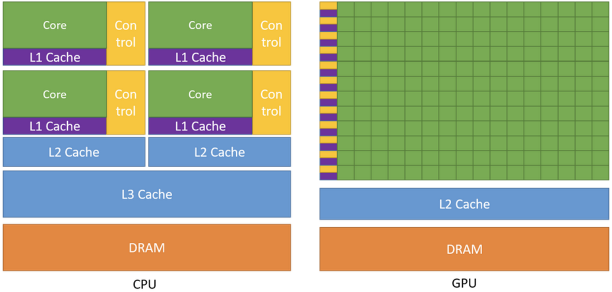
Notes: Circles represent the size of the UA. Experienced Density is the average amount of people in a 10km radius by UA

Wages Low Skilled | Wages High Skilled | Mobility Patterns

Solution Method

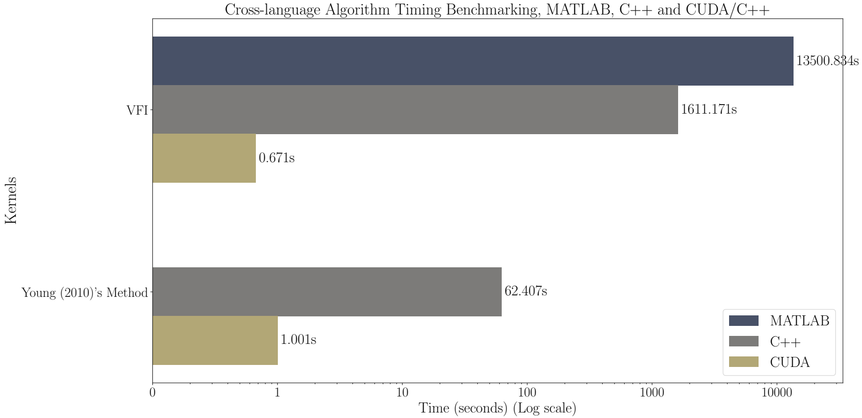
Exploiting the parallel nature of economic models with GPUs

- Most commonly employed algorithms for solving DSGE models (VFI, EGM, PFI, Panel Simulation, Non-Stochastic Simulation...) are parallel in nature
- Each point on the state space or observation in a simulation performs its own operations
- Key idea: rather than relying on sequential implementations, exploit hardware designed to maximize throughput, GPUs (Graphics Processing Units)



Source: CUDA documentation, Nvidia

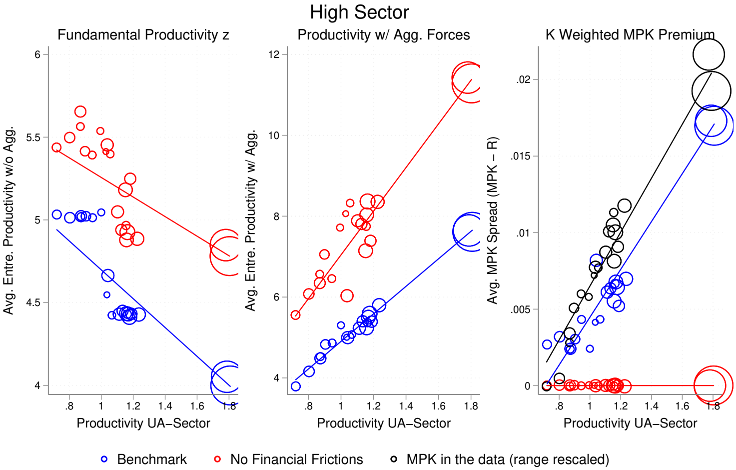
Does parallelization always work?: memory bottlenecks



Notes Execution time of the main kernels of the model, VFI and Young (2010)'s Non-Stochastic Simulation, in MATLAB, C++ and CUDA/C++. The VFI employs linear interpolation and Howard's Improvement. Young (2010)'s method is performed with SPMV COO multiplication. Each bar represents the execution time of each algorithm in each language in seconds. The MATLAB timing in an estimate based on previous benchmarks of fully-vectorized implementations. The C++ implementation is a single-core sequential implementation. The CUDA implementation is SIMT (Single Instruction Multiple Threads). All computations are performed in fp32 and int32 data types. VFI is an example of a computation parallel, memory quasi-parallel algorithm. Young (2010)'s method is an example of a computation parallel, memory bottle-necked algorithm (given specific custom implementation). The employed CPU is a 10600K and the GPU is an RTX 3070 (5888 fp32 pipelines). For a sample code of the Aiyagari (1994) model in CUDA/C++ check `https://github.com/markoirisarri/AiyagariModelCUDA`

Results and Policy Experiments

SS results: larger, skilled, more productive UAs are more constrained



- Differing MPK premiums by UA-Sector generate heterogeneous returns to capital across UAs

Low Sector | Medium Sector | MPKs by UA-Sector in the data

Policy Experiments

- Conduct place-based policy experiments that mimick an expenditure out of GDP equivalent to the main EU's programmes of 0.1% out of GDP

- Exercise: Direct lump-sum transfers to entrepreneurs T_l for $l \in L_P$ such that:

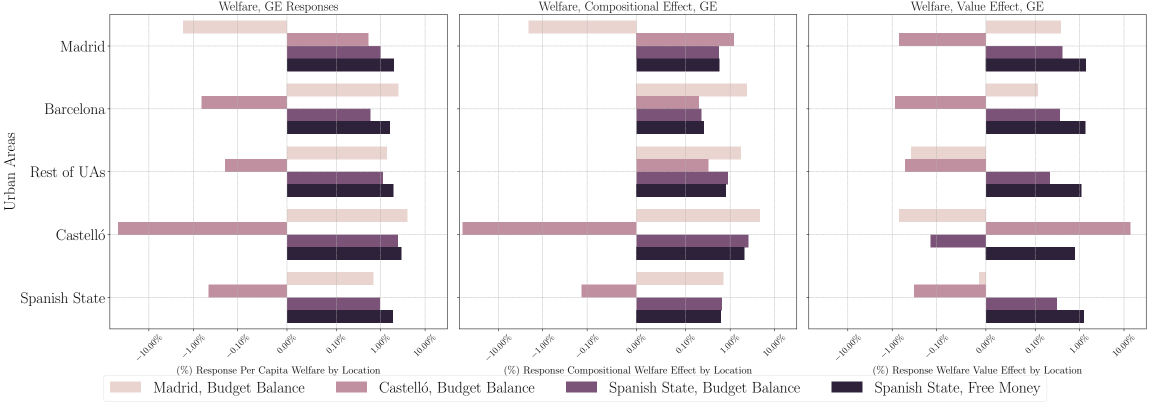
$$\underbrace{\sum_{l=1}^{L}\sum_{j=1}^{J}\sum_{s=1}^{S}(\tau_L + \delta_P) w_{l,j,s} LS_{l,j,s}}_{\text{REVENUES FROM LABOUR}} + \underbrace{\sum_{l=1}^{L}\sum_{j=1}^{J} \tau_K TBK_{l,j}}_{\text{REVENUES FROM PROFITS}} = \underbrace{GY}_{\text{EXOGENOUS EXPENDITURE}} + \underbrace{\sum_{l \in L_P} T_l S_{e,l}}_{\text{TRANSFERS PROGRAMME}}$$

- Find δ_P such that the budget balances with overall transfer cost $\sum_{l \in L_P} T_l S_{e,l}$

- What is the response of welfare and key aggregates to subsidies in (i) Madrid (ii) Castelló (iii) the whole country?

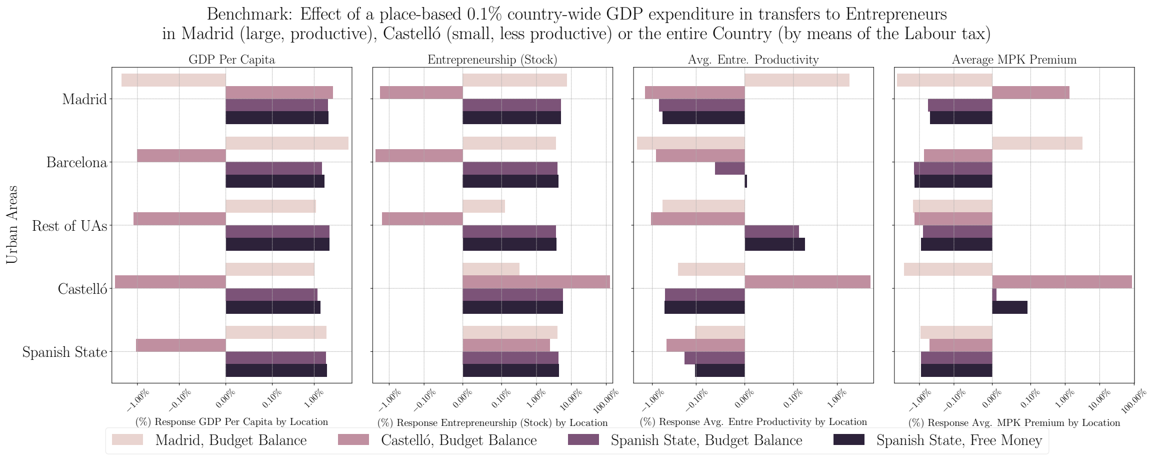
Policy Experiments: Direct Transfers Programme, Welfare

Benchmark: Effect of a place-based 0.1% country-wide GDP expenditure in transfers to Entrepreneurs in Madrid (large, productive), Castelló (small, less productive) or the entire Country (by means of the Labour tax)



No Financial Frictions | Prices and Compositional Effects | Gradual Increases: 0.02%, 0.1%, 0.25%, 1% | Welfare Decomposition

Policy Experiments: Direct Transfers Programme, Entrepreneurship



Conclusion

- Proposed a framework to evaluate place-based entrepreneurial subsidies
- Calibrated the economy the Spanish State's economy
- Proposed an efficient way to compute this class of spatial quantitative models
- Policy Experiments suggest that:
  - Targeting more constrained locations and entrepreneurs is more welfare-enhancing than targeting unconstrained ones
  - Congestion forces might disproportionately and adversely affect the place-based policy recipient location

Motivation for Size and Skill Agglomeration Forces by Sector

Table: Heterogenity of entrepreneurial entry w.r.t. UA characteristics by sector

	Above Median Entrants Mean	Below Median Entrants Mean	diff.
Low sector			
(Log) Experienced Density	12.368	11.675	0.693***
Share of High Skilled in UA	0.223	0.211	0.012*
Medium sector			
(Log) Experienced Density	12.253	11.774	0.479***
Share of High Skilled in UA	0.225	0.209	0.016**
High sector			
(Log) Experienced Density	12.725	11.739	0.985***
Share of High Skilled in UA	0.246	0.206	0.040***
Observations UA $\times$ Year	(225,231,128)	(237,231,334)	539

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Motivation Financial Frictions

- Cumulative income correlates with entry into entrepreneurship at the individual level (MCVL) Results

- UA-sector average MPKs are increasing in UA density / population rank (SABI) Results

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Motivation for Financial Frictions I

- Run following specification to test whether availability of funds is correlatad with entrepreneurial entry:

$$\mathbf{1}_{i,ua,s,t} = \alpha_i + \Theta\,\text{Lagged Cumulative Income}_{i,ua,s,t} + C^{I}_{i,ua,s,t}\Xi + C^{UA}_{i,ua,s,t}\Gamma + d_t + S_s + UA_{ua} + u_{i,ua,s,t}$$

  - $\mathbf{1}_{i,ua,s,t}$ is an indicator variable that takes a value of 1 if individual i, at UA ua, in sector s and time t became an entrepreneur
  - α_i accounts for individual fixed effects
  - $\Theta\,\text{Lagged Cumulative Income}_{i,ua,s,t}$ is the main term of interest
  - $C'^{I}_{i,ua,s,t}$ are controls at the individual level (Skill, Age, Sex, Family Size, Nationality, Internal Migrant).
  - $C'^{UA}_{i,ua,s,t}$ are controls at the UA level (Average Skill, Average Income, Experienced Density, Age Composition, % Workers in Large Firms, Unemployment Rate, Share of Foreigners, Labour Herfindahl Index)
  - Lastly, d_t, S_s, UA_{ua} are the time, sector and UA fixed effects

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Motivation for Financial Frictions II

Table: Estimation of the effect of cumulative income on entrepreneurial entry

Dependent Variable	(1) Pr. of Entry	(2) Pr. of Entry	(3) Pr. of Entry	(4) Pr. of Entry	(5) Pr. of Entry	(6) Pr. of Entry	(7) Pr. of Entry	(8) Pr. of Entry
L.(Log) Cumulative Income	-0.000411***	-0.000295***	0.000929***	0.00103***	0.000835***	0.000925***	0.000818***	0.000921***
	(-5.75)	(-5.64)	(3.70)	(4.31)	(3.19)	(3.66)	(3.19)	(3.68)
Controls	Yes	No	Yes	No	Yes	No	Yes	No
Individual FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Urban Area FE	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Year Effects	Yes	Yes	Yes	Yes	No	No	No	No
Sector FE	Yes	Yes	Yes	Yes	No	No	No	No
Sector x Year FE	No	No	No	No	Yes	Yes	No	No
UA x Sector x Year FE	No	No	No	No	No	No	Yes	Yes
R2	0.000943	0.000455	0.375	0.373	0.375	0.373	0.381	0.380
Cluster	UA	UA	UA	UA	UA	UA	UA	UA
N	641376	641397	592645	592671	592645	592671	592640	592666

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Increasing leverage ratios by UA-Sector productivity

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Full Calibration, I

Object	Num Elements	Internally/Externally	Definition	Target
			State Space	
L	1	Externally	Number of Locations	Top 20 UA by Population
J	1	Externally	Number of Sectors	3 Skill-based Sectors
S	1	Externally	Skill Levels	Low Skilled and High Skilled
			Skill-Sector Distribution	
$\Lambda_{s,j}$	$S \times J$	Externally	Exogenous Skill-Sector Distribution	MCVL Dataset
			Households	
$a_{s,l}$	$S \times L$	Internally	Amenities	Population Dist. by Skill
β	1	Internally	Discount Factor	Capital to Output Ratio 3
σ	1	Externally	Intertemporal Elasticity	Fixed at 1.5
α_c	1	Externally	Weight Consumption CB Utility	Fixed at 0.6
			Migration	
$\tau_{l,k,w}$	1	Internally	Utility Moving Costs	Share of movers 0.43% (Workers) (MCVL 2013-2018)
$\tau_{l,k,e}$	1	Internally	Utility Moving Costs	Share of movers 0.29% (Entrepreneurs) (MCVL 2013-2018)
v	1	Externally	Scale Parameter	Follow Giannone et al. (2023)
			Housing Sector	
$\bar{H}_{-0}$	$L-1$	Internally	Exogenous Housing Supply	Housing Cost w.r.t Madrid
$\bar{H}_0$	1	Internally	Exogenous Housing Supply	Cost in Madrid 40% of Avg. Low Skilled Gross Salary
η_l	L	Externally	Housing Supply Elasticity	Follow Saiz (2010)

Table: Calibrated Parameters in the model: Space, Distribution, Households, Migration and Housing blocks.

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Full Calibration II

Object	Num Elements	Internally/Externally	Definition	Target
			Production	
F_j	J	Internally	Fixed Cost Production	Target Stock of Entrepreneurs by Sector
λ_j	J	Internally	Leverage Ratio	Target Avg. Revenue-Weighted Debt-to-Assets Ratio
$\Phi_{s,j}$	J	Internally	Multiplier High Skilled	Match share High Skilled Entre. by Sector
ϕ_j	J	Internally	Productivity Scaler	Match profit rate by sector, SABI data
$A_{j,l}$	$J \times L$	Externally	Productivity UA-Sector	Follow Solow Residual Approach in Data
$\alpha_{j,i}$	$3 \times J$	Externally	Input Shares CES	Estimate from FOC in the Data
$\Omega_{\text{SKILL,J}}\&\Omega_{\text{SIZE,J}}$	$2 \times J$	Externally	Agglomeration Forces	Employ FOC w.r.t. H labour
γ_j	J	Internally	Weight of Sector in GDP	Official Statistics
ϵ_y	1	Externally	Elasticity of Subs. Production	1.5
ϵ_Y	1	Externally	Elasticity of Subs. Intermediate Goods	1.5
μ_j	J	Internally	DRS by Sector	1 - profit share SABI data
δ	1	Externally	Depreciation Rate	Follow Standard 8%
			Entrepreneurial Process	
ρ_z	1	Internally	Autocorrelation	Generate 5.7% Entry Rate
σ_z	1	Internally	Volatility	Avg. K Weighted MPK Premium 1.5%
			Government Block	
$\tau_{l,L}$	L	Externally	Labour Tax	30% Marginal Rate at Avg. Salary
$\tau_{l,K}$	L	Externally	Profit Tax	15% Effective Corporate Tax Rate
G	1	Internally	Share of Government Expenditure	SS value coming from Labour and Profit taxes

Table: Calibrated Parameters in the model: Production, Entrepreneurial and Government blocks.

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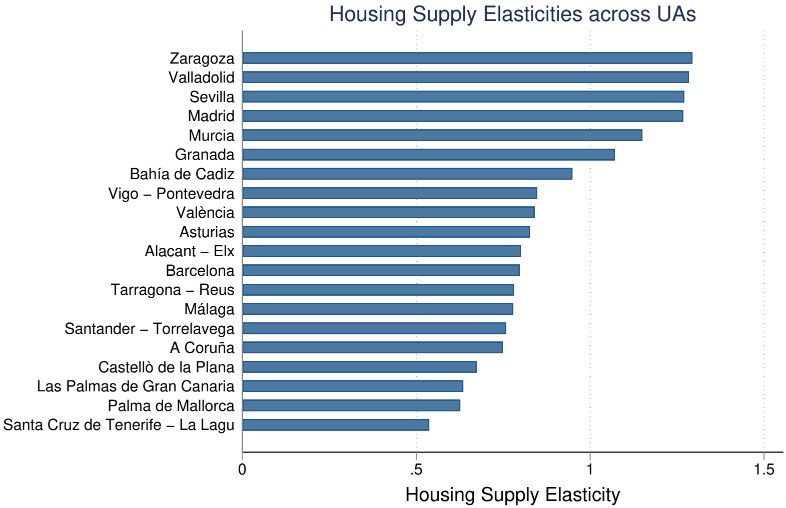
Hosing Supply Elasticities



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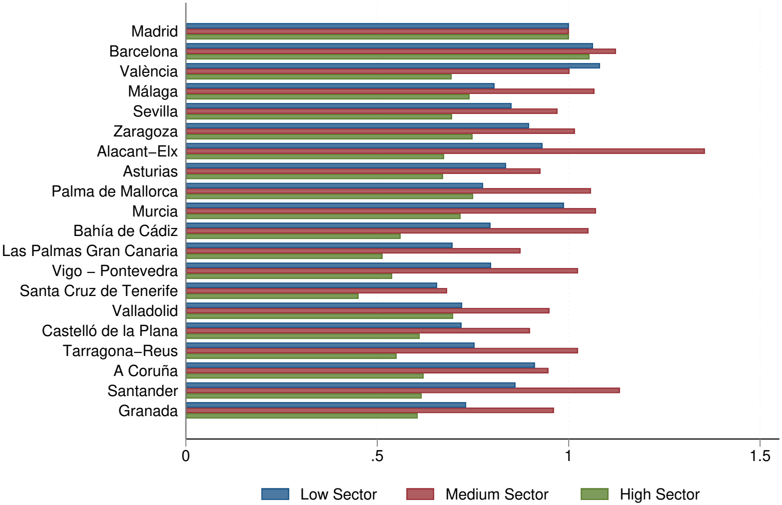
Exogenous Productivities $A_{j,l}$



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Estimating the Agglomreation Forces

- FOC w.r.t h labour in (unconstrained) CES PF:

$$\underbrace{\log w_{h,j,l} + \left(\frac{1}{\epsilon}\right)\log h_{l,j} - \frac{(\mu\epsilon - \epsilon + 1)}{(\epsilon - 1)}\log\left(\sum_{i=0}^{i=N_{l,j}-1}\frac{y_{i,l,j}}{N_{l,j}}\right)}_{\text{DEPENDENT VAR}} = \underbrace{\Omega_{skill}\log\left(\frac{h_l}{u_l}\right)}_{\text{SKILL AGGLOMERATION}} + \underbrace{\Omega_{size}\log\left(\frac{L_l}{L}\right)}_{\text{SIZE AGGLOMERATION}}$$

- Where $\left(\frac{h_l}{u_l}\right)$ is instrumented by the Stock of Inmigrants Bartik Instrument and $\left(\frac{L_l}{L}\right)$ by the Housing Supply Elasticity.

	IV		OLS	
Skill Sectors (Low, Medium, High)	Ω_{size}	Ω_{skill}	Ω_{size}	Ω_{skill}
Low	-0.032*	.107	.007	.389***
Medium	.095**	.351***	.060***	.560***
High	-.019*	.417***	-.004	.479***

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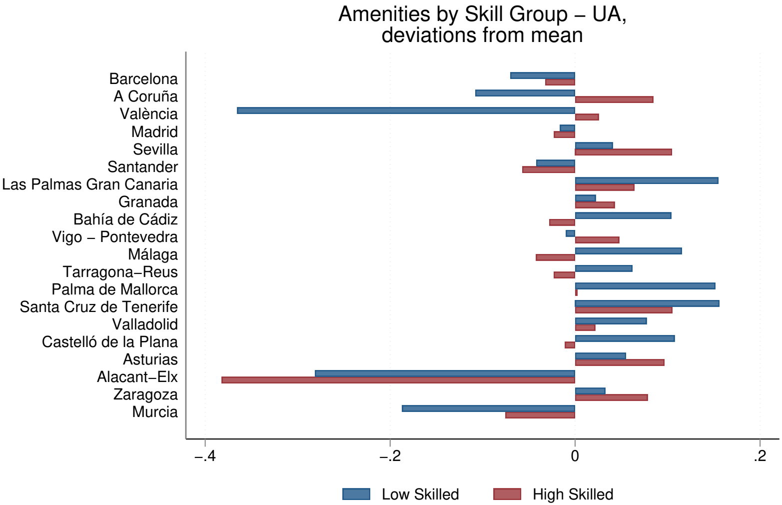
Amenities



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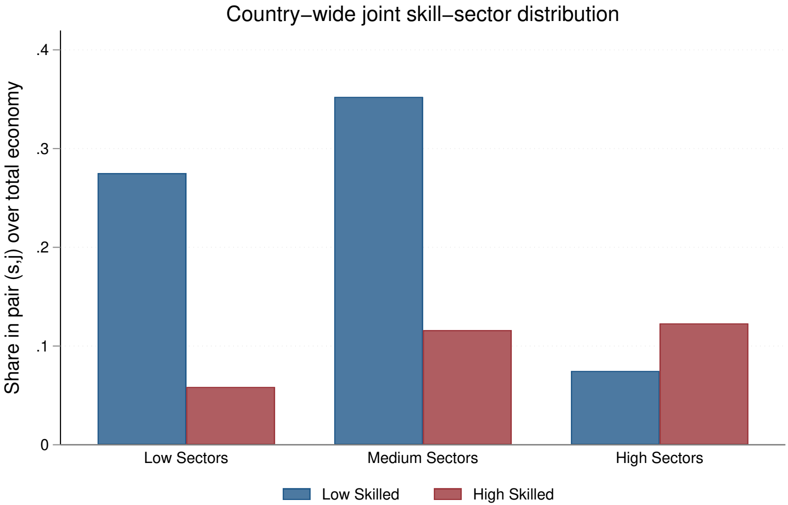
Skill-sector joint distribution $\Lambda_{s,j}$



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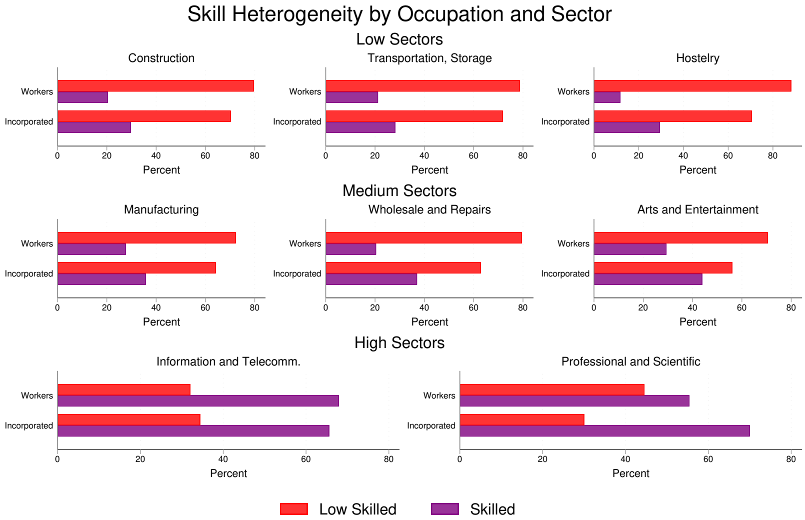
Skill-based Sectors



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Occupation-based Skill Levels (Roca and Puga (2017))

Original MCVL Occupation Classification	Model Skill Level	Unconditional Overall Share
“Engineers, college graduates and senior manager”	“High Skilled”	12.53%
“Technical engineers and graduate assistants”	“High Skilled”	5.15%
“Administrative and technical managers”	“High Skilled”	7.38%
“Non-graduate assistants”	“Low Skilled”	8.96%
“Administrative officers”	“Low Skilled”	19.83%
“Subordinates”	“Low Skilled”	6.73%
“Administrative assistants”	“Low Skilled”	12.63%
“First and second class officers”	“Low Skilled”	17.41%
“Third class officers and technicians”	“Low Skilled”	6.22%
“Labourers”	“Low-Skilled”	3.15%

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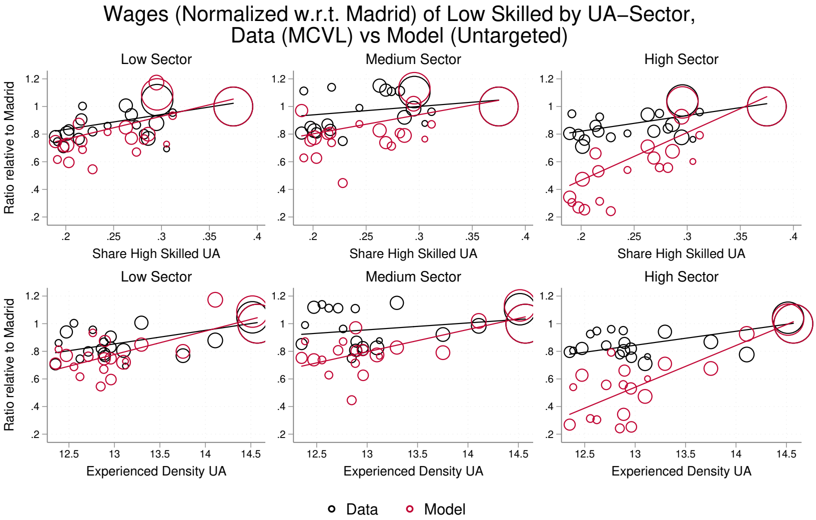
Wages of Low Skilled (normalized w.r.t Madrid)



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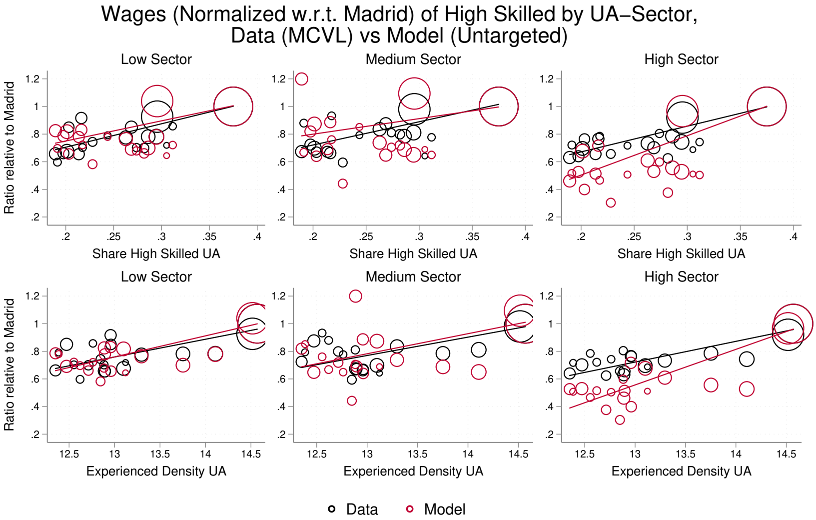
Wages of High Skilled (normalized w.r.t Madrid)



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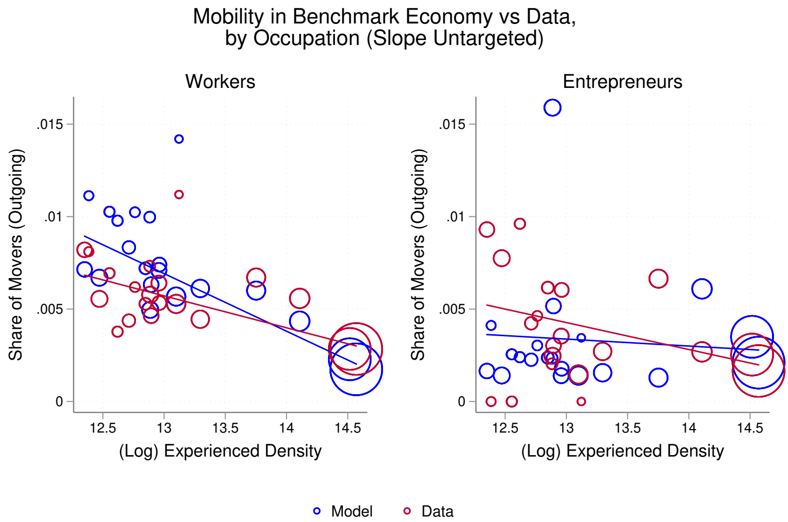
Mobility Patterns across UAs



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Spatial Mobility, Model

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Employed data sources

- MCVL (Continous Sample of Employment Histories). Administrative-level panel data on social security affiliation episodes. Data for 2013-2018
- SABI. Balance Sheet data on Spanish firms. Data for 2013-2018
- Grid cell population data from `worldpop.org`. Data for 2013-2018
- Digital Atlas of Urban Areas (Spanish Ministry of Housing and Urban Agenda)
- CORINE Land Cover data for the year 2018
- GEBCO bathymetric chart of oceans, 2018
- Population data from the Padrón Continuo (Continous Register) on the population of municipalities of the Spanish state, 2013-2018
- Geospatial data from Centro Nacional de Información Geográfica (National Centre of Geographic Information) on the delimitations of Spanish Municipalities and Provinces

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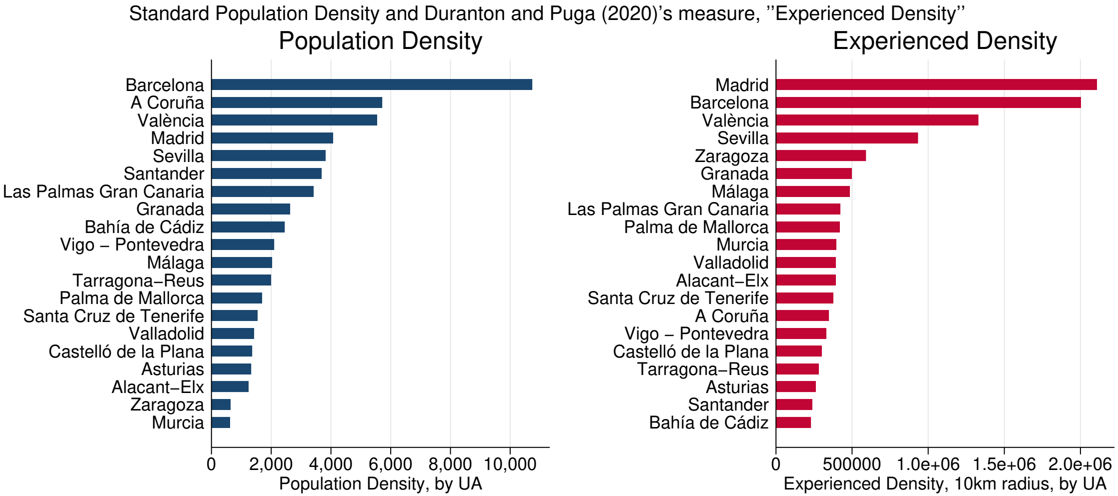
Experienced Density (Duranton and Puga, 2020)



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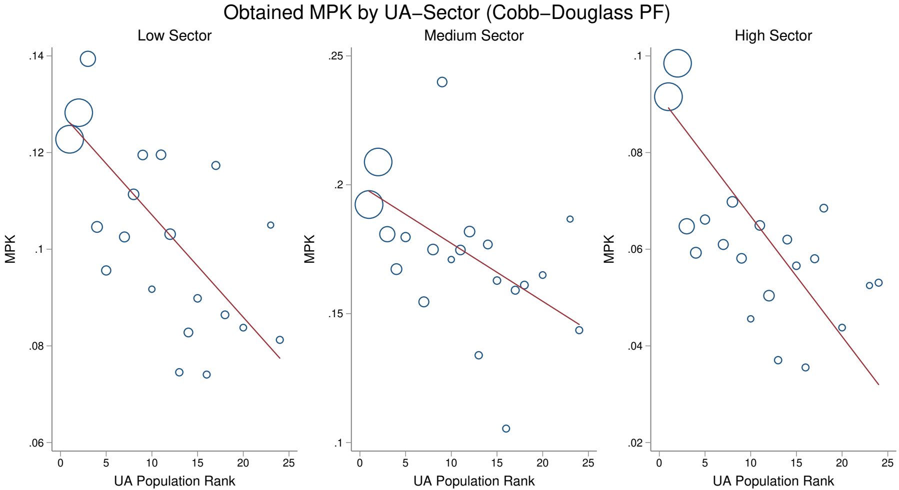
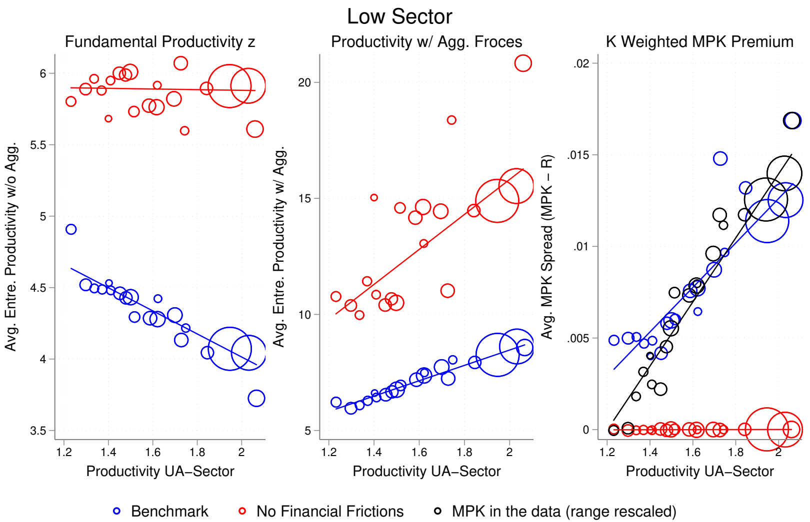
Heterogeneous MPKs by UA in the data (SABI)



Back to Intermediate Goods   Back to Calibration   Back to SS results

SS patterns, Low Sector



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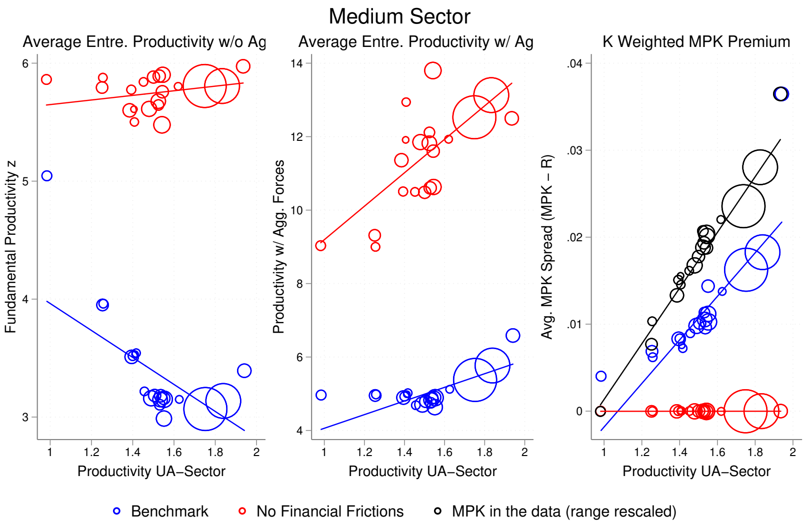
SS patterns, Medium Sector



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Gradual Increases of Expenditure: 0.02%, 0.1%, 0.25% 1%

		Transfers Madrid		Country-wide Transfers	
Relative Size	**Program Expenditure**	**Welfare Gains**	**Ratio**	**Welfare Gains**	**Ratio**
1	0.02%	0.11%	1.00	0.15%	1.00
5	0.10%	0.68%	6.18	0.96%	6.36
12.5	0.25%	1.75%	15.91	2.24%	14.83
50	1%	4.54%	41.27	6%	39.74

Table: Contry-wide Welfare Gains from Transfers (whether in Madrid or Country-wide)

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Welfare Decomposition

- Take following expression per UA or group of UAs:

$$\underbrace{\frac{\frac{\sum w^P V^P}{\sum w^P} - \frac{\sum w^{SS} V^{SS}}{\sum w^{SS}}}{\frac{\sum w^{SS} V^{SS}}{\sum w^{SS}}}}_{\text{Average Per Capita response of Welfare}} = \underbrace{\frac{\frac{\sum w^P V^P}{\sum w^P} - \frac{\sum w^P V^{SS}}{\sum w^P}}{\frac{\sum w^{SS} V^{SS}}{\sum w^{SS}}}}_{\substack{\text{“Value Effect”:} \\ \text{fixed weights, compare values}}} + \underbrace{\frac{\frac{\sum w^P V^{SS}}{\sum w^P} - \frac{\sum w^{SS} V^{SS}}{\sum w^{SS}}}{\frac{\sum w^{SS} V^{SS}}{\sum w^{SS}}}}_{\substack{\text{Compositional Effect:} \\ \text{fixed values, compare weights}}}$$

- $V^{\{P,SS\}}$ are the value functions and $w^{\{SS,P\}}$ are the associated weights at the steady state and policy exercises, respectively
- $\frac{\sum w^{SS} V^{SS}}{\sum w^{SS}}$ is the average value per capita at the SS in a given location or set of locations

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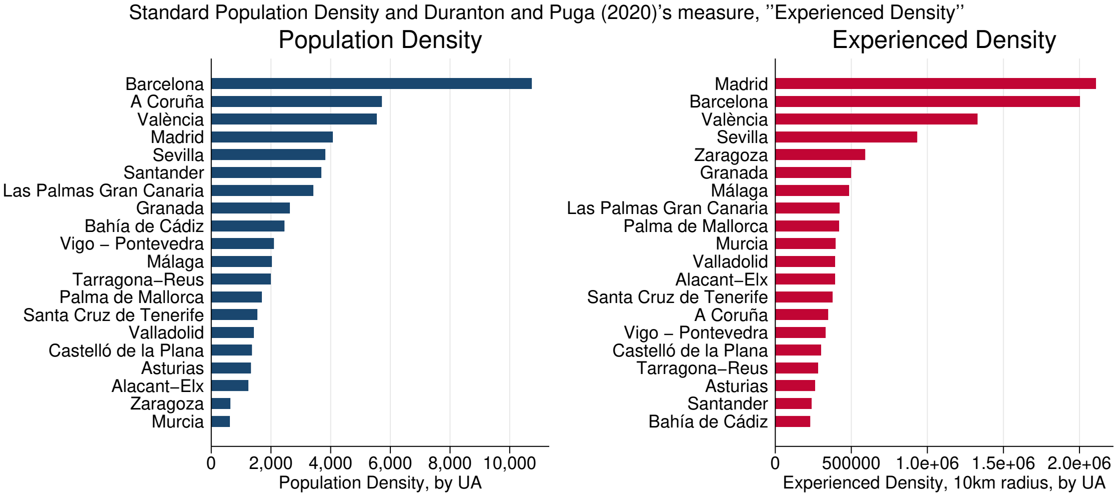
Experienced Density (Duranton and Puga, 2020)



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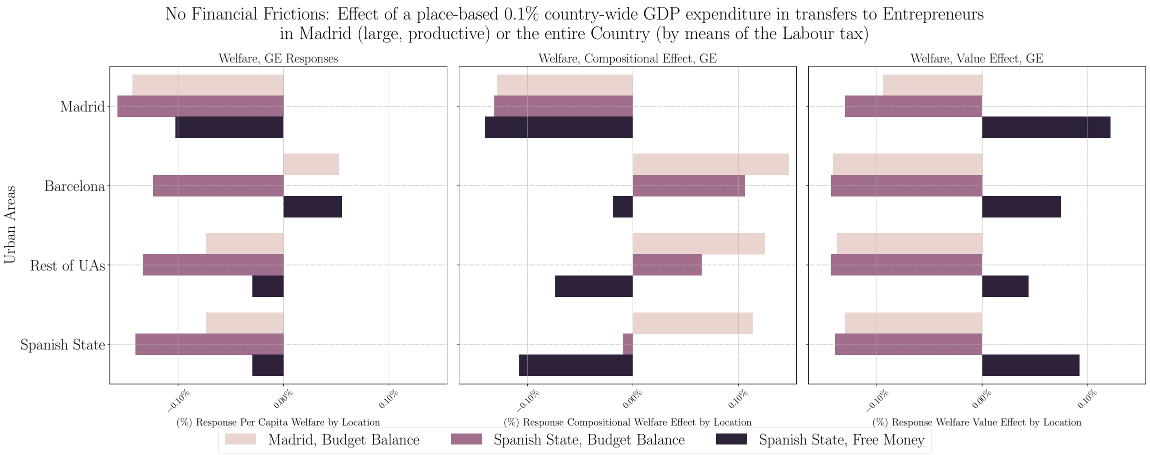
Policy Experiments: Direct Transfers, No Financial Frictions



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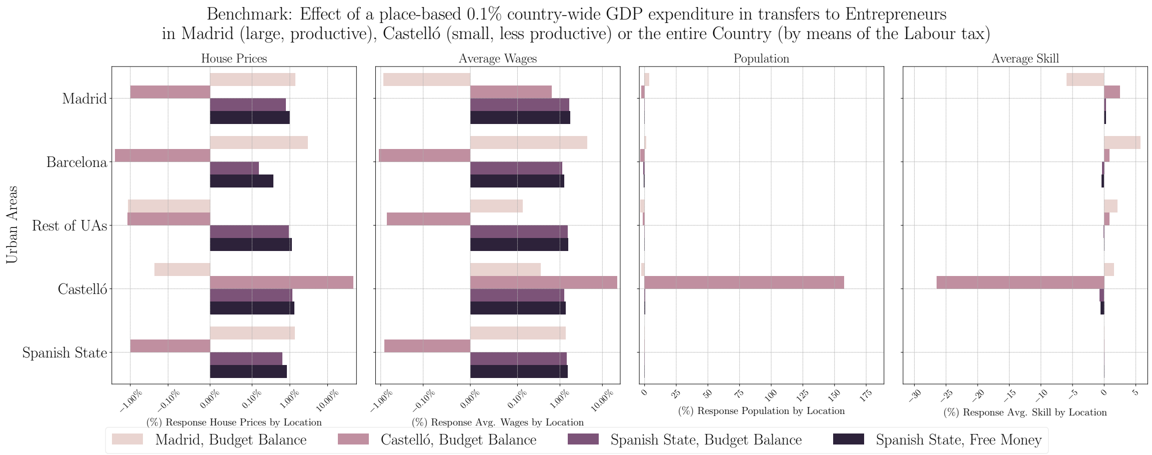
Policy Experiment: Direct Tranfers, Prices and Composition



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Policy Experiments: Collateral Programme, Welfare