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Sectoral spillovers and the price of land: a cost analysis

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Abstract

Under factor mobility, firms locate where local attributes enhance their productivity, but, in equilibrium, those gains are offset by higher local input prices. I study the variation in local input costs to identify production amenities across sectors in two ways. I estimate, first, hedonic rent and wage equations from individual households and workers and, second, local cost functions for different sectors across the US States and across Metropolitan Statistical Areas. I find evidence of externality gains from both a sector's and overall concentration of activity and from a better educated population. These gains are bigger in sectors with higher local land shares in the sample, finance and nondurable goods.

Keywords: Local externalities; Regional growth; Human capital; Input prices

JEL classification: R12; R3

1. Introduction

In equilibrium, agglomeration effects lead to both productivity gains and higher local prices. Firms locate in areas where they enjoy productivity gains due to economies of scale, pecuniary externalities and having a specialized or highly skilled labor force, among other things, but prices for local inputs — land rents and wages — increase because of the pressure exerted in local markets by the

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increased demand (e.g., Roback, 1982; Beeson and Eberts, 1989; Rauch, 1993). Accordingly, the variation in local prices emerges as an appropriate measure to identify the exact sources of externality gains among the list of potential candidates that the agglomeration literature has developed. Moreover, input prices may be studied separately for each sector to capture the particularities of externalities effects in each sector.

In this paper I follow two strategies to study how differences in local costs reflect the importance of local production amenities across sectors. First, I estimate hedonic rent and wage equations using a sample from the 1990 Census. After controlling for housing and workers characteristics, I use measures of sectoral and total activity, sectoral diversity and average human capital for each Metropolitan Statistical Area (MSA) to account for differences in returns to local inputs. Since externality gains potentially differ across sectors, I estimate separate wage equations for the subsamples of workers in the finance and the manufacturing sectors, as well as in the durable and nondurable goods subsectors.

As a second exercise, I construct a weighted cost variable for each sector, using land rents and sectoral wages in each region. This measure reflects variation in costs only due to local inputs and abstracts from prices of tradable inputs, which are similar across locations. I study the relation of this local cost variable to measures of local attributes for both the US states from 1969 to 1992 and Metropolitan Statistical Areas (MSAs) in 1990.

Three findings stand out. First, the finance sector and the nondurable goods subsector profit the most from all types of externalities. Second, a higher level of human capital crucially enhances productivity across all sectors. Finally, measures of economic activity at the state level, rather than at the metropolitan or the regional level, are the most relevant to explain the variance in local costs. By contrast, measures of sectoral diversity or population size do not fare as well as theoretically expected.

The paper is organized as follows. Section 2 presents a model of regional production and describes the two estimation strategies to identify the importance of local externalities using variation in local input costs. Section 3 introduces the types of externalities under study. Section 4 presents evidence from hedonic equations from household and individual data. Section 5 presents the estimated local sectoral costs equations for both the US states and the MSAs. Section 6 follows with some concluding comments.

2. A model of local externalities

Consider, first, a model showing how differences in local productivity should reflect in local prices, both wages and land rents. This model is an adaptation of local public goods models like those in Henderson (1987, 1988) or Roback (1982).

Workers have identical preferences over land (housing) and two tradable goods, manufactures and financial services, and are free to move between regions. Since prices for tradable goods are common throughout the country, prices of local inputs — land rents and wages — determine the distribution of workers across regions.

The production function of tradable goods at the firm level is Cobb Douglas with constant returns. However, certain regional characteristics give rise to externalities that are not internalized by firms but that enhance the productivity of all of them. I parametrize them through G_j, a function of local attributes in region j that depends both on sectoral allocation and on the local level of skills. W_{js} is the regional wage in sector s, R_j is the land rent in the region, r is the rental price of capital and P_s is the price of output. Spatial equilibrium requires that the cost of producing a unit of output of sector s be the same across all regions

$$G_j(.)^{-1}\ W_{js}^{\alpha_s} R_j^{\beta_s} r^{(1-\alpha_s-\beta_s)} = P_s \tag{1}$$

Since r and P_s are constant throughout the country, the equilibrium distribution of sectors across regions hinges both on the strength of the agglomeration gains for each sector and on their particular demand for local factors. As a result, both sectoral wages and local rents depend, in equilibrium, on the local attributes that enhance productivity. To estimate these external effects and, particularly, to measure how they differ across sectors, I undertake two types of analysis described in Subsections 2.1 and 2.2, respectively.

2.1. Wage and rent equations

To understand the effect of local attributes on input prices, I estimate hedonic rent and wage equations, as a reduced form of the model. Roback (1982) and Rauch (1993) present similar specifications. I use individual and household data from the one in 1000 Public Use Microdata Sample B of the 1990 Census of Population collected on a MSA basis. The local attributes given by function $G_j(.)$ are estimated as described in Section 3. Both local sectoral wages and local rents are estimated as a function of individual characteristics in the following way. The wage equation for individuals in each sector is given by

$$\ln W_{ij} = \mu + \ln G_j(.)\delta + X_{ij}\gamma + \upsilon_j + e_{ij} \tag{2}$$

where X_{ij} are individual characteristics of household i, υ_j is an MSA specific error for unmeasured local characteristics and e_{ij} is a white error for individual characteristics. W_{ij}, that is, the average hourly earnings is obtained by dividing total earnings by the number of weeks worked during the year multiplied by the usual amount of time worked per week. The wage equation is estimated using the sample of individuals aged 16 and over who reported their earnings, hours and weeks during the year — that is, 93,846 individuals residing in 262 MSAs of which 15,465 worked in the manufacturing sector (5,841 in nondurable and 9,624 in durable goods) and 5,073 in the finance sector.

The rent equation is similar to (2) The dependent variable, monthly housing expenditures, is calculated from the gross rent plus utilities for rented units. For owner-occupied units, I convert the housing value into an imputed rent using a 7.85% discount rate taken from Peiser and Smith's (1985) user cost study — also used in Beeson and Eberts (1989) and Rauch (1993) — and add utility costs to it. The rent equation includes 66 182 households residing in 262 MSAs for which either the value of the unit or the rent is reported.

The set of individual characteristics used both for workers and for housing units is similar to that in Beeson and Eberts (1989) or Rauch (1993). To account for potential unobserved regional characteristics, the equations are estimated using generalized least squares (GLS) for a random effects model. Results are presented in Section 4 below.

2.2. Sectoral cost functions

A second strategy to understand the relation between local return to inputs and production externalities consists in estimating local cost functions for each sector. Eq. (1) can be rewritten as

$$W_{js}^{\alpha_s} R_j^{\beta_s} r^{(1-\alpha_s-\beta_s)} = P_s G_j(.) U \tag{3}$$

where U are lognormal distributed errors. Since the rental cost of capital and good prices are constant across states, only land rents and labor costs vary across regions. Following Dekle and Eaton's (1993) methodology, I estimate the *local unit cost* in region j to be $(W_{js}^{\alpha_s} R_j^{\beta_s})$. I use the residual of local sectoral wage and of local housing rent, after controlling for both labor and housing quality, as local factor costs. Each input is weighted by the estimated local factor share of each sector. Local factor shares represent the effect on *local* input demand of increasing one unit of the sector's *output*. Appendix A presents these shares and their estimation procedure.[1]

Using the *local unit cost* and taking logs in (3), the following equation can be estimated for each sector.

$$(\alpha_s \ln W_{js} + \beta_s \ln R_j) = \mu_0 + \mu \ln G_j(.) + \ln U \tag{4}$$

[1]Interestingly, Dekle and Eaton's (1993) estimates of local land and labor shares in Japanese prefectures, 0.12 and 0.72 for manufacturing and 0.28 and 0.70 for finance, respectively, are noticeably higher than those I obtain for the US. A relatively lower employee's compensation or lower dependency on regional labor in the production process in the US may, in part, explain this difference. Their higher land share in the finance sector is partially due to land scarcity in Japan, where sectors with higher local value added such as finance fiercely compete for the expensive land.

Local cost functions are estimated using two samples: US states — excluding Alaska and Hawaii — from 1969 to 1992 and MSAs in 1990. For the state sample, W_{js}, the labor cost, is calculated as the residual of the sectoral wages after controlling for the percentage of high school graduates in the state's population. Sectoral wages are obtained by dividing data of the Bureau of Economic Analysis on total wage and salary disbursements by total wage and salary employment for every sector and state. The local cost of land, R_j, is proxy by the residuals of local rents after controlling for state housing characteristics.[2] The gross median rent is used directly as a proxy for the land rent.[3] The median gross rent, the median housing value and housing characteristics are available, for every state, from the *Census of Population and Housing* for 1970, 1980 and 1990 and, for US Census Regions, from the *Annual Housing Survey* (AHS), both from the Bureau of the Census.[4] State values for in-between decennial census observations are then extrapolated according to their regional path. To account for both potential unobserved state characteristics and a time structure that, in part, may proxy changes in capital rental prices over the period of analysis, the panel is estimated through GLS.

To estimate the sectoral cost Eq. (4) at the MSA level, I use average data from each metropolitan area in 1990 obtained from sample of individuals and household in the hedonic equations. Land rent and sectoral wages in the local cost function for each MSA are the average residuals of log monthly housing costs and log average hourly earnings after controlling for individual's characteristics of the dwellings and the workers, respectively. The estimated cost equations, for both the states and the metropolitan areas, are reported in Section 5 below.

3. Externalities

The different types of externalities, whose effects on productivity I study here, are embedded in the following function G_j.

$$G_j = \mathrm{e}^{\gamma_s / Q_j} \ \mathrm{e}^{\gamma_a / A_j} \ \mathrm{e}^{\gamma_d D_j} \ \mathrm{e}^{a_{je} / EL_j} \tag{5}$$

[2]Housing characteristics are percentage of houses built in the last 10 years, percentage without complete plumbing, median persons per house, median number of rooms, percentage in one unit, percentage in buildings of more than five units, and total number of houses.

[3]Alternatively, median housing prices in the state are converted into an imputed monthly rent using a 7.85% discount rate. Though estimations in the paper are robust to both measures, here I only present results derived from the use of gross rents.

[4]The AHS was annual from 1973 to 1981 and biannual thereafter. I gathered data for every Census region for 1970, 1973–1981, 1983, 1985, 1987, 1989–1991 and 1993. Constant growth rate was assumed for missing periods.

3.1. Local agglomeration

The first term captures how the concentration of sectoral or total activity in a region affects productivity. Q_j is either the total gross product (income or employment) in the region or that of a particular sector in the region depending on the estimated equation. Concentration of a sector in a region is thought to enhance sectoral *know-how*, reduce search costs, attract intermediate providers to the area or improve investment incentives in that sector – all known as localization externalities (e.g., Henderson, 1987; Kim, 1990; Rotemberg and Saloner, 1990). In addition, urban agglomerations benefit from pecuniary externalities (e.g., Rivera-Batiz, 1988).

The inverse exponential specification of the externalities in G_j, taken from Henderson (1987), implies that the strength of the external effects — coming from either sectoral or total activity in a region or its neighborhood — ultimately lessens. Both this particular form of externality and the existence of congestion costs — mainly due to land scarcity (e.g., Hansen, 1990; Benabou, 1993; Carlino, 1979) — constrain the continuous concentration of economic activity in the space.

3.2. Neighborhood agglomeration

The second term captures how the concentration of sectoral or total activity in nearby areas increases a region's productivity. In the panel analysis of US states, A_j is a weighted measure of either sectoral or total activity of the form,

$$A_j = \sum_{k \neq j}^{49} \frac{Q_k}{d_{jk}^2} \tag{6}$$

where d_{jk} is the distance (in miles) between the largest cities in states k and j, and Q_k is the sectoral variable considered.[5] When MSA data is used, the state is assumed to be the relevant neighborhood and A_j is simply the state's value of the measure under consideration.

3.3. Sectoral diversity

The third term in (5), D_j, accounts for the sectoral diversity within an area is calculated using a Hirschman type of index of sectoral concentration:

$$D_j = \sum_{s=1}^{n} (q_{js})^2 \tag{7}$$

[5] Appendix B contains the means of these variables.

where q_{js} is the relative weight of income from sector s in the region and n the number of sectors considered. To construct this index, I use, for MSAs, income at 2-SIC level in either manufacturing or services, and, for US States, income at 1-SIC level. Lower values of the index imply higher sectoral diversity. Similar indices are used by Henderson (1994) to convey a relation between local diversity and employment growth. Recent works both in regional growth, such as Glaeser et al. (1992) and Garcia-Mila and McGuire (1993) for US cities and states, and in international growth, such as those reviewed in Grossman and Helpman (1994), persuasively show the potential for a positive relationship between sectoral variety and growth. Sectoral diversity is expected to induce higher productivity by nurturing strategic complementarities between sectors and providing a better choice of intermediate inputs in an area (e.g., Hirschman, 1958; Jacobs, 1984; Faini, 1984; Hall, 1991).

3.4. Human capital

The last term in G_j captures the effect on productivity of average skills in the area. The effective labor in a region, EL_j, is proxied in each sample by measures of the skills of the adult population in the area. A higher level of human capital in a region improves productivity both (i) directly, by increasing labor productivity or effective labor for the same number of workers, and (ii) indirectly, through the higher potential for networks, local learning or peer effects (e.g., Lucas, 1988; Romer, 1989; DeBartolome, 1990; Benabou, 1993; Rauch, 1993).

4. Evidence on household and individual data

Table 1 presents estimates of wage Eq. (2) for workers in the manufacturing (cols. 1–3), finance (cols. 4–6), nondurable goods (cols. 7–8), and durable goods (cols. 9–10) sectors, as well as for the complete sample (cols. 11–12).

All equations include individual characteristics, which have the expected sign and size, and dummies for the Northeast, West and Midwest. Experience measures age minus number of years of education minus six. Schooling measures the number of years of education.

Two types of externalities, those accruing from the agglomeration of activity and from human capital, stand out as the most relevant across all sectors. Negative coefficients on the agglomeration variables imply that the concentration of activity in the MSA or in the state has a positive effect on productivity. Evidence in Table 1 implies robust gains across all sectors from the agglomeration of either own industry income or total income in the state. Estimates, however, do not provide any clear result on the impact of concentration of income at the metropolitan

Table 1
Sectoral wage equations

Variable[a]:	(1)	(2)	(3)	(4)	(5)	(6)
Constant	2.20	2.26	1.87	2.4	2.43	1.68
	(0.376)	(0.369)	(0.387)	(0.401)	(0.400)	(0.418)
Sex (female=1)	−0.041	−0.041	−0.041	0.022	0.022	0.020
	(0.026)	(0.026)	(0.026)	(0.043)	(0.043)	(0.043)
Married (=1)	0.162	0.162	0.162	0.262	0.262	0.263
	(0.014)	(0.014)	(0.014)	(0.038)	(0.038)	(0.038)
×Sex	−0.159	−0.160	−0.159	−0.205	−0.205	−0.205
	(0.022)	(0.022)	(0.022)	(0.046)	(0.046)	(0.046)
Race (non-white=1)	−0.128	−0.128	−0.129	−0.215	−0.215	−0.215
	(0.016)	(0.016)	(0.016)	(0.042)	(0.042)	(0.042)
×Sex	0.092	0.092	0.093	0.190	0.189	0.189
	(0.025)	(0.025)	(0.025)	(0.053)	(0.053)	(0.053)
Years schooling	0.058	0.058	0.058	0.075	0.075	0.075
	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)	(0.006)
Experience	0.039	0.039	0.039	0.051	0.051	0.050
	(0.0015)	(0.0015)	(0.0015)	(0.004)	(0.004)	(0.004)
×Sex	−0.016	−0.016	−0.016	−0.019	−0.019	−0.018
	(0.0025)	(0.0025)	(0.0025)	(0.005)	(0.005)	(0.005)
Square experience	−0.0005	−0.0005	−0.0005	−0.0008	−0.0008	−0.0007
	(0.00003)	(0.00003)	(0.00003)	(0.00008)	(0.00008)	(0.00008)
×Sex	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003
	(0.00005)	(0.00005)	(0.00005)	(0.0001)	(0.0001)	(0.0001)
Sex×Children home	−0.058	−0.058	−0.058	−0.112	−0.111	−0.109
	(0.02)	(0.02)	(0.02)	(0.024)	(0.024)	(0.024)
Professional/manager	0.430	0.430	0.430	0.3917	0.392	0.388
	(0.034)	(0.034)	(0.034)	(0.073)	(0.073)	(0.073)
Technical/sales	0.231	0.231	0.231	0.185	0.187	0.184
	(0.034)	(0.034)	(0.034)	(0.072)	(0.072)	(0.072)
Farming	−0.415	−0.419	−0.409	0.323	0.320	0.309
	(0.102)	(0.102)	(0.102)	(0.252)	(0.248)	(0.245)
Craft	0.175	0.176	0.174	−0.116	−0.113	−0.116
	(0.034)	(0.034)	(0.034)	(0.133)	(0.134)	(0.134)
Operator/laborer	0.077	0.077	0.077	0.144	0.145	0.143
	(0.033)	(0.033)	(0.033)	(0.118)	(0.118)	(0.117)
MSA population	8.1e−06	3.6e−06	−4.3e−06	−6.9e−06	8.1e−06	1.4e−06
	(0.000012)	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
MSA schooling	−16.96*	−17.41*	−13.15*	−19.06*	−19.77*	−10.2***
(inverse average)	(4.33)	(4.24)	(4.44)	(5.46)	(5.52)	(4.68)
MSA experience	−1.34	−1.03	0.247	−5.02***	−5.05***	−4.04
(inverse average)	(2.07)	(2.04)	(2.13)	(2.38)	(2.38)	(2.39)
Manufacture diversity	−0.007	− 0.003	− 0.014	−0.016	−0.023	−0.0137
(MSA income)	(0.061)	(0.059)	(0.061)	(0.063)	(0.064)	(0.062)
Service diversity	−0.008	−0.003	−0.016	−0.017	−0.0182	−0.029
(MSA income)	(0.040)	(0.039)	(0.040)	(0.047)	(0.047)	(0.046)
MSA sector income	1310.9			27.49		
(inverse)	(2240.7)			(37.9)		
State sector income	−1.2e+07**			−1.6e+07*		
(inverse)	(5 541 078)			(2 754 313)		
MSA total income		−28673.2			13 448.3	
(inverse)		(26 890)			(65 390)	
State total income		−2.5e+08*			−2 974 530*	
(inverse)		(6.5e+07)			(525 975)	
MSA sector employment			−681.8*			−773.8*
(inverse)			(222.4)			(226.1)

Table 1. Contined

Variable[a]:	(7)	(8)	(9)	(10)	(11)	(12)
Constant	2.59	2.58	1.93	2.07	2.65	2.609
	(0.352)	(0.351)	(0.607)	(0.592)	(0.091)	(0.091)
Sex (female=1)	−0.053	−0.051	−0.008	−0.009	−0.059	−0.058
	(0.040)	(0.040)	(0.035)	(0.035)	(0.01)	(0.01)
Married (=1)	0.188	0.188	0.148	0.148	0.193	0.194
	(0.025)	(0.025)	(0.017)	(0.017)	(0.007)	(0.007)
×Sex	−0.150	−0.150	−0.172	−0.173	−0.177	−0.178
	(0.036)	(0.036)	(0.029)	(0.029)	(0.01)	(0.01)
Race (black=1)	−0.113	−0.116	−0.130	−0.129	−0.110	−0.116
	(0.028)	(0.028)	(0.020)	(0.020)	(0.008)	(0.008)
×Sex	0.071	0.069	0.112	0.112	0.124	0.124
	(0.04)	(0.040)	(0.032)	(0.032)	(0.011)	(0.011)
Year schooling	0.058	0.057	0.057	0.057	0.062	0.062
	(0.003)	(0.003)	(0.0025)	(0.0025)	(0.0009)	(0.0009)
Experience	0.041	0.041	0.039	0.039	0.0409	0.0409
	(0.003)	(0.003)	(0.0017)	(0.0017)	(0.0007)	(0.0007)
×Sex	−0.015	−0.015	−0.018	−0.018	−0.011	−0.011
	(0.004)	(0.004)	(0.003)	(0.003)	(0.001)	(0.001)
Square experience	−0.0005	−0.0005	−0.0005	−0.0005	−0.0006	−0.0006
	(0.00005)	(0.00005)	(0.00003)	(0.00003)	(0.00001)	(0.00001)
×Sex	0.0002	0.0002	0.0003	0.0003	0.0002	0.0002
	(0.00007)	(0.00007)	(0.00006)	(0.00006)	(0.00002)	(0.00002)
Sex×Children home	−0.052	−0.051	−0.067	−0.067	−0.0886	−0.0867
	(0.031)	(0.031)	(0.027)	(0.027)	(0.008)	(0.008)
Professional/manager	0.457	0.453	0.420	0.419	0.439	0.437
	(0.053)	(0.053)	(0.044)	(0.044)	(0.008)	(0.008)
Technical/sales	0.245	0.240	0.234	0.233	0.235	0.234
	(0.052)	(0.052)	(0.044)	(0.044)	(0.007)	(0.007)
Farming	−0.112	−0.115	−0.488	−0.494	−0.015	−0.016
	(0.233)	(0.233)	(0.115)	(0.116)	(0.0179)	(0.0179)
Craft	0.214	0.212	0.148	0.147	0.249	0.249
	(0.054)	(0.054)	(0.044)	(0.044)	(0.009)	(0.009)
Operator/laborer	0.112	0.108	0.060	0.042	0.159	0.160
	(0.051)	(0.051)	(0.043)	(0.051)	(0.008)	(0.008)
MSA population	0.00001	3.9e−06	−1.6e−06	−2.1e−06	0.000016*	0.000015*
	(9.2e−06)	(0.00001)	(0.00001)	(0.00002)	(2.2e−06)	(2.1e−06)
MSA schooling	−21.21*	−20.8*	−12.93***	−14.44b*	−21.18*	−20.74*
(inverse average)	(3.82)	(3.81)	(7.03)	(6.86)	(1.02)	(1.02)
MSA experience	−3.029	−2.45	−1.21	−1.15	−7.36*	−6.73*
(inverse average)	(2.21)	(2.22)	(3.23)	(3.16)	(0.539)	(0.539)
Manufacturing diversity	−0.0276	−0.03	0.019	0.019	−0.045*	−0.037*
(MSA income)	(0.045)	(0.044)	(0.102)	(0.098)	(0.012)	(0.012)
Service diversity	−0.031	−0.028	−0.013	−0.005	−0.0022	0.00005
(MSA income)	(0.029)	(0.029)	(0.068)	(0.066)	(0.008)	(0.008)
MSA sector income	−1184.03		−13.39		−578.5	−2.501
(inverse)	(914.8)		(862.1)		(576.9)	(6.42)
State sector income	−4 109 476***		−7 520 593***		−1.14e+07*	−1.1e+07*
(inverse)	(2 440 811)		(4 429 537)		(1 393 621)	(679 462.4)
MSA total income		−106 172.2**		11 197.7		
(inverse)		(46 976.7)		(90 899.3)		
State total income		−1.8e+08*		−3.54e+08*		
(inverse)		(6.9e+07)		(9.9e+07)		

[a] GLS with regional dummies. Dependent variable: Log (hourly average wage) in (1–3) manufacturing with 15,466 observations; in (4–6) finance with 5,073 observations; in (7–8) nondurable goods with 5,840 observations; in (9–10) durable goods with 9,624 observations and in (11–12) the total sample of 93,592 individuals where sectoral income is manufacturing in (11) and finance in (12). Standard errors in brackets. Significance levels are: *1%, **5% and ***10% .

level.[6] Interestingly, when I use employment in the MSA instead of income, coefficients are highly significant both for the manufacturing (col. 3) and the finance sector (col. 6) and, although not included here, also for durable and nondurable goods. Employment may act as a better proxy of actual local activity probably because of differences in accounting both generated income and labor across plants within a company. Wages in finance and nondurable goods (results not included here) are the most benefited by own industry's employment concentration. Wages in areas with the smallest finance workforce are a 30% lower than those in areas with a high concentration of finance workers, other things being equal.

The quality of the workforce (measured by the inverse of the average years of education and of experience of individuals in the total sample residing in each MSA) matters for all sectors. A negative coefficient implies that living in an MSA with a high average in years of education enhances an individual's productivity and, hence, increases his wage. The schooling coefficient, which is quite stable across all samples, implies striking wage differences across MSAs. Other things being equal, wages in low-skilled areas such as Mission, San Benito or Laredo (Texas), which average 11 years of schooling, are 38% lower than in high-skilled areas such as Ann Arbor (Michigan), Boulder (Colorado) or Washington, DC, with 14.8 schooling-years on average. Living close to more experienced people significantly pushes up wages for workers in the finance sector and for the average individual in the sample and, when jointly tested with schooling, in the durable and nondurable goods subsectors.[7]

The other measures of externalities, sectoral diversity and population size, perform poorly in most equations. Since a large population constitutes either a consumption desamenity or a production amenity, wages should bear a premium in highly populated areas. Yet the results in Table 1 are weak: the size of the population in the metropolitan area only significantly increases the wage of the average worker (cols. 11–12). Potentially, employment might be a better measure of these types of externalities than population. Total employment, in many MSA, outsizes population. In Boston, for example, the size of population increases more than 10 times during working hours. This fact strengthens the relevance of employment measures at the MSA level.

Since a high value of the diversity index indicates a highly concentrated industry, diversity is expected to enter with a negative sign if it brings productivity gains to any sector. Estimates on diversity have the expected sign but are not significant except for manufacturing diversity, which pushes up wages for the

[6]Data on sectoral income (in thousands) and employment at the MSA level is obtained from the *Regional Economic Information System* published by the Bureau of Economic Analysis.

[7]The distribution of experience is very uneven mainly due to factors beyond the model and inferences should be cautious. Some MSAs in Florida show the highest average experience indices (around 22.5 years) whereas some college areas have the lowest (around 11 years).

average worker (cols. 11–12). The wage of an average worker in Waterloo (Iowa), the MSA with the most concentrated manufacturing sector, is, other things being equal, a 4% lower than that of a similar worker residing in the most diverse manufacturing area in the sample (Cincinnati).

Table 2 presents estimates of the rent equation. Coefficients of housing characteristics are close to those of earlier studies except for the positive signs in the renter and number of units coefficients. Arguably this reflects recent important increases in prices in big metropolitan areas, where these features are more common. After controlling for housing quality, New York City, Los Angeles and San Francisco are the MSAs with higher rent residuals. The concentration of manufacturing (col. 1– 2) and finance (col. 3–4) activity both at metropolitan and state level pushes up local rents. However, again, for the finance sector results are more robust when using metropolitan employment instead of income. Housing costs are high in MSAs located within states with a high percentage of college graduates. The inclusion of education measures at the MSA level, though not presented here, produces similar results. Rents are higher in larger urban agglomerations. Population may be more relevant here than in the wage equation as a better proxy of the pressure over the land. Again results do not support the view that a more diverse environment matters for production and, eventually, has an effect on input costs. Only diversity in manufacturing enters significantly as a desamenity pushing down rents.

5. Evidence on sectoral costs functions

5.1. US States for 1969–1992

Local unit costs for each sector, as defined by $(W_{js}^{\alpha_s} R_j^{\beta_s})$ in Section 2.1, differ throughout the US states. In 1969, the first year of the sample, the standard deviation of the log of manufacturing costs across states was 0.053, whereas that of the finance sector was just 0.036. Since the mid 1980s land prices greatly rose in some states. As a result, in 1992 the standard deviation of the log of manufacturing costs across states had increased slightly to 0.064 but that of the finance costs was three times bigger, 0.117. Measured by local unit costs, the cheapest states are Mississippi and New Mexico for manufacturing, Utah and Montana for finance and North and South Dakota and Wyoming for both sectors. Delaware and DC are the most expensive states for manufacturing production. In particular, costs in nondurable goods are, also, high in Connecticut and New Jersey and, those for the durable goods, in Michigan where wages in the sector are very high. DC and New York are the most expensive locations for a finance firm. Costs for this sector were also high in Illinois, in the 1970s, and in Connecticut, New Jersey and Massachusetts, during the 1980s.

Tables 3 and 4 present estimates of the local costs function (4) for each sector.

Table 2
Rent equation

Variable (mean)[a]:	(1)	(2)	(3)	(4)
Constant	4.86	4.87	4.83	4.95
	(0.070)	(0.067)	(0.066)	(0.67)
House rented (=1)	0.352	0.351	0.353	0.351
(0.322)	(0.054)	(0.054)	(0.054)	(0.054)
Units at address	0.0033	0.0033	0.0033	0.0033
(5.9)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
×renter	−0.00666	−0.0066	−0.0067	−0.0067
(4.17)	(0.0004)	(0.0004)	(0.0004)	(0.004)
Age of house	−0.0034	−0.0035	−0.0035	−0.0035
(28.8)	(0.00014)	(0.00014)	(0.00013)	(0.00013)
×renter	−0.0022	−0.0022	−0.0022	−0.0022
(9.32)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Number of rooms	0.166	0.166	0.166	0.166
(5.41)	(0.0022)	(0.0022)	(0.0023)	(0.0023)
×renter	−0.058	−0.058	−0.058	−0.058
(1.303)	(0.005)	(0.005)	(0.006)	(0.005)
Number of bedrooms	0.072	0.072	0.072	0.072
(3.56)	(0.004)	(0.004)	(0.004)	(0.004)
×renter	−0.033	−0.033	−0.033	−0.033
(0.91)	(0.0084)	(0.0084)	(0.0084)	(0.0084)
Condominium (=1)	0.038	0.038	0.038	0.037
(0.053)	(0.0106)	(0.0106)	(0.0106)	(0.0106)
×renter	0.144	0.144	0.144	0.145
(0.017)	(0.018)	(0.018)	(0.018)	(0.018)
Public sewer (=1)	0.033	0.033	0.033	0.031
(0.82)	(0.0064)	(0.0064)	(0.0063)	(0.0063)
×renter	−0.012	−0.012	−0.012	−0.012
(0.30)	(0.015)	(0.015)	(0.015)	(0.015)
Total plumbing (=1)	0.318	0.318	0.319	0.318
(0.994)	(0.034)	(0.034)	(0.034)	(0.034)
×renter	−0.0026	−0.0023	−0.0028	−0.0022
(0.319)	(0.050)	(0.050)	(0.050)	(0.050)
Lot size>1 acre (=1)	0.149	0.149	0.149	0.149
(0.126)	(0.007)	(0.007)	(0.007)	(0.007)
×renter	−0.172	−0.172	−0.172	−0.171
(0.015)	(0.018)	(0.018)	(0.017)	(0.017)
MSA Population	0.00002***	0.00002**	0.00002**	0.000015
	(0.000001)	(0.00001)	(0.00001)	(0.00001)
State % college	−2.95*	−2.19*	−2.20*	−2.07*
(inverse)	(0.712)	(0.656)	(0.657)	(0.653)
Manufacturing diversity	0.175*	0.147**	0.162*	0.102***
(MSA income)	(0.062)	(0.062)	(0.062)	(0.061)
Service diversity	0.035	0.035	0.038	0.034
(MSA income)	(0.040)	(0.040)	(0.040)	(0.039)
MSA sector income	−3711.02***		8.877	
(inverse)	(2175.6)		(47.2)	
State sector income	−2 982 191***		−7 911 825*	
	(1 646 271)		(1 639 962)	
MSA sector employment		−721.71*		−1124.5*
(inverse)		(157.04)		(102.8)

[a] GLS with regional dummies. Dependent: log monthly housing expenditures (6.424) in 66,182 households. Sector is manufacturing in (1–2) and finance in (3–4). Significance levels are: *1%, **5% and ***10%.

Table 3
US States 1969–1992: local cost functions with income variables[a]

Sector	Manuf.	Finance	Nondurables	Durables	Manuf.	Finance	Nondurables	Durables
Constant	0.081	0.128	0.097	0.108	0.053	0.113	0.087	0.149
	(0.05)	(0.063)	(0.051)	(0.051)	(0.05)	(0.060)	(0.048)	(0.051)
State sector	−10 702.5*	−15 055.4*	−57 66.1*	−3124.9*				
(inverse)	(3741.2)	(2948.7)	(1972.3)	(932.8)				
Neighborhood sector	−13.76*	−3.912*	−5.563*	−4.568**				
(inverse)	(3.25)	(0.932)	(1.35)	(2.087)				
State total					−305 513*	−369 514.6*	−194 304.6*	−379997*
(inverse)					(52 100)	(80 684)	(53 727.9)	(58 090)
Neighborhood total					−70.73*	−80.59*	−52.33*	−16.74
(inverse)					(16.65)	(22.89)	(16.86)	(17.91)
Diversity	−0.039	−0.781*	−0.244**	0.324*	0.065	−0.751*	−0.158	0.414*
	(0.107)	(0.074)	(0.110)	(0.120)	(0.105)	(0.167)	(0.109)	(0.118)
% College	−0.418	−1.372***	−1.374**	−2.120*	−0.616	−1.323***	−1.153**	−2.195*
(inverse)	(0.616)	(0.141)	(0.625)	(0.635)	(0.611)	(0.685)	(0.591)	(0.604)
Density	3.71e−06	7.36e−06	9.89e−06**	0.00001*	2.49e−06	6.68e−06	0.00001**	0.00001**
	(8.52e−07)	(5.93e−06)	(4.95e−06)	(2.20e−06)	(4.87e−06)	(5.51e−06)	(4.73e−06)	(4.8e−06)
% Metropolitan	0.0003	0.0006***	0.00007	0.0003	1.28e−07	0.0007**	−0.00001	−0.00006
	(0.0002)	(0.003)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)

[a] GLS with regional dummies. Dependent variable: Weighted local sectoral cost using median gross rent data for 1969–1992. 1,176 Observations. Standard errors in brackets. Significance levels are: *1%, **5% and ***10%.

Table 4
US States 1969–1986: local cost functions with product variables[a]

Sector	Manuf.	Finance	Nondurables	Durables	Manuf.	Finance	Nondurables	Durables
Constant	0.038	0.10	0.11	0.18	0.035	0.15	0.104	0.165
	(0.041)	(0.030)	(0.042)	(0.047)	(0.04)	(0.046)	(0.041)	(0.043)
State sector	−10 322.9*	−9187.6*	−3150.5***	−2792.3*				
(inverse)	(3.96)	(2.22)	(1.64)	(0.673)				
Neighborhood sector	−18.362*	−0.111	−6.547*	−6.256*				
(inverse)	(0.003)	(0.0008)	(0.0013)	(0.001)				
State total					−496 216*	−478 155.5*	−190 421.2**	−529 467.2*
(inverse)					(94.2)	(123.1)	(91.2)	(99.1)
Neighborhood total					−70.81*	−64.65**	−57.49**	−0.934
(inverse)					(0.024)	(0.031)	(0.023)	(0.025)
Diversity	−0.053	−0.309**	−0.283*	0.143	−0.009	−0.716*	−0.268*	0.211**
	(0.107)	(0.133)	(0.097)	(0.106)	(0.100)	(0.141)	(0.094)	(0.104)
% College	−0.481	−1.11*	−1.45**	−2.52*	−0.238	−1.26**	−1.22**	−2.18*
(inverse)	(0.583)	(0.406)	(0.599)	(0.669)	(0.558)	(0.644)	(0.181)	(0.598)

[a] GLS with regional dummies. Dependent variable: Weighted local sectoral cost using median gross rent data for 1969–1986; 882 Observations. Standard errors in brackets. Significance levels are: *1%, **5% and ***10%.

To measure the total and sectoral activity of the state, I use, in Table 3, income data for the US states from 1969 to 1992 and, in Table 4, data on gross state product from 1969 to 1986. Both series are available from the Bureau of Economic Analysis in thousands of 1982 dollars. Results in both tables are quite similar.[8]

Gains from the concentration of activity and human capital externalities are, once more, the most important factors explaining cost variation across states. The first four columns, in Tables 3 and 4, examine the extent to which geographic concentration of a sector enhances that sector's productivity; that is, what the literature often refers to as localization economies. The negative sign in all the estimates implies that the more income or product is generated in a given state, the more productive the sector is in that state. Finance is clearly the most benefited by concentration. Since the financial sector is mainly clustered in some metropolitan areas, this partly explains the observed differences in financial costs across the country. From estimates in column (2) in Table 3, in 1990 finance costs in New York, the state with the highest concentration of financial income, were 13.3% higher than those in Wyoming, the state with the smallest finance sector. In the case of manufacturing, the implied difference between Michigan and Nevada, states with the biggest and smallest manufacturing sectors, respectively, was somewhat smaller. The size of the sector in nearby states matters the most for the production of nondurable goods. A more intense intra-sectoral trade in nondurable goods might induce clustering into some regions to reduce transportation costs.

The second set of columns, in Tables 3 and 4, examines the extent to which total activity in the state and the neighborhood affect sectoral productivity; that is, they measure what the literature often refers to as urbanization economies. The productivity of all sectors significantly improves with large concentrations of economic activity in the state. But, whereas the finance and the nondurable goods sectors benefit from higher activity in nearby areas, the durable sector does not. In 1990, for example, financial costs in Pennsylvania and New Jersey, the states with more productive neighborhoods, were, other things being equal, an 8.6% higher than those in Idaho or Montana, located in the less active regions.

Again a better educated pool of workers in the area improves productivity in all sectors. Estimates in Table 3 imply that the costs for a financial firm located in Colorado, the state with the highest percentage of college graduates (23% in 1990) were, other things being equal, an 8.2% higher than in West Virginia, where the percentage of college graduates that year was only a mere 10.4%. For a firm in a durable sector, cost differences were even larger, around 12%. Interestingly, for manufacturing as a whole, it is the percentage of high school graduates in the state, in estimates not presented here, and not that of college graduates what seems to enhance its productivity. Differences in demand for skills across sectors explain why measures of high school graduation, however, do not affect the finance sector.

[8] Results are also similar to those for Japanese Prefectures in Dekle and Eaton (1993) but the relevance of local variables is somewhat smaller for the US data.

Table 5
Local cost functions in MSAs in 1990[a]

Sector	Manuf.	Finance	Nondurables	Durables	Manuf.	Finance	Nondurables	Durables
Constant	0.716	0.811	0.599	0.847	0.768	0.836	0.724	0.915
	(0.151)	(0.292)	(0.181)	(0.180)	(0.151)	(0.296)	(0.182)	(0.181)
MSA schooling	−10.05*	−11.15*	−9.58*	−11.71*	−10.49*	−11.09*	−10.59*	−12.36*
(inverse average)	(1.77)	(3.35)	(2.14)	(2.10)	(1.76)	(3.42)	(2.15)	(2.11)
MSA experience	−1.298***	−1.71	0.01	−1.41***	−1.302***	−1.95	−0.282	−1.394***
(inverse average)	(0.727)	(1.47)	(0.87)	(0.87)	(0.72)	(1.49)	(0.869)	(0.867)
Manufacture diversity	0.0296	0.036	0.0059	0.0513***	0.031	0.037	0.007	0.052
(MSA income)	(0.0263)	(0.049)	(0.0314)	(0.0317)	(0.026)	(0.049)	(0.031)	(0.031)
Service diversity	−0.00005	0.006	0.015	−0.014	0.0006	0.004	0.0155	−0.0122
(MSA income)	(0.0177)	(0.033)	(0.021)	(0.021)	(0.017)	(0.033)	(0.021)	(0.021)
MSA population	3.2e−06	2.5e−06	7e−06	1.8e−06	1.8e−06	−5.8e−07	4.9e−06	6.3e−08
	(4.7e−06)	(8.5e−06)	(5.6e−06)	(5.5e−06)	(5.1e−06)	(9.7e−06)	(6.2e−06)	(6.1e−06)
State density	0.0002*	0.0003*	0.00027*	0.00026*	0.0002a*	0.0003*	0.0001*	0.0002*
	(0.00003)	(0.00007)	(0.00003)	(0.00005)	(0.00003)	(0.00007)	(0.00003)	(0.00005)
MSA sector income	406.7	46.346	−453.05	60.250				
(inverse)	(934.2)	(34.57)	(449.06)	(287.43)				
State sector income	−2 433 143	−59 392.2*	−986 295.6	381 352.4				
(inverse)	(2 235 650)	(16 517.3)	(928 552.8)	(1 642 641)				
MSA total income					−10 483.1	−29 005.6	−26 966.2	−10 585.9
(inverse)					(23 971.1)	(45 687.3)	(28 979.3)	(28 815.4)
State total income					−8.2e+07*	−1 444 892*	−1.1e+08*	−7.42e+07**
(inverse)					(2.8e+07)	(441 977.2)	(3.34e+07)	(3.4e+07)
Observations	262	246	259	261	262	246	259	261

[a] OLS with robust errors and regional dummies. Dependent variable: Log MSA sectoral cost in 1990. Standard errors in brackets. Significance levels are *1%; **5%; ***10%.

The other measures of externalities fare better in this sample than in the hedonic equations, though results are not stable across sectors. Diversity, measured using state income at 1-SIC digit level, clearly improves productivity in the finance and nondurable goods sectors whereas durables consistently benefit from a concentrated environment.

State's density and the percentage of metropolitan population enter positively, as expected (e.g., Ciccone and Hall, 1996), though not significantly, in most equations. A large urban population is relevant for the finance sector. Coefficients from column (2) in Table 3 imply that financial costs in New Jersey, where 100% of the population was metropolitan in 1990, were around 4.7% higher than in Montana, where only 24% of the population lived in urban areas.

5.2. MSA in 1990

Table 5 presents estimates of the local costs function (4) for each sector in MSAs in 1990. Once more, the MSA's measures of human capital, and the state's total activity enter significantly and with the expected sign in all the estimated cost functions. If tested jointly with education, experience also seems to enhance productivity for all sectors. Similarly total activity in the MSA is always significant when jointly tested with the state activity. Results on the relevance of the concentration of a sector's income in the MSA are poor, but, in estimates not presented here, sectoral employment in the MSA is, again as in Table 1, relevant for all sectors. The sector's concentration at the state level positively affects all sectors except for durables, but the coefficient is only significant for the financial sector. The state's density enters now strongly and significantly as a production amenity for all sectors. Conversely, local population and local diversity, both for manufacturing and services, are, once more, not significant.

6. Conclusions

In this paper I have studied the variance in local input costs to identify production externalities across sectors. Two types of externalities, those accruing from human capital and from the concentration of activity, consistently stand out as the more relevant across sectors. Human capital measures perform well both in the estimated cost functions and in the hedonic equations for all the sectors analyzed. A highly skilled population consistently improves productivity and pushes up both wages and rents, confirming earlier theoretical work (e.g., Lucas, 1988) as well as previous empirical results (e.g., Rauch, 1993). Schooling alone is the single most important explanation for differences in local costs.

Both localization and urbanization economies are also important sources of productivity gains, particularly for the financial sector and, within manufacturing, the nondurable sector. In the financial world, where information is crucial, there is a clear incentive for clustering. Around the world, localization externalities have been key to the renewal of some decaying nondurable industries. Newly modernized textile firms in Northern Italy, the Swiss watch-making industry, or tile producers in Spain, which profit from being in clusters where joint learning occurs, are examples of this phenomenon. Other nondurable industries that tend to be bulky and perishable, such as food and kindred products, may be profiting from proximity to the market, that is, from urbanization externalities.

A growing divergence in average wages across states in the finance and nondurable goods sectors can potentially be traced to a search for localization gains. In addition, the recent expansion of the finance sector, an avid competitor of local land, has clearly contributed to the uneven increase of land prices across the US since the mid 1980s. Dekle and Eaton (1993) describe a similar though more dramatic process in Japan prefectures. The lower local land shares in US sectors relative to Japan's and the bigger size of the states relative to the prefecture's account for the difference in intensity.

Contrary to earlier results in the literature, sectoral diversity has a weak effect on productivity. Positive evidence of gains from diversity has been only found in some of the finance and nondurable estimates. The presence of sectoral diversity improves finance's productivity mostly through greater risk diversification. Similarly, estimates for population size, which the literature has expected to work both as a consumption disamenity and a productivity amenity pushing up local costs, are not significant. Employment measures seem to proxy better these effects, specially at the metropolitan level.

The state rather than the MSA stands out as the most relevant geographical unit to account for differences in sectoral productivity. Heavy intersectoral trade and networking among neighboring MSAs explains why the activity of the MSA alone performs poorly as a measure of the presence of externalities.

To conclude, the use of a cost approach emerges as an appropriate alternative to the use of production functions to estimate the strength of local externalities. Further research should be concerned in estimating similar cost functions at smaller industry level and contrasting them with earlier results on the production analysis, such as those for two-digit industries in Brazil and the US in Henderson (1988). A closer look at the industries would allow to determine the importance of related sectors in localization decisions and to narrow the type of diversity that matters for each industry.

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Appendix A. Construction of factor shares

I follow Dekle and Eaton (1993) to estimate the direct and indirect effects of an increase in one unit of the tradeable output over the local demand for inputs.

I use the *Input–Output Table* (Survey of Current Business, 1991) for the US Economy in 1987. I partition the matrix between either two (manufacturing and finance–insurance) or three (durables, nondurables and finance–insurance) tradable sectors and five nontradeable sectors (construction, transportation–communication and public utilities, wholesale and retail trade, real estate and services) as follows,

$$\begin{bmatrix} A_{TT} & A_{TN} \\ A_{NT} & A_{NN} \end{bmatrix}$$

Agriculture, agricultural services and mining are not included in the analysis because their location and production technology have little to do with the agglomeration forces under study in this paper.

The total *local share* of factor *n* in the *i*th sector, $\tilde{\beta}_{im}$, is given by the following expression.

$$\tilde{\beta}_{im} = \lambda_i \beta_{im} + \beta'_{Nm}(I - A_{NN})^{-1} A_{Ni} \tag{A.1}$$

where β_{im} is the direct share of factor *m* in value added of sector *i*, λ_i is the share of value added in the output of industry *i*, β'_{Nm} is a 5×1 vector of the direct shares of factor *m* in the value added of the nontradeable sectors, and A_{Ni} is the 5×1 vector of the direct shares of nontradeable sectors in producing the output of sector *i*. The share of value added in the output of the industry is obtained through the 1987 *Input–Output Table* for each sector. In order to obtain the direct factor shares in value added, I use national data on fixed sectoral reproducible capital produced by the Bureau of Economic Analysis (Survey of Current Business, 1992) and multiply it by an average of Prime Bonds real interest rate from 1982 to 1990 to obtain the capital share in production. From the *National Income and Product Accounts*, I use data on total compensation of employees in the sector to obtain the sectoral labor share in value added. Finally the residual is considered to be the land share. Applying the formula above I have obtained the parameters listed below.

Estimated total local input shares

	Manuf.	Durable	Nond.	Finance
Land share	0. 150	0.118	0.185	0.163
Labor share	0.371	0.429	0.308	0.496

Appendix B. Mean of variables

State variables

	Product	Income
State manufacturing	1.303e+07	1.00e+07
State nondurable	5,133,500	3,699,631
State durable	7,901,700	6,302,738
State finance	2,360,100	2,310,076
State total	5.96e+07	4.31e+07
Neigh. manufacturing	4,940	3,845.5
Neigh. nondurable	2,040	1,532.2
Neigh. durable	2,900	2,312.4
Neigh. finance	920	934.5
Neigh. total	21,090	15,811.9

Percent college	15.53	Cost manuf.	8.46e−08
Percent Metro	64.43	Cost finance	9.22e−08
Density (per m^2)	332.6	Cost nond.	1.05e−07
Diversity	0.0335	Cost durab.	6.67e−08

MSA Variables

Schooling	13.68	Experience	18.16
Population	626,363	Total income	1.25e+07
Manuf. income	1.7e+06	Finance income	609,225
Durable income	1.07e+06	Nondurable income	623,969
Manuf. employment	56,411	Finance employment	36,891

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