Are Big Cities Important for Economic Growth?

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Are big cities important for economic growth?

- US income per capita increased by about a factor of 6.1 during 1900-2010. Of this, about 4.8 reflects an increase in TFP (as opposed to factor accumulation).
- The elasticity of urban labor productivity to city size is 4-13%. For patent production this elasticity is 6-20%.
- Are urban scale economies in output and patenting large enough to make an important contribution to the increasing level of technology?

What we do I

- Evaluate the growth in US TFP during 1900-2010 for counterfactuals where urban scale economies are capped at the level of a city of 1m, 100k, and 50k.
- Scale economies interact with systems of cities two ways,
  - As cities grow the urban scale effect on output causes a trend in TFP.
  - As cities grow the urban scale effect on patents directly affects the growth of TFP.
- Assume the US is in ‘technological autarchy’.

What we do II

Steps: For a counterfactual system of cities,

- Evaluate effect of change in urban scale effects for output on aggregate output in 2010.
- Evaluate effect of change in urban scale effects for patents patents by decade for 1900-2010.
- Aggregate decadal changes in patents into changes in the level of technology in 2010.
- Multiply the effects of the two mechanisms for 2010.

We rely on three 'tricks':

1. Particular, simple counterfactuals.
2. Out of equilibrium counterfactuals (as in growth accounting).
3. Output, not welfare.

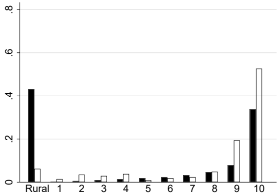
For the most plausible parameter values, restricting cities to a population of 1m reduces the 1900-2010 growth rate of US output from 1.66 to 1.52%.

Data

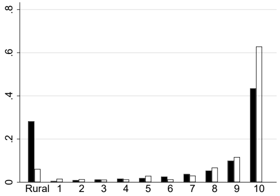
- 274 2010 MSAs plus ‘rural’.
- County level population 1900-2020.
- BEA County level output data 2000-2020.
- CUSP patent data, 1900-2014.
- National TFP series.

When analyzing output we focus on 2010. When analyzing patents and the level of technology, we consider 1900-2010 by decade.

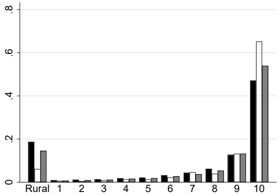
Distribution of population, output and patents by city size



1900



1950



2010

- Black $\sim$ population. Gray $\sim$ output. White $\sim$ patents.
- Output and patents are concentrated in the largest cities. Patenting is more concentrated than output. Output is more concentrated than population. Big cities become more important over time.
- In 2010 52 MSAs $> 1m$; 59% population, 66% output, 78% patents.
- What if all cities over 1m had urban scale economies of a city of 1m?

Urban scale effects for output

$Y_{it},\ Y_t \sim$ MSA i, national output in year t
$K_{it} \sim$ capital, $L_{it} \sim$ Total population, $h^Y_{it} \sim$ human capital per person
$\ell^Y_{it} \sim$ share of labor in output, $\gamma \sim$ capital share $= 0.33$

$$Y_{it} = \left[\widehat{A}_{it}\bar{A}_t L_{it}^{\sigma_A}\right](K_{it})^{\gamma}\left(h^Y_{it}\ell^Y_{it}L_{it}\right)^{1-\gamma}$$

$\bar{A}_t \sim$ National TFP. $\widehat{A}_{it} \sim$ Noise. $L_{it}^{\sigma_A} \sim$ Urban scale effect for output.

Cap urban scale effects for output at L_{max} and do some algebra,

$$\frac{Y_t^{alt}}{Y_t^{base}} = \sum_i \frac{Y_{it}^{base}}{Y_t^{base}} min\left(1, \left(\frac{L_{max}}{L_{it}}\right)^{\sigma_A/(1-\gamma)}\right).$$

We can calculate the change in output relative to the observed case, using only city level output, population, and counterfactual population.

Output in 2010 for three counterfactual size caps and values of σ_A.

σ_A	$L_{max} = 1m$	$L_{max} = 100k$	$L_{max} = 50k$
0.04	0.94	0.84	0.82
0.08	0.88	0.72	0.68
0.12	0.83	0.62	0.57

If $\sigma_A = 0.08$ then capping city size at $L_{max} = 1$m reduces output in 2010 by 12%.

Urban scale effects for patents

$P_{it} \sim$ Patents, $h^R_{it} \sim$ human capital per research worker
$(1-\ell^Y_{it}) \sim$ Share of population in research, $L_{it} \sim$ Total population

MSA i patents at t

$$P_{it} = \left[\widehat{B}_{it}\bar{B}_t L_{it}^{\sigma_B}\right] h^R_{it}(1-\ell^Y_{it})L_{it}$$

This is like output (but no capital) and we can calculate counterfactual patents analogously from observed patents and population,

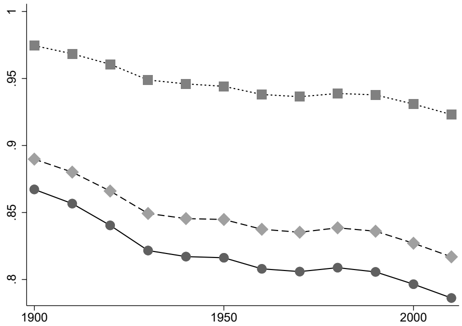
$$\frac{P_t^{alt}}{P_t^{base}} = \sum_i \frac{P_{it}^{base}}{P_t^{base}} min\left(1, \left(\frac{L_{max}}{L}\right)^{\sigma_B}\right).$$

Patents for 2000-9 for counterfactual size caps and values of σ_B.

σ_B	$L_{max} = 1m$	$L_{max} = 100k$	$L_{max} = 50k$
0.06	0.93	0.83	0.80
0.20	0.82	0.58	0.52

Counterfactual patents as a share of observed 2000-2009 totals reported in the CUSP data Berkes [2018], as L_{max} and σ_B vary.

- Moretti [2021] $\Longrightarrow \sigma_B = 0.06$ (panel data).
- Carlino et al. [2007] $\Longrightarrow \sigma_B = 0.20$ (cross-section).



- Counterfactual patents as a fraction of actual patents reported in CUSP when city sizes are capped at 1m (squares), 100k (diamonds), and 50k(circles). Calculations assume $\sigma_B = 0.06$.
- Cities are more important for patenting over time as they get larger.

From Patents to national TFP ($\bar{A}_t$)

- We want to relate the evolution of $\bar{A}_t$ to patents.

$$Y_{it} = \left[\widehat{A}_{it}\bar{A}_t L_{it}^{\sigma_A}\right](K_{it})^{\gamma}\left(h_{it}^{Y}\ell_{it}^{Y}L_{it}\right)^{1-\gamma}$$

- Use Bloom et al. [2020] estimates of the relationship between research effort, adjusted for urban scale effects, and TFP growth. 'Research effort' is employment in R&D.
- Steps: Patents $\rightarrow$ Adjusted Research effort $\rightarrow$ $\bar{A}_t$.
- Assume patents are proportional to adjusted research effort within a decade,

$$P_{it} = \mu_t R_{it}.$$

  We just use patents only to assign research effort to cities and adjust for urban scale effects.
- Why? Time varying relationships between patents and TFP, and between research effort and patents.

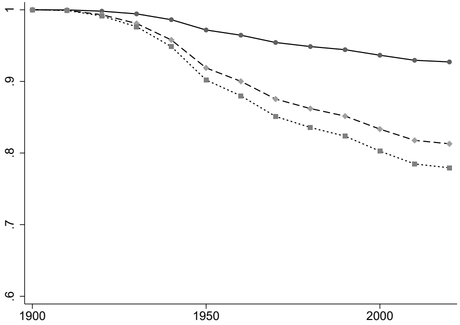
Two more assumptions

- The relationship between adjusted research effort and the adjusted level of technology is ([Bloom et al., 2020]).

$$\Delta \bar{A}_t / \bar{A}_t = \alpha R_t^{\lambda} \bar{A}_t^{-\beta}.$$

  This lets us go back and forth between adjusted research effort and the adjusted level of technology. $\lambda \sim$ 'duplication of effort' and $\beta \sim$ 'frontier moves'. Use $\beta = 3.1$, $\lambda = 1$.
- After doing some algebra, this lets us link counterfactual changes in city sizes to changes in the level of adjusted technology.
- Two detours. (1) calculate the adjusted level of technology $\bar{A}_t$ from aggregate data. (2) impute R_t using results from Bloom et al. [2020].

Counterfactual adjusted level of technology (relative)



Ratio of counterfactual to observed productivity, $\bar{A}_t^{alt}/\bar{A}_t^{base}$, by decade for three different counterfactuals. City sizes are capped at 1m (squares), 100k (diamonds), and 50k(circles). $\lambda = 1$, $\beta = 3.1$, $\sigma_B = 0.06$ and $\sigma_A = 0.08$.

Total effect of city size on output in 2010

	$\sigma_B = 0.06$			$\sigma_B = 0.20$		
	$\sigma_A = 0.04$	$\sigma_A = 0.08$	$\sigma_A = 0.12$	$\sigma_A = 0.04$	$\sigma_A = 0.08$	$\sigma_A = 0.12$
$\lambda = 1.00$, $\beta = 3.1$	0.918	0.864	0.816	0.877	0.826	0.780
$\lambda = 0.75$, $\beta = 2.4$	0.919	0.865	0.817	0.881	0.829	0.784
$\lambda = 1$, $\beta = 0$	0.868	0.820	0.777	0.748	0.710	0.678

- Counterfactual output as a share of realized output in 2010, $L_{max} = 1m$ accounting for urban scale economies for output and patents.
- The best estimates of λ, β, σ_A, σ_B put us in the highlighted cells.
- Most of the decline is due to urban scale effects on output, σ_A, not innovation.
- Observed rate of output growth during 1990-2010 is $g = 1.63\%$. A 14% drop in 2010 implies counterfactual rate of $g = 1.49\%$.

Conclusion

- Under a counterfactual where no city larger than 1m is allowed (top 52/274 MSAs), the decrease in output is less than 14% for the most defensible parameter estimates.
- Most of the effect is due to the static effect of city size on TFP, not the effect of size on research productivity.
- This does not suggest that big cities are playing an important role in the growth process.

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