Spatial concentration and plant-level productivity

Florian Mayneris
Université catholique de Louvain, IRES, CORE
Summer school, Pushkin
July 5th 2013

Motivation

An old story

- Interest of economists for clusters and agglomeration economies is not new (cf A. Marshall, *Principles of Economics*, 1890)

- External economies of scale: average cost of production decreases with the number of active firms in the neighborhood/region

⇒ Firms benefit from externalities when they are located close to each other

- Two types of externalities generally identified

⇒ Localization economies: intra-sectoral externalities (Marshallian externalities)

⇒ Urbanization economies: inter-sectoral externalities (Jacobs' externalities)

Externalities on the input market

- Concentration of firms in a given place

⇒ Incentive for specialized suppliers to locate nearby

⇒ Lower transport costs and greater diversity

- Mutualization of some purchases or infrastructure investments

- Proximity between suppliers and clients increases trust and flexibility in trade relationships

- ***« Smithian » argument :*** Increase in the size of the cluster

⇒ Possibility for firms to specialize on some particular steps of the production process

⇒ Division of labour within the cluster beneficial in terms of productivity in case of « learning by doing »

Externalities on the labour market

- Several firms from the same industry in the same region

⇒ Creation of a pool of specialized workers, with some specific skills beneficial for the firms of the cluster

Ex: links between universities and proximate firms

- Better match between firms and employees that might increase firms and workers productivity

- Greater fluidity on the labour market: if business cycles of firms are not synchronized, workers can move from one firm to the other according to the economic situation of firms

⇒ Risk sharing (Overman and Puga, 2010)

Knowledge externalities

- Geographic proximity => Better circulation of information

- « Cafeteria effects»: workers, engineers, researchers exchange in an informal way information and knowledge that are at the origin of new ideas

- More formal circulation through joint-ventures or common projects between firms and labs for example

- In spite of decreasing communication costs, proximity still important because:

⇒ Strategic information are more and more complex

⇒ All the informations are not codifiable

Urbanization economies

- Externalities linked to the size of the city and/or to the diversity of economic activities within the city

- *Economies of scale again*: Better amortizement of investments with high fixed cost, either for infrastructure or public services

  Ex: Transport infrastructures, childcare services

- Many industries (services in particuar) need some specific skills that they find in cities only

  Ex: Advertisment on Madison Avenue in New-York, the City in London, Hollywood in LA (Duranton and Jayet, 2011)

- ***Sectoral diversity as source of urbanization economies*** (*The economy of cities*, Jane Jacobs, 1969):

$\Rightarrow$ Diversity favorable to radical innovation, often at the frontier of several industries, especially for young industries (cf Duranton & Puga, 2001)

A recent public interest for clusters

- Interest of public authorities for clusters is much more recent

⇒ Dates back to the 1980's, when traditional industries start declining in many developed countries, while still resisiting quite well in Italy

- Italian industy characterized by its spatial orgnanization around industrial clusters of SMEs

- Intensive work by M. Porter (Harvard Business School) to popularize the concept of « clusters »

- From the beginning of the 1990's, many cluster policies implemented over the world (Spanish Basque country, Bavaria, South-Korea, Japan, France etc.)

- Rationale for these policies: *if agglomeration externalities exist, and if they are not well internalized by firms, public intervention necessary to maximize aggregate productivity*

Literature

Pioneer works

- Empirical research on clusters started in the 1970's.

- Lack of data on individual wages and firm-level productivity
  => Measures on aggregated or semi-aggregated data (sector-region level)

- Pioneer productivity analysis:
- ***Shefer (1973):*** doubling city size in the US would increase city-level productivity by 14-27%. Incredibly huge
- ***Sveikauskas (1975):*** elasticity wrt city size equal to 6-7%, also for a sample of industries in US cities. More credible.

- All these measures are hardly reliable: degree of aggregation that does not allow to control for both omitted variables and simultaneity issues the estimation of agglomeration economies usually suffers from

Estimation biases

- Omitted variables: regions with high concentration of firms might also be places with better productive amenities, infrastructure etc., for all firms or for firms in specific sectors

- Simultaneity bias: when a positive (negative) shock affects a sector-region, the number of firms or employment in these firms might increase (decrease), as well as their TFP

- Sorting/selection issues: possible spatial sorting/selection of best performing firms in denser areas (Baldwin and Okubo, 2006; Melitz and Ottaviano, 2008)

$\Rightarrow$ Endogeneity issues that need to be tackled by the econometrician

How solving endogeneity issues? (1)

- Instrumentation: finding a variable that explains current spatial concentration of activities without directly explaining current level of productivity

⇒ Ciccone and Hall (1996): use lagged level of density in US states (more than 100 years ago) ou lagged level of transport infrastructure to instrument current density

⇒ Combes et al. (2010): use geological instruments to explain density of activities

- Two main drawbacks:

⇒ *Exogeneity of the instrument:* not sure than in all contexts, past level of density uncorrelated with unobserved local characteristics explaining both concentration of activities and productivity (especially when strong persistency in the geography of economic activities)

⇒ *Explanatory power of instruments:* not all geological instruments perform well in this respect for example

How solving endogeneity issues? (2)

- Increasing availability of firm-level data has allowed to take into account more dimensions of omitted variables/selection issues

⇒ Resort to fixed effects estimations

- With panel data, possibility to control for time-invariant characteristics and for sectoral or local specific shocks

⇒ *Henderson (2003):* plant-level panel with 5-year intervals observations, allowing to control for plant-location fixed effects, as well as for industry-time fixed effects and/or MSA-time fixed effects

⇒ *Combes et al. (2008):* worker-level panel data, allowing to control for worker fixed effects, i.e. all individual time-invariant observed and unobserved characteristics explaining why some people have higher wages

- ***Consensus:*** elasticity of productivity to local density lies between 3 and 8%.

What we show

Empirical questions

- « Spatial concentration and plant-level productivity in France », Ph. Martin, T. Mayer and F. Mayneris, 2011, *Journal of Urban Economics*

- Focus on the impact of spatial agglomeration on plant-level TFP

- Several questions tackled:

$\Rightarrow$ Do agglomeration economies exist in France ?

$\Rightarrow$ What is their nature and how large are they?

$\Rightarrow$ What is their shape (are they linear)?

$\Rightarrow$ Given this measure, is the geography of economic activities optimal?

Main results

- Localization economies do exist in France…
- …but they are non linear (while previous studies find log-linear relationships)
- Given the estimated bell-shaped gains to agglomeration, French firms seem to have quite well internalized localization economies in their location decisions…
- …which casts doubt on the adequacy of clusters policies devoted to increase the size of existing clusters

Empirical strategy

The empirical model

- We assume a Cobb-Douglas production function: $Y_{it} = A_{it}K^{\alpha}_{it}L^{\beta}_{it}$,

Y_{it}, value added of plant *i* at time *t*

K_{it}, capital of plant *i* at time *t*

L_{it}, employment of plant *i* at time *t*

A_{it}, TFP of plant *i* at time

- Where TFP is decomposed as follows

$$A_{it} = \phi AGGL^{\delta}_{iszt}\, DIV^{\gamma}_{iszt}\, U_{it}$$

$AGGL_{iszt}$ localization variable(s) for plant *i*, from industry *s*, in region *z* at time *t*

DIV_{iszt} urbanization variable(s) for plant *i*, from industry *s*, in region *z* at time *t*

=> *Two-step strategy: estimation of Tfp first and then estimation of agglomeration economies on firm-level Tfp*

Estimation of the production function

$$y_{it} = \alpha k_{it} + \beta l_{it} + a_{it}$$

with $a_{it}=u_i+w_{it}$

- u_i potentially correlated with inputs (firms, entrepreneurs and locations fixed characteristics),
- w_{it} potentially correlated with inputs too (cyclical effects)

- Estimation at the industry 2-digit level

⇒ Industry characteristics that are fixed over time are taken into account, as well as time-varying characteristics, through year fixed effects

- 2 alternative estimations:

- OLS: firm-level unobserved characteristics and idyosyncratic shocks are ignored
- Levinsohn and Petrin (2003): inputs used as instruments

Estimation of agglomeration economies

$$Tfp_{iszt} = \delta aggl_{iszt} + \gamma div_{izt} + v_{it}$$

with $v_{it}=v_i+z_{it}$

- v_i potentially correlated with agglomeration variables (firms, entrepreneurs and locations fixed characteristics),
- z_{it} potentially correlated with agglomeration variables too (cyclical effects)

- To remove time-invariant unobserved characteristics : first differentiation

- To control for unobserved shocks: instrumentation of first-differences by levels in t-2

=> GMM estimation

Rationale for GMM

- Under a convergence process, levels of variable *y* in *t-2* should be negatively correlated with $(y_t - y_{t-1})$

- Estimation based on short-run variations of the variables: may hardly capture knowledge externalitie. May miss long-run effects of agglomeration economies (different from Ciccone & Hall, 1996; Combes et al., 2008)

- Still, able to capture more short-run externalities as pecuniary externalities on the market of inputs, specialised services etc.

- If non-linearities do exist and if firms are rationale, in the long run, all firms should have an optimal location, or local infrastructure should adapt to the density level…

- …which means that in order to exhibit potential non linearities, short-run variations might be more adequate, since we have more chances to have in the sample « suboptimal observations »

Data

The Annual Business Surveys

- Balance-sheet data:

⇒ Capital, value added, aggregate wages etc. at the firm-level

⇒ Employment at the plant-level

- Firms bigger than 20 employees

- Period: 1996-2004

- Are retained in the sample:

⇒ Manufacturing industries

⇒ Continental plants

⇒ Plants which do not change industry or area over the period

Construction of the sample

- We have employment at the plant level but capital and value-added at the firm-level only:

$\Rightarrow$ Pb1: How can we estimate production function at the plant-level?
$\Rightarrow$ Pb2: what is the right geographic environment for multi-plant firms?

- We decide to make a strong assumption in order to estimate production functions at the plant-level: value-added and capital are reallocated to plants proportionately to their share in total employment of the firm

- Main results about non-linearities are robust to different specifications

- 2 levels of geographic disaggregation (départment/employment areas) and sectoral disaggregation (2 digit/3 digit)

- Preferred level: département/3 digit

The variables

- Localization economie:
  $loc_{iszt}=\ln(employees_{szt} - employees_{iszt}+1)$

- Urbanization economies:
  $urb_{szt}=\ln(employees_{zt} - employees_{szt}+1)$
  $div_{szt}=\ln(1/\text{Herfindahl of sectoral diversity})$

- Porterian economies:
  $comp_{szt}=\ln(1/\text{Herfindahl of sectoral concentration})$

Results

Cross-sectional approach

- We first regress plant-level TFP on plant fixed effects and recover these fixed effects, i.e. plant-level average productivity over the period

- We then explain plant-level fixed effects by average industry-département characteristics over the period

$\Rightarrow$ Cross-sectional estimation of agglomeration economies

Dep Var:	Plant fixed effect
Average ln (# employees, other plants, same industry-area+1)	0.016^a
	(0.004)
Average ln(# employees, other industries, same area)	0.038^a
	(0.005)
Industry fixed effects	yes
N	46855
R^2	0.526

Note: Standard errors in parentheses. ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Standard errors are corrected to take into account autocorrelation at the industry-département level.

Controlling for unobserved heterogeneity

Table 1: Fixed effects approach, Naf 3-digit/Département

	Dependent Variable: ln LP Tfp			
Model :	(1)	(2)	(3)	(4)
ln (# employees, other firms, same industry-area+1)	0.024^a	0.008^a	0.037^a	0.007^a
	(0.002)	(0.002)	(0.002)	(0.002)
ln(# employees, other industries, same area)	0.054^a	0.017	0.066^a	0.018
	(0.004)	(0.019)	(0.004)	(0.020)
competition			-0.038^a	0.008^c
			(0.004)	(0.005)
sectoral diversity			-0.072^a	0.003
			(0.007)	(0.011)
Time fixed effect	yes	yes	yes	yes
Firm fixed effects	no	yes	no	yes
N	216340	216340	216340	216340
R^2	0.028	0.018	0.032	0.018

Note: Standard errors in parentheses. ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. Standard errors are corrected to take into account individual autocorrelation.

Controlling for simultaneity
Second stage regressions

Table 2: Instrumental variables approach, Naf 3-digit/Département

	Dependent Variable: Δ ln LP Tfp			
Model :	(1)	(2)	(3)	(4)
Δ ln(# employees, other firms, same industry-area+1)	-0.002	0.059^b	-0.002	0.055^c
	(0.002)	(0.028)	(0.002)	(0.029)
Δ ln(# employees, other industries, same area)	-0.005	-0.060	0.003	-0.005
	(0.021)	(0.149)	(0.022)	(0.206)
Δ ln (sectoral diversity)			0.013	-0.056
			(0.012)	(0.130)
Δ ln (competition)			0.002	0.057
			(0.005)	(0.047)
N	126794	126794	126794	126794
R^2	0.003	0-.006	0.003	0-.008
Kleinbergen-Paap underidentification test		182.121^a		75.646^a
Hansen overidentification test p-value		0.402		0.130

Note: Standard errors in parentheses. ^{a}, ^{b} and ^{c} respectively denoting significance at the 1%, 5% and 10% levels. (1) and (3) simple OLS, (2) and (4) are GMM, with Moulton standard errors.

Marginal effects

Dép./Naf 3-digit	EA/Naf 3-digit	Dép./Naf 2-digit	EA/Naf 2-digit
4.17%	1.96%	n.a.	3.89%

Note: Each column gives the percentage increase in productivity following a doubling of the localization economies for each sample.

Non-linear effects (1)

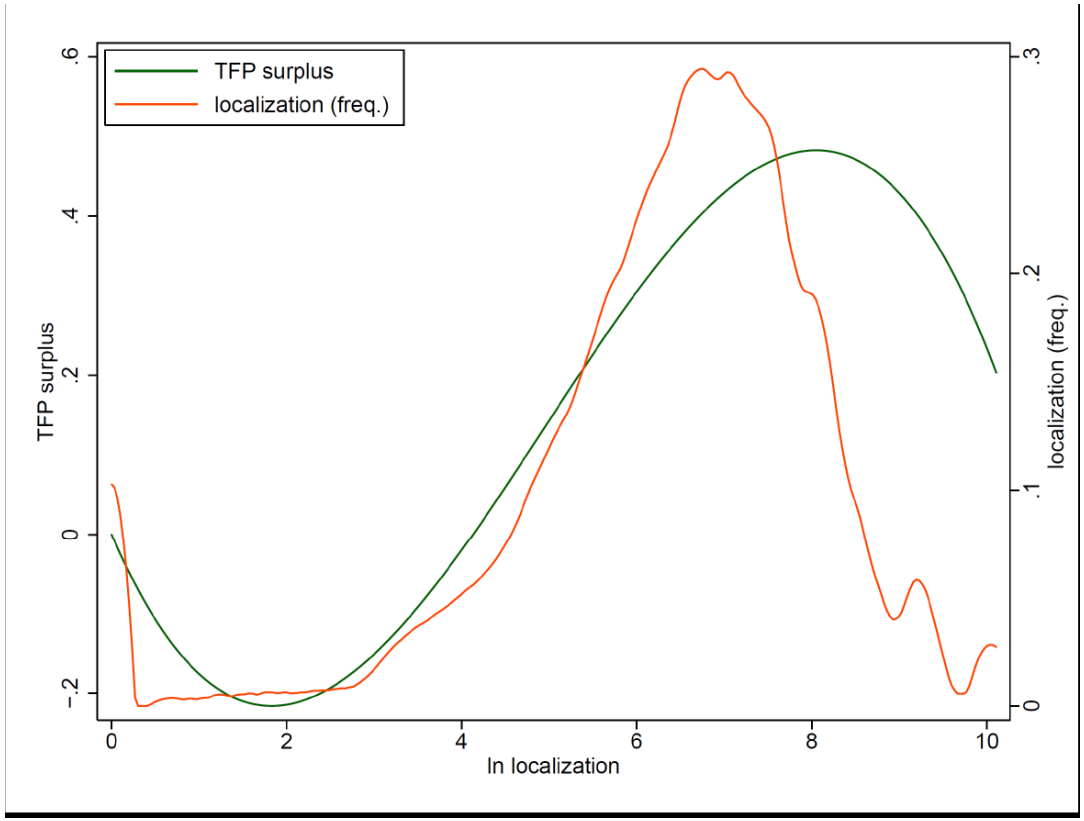
Table 8: Instrumental variables approach/Bell-shaped curve

	Dependent Variable: Δ lnLP Tfp			
Model :	Dep/Naf220	ZE/Naf220	Dep/Naf60	ZE/Naf60
Δ ln(# employees, other firms, same industry-area+1)	-0.256[a]	-0.286[b]	-0.470[a]	-0.295[a]
	(0.088)	(0.118)	(0.170)	(0.108)
Δ ln(# employees, other firms, same industry-area+1)^2	0.086[b]	0.111[b]	0.116[b]	0.105[a]
	(0.034)	(0.050)	(0.055)	(0.041)
Δ ln(# employees, other firms, same industry-area+1)^3	-0.006[c]	-0.009[c]	-0.005	-0.008[b]
	(0.003)	(0.005)	(0.005)	(0.004)
Δ ln(# employees, other industries, same area)	-0.046	-0.118	-0.521	-0.274
	(0.184)	(0.185)	(0.446)	(0.217)
N	126794	126786	129529	129521
R^2	0-.014	0-.024	0-.058	0-.020
Kleinbergen-Paap underidentification test	60.452[a]	25.578[a]	5.066	23.634[a]
Hansen overidentification test p-value	0.047	0.025	0.148	0.084

Note: Standard errors in parentheses. [a], [b] and [c] respectively denoting significance at the 1%, 5% and 10% levels. All regressions are GMM, with Moulton standard errors.

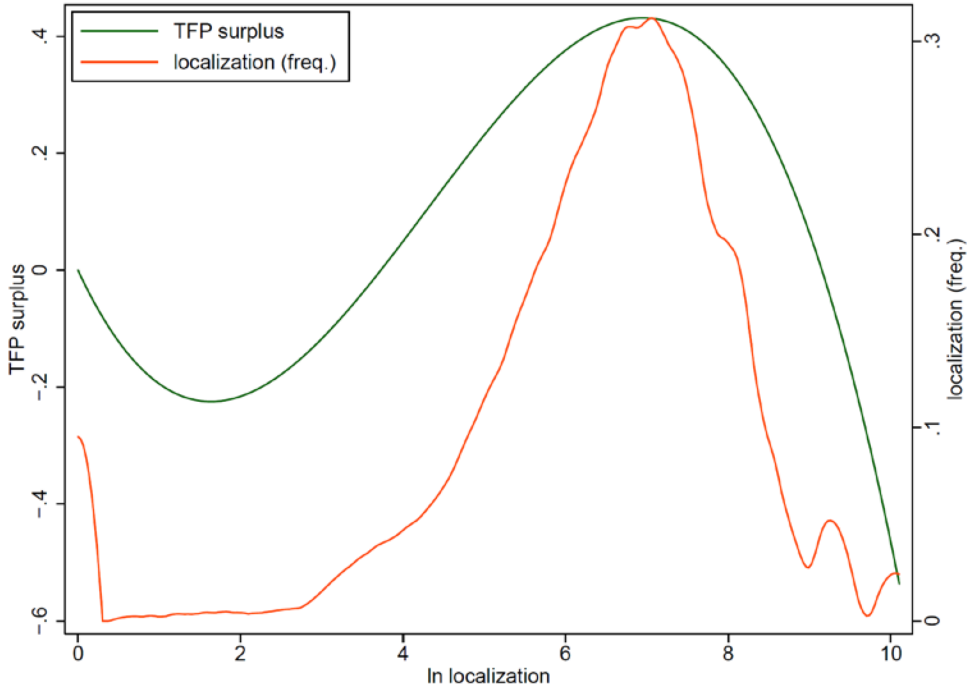
Non-linear effects (2)

Plant level



Non-linear effects (3)

Single plant firms



Are firms spatially rational?

- **At Dep/Naf3 level single plant firms:**
- Estimated peak : 1043 employés
- Observed peak : 1169 employés

- Productivity gain from the oberved to the estimated peak : 0.001%

- Productivity gain for the 10th percent. firm (in terms of agglo): 37.87%
- Productivity gain for the 25th percent. firm: 10.54%
- Productivity gain for the median firm 0.005%
- Productivity gain for the 75th percent. firm: 2.22%
- Productivity gain for the 90th percent. firm: 12.78%

- Productivity gain from 0 to the observed peak : 53.80%

Concluding remarks

- At firm level, MAR-type externalities do exist but no evidence of urbanization economies in the short-run

- In the short-run, localization economies are non linear: there is a point from which marginal congestion costs become bigger than marginal localization economies

- French firms seem to have internalized quite well the gains from agglomeration in their location choice

$\Rightarrow$ Geography matters a lot but quite few gains to expect from a more agglomerated one

- Moreover, an adequate policy should increase clustering for some firms, and decrease clustering for others

$\Rightarrow$ Very demanding in terms of information!

- What should public policies do in that context? Rather than reinforcing the « attractiveness » of territories, shifting the estimated peak on the right

$\Rightarrow$ infrastructure policies etc.