Productivity and Agglomeration Externalities

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Motivation

- It is not obvious that organizing a national economy using a small number of high-density metropolitan areas is desirable.
- Why is it desirable for most high-productivity firms – especially in service sector industries – locate in large cities despite congestion, crime, high housing costs, or long commutes?
- Urban economics deals with understanding the agglomeration and dispersion forces that shape urban economies.
- Agglomeration externalities can be defined as the benefits a firm derives from being located close to other economics actors.
- Agglomeration externalities provide an economic rationale for the existence of cities, since economy has the potential to make forms (and individuals).

Knowledge Spillovers Among Individuals

- Productivities of individuals rise when they interact with other individuals due to knowledge spillovers.
- Think about the importance of your peers when you study for exam!
- Knowledge spillovers are more likely to occur in open environments such as universities or publicly funded research institutions.
- Knowledge spillovers can thus explain the existence of cities when natural advantages do not exist.

Knowledge Spillovers Among Firms

- Marshall (1920) argued that efficiency gains arises because of synergies between firms in the same industry.
- Jane Jacobs (1969) argued that agglomeration arises due to synergies between different industries.
- Knowledge provides comparative advantages over your competitors, and firms need to protect that advantage. (Arrow's Paradox)
- Firms have strong incentives to prevent knowledge spillovers, and they use the full force of the legal system to prevent them from happening.
- Patent and copyright laws protect the intellectual property of inventors, but only apply to formal, codified, or explicit knowledge.
- Patents may be hard to enforce, especially, for smaller firms.

Tacit versus Formal Knowledge

- Tacit knowledge is the kind of knowledge that is difficult to transfer to another person by means of writing it down or verbalizing it.
- Tacit knowledge can be defined as skills, ideas and experiences that people have in their minds and are, therefore, difficult to access because it is often not codified and may not necessarily be easily expressed
- Tacit knowledge spillovers can arise between firms by sharing a common labor pool.
- Large local labor market with many high skill workers may facilitate these knowledge spillover.

An Augmented Production Function Model

- Firm i located in city j produces output for a given set of factor inputs:

$$Q_{ij} = A_{ij} f(L_{ij}, K_{ij}) \quad (1)$$

where A_{ij} measures baseline productivity, L_{ij} is labor, and K_{ij} is capital.

- To accommodate agglomeration externalities, we could, for example, assume that we can decompose productivity into an idiosyncratic component A_i and a location specific externality $E(N_j)$

$$A_{ij} = A_i E(N_j) \quad (2)$$

where N_j is the number of firms in city j.

An Example

- Let's consider a Cobb-Douglas model and a firm i located in city j where

$$Q_{ij} = A_i \, N_j^{\phi} \, L_{ij}^{\alpha} \, K_{ij}^{\gamma} \tag{3}$$

- To compute the cost function, we need to solve the following problem:

$$\begin{aligned} \min_{L_{ij}, K_{ij}} \quad C_{ij} &= w_j \, L_{ij} + r_j \, K_{ij} + F_j \\ s.t. \quad Q_{ij} &= A_i \, N_j^{\phi} \, L_{ij}^{\alpha} \, K_{ij}^{\gamma} \end{aligned} \tag{4}$$

where r_j denotes the rental rate of capital, and w_j the wage rate may be location specific.

The Cost Function

- The cost function of the firm is then obtained by substituting the conditional factor demand functions into the identity that defines costs. Hence we obtain:

$$C\left(w_j, r_j, Q_{ij}\right) = Q_{ij}^{\frac{1}{\alpha+\gamma}} A_i^{\frac{-1}{\alpha+\gamma}} N_j^{\frac{-\phi}{\alpha+\gamma}} \left[w_j \left(\frac{\alpha r_j}{\gamma w_j} \right)^{\frac{\gamma}{\alpha+\gamma}} + r_j \left(\frac{\gamma w_j}{\alpha r_j} \right)^{\frac{\alpha}{\alpha+\gamma}} \right] + F_j \quad (5)$$

- Note that costs are decreasing in the agglomeration externalities.
- Firm locational decisions depend on input prices, externalities and other factors that may affect fixed costs (such as local infrastructure).
- They may also depend on differences in output prices and transportation costs.

What is the empirical evidence?

- The theory is compelling and there is some anecdotal evidence that agglomeration externalities are important.
- Hence, we need to turn to empirical work to determine whether these effects are significant – both from a statistical and economic perspective.
- Obviously, the magnitude and relevance of agglomeration externalities will depend on a number of factors such as the industry we study or the relevant time period under consideration.

The Selection Challenge

- Firms do not make random decisions where to locate a headquarter or a plant.
- Just because we observed a lot of sorting of firms by productivity, that does not necessarily imply that this sorting is driven by agglomeration externalities!
- There are clearly many compelling reasons why one would like to live in New York City or San Francisco.
- Most of these reasons have nothing to do with agglomeration externalities.
- There are many other factors – infrastructure, labor costs, and tax benefits are factors that we will consider in detail in this course – besides agglomeration externalities that determine firm location decisions.

Can we overcome these challenges?

- How would you design a "social experiment" to identify the impact of agglomeration externalities on firms productivities?
- How do you get around the problem that even in a controlled experiment you may not be able to correctly measure the level of agglomeration externalities?
- Why are these types of social experiments not feasible?

The Case of BMW

- In the early 1990s BMW decided to enter the market for Sports Utility Vehicles.
- Since most of the demand for these types of vehicles was in the U.S., BMW decided to produce these new cars in the U.S.
- Since it did not operate a single production plant in the U.S. at that time it was fairly unconstrained in its choice.
- BMW announced in 1992 that it would build a 1,150-acre manufacturing facility in Spartanburg County, South Carolina, to strengthen its international production system.
- The first BMW plant opened in 1994.
- Spartanburg was willing to provide BMW with $115 million in subsidies because it expected economic benefits from BMW's presence.

How can we exploit this event?

- We can observe and measure how the opening of the plant in Spartanburg affected the productivity of existing plants in the county. These firms are our treatment group.
- By comparing outcomes before and after the relocation of BMW, we focus on changes in agglomeration externalities.
- But what about time series trends? We need a control group.
- The main question that arises is then is: which firms do we use as a control group? Where are they located?
- A natural approach is to look at other cities and counties that BMW was evaluating and eventually did not chose.
- These counties were in the race to attract the new BMW plant and must have been considered by BMW to have similar characteristics.

A Quasi-Experimental Design

- Greenstone, Hornbeck, and Moretti (2010), "Identifying Agglomeration Spillovers: Evidence from Winners and Losers of Large Plant Openings." Journal of Political Economy, 2010, 118 (3): 536-598.
- They try to quantify agglomeration spillovers by estimating the impact of the opening of a large new manufacturing plant on the total factor productivity of incumbent plants in the same county.
- They know the county where the Million Dollar Plant ultimately chose to locate (the winning county), as well as the one or two runner-up counties (the losing counties).
- The incumbent plants in the losing counties are used as a counterfactual for the TFP of incumbent plants in winning counties in the absence of the plant opening.

Empirical Implications

1. The opening of a new plant will increase the TFP of incumbent plants.
2. The increase in TFP may be larger for firms that are economically closer to the new plant.
3. The density of economic activity in the county will increase as firms move in to gain access to the positive spillovers (if the spillovers are large enough).
4. The price of locally supplied factors of production will increase.

TABLE 1
THE MILLION DOLLAR PLANT SAMPLE

	(1)
Sample MDP openings:[a]	
Across all industries	47
Within same two-digit SIC	16
Across all industries:	
Number of loser counties per winner county:	
1	31
2+	16
Reported year − matched year:[b]	
−2 to −1	20
0	15
1 to 3	12
Reported year of MDP location:	
1981–85	11
1986–89	18
1990–93	18
MDP characteristics, 5 years after opening:[c]	
Output ($1,000s)	452,801
	(901,690)
Output, relative to county output 1 year prior	.086
	(.109)
Hours of labor (1,000s)	2,986
	(6,789)

[a] Million Dollar Plant openings that were matched to the Census data and for which there were incumbent plants in both winning and losing counties that are observed in each of the 8 years prior to the opening date (the opening date is defined as the earliest of the magazine reported year and the year observed in the SSEL). This sample is then restricted to include matches for which there were incumbent plants in the MDP's two-digit SIC in both locations.

[b] Only a few of these differences are 3. Census confidentiality rules prevent our being more specific.

[c] Of the original 47 cases, these statistics represent 28 cases. A few very large outlier plants were dropped so that the mean would be more representative of the entire distribution (those dropped had output greater than half of their county's previous output and sometimes much more). Of the remaining cases, most SSEL matches were found in the ASM or CM but not exactly 5 years after the opening date; a couple of SSEL matches in the 2xxx–3xxx SICs were never found in the ASM or CM; and a couple of SSEL matches not found were in the 4xxx SICs. The MDP characteristics are similar for cases identifying the effect within same two-digit SIC. Standard deviations are reported in parentheses. All monetary amounts are in 2006 U.S. dollars.

The Empirical Model

- Let's assume a Cobb-Douglas technology. Hence, observed output of firm i in county j at time t is given by

$$\ln(Q_{ijt}) = \ln(A_{ijt}) + \alpha \ln(L_{ijt}) + \gamma \ln(K_{ijt}) \quad (6)$$

- GHM also account for material inputs, industry-time fixed effects. WLOG, we can ignore these factors since they just add additional regressors or fixed effects to the model.
- GHM do not explicitly use county as subscript which is somewhat misleading since the county is the effective unit of analysis.
- Instead they use a "case" subscript and later on introduce winning and losing counties as additional regressors.

The Empirical Model

- GHM then decompose total factor productivity into a location-time specific component, denoted by δ_{jt}, and firm-time specific shock, a fixed productivity shock μ_i, and a random noise error ϵ_{ijt}:

$$\ln(A_{ijt}) = \mu_i + \delta_{jt} + \epsilon_{ijt} \tag{7}$$

- Changes in agglomeration externalities then primarily affect the common component, denoted by δ_{jt}
- We would, therefore, expect that δ_{jt} increases if agglomeration externalities increase in city j at time t and vice versa.
- ϵ_{it} is treated as purely exogenous shock uncorrelated with inputs.
- GHM follow a fixed effects approach that abstract from a structural time varying productivity shock and hence assumes away the transmission bias problem.

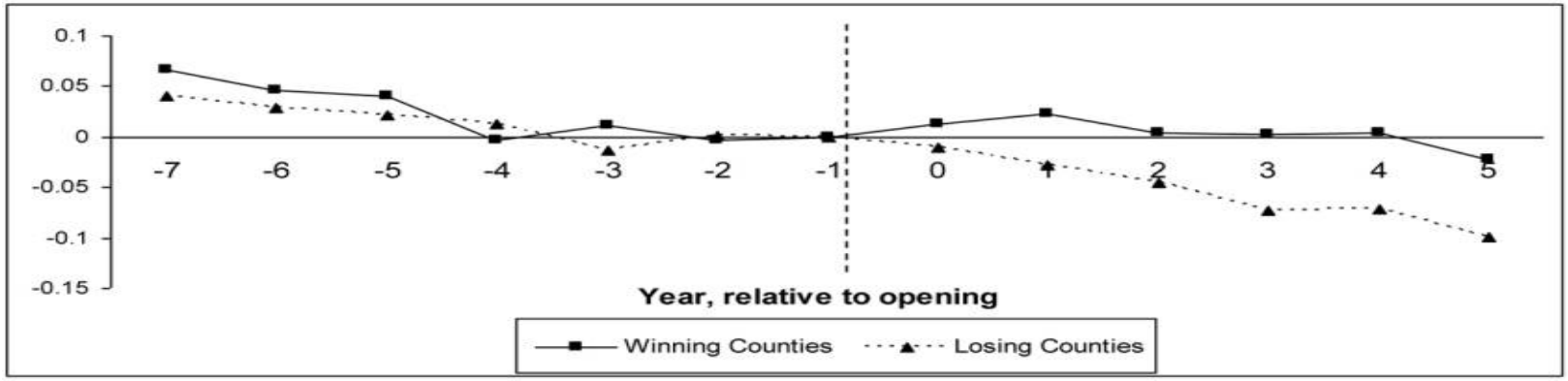
Difference-in-Difference Estimation

- These assumptions imply that they can use the winning and losing counties in DiD estimator.
- So let's assume that

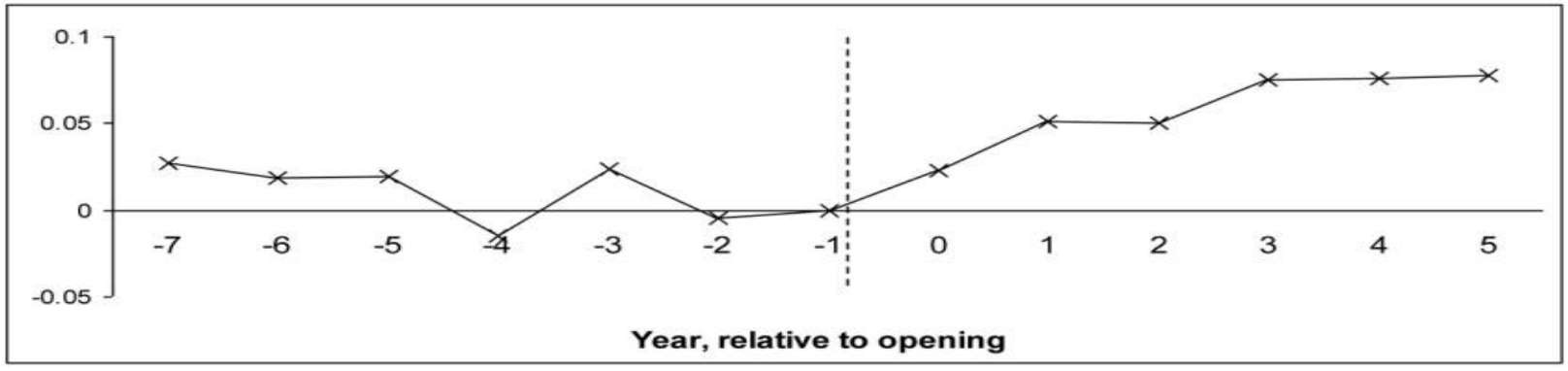
$$\begin{aligned} \delta_{jt} &= \tau_{1t} 1\{\text{j is losing}\} + \tau_{2t} 1\{\text{j is winning}\} \\ &+ \tau_{3t} 1\{\text{j is losing}\}\ post + \tau_{4t} 1\{\text{j is winning}\}\ post \end{aligned} \tag{8}$$

  where post is a dummy that is one after the MDP opened and zero otherwise.
- Basically, GHM estimate different pre- and post-trends in winning and losing counties controlling for firm fixed effects, industry-time fixed effects, and a case fixed effect while controlling for differences in observed inputs.

All Industries: Winners vs. Losers



Difference: Winners – Losers



Evidence from Million Dollar Plants

- The impact of the agglomeration externalities is then measured as the average difference in the δ_{jt}'s between winning and losing counties.
- After the new plant opening, incumbent plants in winning counties experience a sharp relative increase in TFP. Five years after the opening, TFP of incumbent plants in winning counties is up to 12% higher than TFP of incumbent plants in losing counties.
- Consistent with some theories of agglomeration, this effect is larger for incumbent plants that share similar labor and technology pools with the new plant.
- They also find evidence of a relative increase in skill-adjusted labor costs in winning counties, indicating that the ultimate effect on profits is smaller than the direct increase in productivity.

Some Questions

- Why does productivity not increase in winning countries?
- Is the negative trend in the losing countries causally driven by the lost in competition or are the losing counties struggling for reasons we do not measure or know?
- Is the sample size large enough?
- The simple difference-in-difference estimator does not control for the endogeneity of inputs.
- How does that bias the estimates for α and γ, and hence the estimates of δ_{jt}?

The Impact of Large Infrastructure Investments

- The Tennessee Valley Authority (TVA) was intended to modernize the economy of the Tennessee Valley region via a series of large scale infrastructure investments including electricity generating dams and an extensive network of new roads, canals, and flood control systems.
- Kline and Moretti (2013, QJE) use a similar research design as GHM to estimate the impact of TVA on productivity.
- They find that between 1930 and 1960 – the period during which federal transfers were greatest – the TVA generated gains in both agricultural and manufacturing employment.
- However, between 1960 and 2000 – during which time federal transfers were scaled down – the gains in agriculture were completely reversed, while the gains in manufacturing employment continued to intensify.
- Thus, forty years after TVA became financially self-sufficient, manufacturing employment in the region was still growing at a significantly faster pace than the comparison group.

The Local Nature of Agglomeration Externalities

- One important challenge is to determine the geographic scale on which agglomeration externalities operate.
- Is it the region, the city, or the local neighborhood?
- Rosenthal and Strange (2003) were the first to address this question in a systematic analysis.
- They focus on a variety of different high tech and manufacturing industries and find that the benefits of agglomeration are highly localized.
- For many industries, agglomeration benefits disappear outside of a radius of 1 mile.
- So it not only matters whether or not your firm is located, for example, in Manhattan or Silicon Valley, but it also matters where exactly it is located within those places.

Agglomeration in Professional Services and FIRE

- Almost all of the literature that has tried to estimate agglomeration externalities has focused on manufacturing. largely because we have much better data on manufacturing plants.
- However, most of manufacturing occurs in in small and medium size cities as well as the rural fringes of cities.
- If we want to understand the economic rationale of large (global) cities such as New York we need to focus on high-end professional services as well as finance, insurance, and real estate.


Location of Agencies
1 Mile
Central Park
Central Park S
Central Park N
W 100th St
W 81st St
W 58th St
W 31st St
E 14th St
Washington Pl
Houston St
Broadway
Hudson River
East River
New Jersey
New York
Queens County
Kings County
Williamsburg Bridge
Brooklyn Bridge
I 78
I 495
West St
Locus Map
State of New York

Agglomeration in Professional Services

- Arzaghi and Henderson (2008) consider advertising agencies in Manhattan which accounts for 24% of advertising agency receipts in the U.S.
- Advertising is known for the key role that networking and information exchanges play in the operation of agencies.
- We can interpret localized networking as a case of information spillovers.
- AH (2008) examine the effect of the concentration of advertising agencies in a neighborhood on entry of new firms.

Methodological Approach

- They use data from the Census Business Register and the Advertising Red Books.
- They focus on the number of new firm births in a neighborhood.
- They estimate a Poison regression model using OLS and Instrumental Variable estimation techniques.
- They use historical neighborhood characteristics (15 year lagged) as instruments for current characteristics.
- They show that there is a rapid spatial decay in the benefits of nearer neighbors even in the close quarters of southern Manhattan.

TABLE 4

Birth models

	Birth 1993–1994 Poisson (1)	Birth 1993–1994 IV-GMM (2)	Birth 1992–1997 Poisson (3)	Birth 1992–1997 IV-GMM (4)
Ln(total no. establishments)	0·411**	0·530**	0·462**	0·498**
	(0·137)	(0·216)	(0·0756)	(0·117)
Ln(rent/sq. ft.)	−1·72**	−2·74*	−0·819**	−2·57**
	(0·572)	(1·46)	(0·289)	(0·773)
Stock of agencies 0–250 m.	0·0334**	0·0209*	0·0206**	0·0198**
	(0·00817)	(0·0119)	(0·00430)	(0·00758)
[Willingness-to-pay/sq. ft. (%)]	[1·9]	[0·76]	[2·5]	[0·77]
Stock of agencies 250–500 m.	0·0147**	0·0191**	0·0167**	0·0228**
	(0·00494)	(0·00953)	(0·00264)	(0·00538)
Stock of agencies 500–750 m.	0·00451*	0·00648	0·00387**	0·00419
	(0·00250)	(0·00500)	(0·00137)	(0·00259)
Stock of agencies 750–1000 m.	0·000702	−0·00336	−0·00149	−0·00149
	(0·00281)	(0·00639)	(0·00158)	(0·00274)
Stock of agencies 1000–1250 m.	−0·00577**	−0·00519	−0·00219	−0·00241
	(0·00272)	(0·00605)	(0·00147)	(0·00251)
N	164	164	164	164
Pseudo R^2	0·343	—	0·504	—
Sargan (p-value)	—	3·88 (0·694)	—	1·71 (0·945)
First-stage average R^2	—	0·50	—	0·50
Average F (min F)	—	13·0 (7·9)	—	13·0 (7·9)

Notes: The instrument list is distance to Rockefeller Center, 1970 log of total housing units, 1970 share of housing units in buildings with less than five units, stocks of single-unit advertising agencies in each of the five rings in 1977, total count of all establishments in each of the first four rings in 1977, and 1992 total number of establishments in the own tract. **Significant at 5% level; *significant at 10% level.

Innovation and Cities

- Experimentation with new concepts and ideas may require finding like-minded, creative people who live and work in close proximity. (Read the op-ed by Seinfeld!)
- Chatterji, Glaeser, and Kern (2014) report that 92 percent of all patents in the US were granted to residents of metropolitan areas, and virtually all venture capital investments were made in major cities between 1990 and 2005.
- Just four metropolitan areas (Boston, New York City, San Francisco, and Los Angeles) accounted for almost half of the new product innovation.
- Moretti (2011) reports that firms in Santa Clara (San Jose) generate 3,390 (1,906) new patents in a typical year, while the median US city generates less than 1 patent per year.