Agglomeration Economies

Urban Economics

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Agenda

1 Quantitative Spatial Models

Quantitative Spatial Models

- One of the most striking economic features of our world is the uneven distribution of economic activity across space.
- These rich patterns of the concentration of economic activity can be explained by a three-way interaction between natural advantages, agglomeration forces, and dispersion forces.
- The complexity of modeling these forces in spatial equilibrium has meant that the traditional theoretical literature on cities focused on stylized settings, such as a monocentric city or the Rosen Roback framework.
  - These models, however, **cannot** capture the rich internal variation in patterns of economic activity within and between real world locations

Quantitative Spatial (Urban) Models

- Although traditional models in urban economics explain certain features of the data, their simplifying assumptions olimit their usefulness for empirical work.
- These simplifying assumptions abstract from empirically relevant differences in natural advantage across locations, such as access to natural harbors or green parks.
- To address these limitations, recent quantitative spatial (urban) models allow for empirically relevant differences in natural advantage while also incorporating agglomeration forces.
- These models are designed to connect directly to observed data on cities.

Introduction to a basic quantitative spatial model

- Consider a city (or coutry), embedded in a wider economy.
- The city/country consists of a set of discrete locations (blocks/cities).
- These locations are populated by workers, who are mobile between locations and the larger economy.
- Workers have idiosyncratic preferences for living and working in different locations within the city/country).
- They consider all the personal, work-related, or amenity-related reasons and pick the locations that yields the highest utility.

Introduction to a basic quantitative spatial model

- We begin with a twist to Rosen-Roback; between cities
- Rosen–Roback key insight is that any local shock to the demand or supply of labor in a city is, in equilibrium, fully capitalized in the price of land.
- As a consequence, shocks to a local economy do not affect worker welfare.
- This rule's outs some interesting questions

Introduction to a basic quantitative spatial model

- The goal of the model is to clarify what happens to wages, costs of housing and worker utility when a local economy experiences a shock to labor demand or labor supply.
- An example of a shock
  - to labor demand is an increase in productivity.
  - to labor supply is an increase in amenities.

Introduction to a basic quantitative spatial model

- We'll work through a 2 location case to develop intuition, but it can be easily extended to n locations
- We assume that workers and firms are mobile across cities, but worker mobility is not necessarily infinite, because workers have **idiosyncratic preferences for certain locations**.

Rosen-Roback model: Exogenous Prices

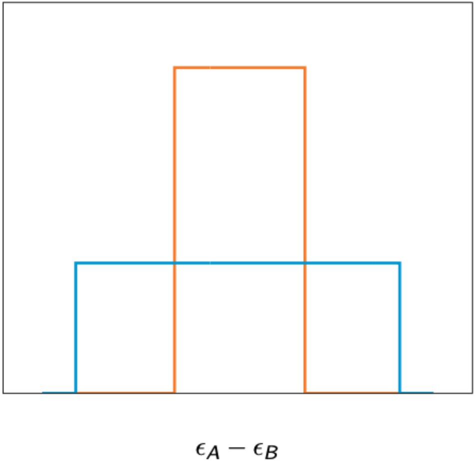
- Assume wages, rents, amenities are exogenous
- Person i's indirect utility of being in A:

$$V_A^i = w_A - r_A + A_A + \epsilon_A^i \tag{1}$$

- Person i's indirect utility of being in B:

$$V_B^i = w_B - r_B + A_B + \epsilon_B^i \tag{2}$$

Rosen-Roback model: Exogenous Prices



Firms

- The production function for firms in city c is Cobb–Douglas with constant returns to scale, so that

$$\ln y_c = X_c - hN_c + (1-h)K_c \tag{3}$$

- where X_c is a city especific productivity shifter.
- there is an international capital market, and that capital is infinitely supplied at a given price i

Construction

- The supply of housing is

$$r_c = z + k_c N_c \tag{4}$$

- number of housing units in city c is assumed to be equal to the number of workers.
- k_c is the elasticity of the supply of housing

Equilibrium

- Local labor market supply

$$w_B = w_A + (r_B - r_A) + (A_A - A_B) + s\frac{(N_B - N_A)}{N} \tag{5}$$

- Labor demand

$$w_c = X_c - (1-h)N_c + (1-h)K_c + ln(h) \tag{6}$$

- Local housing demand

$$r_B = r_A + (w_B - w_A) + (A_B - A_A) - s\frac{(N_B - N_A)}{N} \tag{7}$$

- Housing supply

$$r_c = z + k_c N_c \tag{8}$$

Effect of a labor demand shock on wages and prices

- Two periods
  - Period 1: cities are identical
  - Period 2: TFP increases in b: $X_{B2} = X_{B1} + \Delta$ where $\Delta > 0$
- Workers are more productive in B than A.

Effect of a labor demand shock on wages and prices

Change in nominal wages?

$$w_{B2} - w_{B1} = \Delta \tag{9}$$

$$w_{A2} - w_{A1} = 0 \tag{10}$$

Effect of a labor demand shock on wages and prices

Change in population?

$$w_{B2} = w_{A2} + (r_{B2} - r_{A2}) + s\frac{(N_{B2} - N_{A2})}{N} \tag{11}$$

$$w_{B1} = w_{A1} + (r_{B1} - r_{A1}) + s\frac{(N_{B1} - N_{A1})}{N} \tag{12}$$

$$\Delta = k_B N_{B2} - k_A N_{A2} - k_B N_{B1} + k_A N_{A1} + s\frac{(N_{B2} - N_{A2} - N_{B1} + N_{A1})}{N} \tag{13}$$

$$(N_{B2} - N_{B1}) = \frac{N}{N(k_B + k_A) + 2s}\Delta \geq 0 \tag{14}$$

Effect of a labor demand shock on wages and prices

Change in housing markets?

- In B

$$r_{B2} - r_{B1} = \frac{Nk_B}{N\left(k_B + k_A\right) + 2s}\Delta \geq 0 \tag{15}$$

- In A

$$r_{A2} - r_{A1} = \frac{-k_A N}{N\left(k_B + k_A\right) + 2s}\Delta \leq 0 \tag{16}$$

Effect of a labor demand shock on wages and prices

Change in Real wages?

- In B

$$(w_{B2} - w_{B1}) - (r_{B2} - r_{B1}) = \frac{Nk_A + 2s}{N(k_B + k_A) + 2s}\Delta \geq 0 \tag{17}$$

- In A

$$(w_{A2} - w_{A1}) - (r_{A2} - r_{A1}) = \frac{k_A N}{N(k_B + k_A) + 2s}\Delta \geq 0 \tag{18}$$

Effect of a labor demand shock on wages and prices

Marginal worker?

$$V_c^i = w_c - r_c + A_c + \epsilon_c^i \tag{19}$$

- The change in the relative preference for city a of the marginal worker is equal a

$$\left(\epsilon_{A2}^i - \epsilon_{B2}^i\right) - \left(\epsilon_{A1}^i - \epsilon_{B1}^i\right) = \frac{2s}{N\left(k_B + k_A\right) + 2s}\Delta \geq 0 \tag{20}$$

- The marginal worker in period 2 is different from the marginal worker in period 1.
- Since city b offers higher real wages in period 2, the new marginal worker in period 2 has stronger preferences for city a.

Spatial Equilibrium with Agglomeration Economies

- Consider the case where there are agglomeration economies so that the productivity of firms in a locality is an endogenous function of the level of economic activity in that locality.
- This amounts to endogenizing the city-specific productivity shifter.
- Eg. productivity in a locality is a function of the number of workers in that locality

$$X_c = f(N_c) \tag{21}$$

- with $f' > 0$
- Decisions of workers generates a positive externality.

Spatial Equilibrium with Agglomeration Economies

- Assume

$$X_c = x_c + \gamma N_c \tag{22}$$

- The MPL

$$w_c = x_c + (\gamma - (1-h))\, N_c + (1-h)\, K_c + ln(h) \tag{23}$$

Spatial Equilibrium with Agglomeration Economies

- Two periods
  - Period 1 both cities are identical
  - Period 2 amenity increases in B: $X_{B2} = X_{B1} + \Delta$ where $\Delta > 0$

Spatial Equilibrium with Agglomeration Economies

- Two periods
  - Period 1 both cities are identical
  - Period 2 productivity increases in B: $X_{B2} = X_{B1} + \Delta$ where $\Delta > 0$

Spatial Equilibrium with Agglomeration Economies

Change in nominal wages?

$$w_{B2} - w_{B1} = \frac{h\left(N\left(k_B + k_A\right) + 2s\right) - \gamma N}{h\left(N\left(k_B + k_A\right) + 2s\right) - 2\gamma N}\Delta \geq \Delta \geq 0 \tag{24}$$

$$\frac{\partial\left(w_{B2} - w_{B1}\right)}{\partial\gamma} = \frac{Nh\left(N\left(k_B + k_A\right) + 2s\right)}{\left(h\left(N\left(k_B + k_A\right) + 2s\right) - 2\gamma N\right)^2}\Delta \geq 0 \tag{25}$$

Spatial Equilibrium with Agglomeration Economies

Change in population?

$$(N_{B2} - N_{B1}) = \frac{Nh}{h\left(N\left(k_B + k_A\right) + 2s\right) - 2\gamma N}\Delta \geq 0 \tag{26}$$

Spatial Equilibrium with Agglomeration Economies

Change in housing markets?

$$r_{B2} - r_{B1} = \frac{hNk_B}{h\left(N\left(k_B + k_A\right) + 2s\right) - 2\gamma N}\Delta \geq 0 \tag{27}$$

Spatial Equilibrium with Agglomeration Economies

Change in Real wages?

$$(w_{B2} - w_{B1}) - (r_{B2} - r_{B1}) = \frac{(k_A N + 2s)\, h - \gamma N}{h\,(N\,(k_B + k_A) + 2s) - 2\gamma N}\Delta \tag{28}$$

$$\frac{\partial\,(w_{B2} - w_{B1}) - (r_{B2} - r_{B1})}{\partial\gamma} = \frac{Nh\,(N\,(k_A - k_B) + 2s)}{(\gamma N - 2hs - k_B Nh - k_A Nh)^2}\Delta \tag{29}$$

Agglomeration and Empirics
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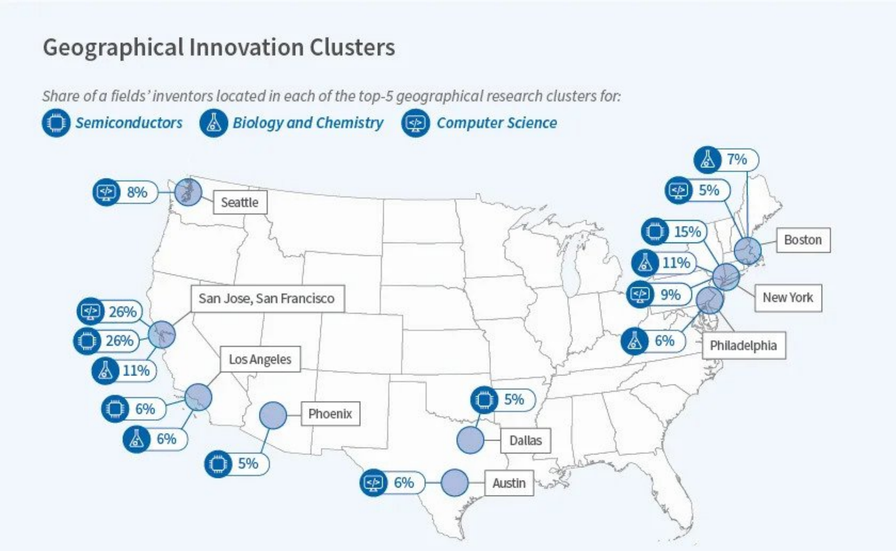

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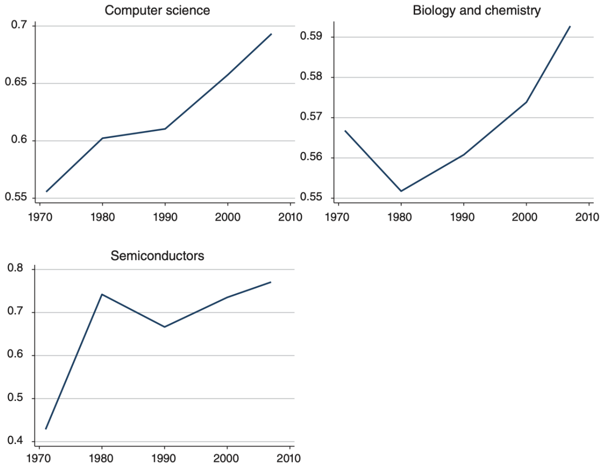

FIGURE 1. SHARE OF TOP TEN CITIES OVER TIME

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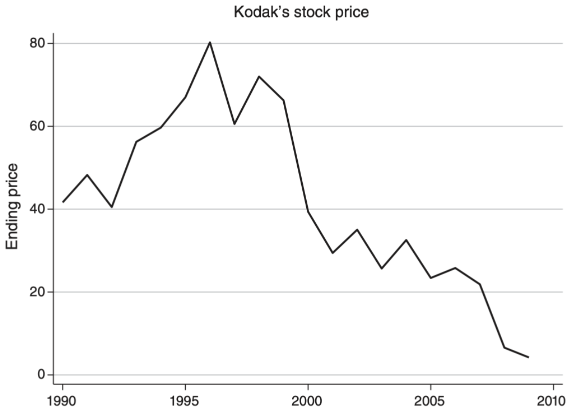

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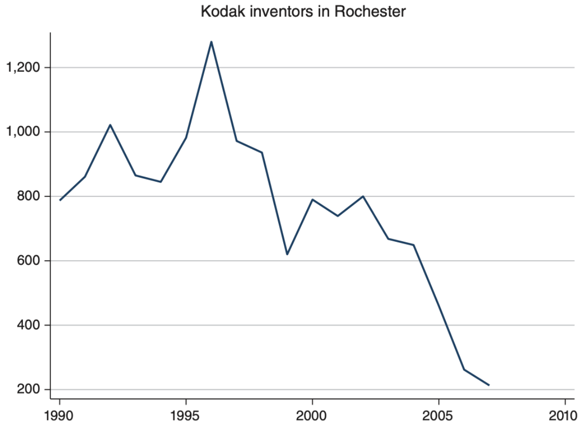

FIGURE 2. KODAK'S DECLINE

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FIGURE 3. AVERAGE INVENTOR PRODUCTIVITY IN ROCHESTER OUTSIDE KODAK

Note: Controls include research field dummies.

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TABLE 2—DIFFERENCE-IN-DIFFERENCE ESTIMATES: 1996–2007 PRODUCTIVITY CHANGE OF NON-KODAK INVENTORS IN ROCHESTER COMPARED TO OTHER CITIES

					Weighted
	(1)	(2)	(3)	(4)	(5)
Panel A					
Rochester × 2007	−0.0641	−0.0673	−0.0805	−0.0916	−0.0947
	(0.00757)	(0.00674)	(0.00631)	(0.00665)	(0.00860)
Rochester	−0.0148	−0.0364	−0.0317		
	(0.0105)	(0.0101)	(0.00987)		
2007	−0.190	−0.189			
	(0.00757)	(0.00713)			
Observations	194,120	194,120	194,120	194,120	193,331
Field		Yes	Yes	Yes	Yes
Field × year			Yes	Yes	Yes
Field × city				Yes	Yes

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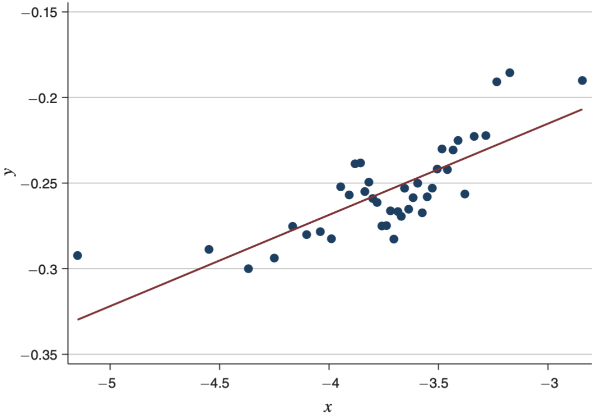

FIGURE 4. AVERAGE LOG NUMBER OF PATENTS PER INVENTOR PER YEAR AND LOG CLUSTER SIZE: ALL YEARS AND FIELDS

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TABLE 3—EFFECT OF CLUSTER SIZE ON INVENTOR PRODUCTIVITY: BASELINE MODELS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log size	0.0518							
	(0.00815)							
Observations	932,059							
Year	Yes							
City	Yes							
Field	Yes							
Class	Yes							
City × field								
City × class								
Field × year								
Class × year								
Inventor								
City × year								
Firm								

Notes: Each column is a separate regression. The level of observation in the regressions is inventor-year. The dependent variable is log of number of patents filed in a year. The model estimated is equation (1). Standard errors are clustered by city × research field.

Agglomeration and Empirics

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Table 3—Effect of Cluster Size on Inventor Productivity: Baseline Models

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log size	0.0518	0.0762	0.0881	0.0907				
	(0.00815)	(0.0167)	(0.0187)	(0.00926)				
Observations	932,059	932,059	932,059	932,059				
Year	Yes	Yes	Yes	Yes				
City	Yes	Yes	Yes	Yes				
Field	Yes	Yes	Yes	Yes				
Class	Yes	Yes	Yes	Yes				
City $\times$ field		Yes	Yes	Yes				
City $\times$ class			Yes	Yes				
Field $\times$ year				Yes				
Class $\times$ year								
Inventor								
City $\times$ year								
Firm								

Notes: Each column is a separate regression. The level of observation in the regressions is inventor-year. The dependent variable is log of number of patents filed in a year. The model estimated is equation (1). Standard errors are clustered by city $\times$ research field.

Agglomeration and Empirics

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TABLE 3—EFFECT OF CLUSTER SIZE ON INVENTOR PRODUCTIVITY: BASELINE MODELS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log size	0.0518	0.0762	0.0881	0.0907	0.0677			
	(0.00815)	(0.0167)	(0.0187)	(0.00926)	(0.00862)			
Observations	932,059	932,059	932,059	932,059	932,059			
Year	Yes	Yes	Yes	Yes	Yes			
City	Yes	Yes	Yes	Yes	Yes			
Field	Yes	Yes	Yes	Yes	Yes			
Class	Yes	Yes	Yes	Yes	Yes			
City $\times$ field		Yes	Yes	Yes	Yes			
City $\times$ class			Yes	Yes	Yes			
Field $\times$ year				Yes	Yes			
Class $\times$ year					Yes			
Inventor								
City $\times$ year								
Firm								

Notes: Each column is a separate regression. The level of observation in the regressions is inventor-year. The dependent variable is log of number of patents filed in a year. The model estimated is equation (1). Standard errors are clustered by city $\times$ research field.

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TABLE 3—EFFECT OF CLUSTER SIZE ON INVENTOR PRODUCTIVITY: BASELINE MODELS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log size	0.0518	0.0762	0.0881	0.0907	0.0677	0.0923		
	(0.00815)	(0.0167)	(0.0187)	(0.00926)	(0.00862)	(0.00990)		
Observations	932,059	932,059	932,059	932,059	932,059	932,059		
Year	Yes	Yes	Yes	Yes	Yes	Yes		
City	Yes	Yes	Yes	Yes	Yes	Yes		
Field	Yes	Yes	Yes	Yes	Yes	Yes		
Class	Yes	Yes	Yes	Yes	Yes	Yes		
City × field		Yes	Yes	Yes	Yes	Yes		
City × class			Yes	Yes	Yes	Yes		
Field × year				Yes	Yes	Yes		
Class × year					Yes	Yes		
Inventor						Yes		
City × year								
Firm								

Notes: Each column is a separate regression. The level of observation in the regressions is inventor-year. The dependent variable is log of number of patents filed in a year. The model estimated is equation (1). Standard errors are clustered by city × research field.

Agglomeration and Empirics

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TABLE 3—EFFECT OF CLUSTER SIZE ON INVENTOR PRODUCTIVITY: BASELINE MODELS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log size	0.0518	0.0762	0.0881	0.0907	0.0677	0.0923	0.0545	
	(0.00815)	(0.0167)	(0.0187)	(0.00926)	(0.00862)	(0.00990)	(0.0116)	
Observations	932,059	932,059	932,059	932,059	932,059	932,059	932,059	
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
City	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Field	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Class	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
City × field		Yes	Yes	Yes	Yes	Yes	Yes	
City × class			Yes	Yes	Yes	Yes	Yes	
Field × year				Yes	Yes	Yes	Yes	
Class × year					Yes	Yes	Yes	
Inventor						Yes	Yes	
City × year							Yes	
Firm								

Notes: Each column is a separate regression. The level of observation in the regressions is inventor-year. The dependent variable is log of number of patents filed in a year. The model estimated is equation (1). Standard errors are clustered by city × research field.

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TABLE 3—EFFECT OF CLUSTER SIZE ON INVENTOR PRODUCTIVITY: BASELINE MODELS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log size	0.0518	0.0762	0.0881	0.0907	0.0677	0.0923	0.0545	0.0676
	(0.00815)	(0.0167)	(0.0187)	(0.00926)	(0.00862)	(0.00990)	(0.0116)	(0.0139)
Observations	932,059	932,059	932,059	932,059	932,059	932,059	932,059	823,375
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Field	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Class	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City × field		Yes	Yes	Yes	Yes	Yes	Yes	Yes
City × class			Yes	Yes	Yes	Yes	Yes	Yes
Field × year				Yes	Yes	Yes	Yes	Yes
Class × year					Yes	Yes	Yes	Yes
Inventor						Yes	Yes	Yes
City × year							Yes	Yes
Firm								Yes

Notes: Each column is a separate regression. The level of observation in the regressions is inventor-year. The dependent variable is log of number of patents filed in a year. The model estimated is equation (1). Standard errors are clustered by city × research field.

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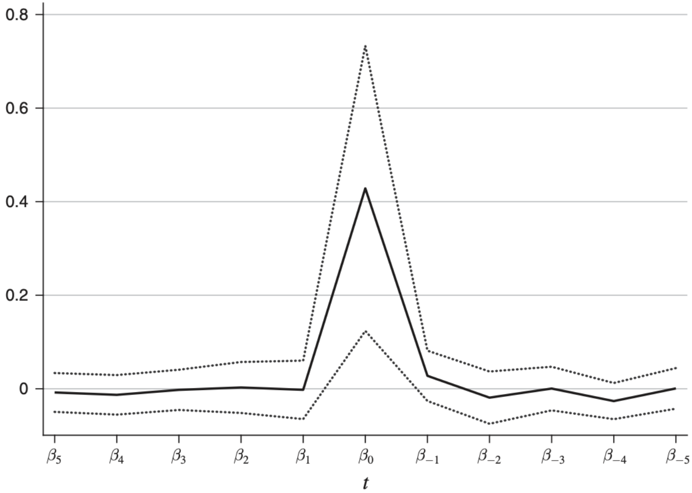

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Table 5—Models in Differences: Effect of Changes in Cluster Size on Changes in Inventor Productivity: OLS and IV Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. OLS						
Δlog size	0.0141	0.0145	0.0153	0.0164	0.0162	0.0159
	(0.00394)	(0.00392)	(0.00376)	(0.00397)	(0.00392)	(0.00385)
Panel B. 2SLS						
Δlog size	0.0422	0.0630	0.0502	0.0496	0.0502	0.0491
	(0.0186)	(0.0211)	(0.0189)	(0.0131)	(0.0137)	(0.0144)
First stage	1.109	1.076	1.096	1.431	1.475	1.488
	(0.151)	(0.170)	(0.167)	(0.214)	(0.189)	(0.185)
F-statistic	53.8	40.2	43.0	44.5	60.8	64.2
Observations	419,596	419,596	419,565	405,111	405,111	403,955
Year	Yes	Yes	Yes	Yes	Yes	Yes
Field		Yes	Yes	Yes	Yes	Yes
Class			Yes	Yes	Yes	Yes
Firm				Yes	Yes	Yes
Field × year					Yes	Yes
Class × year						Yes