INRA SCIENCES SOCIALES

N° 3 – JUNE 2006

RESEARCH IN ECONOMICS AND RURAL SOCIOLOGY

WORKPLACE COMMUNICATION AND PRODUCTIVITY: DIRECT EFFECT AND AGGLOMERATION EXTERNALITIES

The economic explanation of the spatial concentration of activities in cities is based in part on the assumption that there is a productivity gain linked to the greatest possibility of exchanging pertinent information face-to-face, without extra cost (especially transport) in places with a high population density. The measurement of these communication externalities, on the one hand, helps evaluate their effective impact on productivity, and on the other hand, understand the possible effects of the information and communication technologies (ICT) in terms of re-dispersion of activities towards rural areas. The indirect effects of the local environment (population size and local share of highly skilled employees) percolating through the intensity of communication represent about 22% of their direct effects, thereby confirming the assumption of agglomeration externality and strongly questioning the possibility of reorganizing activities towards rural areas, if only based on the development of ICT.

Exchange of information and agglomeration externalities

Historically, to explain the development of cities, the role of knowledge exchange and communication is one of the first to have been put forward. Since A. Marshall's work, agglomeration externalities (that is to say, gains due to city location) have classically been listed in three main categories: the size and diversity of the labour market, the vertical linkages between firms, and the exchange of information and knowledge. This last effect is directly linked to the proximity of a great number of workers who can, in a formal or informal way, exchange knowledge which makes them more productive, or even innovative. Thus, geographical proximity, by making face-to-face exchanges easier, would lead to an increase in productivity in the firms concentrated in city.

The development of ICT, by allowing long-distance communication at a low cost, could weaken this increase in concentration and favour the restructuring of certain activities towards rural spaces. The description of this reorganization ranges from the utopia of teleworking to the less systematic forms of relocation, concerning only certain activities, especially those less intensive in technology. These studies, calling into question the advantages of the concentration of activities linked to the diffusion of information, often do so without thinking about the contribution of communication to the agglomeration economies. The complexity of the process which links employees' geographical proximity and positive externalities due to their increase in productivity is rarely tackled. This complexity is essentially due to the difficulty in distinguishing the employees' productivity gains, which follow from their characteristics (more skilled, more mobile, better educated…), from the ones which follow from the fact that these employees work close to each other. The identification of such externalities raises recurring methodological difficulties, especially because of their spatial characteristic, since the area concerned is, *a priori*, difficult to identify. The intensity of workplace communication on the urban-rural gradient is measured from the available data of the *Organizational changes and computerization* inquiry (COI) carried out in France in 1997. Although overall communication increases with city size, face-to-face communication is not spatially discriminating. Next, we show that communication has an effect on workers' productivity. This effect is largely the consequence of their individual characteristics, but there is also a substantial communication externality, independent of those characteristics, which increases with the city size.

Spatial distribution of workplace communication: a few major trends

Table 1 presents the values taken by the average communication index per type of space, as described in frame 1, as well as the communication modes measurable from the COI inquiry in 1997, allowing a certain

descriptive approach which goes against some claims. The intensity of communication is clearly stronger in urban areas than in rural areas and increases with the size of the city. In Paris, the average communication is about 50% higher to that observed in rural areas and 25% higher than in small cities.

Face-to-face communication is very high, irrespective of the location of the worker. Even in rural areas, it goes up to nearly 85%. Therefore, this communication mode is only slightly discriminating in space. The same is true for the city of Paris, as far as written communication is concerned. On the other hand, telephone is much more used in big cities than in small ones, in remote suburbs and in rural areas. The same phenomenon is observed with e-mail, with an even greater intensity. These spatial differences in the use of most advanced communication modes are confirmed by the answers on the use of micro-computers. ICT are much more widely used by workers in city than by rural ones. In the cities, ICT use rises in accordance with the city size. *A priori*, there would therefore not be any greater face-to-face communication in city; on the other hand, the use of telecommunications intensifies with urbanization.

Though these statistics throw light on the lack of homogeneity in the spatial distribution of communication intensity in the workplace, they do not teach us anything about the causal link between communication intensity and workers' productivity, even if, in parallel, it is a well-known fact that wages are higher in urban areas than in rural areas.

Communication effects on productivity

The results of the communication equation (frame 2, table 2) confirm that individual characteristics do explain the communication level, in particular the level of education. The effect of age on workplace communication is non-monotonous, reaching a maximum around 50 years. Women communicate slightly less than men do. As far as environmental characteristics are concerned, the type of area where the work is located is determining in the communication level; to move from the smallest urban area (about 10,000 inhabitants) towards Paris causes the communication index to increase by 4 points. In the same way, the local share of highly skilled workers has a strong impact on individuals' communication level.

As regards the earnings equation, worker's characteristics are important too. Like previous literature, we find that women have lower wages than men, that the education level is a strong determining factor in earnings level and that experience is an asset, then a handicap. But above all, a rise by one point of the communication index raises earnings by 0.5%, confirming the productive effect of communication.[1] The city-size effect on earnings is equally important: an increase by 10% of the former raises the earnings by 3.6% for a worker whose individual characteristics are the same. Similarly, an increase by 1% in the local part of highly skilled workers corresponds to a 0.2% rise in each individual's earnings. Therefore, local environmental characteristics have an appreciable direct effect on individuals' earnings, once individual characteristics are controlled.

[1] We were able to check that these results were robust to the introduction of the type of job occupied by the worker.

If we now combine the results of both equations, a rise by 1 point log in the city size increases individual communication, varying from 0 to 100, by 4.5 points. This implies an indirect rise in earnings of around 0.22%. In parallel, in the earnings equation, the coefficient of the city size, which measures its direct effects, is 3.6%.

Therefore, in terms of salary rises, nearly 16% of the benefits of the size of the city where employees work is related to communication. If the same reasoning process is followed for the highly skilled part of city employees, nearly 28% of its beneficial effects are related to communication. If both results are combined, we may conclude that about 22% of the agglomeration externalities are related to communication.

Conclusion

In terms of measurement of workplace communication, the richness of the COI survey helps us observe that if there is a rural-urban gradient of communication intensity it is not due to a stronger intensity of face-to-face communication in city but to a more intensive use of telecommunications. The direct effects of the local environment (population size and local part of highly skilled workers) on earnings, but above all its indirect effect, related to the intensity of communication, has also been measured. Thus, about 22% of its effects are indirect and act through the employee's intensity of communication.

Therefore, in terms of productivity gains, the advantage of the urban location tends to remain steady and not be due to a strong intensity of face-to-face communication, making a delusion of the reorganization of economic activities in rural areas thanks to the sole development of ICT.

Sylvie Charlot INRA-CESAER Dijon
Gilles Duranton, Departement of Economy, University of Toronto

charlot@enesad.inra.fr –
http://www.dijon.inra.fr/esr/pagesperso/charlot/
gilles.duranton@utoronto.ca –
http://individual.utoronto.ca/gilles/default.htm/

This research was given a financial support by CESAER and the Leverhulme Trust. We thank Nathalie Greenan for providing us with the COI data and Virginie Piguet for locating them.

For further information

Charlot, S.; Duranton, G. (2006). Cities and workplace communication: some quantitive evidence, *Urban Studies*, Vol 43, n°8, pp. 1369-1394.
Charlot S., G. Duranton (2006). Les modes de communication et leurs complémentarités : quand l'espace compte toujours, *Revue Economique*, vol. 57, n°6, pp.1427-1447.
Charlot, S.; Duranton, G. (2004). Communication externalities in cities, *Journal of Urban Economics*, n°56, pp 581-613.
Greenan, N.; Hamon-Cholet, S. (2001). *COI un dispositif d'enquêtes couplées employeurs/employés sur les changements organisationnels et l'informatisation. Tome 1 : Présentation et questionnaires,* Centre d'Etude de l'Emploi, Paris.

Published by the INRA Social Sciences, Agriculture and Food, Space and Environment
Publishing unit
Editorial Director: Hervé Guyomard – Editor: Didier Aubert (Chief Editor), translation and composition: Ariel Gille

Frame 1: Data

The Organizational changes and computerization (COI) survey is made up of two sections: a "firms" section and a "workers" section. 4025 representative firms were selected, among which 2541 in general manufacturing, 478 in the Food industry, 734 in accounting and 272 in "do-it-yourself" shops. Within each group firms were randomly drawn among those with 50 or more employees. In each firm, 1, 2 or 3 randomly selected employees were questioned. A total amount of 5583 workers' questionnaires, coupled with information from the DADS (annual inquiry questioning employers on workers'social data - salaries, pensions - from INSEE, French National Institute on Statistics) belonging to 3153 firms, were collected (section *firms* was coupled with the EAE (French annual inquiry on firms)). This survey is described and analysed in great detail in Greenan and Hamon-Cholet (2001).

In the "workers" section, there are about 10 questions on the workers' forms of communication. They concern the communication between workers inside the firm, communication with other workers outside the firm, with clients. These questions also concern the mode of communication (face-to-face, written, telephone…) as well as the use of a micro-computer and an intranet or the internet. The combination of the COI survey with the local position of the firms helps divide workers in different zoning areas (ZAU) (INSEE 1999). We keep three main spatial categories: urban, suburban (remote) and rural areas. The urban areas correspond to agglomerations of at least 5000 jobs. Suburban areas are composed of municipalities that do not belong to a city but have at least 40% of their residents working in a city.

To include all the aspects of workplace communication, a synthetic index has been created (Com). It is a weighted mean, with equal weight given to each of the following dimensions: communication external to the firm, intensity of communication, media and involvement in creative activities with others. The answers to binary questions were coded 1 for yes and 0 for no. The answers on the intensity of communication were coded 3 for the highest level, 2, 1 and 0 for the lowest ones. *Com* is normalised to range from 0 and 100. Its average score is 39.1 and its standard deviation is 20.7.

Table 1: Communication modes and use of ICT in 1997

	Rural	Suburban	Urban < 100,000 in.	Urban >100,000 <500,000	Urban >500,000 < 2 millions	Paris
Average *c*ommunication index	31.9	36.0	38.8	41.4	42.5	50.3
% of workers using media						
Voice / face-to-face	84.6	84.9	86.6	84.8	87.6	86.7
Written - Paper	63.7	67.6	68.5	66.0	64.3	75.3
Telephone	24.5	25.8	26.2	27.4	28.7	41.7
E-mail	13.4	16.1	15.0	18.2	19.4	31.3
A PC	39.8	46.0	54.7	59.6	63.7	72.5
A PC to search information	29.4	36.6	39.8	42.3	47.4	49.2
Internet	2.5	4.4	2.5	4.2	6.8	11.1
Intranet	18.2	23.0	25.3	31.7	35.9	44.7

Sylvie Charlot, INRA CESAER, Dijon, France
Gilles Duranton, Departement of Economy, University of Toronto, France
ISSN1778-4379, n°3–June 2006

Frame 2: Method for identification of communication externalities

Earnings, a measure of workers' productivity, are determined by individual characteristics as well as by their environment. At the same time, the intensity of communication also depends on the worker's characteristics and their environment.

Traditionally, the main variables defining a worker's skills are the level of education and experience as well as her ability to exchange pertinent then productive pieces of information. Our index of communication allows us to measure directly the intensity of communication in the workplace by distinguishing the effects linked to education and experience and therefore to evaluate the effect on earnings. As regards environmental characteristics working on salaries, earlier research showed that workers tend to be more productive in the biggest cities and places where there is a concentration of educated individuals. Simultaneously, these two variables work on communication: larger cities increase possibilities of face-to-face communication and better-educated workers are more likely to exchange more with other educated workers.

Therefore, by correcting the endogeneity of variables with the help of instrumental variables, we test an earnings equation and a communication equation taking the following form:

$$\begin{aligned} Com_j = {} & d_0 + d_1 Gender_j + d_2 Educ_j + d_3 Age_j + d_4 Age_j^{\,2} \\ & + e_1 Urban_j * \log Pop_{i(j)} + e_{1'} Suburb_j + e_{1''} Rural_j \\ & + e_2 Sharegraduates_{i(j)} + \mu_j \end{aligned}$$

$$\begin{aligned} \log W_j = {} & a_0 + a_1 Gender_j + a_2 Educ_j + a_3 Age_j + a_4 Age_j^{\,2} + b\overline{Com}_j \\ & + c_1 Urban_j * \overline{\log Pop_{i(j)}} + c_{1'} Suburb_j + c_{1''} Rural_j \\ & + c_2 \overline{Sharegraduates_{i(j)}} + \varepsilon_j \end{aligned}$$

Where W_j and Com_j are respectively the earnings per hour and the communication index of the worker j. $Gender_j$ is a dichotomous variable which carries value 1 if the worker is a female, $Educ_j$ is her education level and Age_j her age. $Urban_j$ carries value 1 if the individual is located in a city, 0 otherwise, the same for $suburban_j$ and $rural_j$. $\log Pop_{i(j)}$ is the (natural) log of the population of the city in which the worker is located, and takes value 0 when the worker is located in suburban or rural area. $Sharegraduates_{i(j)}$ is the share of workers of higher-education graduates; it is therefore the share of college and university graduates, in the city where the worker is located.
ε_j and μ_j are the error terms.

The earnings equation is estimated using instrumental variables method. $\overline{Com}_j$, $\overline{\log Pop}_j$ and $\overline{sharegraduates}_{i(j)}$ are the communication variables, size of the city and part of the educated instrumented in order to correct the bias of endogeneity. This bias is linked to the fact that wages depend on these variables but that these variables also depend on the wages: the best paid workers are led to communicate more, the biggest cities attract the most efficient and best paid individuals and the average education level also depends on local wages.

The direct effects of the local environment on earnings may be measured from these two relations. But chiefly, the indirect effects of this environment which go through the worker's level of communication may be measured by calculating $e_1 * b$ and $e_2 * b$. These are the effects we call externalities of communication.

COMMUNICATION IN THE WORKPLACE AND PRODUCTIVITY: DIRECT EFFECTS AND AGGLOMERATION EXTERNALITIES
Sylvie Charlot, INRA CESAER, Dijon, France
Gilles Duranton, Departement of Economy, University of Toronto, France
ISSN1778-4379, n°3–June 2006

Table 2 – Equations of communication and earnings

	Communication	***Earnings***
Method of estimation	OLS	Instrumental variables
Constant	-11.08	1.50
	(4.29)	(0.103)
Gender	-0.848[b]	-0.22
	(0.47)	(0.009)
Educ1	37.57	0.57
	(0.86)	(0.02)
Educ2	33.06	0.31
	(0.79)	(0.02)
Educ3	25.88	0.20
	(0.83)	(0.02)
Educ4	13.97	0.10
	(0.61)	(0.01)
Educ5	5.32	0.003 [ns]
	(0.84)	(0.02)
Age	1.13	0.07
	(0.19)	(0.004)
Age²	-0.01	-0.0006
	(0.002)	(0.00005)
Communication		**0.005**
		(0.0003)
Rural	1.33 [ns]	0.40
	(1.98)	(0.07)
Suburban	2.93 [ns]	0.42
	(2.19)	(0.08)
Logpop	**0.44** [a]	**0.036**
	(0.17)	(0.006)
Sharegraduates	**17.78**	**0.221** [b]
	(5.33)	(0.13)
Adj. R²	0.36	0.51
N. obs.	5309	5309
Sargan test (probability)		0.389

Notes. All coefficients significant at the 1% level except: [a] significantly different from zero at the 5% level, [b] at 10% and [ns] non significant.

Educ1 corresponds to university graduates, *Educ2* denotes college graduates, *Educ3* is for high-school graduates, *Educ4* is graduates from vocational schools, *Educ5* is for junior high-school graduates, *Educ6* corresponds to the absence of degree (our reference). The variable measuring the local education level, *Sharegraduates* is built from the 1999 Census of population in France. It corresponds to the share of college and university graduates (*Educ1* plus *Educ2*) in the area where the worker is located.

In the second column, *Communication* is instrumented by: the use (or not) of computer, to do some repetitive (or not) movements, the occupational status of the worker's father or mother. *Sharegraduates* and *log Pop* are instrumented by the city population in 1936, 1954, the birth rate in 1990 and the share of high-school graduates in 1968. For the whole instrumented variables, the exogeneity is strongly rejected and the instruments are not correlated with the error term.