HOW TO MEASURE ECONOMIES OF AGGLOMERATION

- Agglomeration economies imply that firms located in an agglomeration are able to produce more output with the same inputs

$\Rightarrow$The most natural and direct way to quantify agglomeration economies is to estimate the elasticity of some measure of average productivity with respect to some measure of local scale, such as employment density or total population

- There are at least three dimensions over which these externalities may extend

  Which is the scope of agglomeration economies?.

1. **Industrial scope.** The degree to which agglomeration economies extend across industries
   Localization economies vs. Urbanization economies

2. **Geographic scope.** Attenuation of agglomeration economies with distance
   If agents physically closer, there is more potential for interaction

3. **Temporal scope.** It is possible that one agent's interaction with another agent at a point in the past continues to have an effect on productivity in the present.
   Learning may take place only gradually, and awareness of a location's supply chain possibilities may take time to develop.
   Dynamic agglomeration economies

- External economies are shifters of an establishment's production function

$$y = g(A) f(x)$$

A characterizes the establishment's environment

x is a vector of usual inputs (land, labor, capital and materials)

- What do we have in $g(A)$

  We start with the basic interaction between two establishments j y k

  The effect of k on j depends on the scale of activity at both establishments

  The impact of k on j depends on the distance

  d_{jk}^{G} geographic distance

  d_{jk}^{I} industrial distance

  d_{jk}^{T} temporal distance

$q\left(x_j, x_k\right) a\left(d_{jk}^G, d_{jk}^S, d_{jk}^T\right)$ benefits to j from interactions with k

$q\left(x_j, x_k\right)$ benefits from interaction that depend on the size of the establishments (for example, the workforce of k)

$a\left(d_{jk}^G, d_{jk}^S, d_{jk}^T\right)$ the attenuation of the interaction as establishments become more distant.

$A_j = \sum_{k \in K} q\left(x_j, x_k\right) a\left(d_{jk}^G, d_{jk}^S, d_{jk}^T\right)$ total benefit to j from all establishments $k \in K$

Assuming that A_j coul be fully specified and measured without error, the initial equation becomes

$$y_j = g\left(A_j\right) f\left(x_j\right)$$

MODELING APPROACHES

1. Production Function

The most natural and direct way to measure economies of agglomeration

$q = g(A)\, f(land, labor, materials, capital)$

Fundamental challenge is to find data on all inputs

The easiest to find:

- Employment/Hours of work

The rest not so easy:

- Physical capital
- Land
- Materials (purchased by the firm not made by the firm)

Measures of $\boldsymbol{A}$ (s sector, c city)

- Size of employment (nº de firms) from firm's industry in the city (economies of localization)
- Size of employment or population of the city (economies of urbanization)
- Employment density $denemp_c = \frac{Employment_c}{Area_c}$
- Measures of specialization of city in sector $esp_{cs} = \frac{employment_{cs}}{employment_c}$ or

$$coef\ esp_{cs} = \frac{employment_{cs} / employment_c}{employment_{country,s} / employment_{country}}$$

- Measures of industrial diversity of the city $H_c = \sum_s \left(\frac{employment_{cs}}{employment_c} \right)^2$

2. Wages

Assumption:

In competitive markets $w = VMPL$

Even without perfect competition, in more productive locations, wages will be higher

Economies of agglomeration $\Rightarrow$ Higher productivity $\Rightarrow$ Higher wage

$$w_{ij} = f\left(\text{individual characteristics, agglomeration variables}\right)$$

Microdata on wages increasingly available

3. Births of new establishments

Assumption:

Entrepreneurs seek out profit-maximizing locations and are disproportionately drawn to the most productive regions

Economies of agglomeration $\Rightarrow$ Higher productivity $\Rightarrow$ Higher profit $\Rightarrow$ Location decision

No need of data of purchased inputs

New establishments are largely unconstrained by previous decisions

Decisions are made taken as exogenous the existing economic environment

$$NoFirms = f\left(\text{Agglomeration variables, Other controls } \left(\text{competition, input costs,...}\right)\right)$$

4. Employment Growth

Assumption:

Agglomeration economies enhance productivity and productive regions grow more rapidly as a result

Economies of agglomeration $\Rightarrow$ Higher productivity $\Rightarrow$ Shift labor demand $\Rightarrow$ Employment growth

Data on employment easily available

$$\ln E_1 - \ln E_0 = f(\text{Agglomeration variables}_0, \text{Other control variables}_0)$$

DETERMINANTS OF LOCAL PRODUCTIVITY

We will see how can be derived an estimable equation relating productivity/wage and agglomeration economies, taking as a departure point a production function

We assume a firm	j
Located in	r
Operating in sector	s
Using labor in quantity	l_j
And other factors	k_j

Production function given by: $y_j = A_j \left(s_j l_j \right)^{\mu} k_j^{1-\mu}$

μ is the proportion of labor in production

A_j is a Hicks-neutral factor augmenting technology level

s_j is the efficiency level of workers

Profit of the firm:

$$\pi_j = \sum_b p_{jb} y_{jb} - w_j l_j - r_j k_j = p_j y_j - w_j l_j - r_j k_j$$

y_{jb} is the quantity exported to region b, p_{jb} is the mill price set in region b net of the marginal cost of intermediate inputs,

$p_j = \sum_b p_{jb} \frac{y_{jb}}{y_j}$ is the average unit value, net of the cost of the intermediate inputs

w_j is the wage rate

r_j is the cost of inputs other than labor and intermediate inputs

$(p_j y_j)$ is the value added of the firm (Value of production minus cost of intermediates)

Applying FOC and rearranging terms:

$$w_j = \mu p_j A_j s_j^{\mu} \left(\frac{k_j}{l_j} \right)^{1-\mu}$$

$$r_j = (1-\mu) p_j A_j s_j^{\mu} \left(\frac{k_j}{l_j} \right)^{-\mu}$$

By plugging the second expression into the first, we obtain:

$$w_j = \mu (1-\mu)^{\frac{1-\mu}{\mu}} s_j \left(\frac{p_j A_j}{r_j^{1-\mu}} \right)^{1/\mu}$$

By aggregating:

$$w_{rs} = \frac{\mu (1-\mu)^{\frac{1-\mu}{\mu}}}{n_{rs}} \sum_{j \in (rs)} s_j \left(\frac{p_j A_j}{r_j^{1-\mu}} \right)^{1/\mu}$$

n_{rs} is the number of firms in region *r* and sector *s*

In which region is the marginal productivity of labor the highest?

$$w_j = \mu(1-\mu)^{\frac{1-\mu}{\mu}} s_j \left(\frac{p_j A_j}{r_j^{1-\mu}} \right)^{1/\mu}$$

The equation shows that wages are directly proportional to workers' efficiency, s_j

This has to do with workers' endowments but not with space (in principle, but will see later)

Still we have p_j, r_j, A_j through which agglomeration effects show up

- A higher p_j, because of high demand, weak competition or cheap intermediates, positively affects wages and worker attraction contributing to a higher degree of agglomeration in the region.
- r_j captures the effects transmitted through other factor prices.

  When production factors have a low supply elasticity (e.g., land), prices will be higher in agglomerated areas, which pushes down the wage rate

p_j and r_j are affected by pecuniary externalities that work through market mechanisms

- Technological externalities are taken into account through A_j.

Regions with easy circulation of information and/or high concentration of skilled workers are likely to benefit from more productive technologies, then higher wages.

Conversely, transport congestion or pollution worsen productivity and wages

Alternatively, if data related to value-added and capital stocks are available:

$$\frac{p_j y_j}{l_j} = (1-\mu)^{(1-\mu)/\mu} s_j \left(\frac{p_j^{1-\mu} A_j}{r_j^{1-\mu}} \right)^{1/\mu} \qquad \frac{p_j y_j}{l_j^{\mu} k_j^{1-\mu}} = p_j A_j s_j^{\mu}$$

ECONOMETRIC ISSUES

We regress the total factor productivity, average labor productivity or nominal wage on the employment or population density. We can use logs to interpret the coefficient directly as an elasticity

$$\ln w_{rs} = \alpha + \beta \ln den_r + \varepsilon_{rs} \quad \text{where} \quad den_r = \frac{emp_r}{area_r}$$

Estimating the above equation is equivalent to estimate:

$$\ln \frac{1}{n_{rs}} \sum_{j \in (rs)} s_j \left(\frac{p_j A_j}{r_j^{1-\mu}} \right)^{1/\mu} = \alpha + \beta \ln den_r + \varepsilon_{rs}$$

- Implicit assumption:

Density affects wage level through: the local level of technology, A_j; the output price, p_j; the prices of other inputs, r_j; the local efficiency of labor, s_j

Not able to determine through which variables. Only the net effect of density is identified

But this still relevant for policies designed to concentrate or disperse activities

Omitted variables

1. Skills

Differences of skill across space partly explain productivity differentials

Not controlling for average regional skill levels $\Rightarrow$ labor skills are randomly distributed across regions and captured by the error term

If skill controls are not introduced:

If denser areas are more skilled, the effect of density will be overestimated

2. Intra and Inter-sectorial externalities

Wage varies by region and sector but density only varies by region $\Rightarrow$ Industrial mix should be controlled

Industrial mix is important where:

- output is sold to a small number of industries
- inputs used are industry specific

it affects the level of productivity through price effects

$spe_{rs} = \dfrac{emp_{rs}}{emp_r}$ specialization index captures intraindustry externalities

For interindustry externalities, an "industrial diversity" variables is included (Herfindhal index)

$$div_r = \left[\sum_s \left(\frac{emp_{rs}}{emp_r} \right)^2 \right]^{-1}$$

3. Natural amenities and local public goods

Amenities:

- Naturals: favorable climate, coast-line location, presence of lakes and mountains, natural endowments in raw materials
- Man-made: the result of public policy like leisure facilities (theaters, swimming pools,…) or public services (schools, hospitals,…)

Local Public Goods → benefits reaped by local consumers

LPG can be used by firms: Transport infrastructures, research laboratories, job training centers

LPG can affect productivity of production factors

If randomly located → captured by ε_{rs}

Problem: Supply of LPG greater in areas characterized by concentrated activity (public policy decisions)

Consequence: overestimation of density effect

But amenities may have additional effects

On the supply side:

If a region has amenities that attract population → Upward pressure on demand for housing → Pushing up rents

On the demand side:

Higher land rents → Higher cost for firms → Substitute other production factors, labor, for land → Marginal productivity of labor decreases → Drop in wages

If natural amenities are more abundant in heavily populated regions (e.g., leisure facilities) ⇒ the effect of density is underestimated

4. Effects of interaction with neighboring regions

Some form of density market potential

5. ¿Using fixed effects?

If available a panel of industries and regions, it is possible to use fixed effects to control for omitted variables

We need to make the assumption that during the panel period, the omitted we want to control for are constant. For example, amenity and public good endowments

Endogeneity bias

OLS estimates are biased when some explanatory variables are correlated with the residuals of the regression. These variables are said to be endogenous

Assume that a given region experiences a shock observed by economic agents but overlooked by the researcher:

Positive shock $\rightarrow$ some correct decisions made by the regional government that increases productivity

Negative shock$\rightarrow$ an increase of oil price negatively affects regions with intensive use of oil

If shocks are localized and affect the location of agents:

Positive shocks may attract workers to the affected region where wages are increasing

Negative shocks may expel workers from the affected regions

Shocks can have effects on the attraction of regions

$$\Downarrow$$

Impact on activity

$$\Downarrow$$

Impact on employment density

$$\Downarrow$$

$$corr(\ln den_s, \varepsilon_{rs}) \neq 0$$

$$\Downarrow$$

Inverse causality: Shocks $\rightarrow$ Δw $\rightarrow$ attraction/expulsion of workers $\rightarrow$ Increase/Decrease of density

Low mobility of factors $\rightarrow$ weaker bias

However, still endogeneity bias through creation/destruction of jobs

Most common approach to address the problem:

Instrumental variables technique $\rightarrow$ finding variables (**instruments)** correlated with the endogenous variable but not with the residual

1. The first step is regressing the variable we consider endogenous on the chosen instrument.

Ciccone & Hall (1996) are the first to take into account the problem of endogeneity in this context. They use as an instrument past density.

Instrumental regression: $\ln den_r = \rho \ln den_{r,t-150} + \upsilon_r$

This provides us with a prediction of density:

$\ln d\hat{e}n = \hat{\rho} \ln den_{r,t-150}$ where $\hat{\rho}$ is the OLS estimator for ρ

2. The density in the initial regression $\ln w_{rs} = \alpha + \beta \ln den_r + \varepsilon_{rs}$

is replaced by its predicted value (den_r is instrumented) which uncorrelated with the residuals since the instrument is by construction exogenous:

$$\begin{aligned} corr\left(\ln d\hat{e}n_r, \varepsilon_{rs}\right) &= corr\left(\hat{\rho} \ln den_{r,t-150}, \varepsilon_{rs}\right) \\ &= corr\left(\ln den_{r,t-150}, \varepsilon_{rs}\right) \\ &= 0 \end{aligned}$$

The OLS estimate of the equation no longer suffers from endogeneity bias

$$\ln w_{rs} = \alpha + \beta \ln d\hat{e}n_r + \varepsilon_{rs}$$

- Crucial point: assumption of exogeneity of the instrument

  Assumption: there is persistence in agglomeration but there is no correlation between past employment density and present productivity shocks

  Nevertheless a long lag is not a sufficient condition:

  The source of a shock may be linked to unobserved factors that persist over time

Estimates of Agglomeration Economies from Production Function Analyses

Author	*Unit of analysis*	*Independent variable*	*Elasticity*
Aaberg (1973)	Swedish cities	city size (population)	0.02
Shefer (1973)	US MSAs	RTS at MSA aggregation	0.20
Sveikauskas (1975)	US MSAs	city size (population)	0.06
Kawashima (1975)	US MSAs	city size (population)	0.20
Fogarty and Garofalo (1978)	US MSAs	city size (population)	0.10
Moomaw (1981)	US MSAs	city size (population)	0.03
Moomaw (1985)	US MSAs	city size (population)	0.07
Nakamura (1985)	Japanese Cities	city size (population)	0.03[a]
Tabuchi (1986)	Japanese Cities	city size (population)	0.04
Louri (1988)	Greek Regions	city size (population)	0.05
Sveikauskas *et al.* (1988)	US MSAs	city size (population)	0.01[b]
Nakamura (1985)	Japanese Cities	industry size (employment)	0.05
Henderson (1986)	Brazilian Cities	industry size (employment)	0.11[c]
Henderson (1986)	US MSAs	industry size (employment)	0.19[d]
Henderson (2003)	US MSAs	industry size (no. of plants)	0.03[e]
Ciccone and Hall (1996)	US States	employment density	0.06
Ciccone (2000)	EU regions	employment density	0.05

Notes: MSA, Metropolitan Statistical Area; a, mean value for 14 industries; b, mean value from 5 model specifications; c, mean value for ten industries; d, mean value for 9 industries; e, mean value for 4 model specifications.

- An alternative strategy: Greenstone et al. (2008)

- Estimate the effect of the attraction of large plants to US counties on the existent plants

- Strategy:

  - Corporate real estate journal *Site Selection:* includes regular feature "Million Dollar Plants"

Describes how a large plant decided where to locate

Typically start by considering dozens of possible locations

Subsequently narrow the list to roughly 10 places

Finally, 2 or 3 finalist are selected

  - "Million Dollar Plants" articles report the county that the plant ultimately chose ("winner"), as well as the one or two runner-up counties ("losers")

- The losers are counties that have survived a long selection process but narrowly lost the competition

- Identifying assumption:

  The incumbent plants in the losing counties form a valid counterfactual for the incumbents in the winning counties, after conditioning on differences in preexisting trends, plant fixed effects, industry by year fixed effects, and other control variables

- Case: BMW plant

After overseeing a worldwide competition and considering 250 possible sites, BMW announced in 1991 that it had narrowed the list to 20 US counties.

Six months later, BMW announced that the two finalists in the competition were:

Greenville-Spartanburg, South Carolina, and Omaha, Nebraska

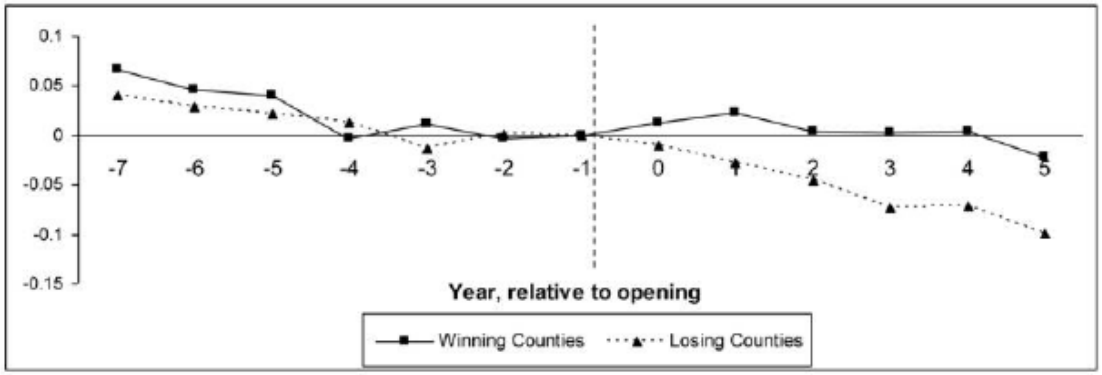
In 1992, BMW announced that it would site the plant in Greenville-Spartanburg and that it would receive a package of incentives worth approximately $115 million funded by the state and local governments

¿Why Greenville-Spartanburg?

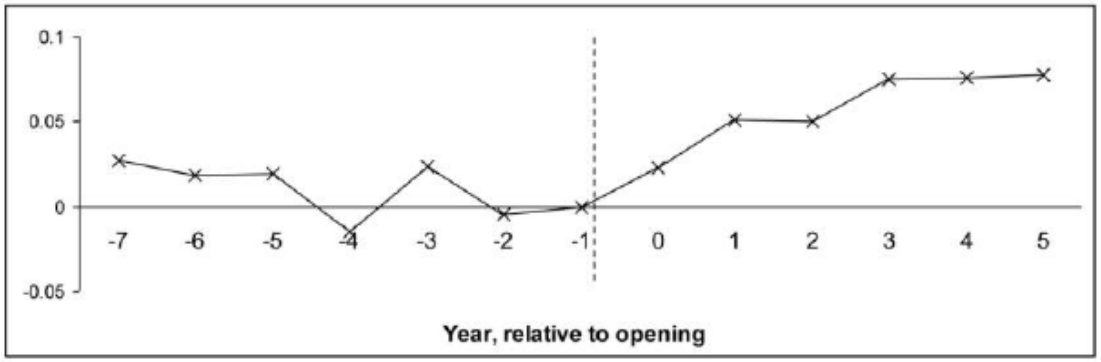
- Most of the reasons are county characteristics that are a potential source of unobserved heterogeneity: low union density, a supply of qualified workers, numerous global frims in the area, including 58 German companies; high-quality transportation infrastructure, access to key local services.
- Greenville was willing to provide BMW with $115 million in subsidies because it expected economic benefits from BMW's presence.
- The facility's ex ante expected 5-year economic impact on the region was $2 billion.
- As part of this $2 billion , the plant was expected to create 2000 jobs directly and another 2000 jobs indirectly
- In principle, these 2000 additional jobs could reflect the entry of new plants or the expansion of existing plants caused by agglomeration economies.
- Thus, the subsidy is likely to be a function of the expected gains from agglomeration for the county.

They consider 45 cases of "Million Dollar Plants"

All Industries: Winners vs. Losers



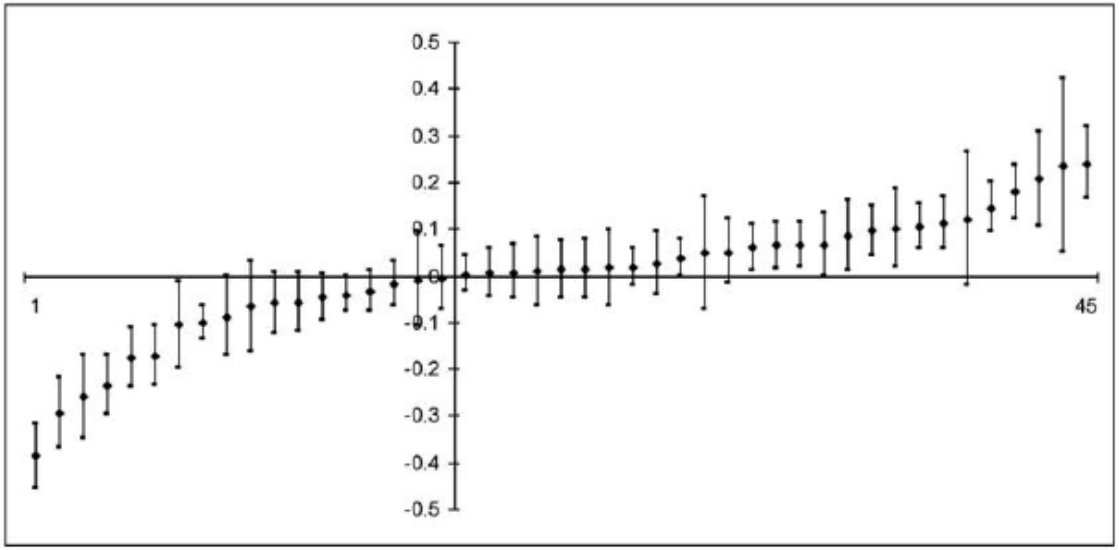
Difference: Winners – Losers



Changes in Incumbent Plant Productivity Following an MDP Opening

	All Counties: MDP Winners − MDP Losers		MDP Counties: MDP Winners − MDP Losers		All Counties: Random Winners
	(1)	(2)	(3)	(4)	(5)
			A. Model 1		
Mean shift	.0442*	.0435*	.0524**	.0477**	− 0.0496***
	(.0233)	(.0235)	(.0225)	(.0231)	(.0174)
				[$170 m]	
R^2	.9811	.9812	.9812	.9860	~0.98
Observations (plant by year)	418,064	418,064	50,842	28,732	~400,000
			B. Model 2		
Effect after 5 years	.1301**	.1324**	.1355***	.1203**	−.0296
	(.0533)	(.0529)	(.0477)	(.0517)	(.0434)
				[$429 m]	
Level change	.0277	.0251	.0255	.0290	.0073
	(.0241)	(.0221)	(.0186)	(.0210)	(.0223)
Trend break	.0171*	.0179**	.0183**	.0152*	− 0.0062
	(.0091)	(.0088)	(.0078)	(.0079)	(.0063)
Pre-trend	−.0057	−.0058	−.0048	−.0044	−.0048
	(.0046)	(.0046)	(.0046)	(.0044)	(.0040)
R^2	.9811	.9812	.9813	.9861	~.98
Observations (plant by year)	418,064	418,064	50,842	28,732	~400,000
Plant and industry by year fixed effects	Yes	Yes	Yes	Yes	Yes
Case fixed effects	No	Yes	Yes	Yes	NA
Years included	All	All	All	$-7 \leq \tau \leq 5$	All

Heterogeneity of the effects across cases



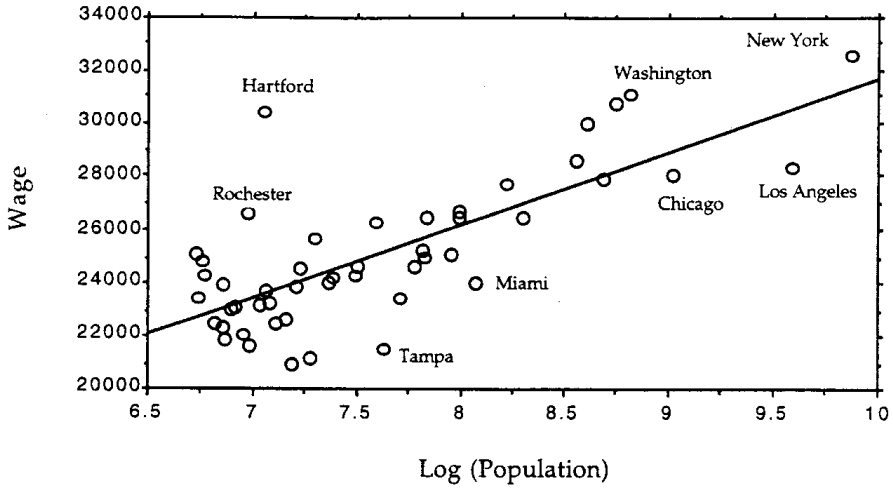
27 out of 45 show positive effects

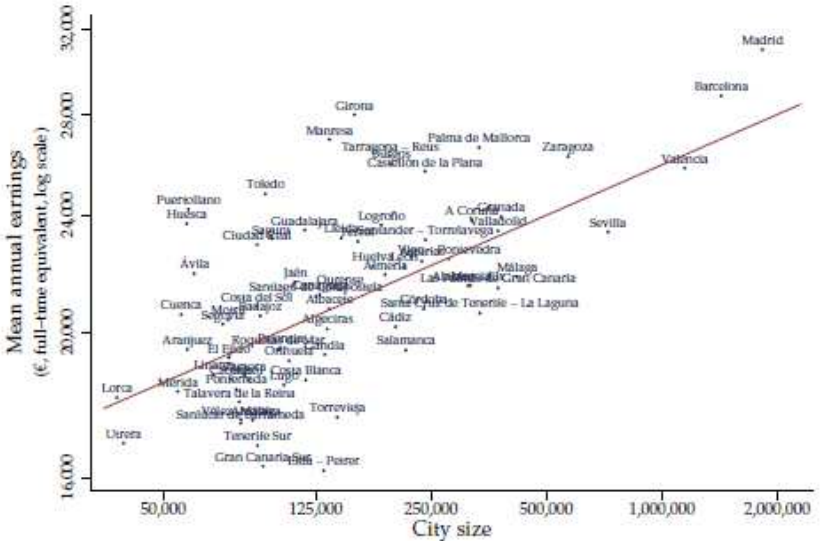
- The effects are more important the nearer are the existent plants in economic terms (matching and knowledge spillovers)
- The chosen counties attract new firms afterwards (12.5%) and wages increase (2.7%)
- A 12% increment of TFP is equivalent to moving from the 10th percentile of the county-level TFP distribution to the 27th percentile.
- The increment of wages affect to all the firms in the county but the benefits of agglomeration do not affect to all firms in the county (cluster)

➢ Wages

In competitive markets labour is paid the value of its marginal product

Larger employment size/density $\Rightarrow$ Higher productivity $\Rightarrow$ Higher wage





$$\ln w = \beta \cdot \ln \text{employment density/size} + \text{control variables}$$

$\beta \rightarrow$ Urban wage premium

- **But** not the only possible reason for higher wages in larger cities

1. Sorting of the skilled into cities?
2. Human capital accumulation?

So

- Two basic questions:
  - ✓ Is it that most skilled sort into cities or that cities improve productivity?
  - ✓ Is the effect important when people get to the city or do wages grow over time faster?

➢ Sorting

- Most skilled might sort into cities because:
  - Information flows are relatively more valuable to them
  - Consumption amenities might be more attractive for skilled people

  - If wages are higher cities, why workers do not flock to higher wage cities?
  - If wages are higher cities, why firms do not flee the higher wage cities?

- Labour supply

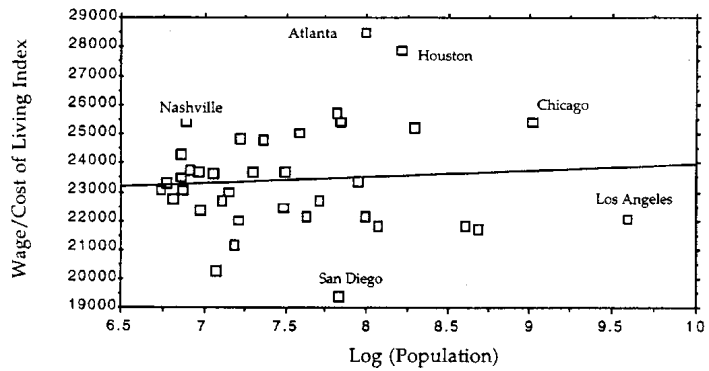
In order to have a spatial equilibrium real wages per unit of skill equalize:

$\frac{\phi_k \omega_i}{P_i}$ needs to be constant across cities i

ϕ_k units of skill ω_i wage in city i P_i price index in city i

Implies that $\tilde{W}_i - \tilde{W}_j = \tilde{\phi}_i - \tilde{\phi}_j + \log\left(\frac{P_i}{P_j}\right)$

So if $\tilde{W}_i - \tilde{W}_j - \log\left(\frac{P_i}{P_j}\right) = \tilde{\phi}_i - \tilde{\phi}_j = 0$, there are no ability differences across cities



- Labour demand
- In order for firms to demand workers in a city and pay higher wages it most be that they
  - ✓ Obtain higher productivity
  - ✓ Charge higher prices because transport costs are lower

- Suppose firms maximize: $A_i K^{\sigma} L^{1-\sigma} - \omega_i L - RK$

  - ✓ L is labor in unit of efficiency and A_i includes efficiency and prices
  - ✓ Then, firm maximization and zero profits imply $\omega_i = (1-\sigma)\sigma^{\sigma/1-\sigma} R^{-\sigma/1-\sigma} A_i^{1/1-\sigma}$

- Implies that

$$\tilde{W}_i - \tilde{W}_j = \tilde{\phi}_i - \tilde{\phi}_j + \frac{1}{1-\sigma}\log\left(\frac{A_i}{A_j}\right)$$

- For firms to stay in high wage areas, either workers in those areas have higher ability levels or productivity must be higher in those areas

- The goal is to obtain an estimate of A_i / A_j

- Robust evidence for wage premium France 5%, US 4.1%, Spain 4.8%
- But when controlling for sorting (individual fixed effects), premium reduction France 35% , Spain 46% (no clear evidence in US)

- Timing effects
  - Most standard theories imply that effects happen at impact
    - ✓ So wages should jump up when people move to cities and should jump down when they move out
  - Alternatively, cities might act through human capital accumulation or labor-market matching
    - ✓ In this case wages should grow over time and should not jump down when worker leaves

Spain: Experience accumulated in bigger cities more valuable than experience accumulated elsewhere

First year of experience in Madrid or Barcelona raises earnings by 2.7% relative to having worked in a city below top five

Most of the earnings premium in bigger cities is not instantaneous but accumulates over time and highly portable