Capital Unemployment in Space

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EEA
August 2025

Introduction

- Spatial econ studies causes and consequences of geographic diff. in econ activities.
- Long tradition assigns central role to **physical capital** in econ activities.
  - → New micro data show physical capital markets impaired by **trading frictions**.
  - → Leading to **capital unemployment**, i.e. **idle units searching to be traded**.
- Government concerned with spare capacity, particularly in deprived areas.

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- Government concerned with spare capacity, particularly in deprived areas.

Research questions:

Q1: What are the facts of capital unemployment in space?

Q2: What is the quantitative contribution of capital unemployment to local prosperity?

Q3: What are its implications for welfare and place-based policies?

Main Findings

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   - **F1:** Capital unemployment differences are large and persistent.
   - **F2:** Investment rate is at the replacement rate and does not close local capital u. rate gaps.
   - **F3:** Capital unemployment gaps driven by local differences in separation rates.

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   - **F2:** Investment rate is at the replacement rate and does not close local capital u. rate gaps.
   - **F3:** Capital unemployment gaps driven by local differences in separation rates.
3. **Model:** Dynamic spatial capital acc. model grounded on SaM frictions.
   - **R1:** Explains qualitatively and quantitatively with F1-F3.
   - **R2:** SaM frictions substantially hinder aggregate output.
   - **R2:** Scope for place-based policies due to decentralized equilibrium inefficiencies.

Data

Dataset

- **New dataset:** panel data on structures from Property Market Analysis (PMA) LLP.
- Covers $\sim$ 50% of UK physical capital, info on office, industrial and logistic buildings:
    - Total capital stock (in thousands of square meters).
    - Capital unemployment rate.
    - Take-ups, indicating the space taken up in the year.
- 67 UK cities, contributing $\sim$ 46% to UK GDP (plus EU cities used for checks).
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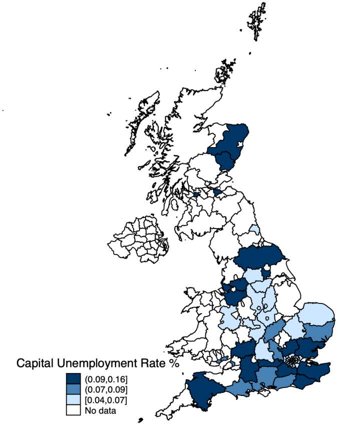
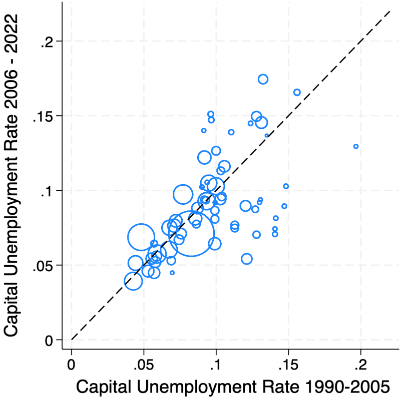
- Covers from 1981 to 2022, but we use from 1990 for data quality.
- Validation: stocks highly correlated with local GDP, population, and capital proxies.

Empirical Analysis



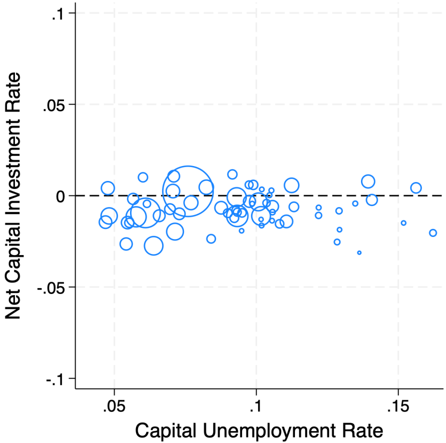
(a) Local Capital U. Rate



(b) Persistence of Capital U. Rate

F1: Capital u. rates are dispersed + persistent (not driven by persistent shocks).

Fact 2



F2: Inv. rates equal replacement rate and don't move to close capital u. rate gaps.

The Spatial Ins and Outs of Unemployed Capital

- What long-run forces shape persistent differences in local capital u. rates?
- Specifically, focus on the *ins and outs* of capital unemployment at location j.
- **Parameters:** δ calibrated to 0.02 (BEA tables for structures).
- **Observables:**
  - Employed capital: K^e_{jt}.
  - Unemployed capital: K^u_{jt}
  - Total capital: $K_{jt} = K^e_{jt} + K^u_{jt}$.
  - Investment: $X_{jt-1} = K_{jt} - (1-\delta)K_{jt-1}$.
  - Capital transitioning into employment: M_{jt}.
- **Unknowns:**
  - Probability of unemployed capital becoming employed, i.e. **finding rate:** f_{jt}.
  - Probability of employed capital becoming unemployed, i.e. **separation rate:** s_{jt}.

The Spatial Ins and Outs of Unemployed Capital Cont'd

- We can infer **unknowns** using a simple accounting:

$$K^u_{jt} = (1 - f_{jt})[(1-\delta)K^u_{jt-1} + X_{jt-1}] + s_{jt}(1-\delta)K^e_{jt-1}.$$
$$K^e_{jt} = \underbrace{f_{jt}[(1-\delta)K^u_{jt-1} + X_{jt-1}]}_{=M_{jt}} + (1 - s_{jt})(1-\delta)K^e_{jt-1}.$$

- For $\delta \approx 0$, we can derive the following steady-state relation:

$$\log\left(\frac{k^u_j}{k^e_j}\right) \approx \log(s_{jt}) - \log(f_{jt}).$$

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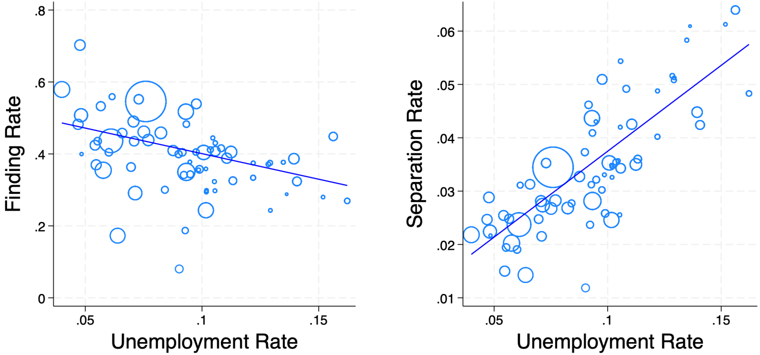
- Variance decomposition of capital unemployment rate over locations:

$$\mathbb{V}\left(\log\left(\frac{k^u_j}{k^e_j}\right)\right) = \mathbb{C}\left(\log\left(\frac{k^u_j}{k^e_j}\right), \log(s_{jt})\right) + \mathbb{C}\left(\log\left(\frac{k^u_j}{k^e_j}\right), -\log(f_{jt})\right) + \varepsilon_j.$$



$$\mathbb{V}\left(\log\left(\frac{k_j^u}{k_j^e}\right)\right) = \underbrace{\mathbb{C}\left(\log\left(\frac{k_j^u}{k_j^e}\right), \log(s_{jt})\right)}_{68\%} + \underbrace{\mathbb{C}\left(\log\left(\frac{k_j^u}{k_j^e}\right), -\log(f_{jt})\right)}_{30\%} + \underbrace{\varepsilon_j}_{2\%}.$$

F3: Local capital u. rate gaps are driven by differences in separation rates.

Model

Primitives

- Discrete time t and **locations** $j = 1, ..., J$. Each j:
  - Comprises three sectors: production (PS), real estate (RES), and housing sector (HS).
  - Characterized by productivity $\mathcal{Z}_j$, amenities $\mathcal{A}_j$, and real estate productivity $\mathcal{P}_j$.

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  - Characterized by productivity $\mathcal{Z}_j$, amenities $\mathcal{A}_j$, and real estate productivity $\mathcal{P}_j$.
- Each j populated by an **infinitely lived representative family**.
  - The family supplies labor, consumes housing, invests in capital, and rents it out.
  - Emp. capital K_j^e yields return r_j; all capital $K_j = K_j^e + K_j^u$ depreciates at rate δ.
  - Participation in capital markets requires RES services at price p_j^r.
  - Labor L_j supplied inelastically, yields wage W_j.
  - Housing H_j demanded inelastically, price per unit is p_j^h.

Primitives Cont'd

- Each j has an endogenous mass of **firm** with discount factor β.
  - Firms have *free entry* and choose where to exert search effort E_j^k at a per-period cost κ.
  - Firms operate one capital unit CRTS technology $y_j(z) = (\mathcal{Z}_j z)^\alpha \ell_j(z)^{1-\alpha} - c$.
  - Firms have an i.i.d. productivity $z \sim F(z)$ leading to endogenous separations.
  - Matches are destroyed exogenously at rate d.

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- Local capital market with **search-and-matching frictions**.
  - Capital and firms match according CRTS-CD matching function $m((1-\delta)K_j^u + X_j)^{\mu}(E_j^k)^{1-\mu}$.
  - Capital market tightness is denoted by $\theta_j = E_j^k/((1-\delta)K_j^u + X_j)$.
  - The contact rate for searching capitalists is $p(\theta_j) = m\theta_j^{1-\mu}$.
  - The contact rate for searching firms, it is $q(\theta_j) = m\theta_j^{-\mu}$, with $p(\theta_j) = \theta_j q(\theta_j)$.

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- Rental rates $r_j(z)$ from state-contingent generalized Nash bargaining.
    - Where capital owners have bargaining power $\eta \in (0, 1)$.

Representative Family

- Representative family problem:

$$\mathcal{W}(K_j, K_j^e) = \max_{\{C_j, K_j'\}} \mathcal{A}_j \log(C_j) + \beta \mathcal{W}(K_j', K_j^{e'});$$

$$\text{s.t.} \quad C_j = W_j L_j + \int_{z \geq z_j^c} r_j(z) dF(z) K_j^e + (1-\delta)K_j + \Pi_j - p_j^r K_j - p_j^h H_j - K_j',$$

$$K_j^{e'} = (1-s_j)(1-\delta)K_j^e + f_j(K_j' - (1-\delta)K_j^e),$$

$$H_j = L_j.$$

- Capital Euler equation:

$$Q_j = \beta Q_j' \left[\left(1 - \delta - p_j^{r'}\right) + f_j \eta \mathbb{E} \widetilde{S}_j' \right].$$

Value Functions and Other Equilibrium Objects

- Unemployed u and employed e capital owners:

$$V_j^u = -Q_j p_j^h + (1-\delta)\beta \left\{ V_j^u + p(\theta_j)(1-d)\mathbb{E}[V_j^e(z') - V_j^u]^+ \right\},$$
$$V_j^e(z) = Q_j(r_j(z) - p_j^h) + (1-\delta)\beta \left\{ V_j^u + (1-d)\mathbb{E}[V_j^e(z') - V_j^u]^+ \right\}.$$

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- Producing p and vacant v firms:

$$V_j^p(z) = Q_j\left(\max_{\ell_j(z)} (\mathcal{Z}_j z)^\alpha \ell_j(z)^{1-\alpha} - W_j\ell_j(z) - c - r_j(z)\right) + (1-\delta)\beta(1-d)\mathbb{E}[V_j^p(z') - V_j^s]^+,$$
$$V_j^s = -Q_j\kappa + \beta q(\theta_j)(1-d)\mathbb{E}[V_j^p(z') - V_j^s]^+.$$

Towards Equilibrium

- Within location forces:
  - Endogenous separations: when $z \leq z^c \leftrightarrow V_j^p(z^c) = 0$,
  - HS and RES competitive with DRTS technology: $p_j^h = mc^h(L_j)$ and $p_j^r = mc^r(K_j, \mathcal{P}_j)$.
- Between location forces:
  - Free entry: θ_j s.t. $V^s(\theta_j) = 0$,
  - Free workers mobility as in Rosen (1979)-Roback (1982): $Q_j(W_j - p_j^h) = \underline{\mathcal{W}}$.

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- Equilibrium separation and finding rates:

$$s_j = 1 - (1-d)\left(1 - F(z_j^c)\right) \quad \text{and} \quad f_j = p(\theta_j)(1-d)\left(1 - F(z_j^c)\right).$$

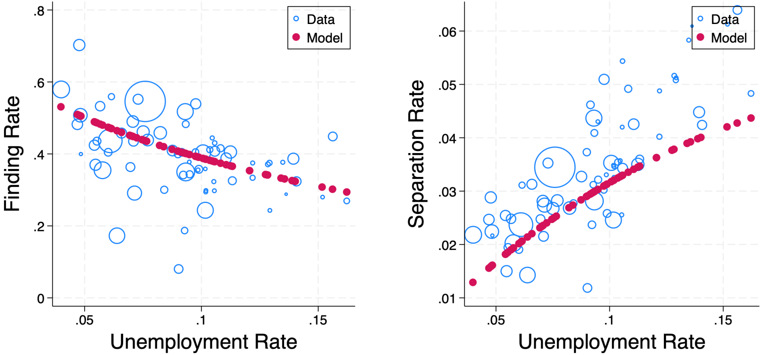
- Elasticities of s_j and f_j to $\mathcal{Z}_j$ as function parameters and equilibrium objects.

Quantitative Analysis

- **Externally calibrated** parameters:
    - **Standard or normalizations:** β, δ, α, $\bar{L}$, $\underline{\mathcal{W}}$, and $\mathcal{Z}_{med}$.
    - **Firm-level moments:** $F(z)$.
    - **Matching function from Ottonello (2021):** μ.
    - **Housing supply elasticity and real estate returns to scale:** ϕ and γ.
- **Internally calibrated** parameters:

Parameter	Description	Value	Moment	Data	Model
m	Matching efficiency	0.112	f_{med}	0.40	0.40
κ	Capital vacancy posting cost	0.002	s_{med}	0.03	0.03
c	Fixed operating cost	0.850	$\frac{c_{med}}{W_{med}\ell_{med}+r_{med}+c_{med}}$	0.30	0.30
η	Capitalists bargaining power	0.455	K^u_{med}	0.09	0.09
$\{\mathcal{Z}_j\}_{j=1}^J \setminus \{\mathcal{Z}_{med}\}$	Fundamental productivity levels		$\{K^u_j \setminus K^u_{med}\}$		
$\{\mathcal{A}_j\}_{j=1}^J$	Amenities	Values	L_j	Moments	
$\{\mathcal{P}_j\}_{j=1}^J$	Real estate sector productivity		K_j		

Separation and Finding Rates



$$\mathbb{V}\left(\log\left(\frac{k_j^u}{k_j^e}\right)\right) = \underbrace{\mathbb{C}\left(\log\left(\frac{k_j^u}{k_j^e}\right), \log(s_{jt})\right)}_{\textit{Data}:68\% \quad \textit{Model}:70\%} + \underbrace{\mathbb{C}\left(\log\left(\frac{k_j^u}{k_j^e}\right), -\log(f_{jt})\right)}_{\textit{Data}:30\% \quad \textit{Model}:32\%}.$$

Aggregate Implications

Aggregate Cost of SaM Frictions in Local Capital Markets

- **Idea:** Study macro consequences of rising (matching) efficiency of search process.

		Change	
	Baseline	**1.5** $\times$ $\boldsymbol{m}$	**2** $\times$ $\boldsymbol{m}$
Avg. capital unemployment rate	9.20	-1.45 p.p.	-3.44 p.p.
Avg. finding rate	40.74	+19.66 p.p.	+38.96 p.p.
Avg. separation rate	2.86	+1.03 p.p.	+1.55 p.p.
Avg. rental rate	14.03	-0.23 p.p.	-0.35 p.p.
Total output	1.88	+2.38 %	+4.85 %
Total consumption	1.86	+2.41 %	+4.90 %

A Note on Efficiency

- Planner problem:
  - Efficiency condition akin to Hosios (1990): $\mu = \eta$.
  - Policy tool: place-based subsidy (or tax) to capital owners with u. capital.
- Quantitatively we retrieve: $\mu >> \eta$
  - Capital owner's bargaining power is too low.
  - Implications: over-investment, too much firm entry.
  - Validate this with relationship between rental rate and capital u. rate BP validation.

Macroeconomic Implications of Social Planner Allocation

	Baseline	Social Planner	Change
Avg. capital unemployment rate	9.25	13.39	+4.14 p.p.
Avg. finding rate	40.85	30.16	-10.69 p.p.
Avg. separation rate	2.89	3.20	+0.31 p.p.
Avg. rental rate	14.21	15.59	+1.38 p.p.
Total capital	1.000	1.042	4.20 %
Total output	1.918	1.924	0.30 %
Total consumption	1.898	1.903	0.26 %
Consumption equivalent welfare			0.28 %

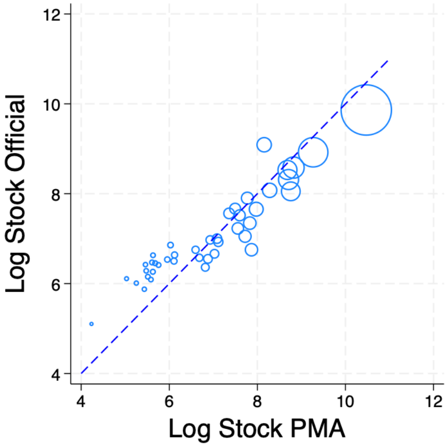
Conclusion

Conclusion

- New set of evidence on the spatial distribution of capital unemployment
- Dynamic quantitative SaM model rationalizes well these regularities
- SaM frictions in local capital markets offer new rationale for place-based policies

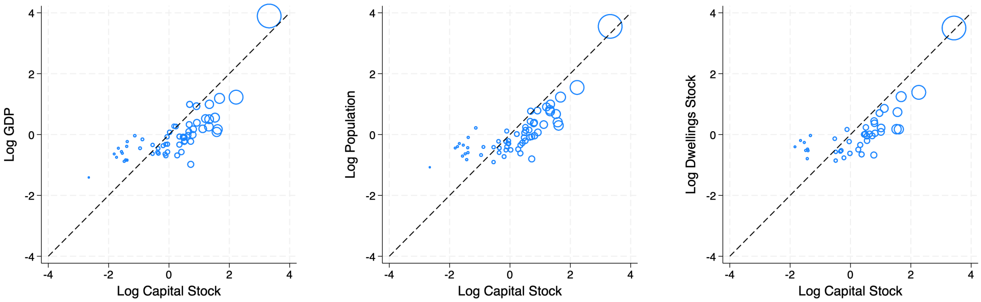
Appendix

Official vs. PMA Capital Stock



Main

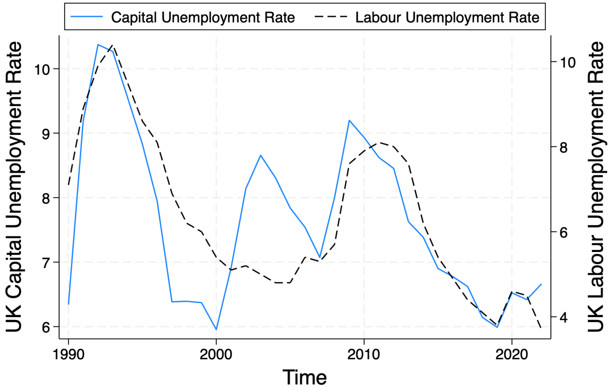
Spatial Corr. b/w PMA Capital Stock and GDP, Population, and Dwellings



(a) GDP **(b)** Population **(c)** Dwellings

Main

Time Series of Capital Unemployment and Labor Rates



Main

More prosperous locations have lower local capital u. rates

Dependent Variable	**Capital Unemployment Rate**						
Labor Productivity	-0.181^{+}						
	(0.115)						
Capital Productivity		-0.140**					
		(0.073)					
Density			-0.105				
			(0.116)				
Rental Rate				-0.072**			
				(0.030)			
House Price					-0.71**		
					(0.035)		
Household Income						-0.376*	
						(0.219)	
Labor Unemployment Rate							0.696*
							(0.356)
City and Time FE	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y
Observations	827	854	856	743	811	873	887

Spatial Decomposition of Output Per Capita

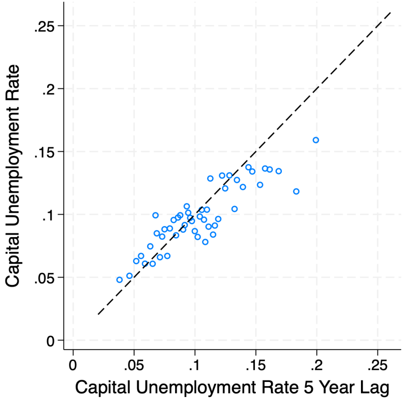
$$\mathbb{V}\left(\log\left(\frac{Y_{jt}}{N_{jt}}\right)\right) = \underbrace{\overbrace{\mathbb{C}\left(\log\left(\frac{Y_{jt}}{N_{jt}}\right), \alpha\log(1-k^{u}_{jt})\right)}^{\text{Unemployment rate contribution}} + \overbrace{\mathbb{C}\left(\log\left(\frac{Y_{jt}}{N_{jt}}\right), \alpha\log\left(\frac{K_{jt}}{N_{jt}}\right)\right)}^{\text{Total capital contribution}}}_{\text{Employed capital contribution}}$$

$$+ \underbrace{\mathbb{C}\left(\log\left(\frac{Y_{jt}}{N_{jt}}\right), (1-\alpha)\log\left(\frac{L_{jt}}{N_{jt}}\right)\right)}_{\text{Labor force participation contribution}} + \underbrace{\mathbb{C}\left(\log\left(\frac{Y_{jt}}{N_{jt}}\right), \log\left(Z_{jt}\right)\right)}_{\text{Productivity contribution}}.$$

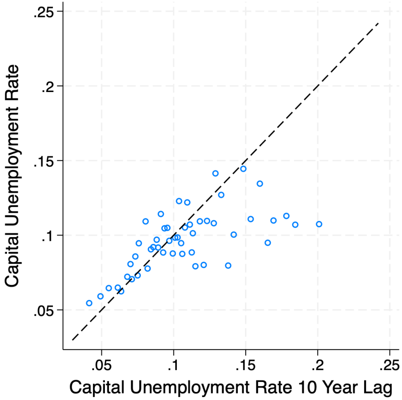
	Output p.c. explained
Employed capital (%)	25
Unemployment rate (%)	5
Total capital (%)	20
Labor force participation (%)	15
Productivity (%)	60

Main

Additional Evidence on the Persistence of Capital Unemployment Rate



(a) 5-Year Lag with Time Fixed Effects

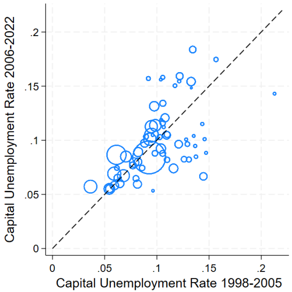


(b) 10-Year Lag with Time Fixed Effects

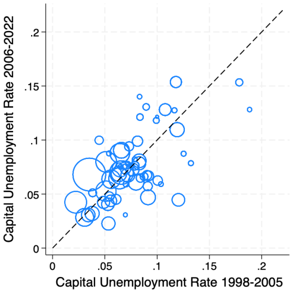
Main

Spatial Persistence Accounting for Persistent Shocks

$$E_{jt-1990} = \sum_i \omega_{ij1990} \times \Delta_{t-1990} \log Y_{it},$$



(a) W/o Time FE



(b) W/o Time FE and Industry Cycles

Main

Extensive Margin

$$\log\left(\frac{\boldsymbol{k}_j^u}{\boldsymbol{k}_j^e}\right) = \log(s_j) - \log(f_j) + \log\left(\left(\frac{s_j(1-\delta) + (1-f_j)\delta/\boldsymbol{k}_j^e}{\delta + f_j(1-\delta)}\right)\frac{f_j}{s_j}\right)$$

	UK		Europe	
Direct flows: separation and finding rates (%)	98	98	104	104
Separation rate (%)	68	68	82	82
Finding rate (%)	30	30	22	22
Extensive margin due to investment (%)	–	-11	–	-10
Measurement error (%)	2	13	-4	6

Main

Fundamental Surplus Extended

- Elasticities of s_j and f_j to $\mathcal{Z}_j$

$$\varepsilon_{\mathbf{s_j},\boldsymbol{\mathcal{Z}_j}} = -\frac{1-s_j}{s_j}\varepsilon_{1-F(z_j^c),z_j^c}\varepsilon_{\mathbf{z_j^c},\boldsymbol{\mathcal{Z}_j}} \quad \text{and} \quad \varepsilon_{\mathbf{f_j},\boldsymbol{\mathcal{Z}_j}} = (1-\mu)\varepsilon_{\boldsymbol{\theta_j},\boldsymbol{\mathcal{Z}_j}} + \varepsilon_{1-F(z_j^c),z_j^c}\varepsilon_{\mathbf{z_j^c},\boldsymbol{\mathcal{Z}_j}}$$

- What makes $\varepsilon_{\boldsymbol{\theta_j},\boldsymbol{\mathcal{Z}_j}}$ small as in the data?

$$\varepsilon_{\boldsymbol{\theta_j},\boldsymbol{\mathcal{Z}_j}} = \underbrace{\Upsilon_j\frac{\mathbb{E}\pi_j(z')}{\mathbb{E}\pi_j(z')-c}}_{\substack{\text{Standard}\\\text{search-and-matching}\\\text{amplification}}}\left[\underbrace{1}_{\substack{\text{Direct}\\\text{effect}}} + \underbrace{\Omega_j\varepsilon_{z_j^r,\mathcal{Z}_j}}_{\substack{\text{Endogenous}\\\text{separation}\\\text{effect}}} - \underbrace{\frac{1-\alpha}{\alpha}\varepsilon_{W_j,\mathcal{Z}_j}}_{\text{GE effect}}\right],$$

- What makes $\varepsilon_{\mathbf{z_j^c},\boldsymbol{\mathcal{Z}_j}}$ large as in the data?

$$\varepsilon_{\mathbf{z_j^c},\boldsymbol{\mathcal{Z}_j}} = -\underbrace{1}_{\substack{\text{Direct}\\\text{effect}}} - \underbrace{\frac{\kappa\theta_j(1-\delta)}{(1-\eta)\pi_j(z_j^c)}\left(\frac{\mu}{p(\theta_j)}-\eta\right)\varepsilon_{\theta_j,\mathcal{Z}_j}}_{\text{Indirect effect}} + \underbrace{\frac{1-\alpha}{\alpha}\varepsilon_{W_j,\mathcal{Z}_j}}_{\text{GE effect}}.$$

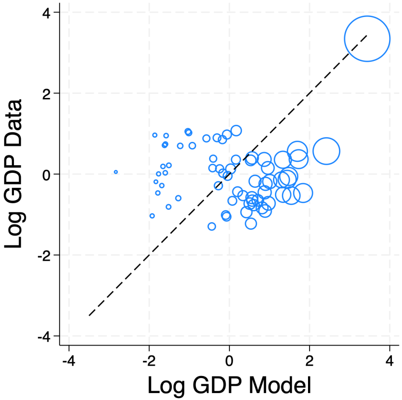
Extended fundamental surplus

Variance Decomposition of Y/L

	Output p.c. explained	
	Data	Model
Employed capital (%)	25	35
Unemployment rate (%)	5	1
Total capital (%)	20	34
Others (%)	75	65

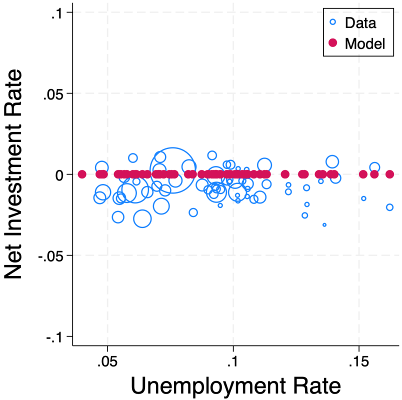
Main

GDP



Main

Net Investment Rate



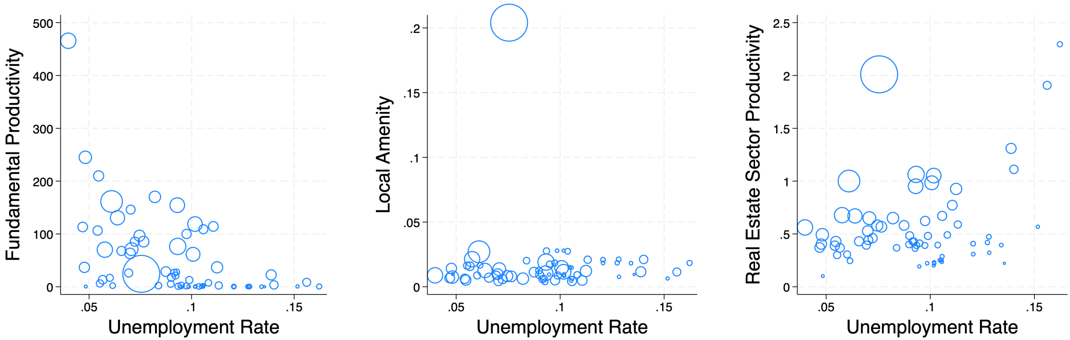
Main

Amenities

Dependent Variable			Amenities			
Amenity index	0.225					0.47
	(0.213)					(0.35)
Establishments per 10,000 people						
General practitioner		0.094				0.063
		(0.104)				(0.12)
Dentists			0.400			0.17^{*}
			(0.280)			(0.093)
Sports facilities				0.125^{**}		0.69^{+}
				(0.047)		(0.49)
Supermarkets					0.081	0.54
					(0.15)	(0.49)
Observations	64	53	53	51	57	51
R^2	0.05	0.007	0.13	0.012	0.006	0.28

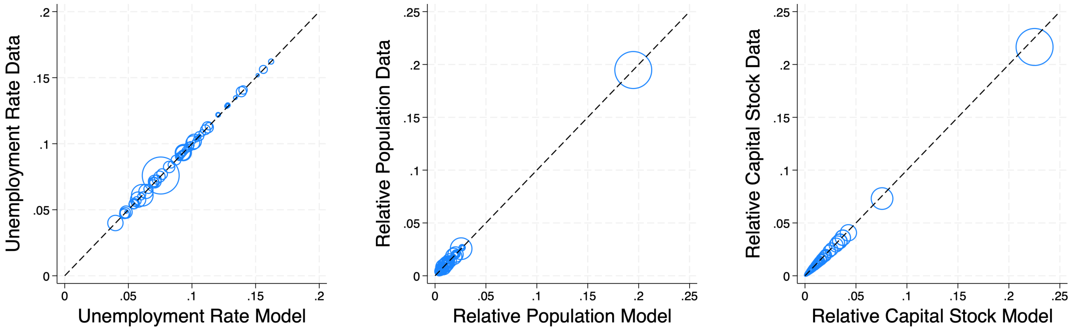
Main

Location-Secific Parameters



Main

Location-Specific Moments



Main

Bargaining Power Validation

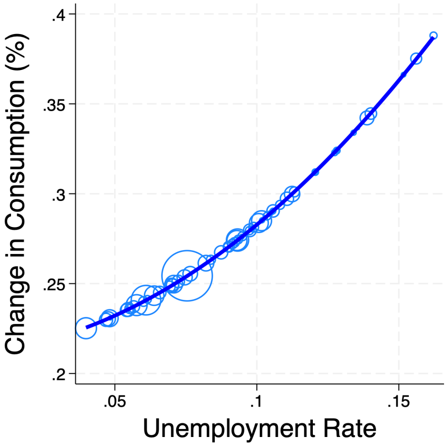
- Rental rate elasticity of capital unemployment rate:

$$\varepsilon_{r_j, k_j^u} = -\eta \frac{\kappa \theta_j}{\mathbb{E} r_j(z)},$$

Dependent Variable	Rental Rate			
	Data (OLS)	Data (TSLS)	Data (TSLS)	Model
	(1)	(2)	(3)	(4)
Capital unemployment rate	-0.11**	-0.54**	-0.29***	-0.46
	(0.05)	(0.23)	(0.07)	
Fixed Effects				
City	Y	Y	Y	
Time	Y	Y	Y	
Controls				
City-specific Time Trend	Y	Y	Y	
Instrument				
Labor productivity		Y		
Past unemployment rate			Y	
Observations	743	642	453	

Main

Spatial Welfare Gains



Main