Population Density and the Local Economy pre- and post-Pandemic Breakout

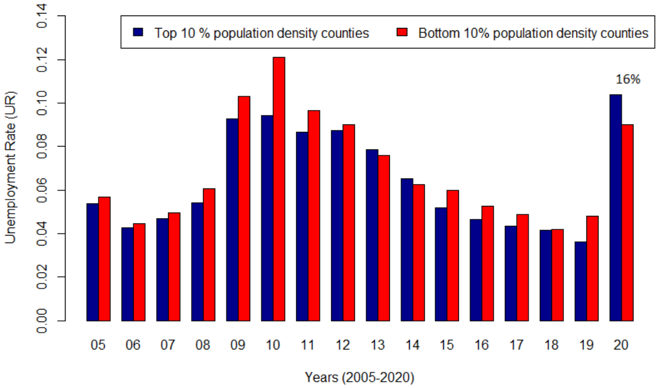
Despoina Balouktsi

20th Conference on Research on Economic Theory and Econometrics

11 July 2022

Motivation

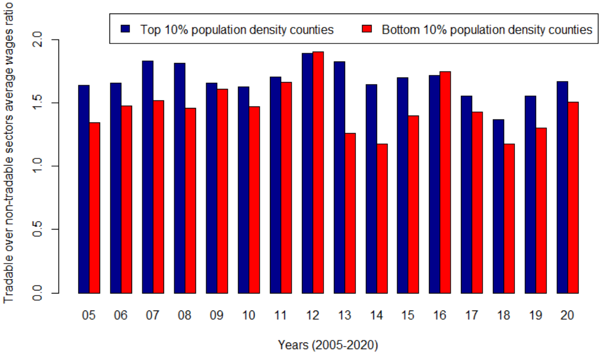
Average unemployment rate for HD and LD counties in US



supplemental LF (LAUS)

Motivation

Tradable to non-tradable sector average wage ratio for HD and LD counties in US (tradable wage premium)



supplemental

Related Literature & Contribution

1. Systems-of-locations theories:
Especially those on heterogeneous agents sorting & selection (e.g., Davis & Dingel, 2019)

2. Local multiplier:
Predominantly empirical (e.g., Moretti, 2010; Moretti & Thulin, 2013)

3. Search & matching in spatial equilibrium

This paper builds upon the model of Davis and Dingel (2019) and

- extends it: includes labor market frictions and an endogenous mass of firms in each location
- alters preferences: non-homothetic, local good's expenditure share increases in income

Mechanisms & Results

Main mechanisms:

- Complementarity between local level of idea exchange & a worker's skill
- Skill elasticity of tradable sector workers' demand for local good non-decreasing in skill & local level of idea exchange
- Same for tradable sector workers' average wage (albeit more)

Main results:

- Higher skilled individuals collocate and are in tradable sector
- Higher local good's prices and urban costs in HD locations
- Higher employment rate in HD locations
- Higher tradable sector wage premium in HD locations

WFH and relocation of tradable sector workers:

- Boosts employment rate in destination region. Reverse in origin location
- Increases tradable sector wage premium in destination and origin location

Economy setup

General

- C locations, continuum of individuals of mass L per C unit areas
- 2 sectors in each location: tradable (T), non-tradable (N)
- Tradable good (TG) numéraire. Non-tradable good (NG) in location c: p_{nc}
- Individuals distributed on the interval $[zmin, zmax] \subset \mathbb{R}_+$ with pdf $\phi(z)$
- Price Independent Generalized Linearity (PIGL) type preferences (Boppart, 2014)

$$v(p_{nc}, p_{hc}, I) = \frac{1}{\epsilon}\frac{(I^{\epsilon} - r)}{p_{nc}^{\epsilon}} + \frac{r-1}{\epsilon} - p_{hc}(L_c)$$

- I-income, L_c-population density in c, $p_{hc}(L_c)$-urban cost, $\frac{\partial p_{hc}}{\partial Lc} > 0$
- Expenditures $\longrightarrow$ TG: $rI^{1-\epsilon}$, NG: $I - rI^{1-\epsilon}$, $r > 0$, $0 < \epsilon < 1$

Economy setup

Labor market frictions

- Directed search ($m(v,u) = Bv^\eta u^{1-\eta}$, $q = \frac{v}{u}$)

N sector firms

- Labor is the only factor of production
  Uniform productivity normalized to 1
- k_n-vacancy cost
  Maximize expected profit given reservation wage U_c

T sector firms

- $\tilde{z}(z, Z_c)$
- k_t-vacancy cost
  Maximize expected profit given reservation wage $U_c(z, Z_c)$

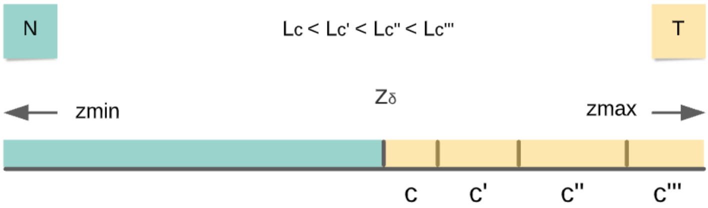
profit maximization local level of idea exchange

Assumption: $\tilde{z}(z, Z_c)$ is C^2, $\frac{\partial \tilde{z}(z,Z_c)}{\partial z}$, $\frac{\partial \tilde{z}(z,Z_c)}{\partial Z_c}$ & $\frac{\partial^2 \tilde{z}(z,Z_c)}{\partial z \partial Z_c} > 0$

Economy setup

It follows (Lemmata 1+2):

- Critical skill level, z_δ, everyone with $z > z_\delta$ looks for a job in the T sector (comparative advantage)
- If $L_c < L_{c'}$, then $p_{nc} < p_{nc'}$ and $p_{hc} < p_{hc'}$



lemma 1 lemma 2 equilibrium conditions

Unemployment Rate

Two locations case (Assume $L_2 > L_1, Z_2 > Z_1$)

Sufficient conditions (Proposition 1)

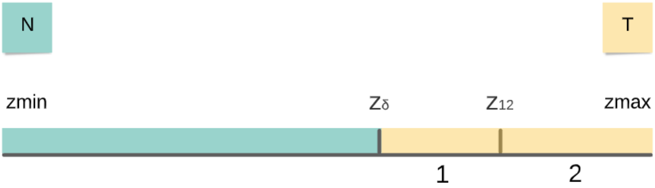
(a) $\tilde{z}$ (log-supermodular, log-convex in z)
(b) skill distribution (non-increasing)
(c) r ($r \leq 1$)

Location 2 has both:

- higher $\frac{\text{N sector employed}}{\text{Labor force}}$
- higher $\frac{\text{T sector employed}}{\text{Labor force}}$

Proposition 1 implies

- $\frac{\text{\%change in T's demand for N}}{\text{\%change in z}}$ non-decreasing in z, Z_c
- $zmax - z_{12} > z_{12} - z_{\delta}$

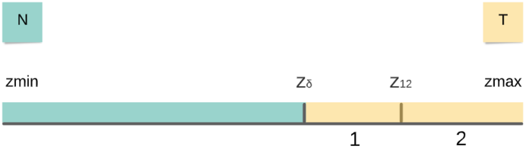


fictitious example

Wage Premium

Same conditions ensure that (Proposition 2):

$$\frac{\int_{t,1} U_1(z,Z_1)\,\phi(z)\,dz}{U_1 \int_{t,1} \phi(z)\,dz} < \frac{\int_{t,2} U_2(z,Z_2)\,\phi(z)\,dz}{U_2 \int_{t,2} \phi(z)\,dz}$$



Note: D&D (2019) and this paper's skill premia comparison

- Wage premium w/o unemployment adjustment: Beneficial effects of concentration only on workers'income
- Wage premium adjusted for unemployment: Beneficial effects of concentration both on workers' income and matching rate

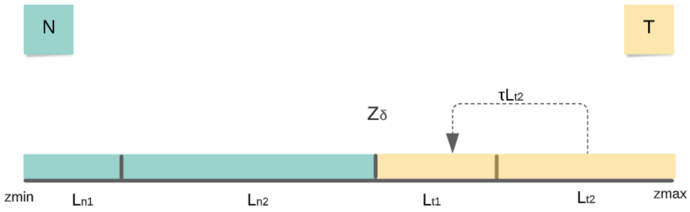
Relocation

Location 1 (LD)

- $L_1' = L_1 + \tau L_{t2}$
- N demand: $+\tau$(N demand by T in 2) $\rightarrow q'^{*}_{n1} > q^{*}_{n1}, w'_{n1} > w_{n1} \rightarrow U_1' > U_1'$

Location 2 (HD)

- $L_1' = L_2 - \tau L_{t2}$
- N demand: $-\tau$(N demand by T in 2) $\rightarrow q'^{*}_{n2} < q^{*}_{n2}, w'_{n2} < w_{n1} \rightarrow U_2' < U_2'$



Relocation: Unemployment Rate & Wage Premium

Alternative $(\boldsymbol{B})$: Individuals considered based on residence location alternative (a)

Unemployment rate

- Unemployment rate in in 2 $\uparrow$
- Unemployment rate in in 1 $\downarrow$ proposition 3

Wage premium

- Wage premium in 2 $\uparrow$ $\left(\frac{(1-\tau)\int_{t,2} U_2(z,Z_2)\,\phi(z)\,dz}{U_2'(1-\tau)\int_{t,2}\phi(z)\,dz}\right)$
- Wage premium in 1 $\uparrow$ (Proposition 4)

Quantitative analysis

Data sources

- IPUMS-CPS
- US Census Bureau

Data processing

- Panel of counties
- Ranking based on average population density
- Population density weighted average of measures
- Time average for equilibrium (2016-2019, 2005-2008)

Quantitative analysis

Targeted moments

- Unemployment rate in high density counties (URHD)
- Unemployment rate in low density counties (URLD)
- Tradable to non-tradable sector average wage in the high density counties (TWHD/NWHD)
- Tradable to non-tradable sector average wage in low density counties (TWLD/NWLD)
- High to low population densities ratio (HD/LD)
- High to low density average non-tradable wage ratio (NWHD/NWLD)

Distributions and forms

Quantitative analysis

Table: Equilibrium

Measures	Data US	Normal, US	Uniform, US	Data PA	Normal, PA	Uniform, PA
HD/LD	3	3	3	3	3	3
URHD	4%	4%	4%	3%	3%	3%
URLD	4.3%	4.3%	4.3%	3.7%	3.7%	3.7%
TWHD/NWHD	1.59	1.59	1.59	1.51	1.55	1.51
TWLD/NWLD	1.5	1.21	1.23	1.33	1.23	1.21
NWHD/NWLD	1.13	1.13	1.15	1.24	1.24	1.24

calibrated parameter set

Quantitative analysis

Table: Model relocation moments

Moments	Data US (2020)	Uniform, US	Normal, US
URLD	8.4%	8.4%	8.4%
URHD	10%	10%	10%

Table: Model relocation parameters

Parameter	Uniform, US	Normal, US
τ	6.7%	6.6%
B	1.66	1.34

Normal, US, URLD indifference curves
Normal, US, URHD indifference curves
Uniform, US, URLD indifference curves
Uniform, US, URHD indifference curves

Conclusions

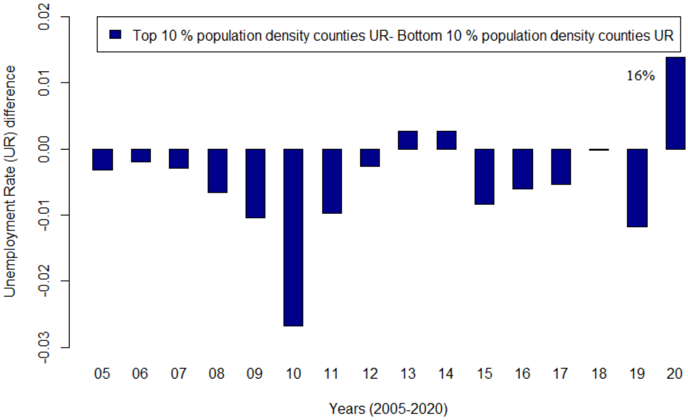
1. Facts:

- Documents higher T wage premium and lower unemployment rate (UR) in HD counties. Atypical reversal in UR during 2020

2. Develop a framework that endogenously explains these patterns and starts from symmetric fundamentals. Some building blocks:

- Complementarity between z and Z_c
- Skill-elasticity of production non-decreasing in z, Z_c
- Non-homothetic preferences (higher income-larger N good's income share)

3. Provides a first look to potential economic rearrangements following post-covid relocation and living patterns



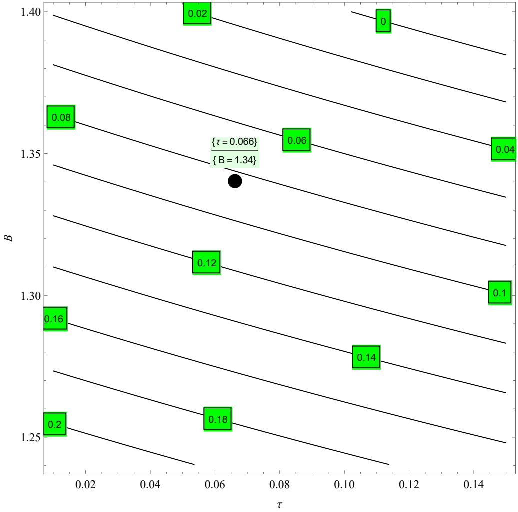
Unemployment rate difference between the most and least densely populated counties in US for the years 2005-2020

Back to Motivation

Table: Parameters (Equilibrium)

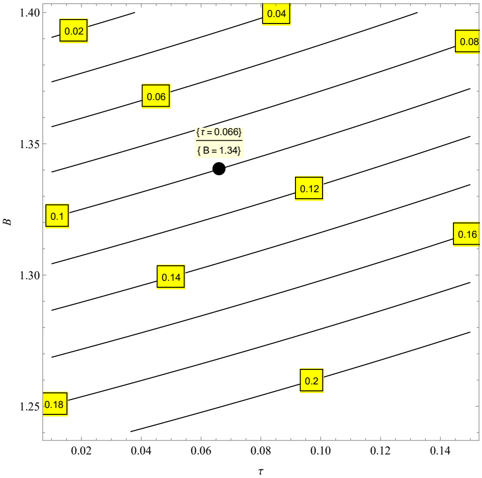
Parameters	Normal, US	Uniform, US	Normal, PA	Uniform, PA
B	1.4	1.75	1.4	1.75
η	0.38	0.35	0.38	0.35
β	0.72	0.72	0.72	0.72
ϵ	0.1	0.1	0.1	0.1
k_t	0.54	1.2	1.08	1.2
k_n	0.89	2.2	2.24	2.3
A	1.29	1.96	2.35	2
θL^γ	1.16	0.98	0.56	0.36
r	0.35	0.5	0.35	0.52
γ	0.1	0.1	0.13	0.08

Back to Quantitative analysis



Normal, US, URLD indifference curves

Back to Quantitative analysis



Normal, US, URHD indifference curves

Back to Quantitative analysis

- N sector

$$\max_{q_{nc},w_{nc}} Bq_{nc}^{\eta-1}\left(p_{nc}-w_{nc}\right)-k_n \quad s.t. \quad U_c = Bq_{nc}^{\eta}w_{nc}$$

Result:$q_{nc}^{*} = \left(\frac{U_c}{Bw_{nc}}\right)^{\frac{1}{\eta}}, w_{nc} = (1-\eta)p_{nc}$

- T sector

$$\max_{q_{tc},w_{tc}} Bq_{tc}\left(z,Z_c\right)^{\eta-1}\left(\tilde{z}\left(z,Z_c\right)-w_{tc}\left(z,Z_c\right)\right)-k_t$$

$$\text{s.t.} \quad U_c\left(z,Z_c\right) = Bq_{tc}^{\eta}\left(z,Z_c\right)w_{tc}\left(z,Z_c\right)$$

Result:$q_{tc}^{*}(z,Z_c) = \left(\frac{U_c(z,Z_c)}{Bw_{t,c}(z,Z_c)}\right)^{\frac{1}{\eta}}, w_{t,c}(z,Z_c) = (1-\eta)\tilde{z}(z,Z_c)$

Back to Setup

$$Z_c = \left(1 - e^{\left(-\nu L \int_{t,c} (1-\beta)\,\phi(z)\,dz\right)}\right) \int_{t,c} \frac{z}{\int_{t,c} \phi(z)\,dz} \phi(z)\,dz$$

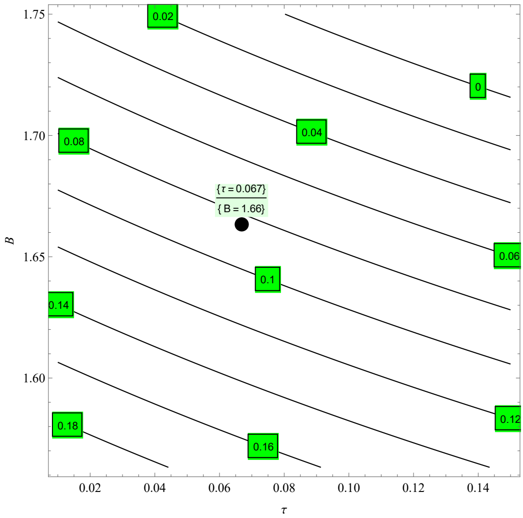
Z_c from Davis & Dingel (2019), $0 < \beta < 1$, $\nu > 0$

Back to Setup

Fictitious example:

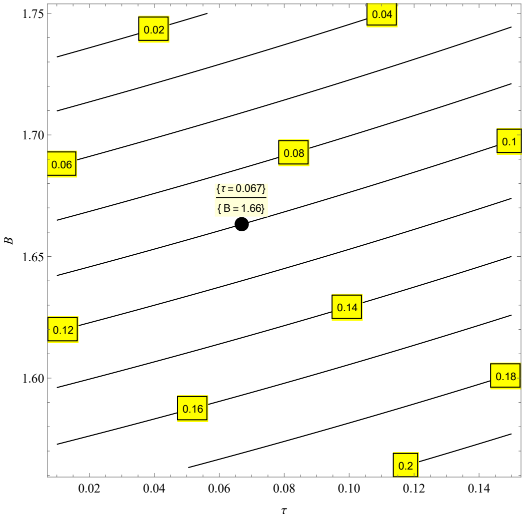
in 2: $z = 7 \longrightarrow$ demand for N = 4, $z = 7.7 \longrightarrow$ demand for N = 4.4
in 1: $z = 5 \longrightarrow$ demand for N = 3, $z = 5.5 \longrightarrow$ demand for N = 3.15

Back to Proposition 1



Uniform, US, URLD indifference curves

Back to Quantitative analysis



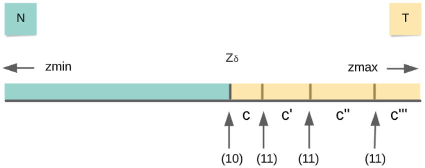
Uniform, US, URHD indifference curves

Back to Quantitative analysis

Equilibrium

In equilibrium, firms maximize their expected profits and agents make the optimal consumption, occupational and locational choices. Moreover, the following conditions are true:

- Adding-up constraints for location populations (4), (5)
- Zero profit conditions (6), (7)
- Labor market clearing (8)
- Non-tradable goods market clearing (9)
- Skill type indifferent between the two sectors (10)
- Skill type indifferent between tradable sector in c and c' where c' is the next, population-wise, denser location than c (11)



Back to Setup

$$L_c = L_{tc} + L_{nc} \text{ where } L_{tc} = L \int_{t,c} \phi(z)\, dz \,,\; L_{nc} = L \int_{n,c} \phi(z)\, dz \; (4)$$

$$L = \sum_{c=1}^{C} L_c \; (5)$$

$$U_c(z, Z_c) = \left(\frac{\eta}{k_t}\right)^{\frac{\eta}{1-\eta}} B^{\frac{1}{1-\eta}} (1-\eta) \tilde{z}(z, Z_c)^{\frac{1}{1-\eta}} \; (6)$$

$$U_c = \left(\frac{\eta}{k_n}\right)^{\frac{\eta}{1-\eta}} B^{\frac{1}{1-\eta}} (1-\eta) p_{nc}^{\frac{1}{1-\eta}} \; (7)$$

$$L \int_{t,c} q_{tc}^*(z, Z_c)\phi(z)\, dz = Q_{tc} \text{ and } L \int_{n,c} q_{nc}^* \phi(z)\, dz = Q_{nc} \; (8)$$

$$U_c \int_{n,c} \phi(z)\, dz = U_c \int_{n,c} \phi(z)\, dz + \int_{t,c} U_c(z, Z_c)\phi(z)\, dz - r\left(U_c^{1-\epsilon} \int_{n,c} \phi(z)\, dz + \int_{t,c} U_c(z, Z_c)^{1-\epsilon} \phi(z)\, dz\right) \; (9)$$

$$U_c(z_\delta, Z_c) = U_c (10)$$

$$\frac{1}{\epsilon} \frac{(U_c^\epsilon(z_{cc'}, Z_c) - r)}{p_{nc}^\epsilon} - p_{hc} = \frac{1}{\epsilon} \frac{(U_{c'}^\epsilon(z_{cc'}, Z_{c'}) - r)}{p_{nc'}^\epsilon} - p_{hc'} \; (11)$$

Back to Equilibrium

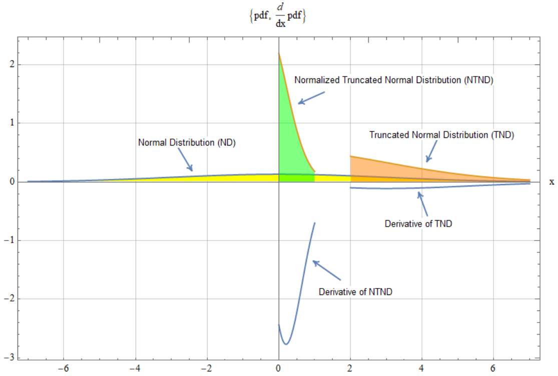
Quantitative analysis

$p_{hc} = \theta L_c^{\gamma}$

$\tilde{z}$ form from Davis & Dingel (2019):

$$\tilde{z}(z_n, Z_c) = \beta z_n + (1-\beta) A z_n^2 Z_c$$

Distribution:



Back to Quantitative analysis

Unemployment rate

Alternative (A): Individuals considered based on job location

- Only N job finding rates change
- Unemployment rate in 1 $\downarrow$ and in 2 $\uparrow$

Wage premium

Alternative (A): Individuals considered based on job location

- Job finding rate and wage change only for N
- Wage premium in 1 $\downarrow$ and in 2 $\uparrow$ $\left(\frac{\int_{t,c} U_c(z, Z_c)\,\phi(z)\,dz}{U_c' \int_{t,c} \phi(z)\,dz}\right)$

Back to Relocation

$z \in \Theta_{ntc}, z' \in \Theta_{tc}, z'' \in \Theta_{ntc'}, z < z' < z''$,

$$\frac{1}{\epsilon}\frac{(U_c^\epsilon - r)}{p_{nc}^\epsilon} - p_{hc} = \frac{1}{\epsilon}\frac{(U_{c'}^\epsilon - r)}{p_{nc'}^\epsilon} - p_{hc'}$$

At the same time, for z' that is looking for a job in the tradable sector in c, it holds that:

$$\frac{1}{\epsilon}\frac{(U_c^\epsilon\ (z', Z_c) - r)}{p_{nc}^\epsilon} - p_{hc} \geqslant \frac{1}{\epsilon}\frac{(U_c^\epsilon\ - r)}{p_{nc}^\epsilon} - p_{hc}$$

Since $z'' > z'$, given Assumption 1,

$$\frac{1}{\epsilon}\frac{(U_c^\epsilon\ (z'', Z_c) - r)}{p_{nc}^\epsilon} - p_{hc} > \frac{1}{\epsilon}\frac{(U_c^\epsilon\ (z', Z_c) - r)}{p_{nc}^\epsilon} - p_{hc}$$

and z'' would have a higher utility as tradable sector job seeker in location c than as a non-tradable sector job seeker in location c'. Hence, it cannot be the case that any non-tradable sector job seeker has higher ability than any tradable sector job seeker in the economy.

Back to Equilibrium

Let us assume that $L_c < L_{c'}$, and, hence, $p_{hc} < p_{hc'}$, but that $p_{nc} > p_{nc'}$. Then, in equilibrium, from the utility equalization among non-tradable sector workers and from (8), it should hold that:

$$\frac{(U_c^{\epsilon} - r)}{p_{nc}^{\epsilon}} < \frac{(U_{c'}^{\epsilon} - r)}{p_{nc'}^{\epsilon}} \Rightarrow$$

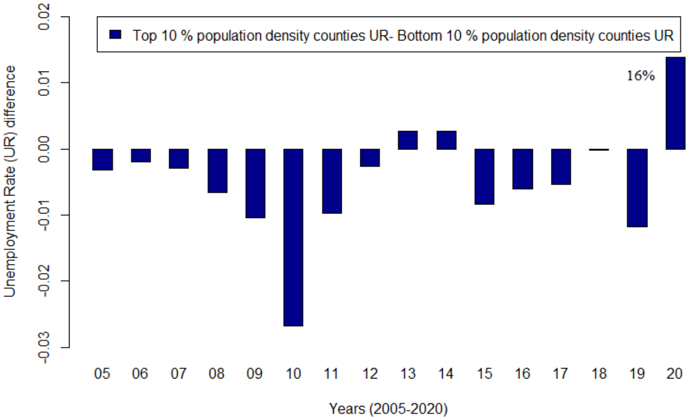
$$\frac{\left(\left(\left(\frac{\eta}{k_n}\right)^{\frac{\eta}{1-\eta}} B^{\frac{1}{1-\eta}} (1-\eta) p_{nc}^{\frac{1}{1-\eta}}\right)^{\epsilon} - r\right)}{p_{nc}^{\epsilon}} < \frac{\left(\left(\left(\frac{\eta}{k_n}\right)^{\frac{\eta}{1-\eta}} B^{\frac{1}{1-\eta}} (1-\eta) p_{nc'}^{\frac{1}{1-\eta}}\right)^{\epsilon} - r\right)}{p_{nc'}^{\epsilon}} \Rightarrow$$

$$\left(\left(\frac{\eta}{k_n}\right)^{\frac{\eta}{1-\eta}} B^{\frac{1}{1-\eta}} (1-\eta)\right)^{\epsilon} p_{nc}^{\frac{\eta\epsilon}{1-\eta}} - \frac{r}{p_{nc}^{\epsilon}} < \left(\left(\frac{\eta}{k_n}\right)^{\frac{\eta}{1-\eta}} B^{\frac{1}{1-\eta}} (1-\eta)\right)^{\epsilon} p_{nc'}^{\frac{\eta\epsilon}{1-\eta}} - \frac{r}{p_{nc'}^{\epsilon}} \Rightarrow$$

$$\left(\left(\frac{\eta}{k_n}\right)^{\frac{\eta}{1-\eta}} B^{\frac{1}{1-\eta}} (1-\eta)\right)^{\epsilon} p_{nc}^{\frac{\eta\epsilon}{1-\eta}} - \left(\left(\frac{\eta}{k_n}\right)^{\frac{\eta}{1-\eta}} B^{\frac{1}{1-\eta}} (1-\eta)\right)^{\epsilon} p_{nc'}^{\frac{\eta\epsilon}{1-\eta}} < \frac{r}{p_{nc}^{\epsilon}} - \frac{r}{p_{nc'}^{\epsilon}}$$

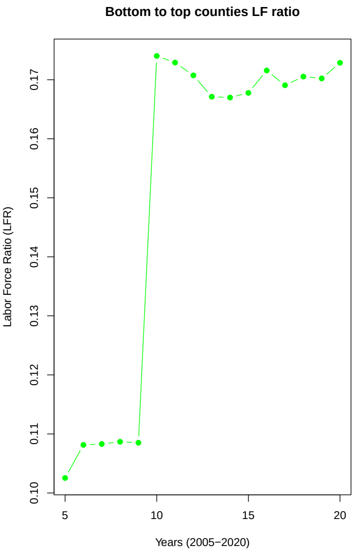
Since we assumed that $p_{nc'}^{\epsilon} < p_{nc}^{\epsilon}$, the inequality cannot hold.

Back to Equilibrium

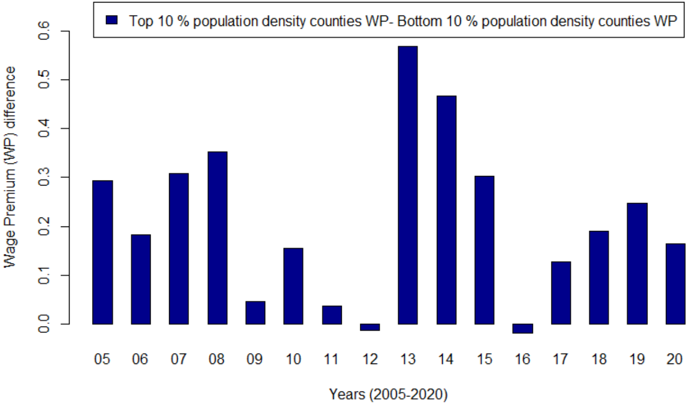


Unemployment rate difference between the most and least densely populated counties in US for the years 2005-2020

Back to Motivation



Back to Motivation



Tradable sector wage premium difference between the most and least densely populated counties in US for the years 2005-2020

Back to Motivation

Sufficient condition (Proposition 3)

(a) $\frac{\eta}{1-\epsilon} \geq 1$

- Could be problematic if very low elasticity of N's quantity produced with respect to the N expenditure of a location's T residents

Back to Relocation unemployment rate