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Environment and Planning A 2004, volume 36, pages 2033 – 2045

DOI:10.1068/a36207

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Received 27 August 2003; in revised form 23 January 2004

Abstract. This paper analyses the spatial heterogeneity of labour demand. Our main assumption is that for each location there is a combination of factors which is the most efficient, given the endowment of the location in terms of technology access and the relative cost of factors. We estimate our model using a panel of more than 1000 industrial firms over a six-year period. The contribution of skilled labour is emphasised in the firms located in urban areas, unskilled labour in rural firms, and capital in periurban units. The functional distribution of jobs also plays a discriminating role: direct production and similar functions seem to be more concentrated in periurban and rural areas, whereas tertiary functions are clearly assigned to urban units. We then make conclusions as to the existence of different technical paths of growth, with high productivity growth and a dramatic decline of demand for unskilled labour in urban areas, and the maintenance of a labour-intensive method of production in rural areas.

1 Introduction

Although the macroeconomic level of employment is still a fundamental issue for scientific enquiry and policymaking, it is now obvious that, for a given employment level, the spatial distribution of jobs also matters. The economic and social consequences of the creation or destruction of a hundred jobs are quite different depending on where this occurs. Likewise, the employment situation differs greatly between different spatial areas. For instance, in France employment patterns differ widely between urban and rural areas. From 1975 to 1999 urban areas fared better, with employment levels rising by 13%, as opposed to falling by 5% in rural areas, largely because of the decline of agriculture. But, at the same time, the substantial decline in industrial employment was less marked in rural areas, with a fall of 18%, as opposed to 35% in urban areas. This situation is not peculiar to France and one can observe similar results for other OECD countries: rural employment in industry either rose or, at least, did not fall as much as in urban areas (Bryden and Bollman, 2000; OECD, 1996).

But the pattern of labour demand from firms cannot be reduced to a single number of workers. What is often overlooked is the qualitative dimension of labour demand, or the structure of employment. In this respect too, rural employment appears to be structured differently to urban employment in that there are fewer skilled workers and a higher proportion of blue-collar workers (INSEE – INRA, 1998).

The aim of this paper is to analyse how and why labour demand differs between firms located in rural and urban areas. Spatial location matters in terms of employment levels and job structures. Moreover, the food industry provides a suitable empirical domain for describing the forms of spatial differentiation and for suggesting an explanation to the phenomenon. First, this sector represents more than 15% of industrial employment in France (Cohen-Solal, 1997). Moreover, with regard to spatial distribution, these activities are present in each category of area and are often the only significant source of jobs in a number of rural areas.

Our model is derived from the usual framework for labour-demand analysis (Hamermesh, 1993). We use a translog production function that includes three inputs: physical capital, skilled labour, and unskilled labour. We complete the empirical analysis by estimating production functions with more detailed labour-factor decomposition, based on two dimensions: skill and function. The increase in the number of factors requires the use of a simpler functional form.

We show that the contribution of skilled labour is emphasised in firms located in urban areas, unskilled labour in rural firms, and capital in periurban units. The functional distribution of jobs also plays a discriminating role: direct production functions seem to be of most importance in periurban and rural areas, whereas tertiary functions are clearly developed in urban units. All this suggests the existence of different technical paths of growth. High productivity growth and a dramatic decline in demand for unskilled labour occur in urban areas, whereas one can observe the maintenance of a labour-intensive method of production in rural areas.

Section 2 presents the theoretical framework, with some guidelines helping us to understand how and why labour demand should vary in relation to firms' spatial location, and especially between rural and urban firms. The data and some empirical issues are presented in section 3. Our econometric model and the estimation results are exposed in section 4. Part 5 is devoted to a more refined analysis of spatial differentiation in job structure, introducing the functional distribution of jobs. Concluding remarks complete the paper.

2 Some theoretical guidelines and assumptions about labour demand and space

Empirical facts clearly show that the level and structure of employment differ across space. In other words, the firm's labour demand differs in relation to its location. But why? In this part we first try to bring together some facts that have not received much attention within the theoretical literature. Then we suggest some assumptions and indicate a way to test our propositions.

2.1 Some theoretical guidelines

At the birth of the study of the spatial economy, Predöhl (1928) conceived a general theory of location of economic activities based on the principle of substitution:

> "every distinct location of every distinct process of production can be expressed as a distinct combination or composition of three particular groups of means of production. First, the land to be used changes with respect both to its quality and its situation ... . Second, all natural and cultural conditions may change requiring a different quantity of capital and labour ... ; the sociological conditions in general may affect the overhead expenses, etc. ... Third, the quantity and the quality of means of transportation" (page 380).

The location choice for production and the choice of a technical process amount to the same economic problem: to select from the different available methods of production the one which should be applied. Predöhl's solution to the location problem is based on the principle of substitution: if two methods are available to obtain the same result, the one chosen will be most cost efficient. Then, changing location means changing input combination and substitution between capital, labour, and means of transportation.

In industrial location history, each stage—from manufacture to neo-Fordist organisation—represents a different way of combining capital and labour in the production process. The shift that occurred in labour processes with the Fordist regime, based above all on the separation of conception and execution of tasks, allowed the multiplant companies to choose the location of each production unit in relation to

the labour endowment of the alternative sites. During that stage of spatial labour division, location is associated with labour requirements in quantity but also in quality (skill level and other characteristics) for any given level of output (Massey, 1984). For one country the pattern of location depends on the interactions between these requirements and the labour endowment inherited from its previous history. In particular, rural areas, with more traditional lifestyle, should have lower reproduction costs, and so low wage costs. Furthermore, rural workers should be better able to accept hard working conditions. This idea is very much like Predöhl's consideration of "sociological conditions in general".

Now, at a microeconomic level, attention tends to be concentrated upon the functional specialisation of plants and spaces in the case of multiplant firms. The recent increasing separation of firm activities is partly the result of the development of communication technologies. A typical large firm may keep its headquarters and business activities in a front office located in the city centre. The rest of its activities (office activities or manufacturing) are carried out at a back unit (office or plant) located in a remote area, and the two dimensions of activity can be connected by modern communications (Ota and Fujita, 1993). The firm gains an advantage in employment and in face-to-face communications with other business offices, without incurring urban congestion costs for its larger production units. Such a location choice, empirically observed for a large number of firms, affects the employment pattern of cities, which is itself what makes the organisational choice worthwhile (Duranton and Puga, 2001).

Let us consider the role played by the labour markets in the evolution of the spatial distribution of monolocalised firms. Distinguishing two types of workers, skilled and unskilled, Fujita and Thisse (2002) show that, when production externalities are big enough, skilled workers concentrate in one region. As a result, wages paid to unskilled workers will increase in this region. Wage heterogeneity, combined with immobility of labour, product a limit to the agglomeration (Krugman and Venables, 1995).

More precisely, the role of heterogeneous labour markets can be observed by considering a spatial system of one large metropolitan area and small rural areas surrounding the city, as in Jayet (2000). Workers are differentiated with respect to their skill and firms with respect to their technological level. Rural labour markets are monopsonistic, whereas the urban labour market is segmented in many competing firms with differentiated technological levels, looking for workers of differentiated skill levels. The highest productivity level is obtained in the case of perfect match between skill needed and the skill possessed by the employed worker. The driving force of location choice is the asymmetry between rural and metropolitan labour markets. Firms choose their location as a function of the profit level they can obtain, which is a function of their own technological level θ, the workers' skill level q available in the area, and fixed costs. The main effects that influence a firm's profitability can be described as follows.

1. As workers' productivity increases with q, the contribution of a q-skilled worker to the firm's profit increases with q. In other words, the higher the proportion of lower skill levels, the lower the profit of the firm.
2. As a firm needs one skill level q corresponding to θ, the higher the density of the labour force, the better the match between q and θ, and the higher the profitability.
3. A location in the urban area allows the firm to benefit from the urban externalities generated by the metropolis. In this case, its fixed costs are likely to be lower than in rural areas, with concordant higher profits.

These three effects imply a lower profit when the firm is located in a more remote rural area. At the same time, Jayet shows that highly skilled workers migrate to the

metropolis to earn more. So, as migration costs increase with distance, this migration implies lower profits when firms are close to the metropolis. Jayet concludes "whatever the balance among these effects, each rural area will have a labor force with few high-skill workers, which implies that the incentive to decentralize is likely to be stronger for firms producing at lower technological levels" (2000, page 406).

2.2 The urban–rural opposition: our assumptions and how to test them

Depending on the theoretical background, different mechanisms lead to a variation of the labour demand in relation to the firm location. To test this hypothesis we come back to the reduced representation of the firm, the production function:

$$Q = \mathrm{f}(K, L^{\mathrm{S}}, L^{\mathrm{U}}) \ .$$

A special point of interest is the combination of three factors: capital (K), skilled labour (L^{S}), unskilled labour (L^{U}). Surveying the numerous studies devoted to labour demand, Hamermesh (1993) studied substitution and/or complementarity effects between those three inputs. He concluded that capital and unskilled labour, as well as skilled labour and unskilled labour, are generally substitutable, and a certain complementarity appears between capital and skilled labour. But he also showed that results can differ according to the period and/or the economic activity.

According to the theoretical guidelines, we can conjecture that matching between production technology and labour demand would produce results that differ between urban and rural firms. More precisely, we can make the following assumptions:
(a) in a general sense, labour demand and the associated upstream production function can differ between rural and urban groups of firms because of the available state of technology and the relative costs of factors;
(b) with respect to the spatial division of labour, rural firms should employ more unskilled workers and use lower technological levels than urban firms. Moreover, the substitution of capital by the unskilled labour market would be more intense in urban than in rural firms.

In order to observe substitution and/or complementarity between different factors, we use a flexible translog form,

$$\begin{aligned}\ln Q = {} & C + a_{\mathrm{K}} \ln K + a_{\mathrm{S}} \ln L^{\mathrm{S}} + a_{\mathrm{U}} \ln L^{\mathrm{U}} + a_{\mathrm{KK}} (\ln K)^2 \\ & + a_{\mathrm{SS}} (\ln L^{\mathrm{S}})^2 + a_{\mathrm{UU}} (\ln L^{\mathrm{U}})^2 + a_{\mathrm{KS}} \ln K \ln L^{\mathrm{S}} \\ & + a_{\mathrm{KU}} \ln K \ln L^{\mathrm{U}} + a_{\mathrm{SU}} \ln L^{\mathrm{S}} \ln L^{\mathrm{U}} \ ,\end{aligned}$$

where C is a constant and the a are coefficients. Then, we estimate this form for different samples composed of firms located in specific areas in order to observe how the estimates and associated values vary, as elasticities.

3 Data and some empirical issues

3.1 Data

In order to estimate the forms, we use data on individual firms that have been combined from two separate surveys conducted by INSEE (the French office of statistics). The first survey is the *Enquête Annuelle d'Entreprise* (annual firm survey). It provides a complete set of economic results for each firm, that is, the nonlabour arguments of the production function, but very little information about employment. The *Enquête sur la Structure des Emplois* (employment structure survey) provides a good measure of job structure. Practically, in the employment structure survey, jobs are classified according to different overlapping levels. The most aggregated is composed of six positions and is based mainly upon the skill level criterion, and we use it

to distinguish between unskilled workers (namely the categories 'clerks' and 'blue-collar workers') and skilled workers (other categories).

To specify the firm's spatial location, we use a typology constructed by INSEE and complemented by the National Institute for Agricultural Research (INRA), which classifies the 36 551 French communes into basic categories depending on the intensity of their relations with cities (INSEE – INRA, 1998). We construct three aggregated positions: *urban*, *periurban*, and *rural*. By periurban we mean areas between suburbs of urban centres and remote rural areas. One of their major characteristics is the importance of commuting to urban centres. More precisely, urban areas include urban units that offer 5000 jobs or more, periurban communes have at least 40% of their resident active population working in one or several urban units. Rural areas include all the communes that belong to neither of the previous categories.

The sample of individual firms covers the period 1987 – 92. We chose to use a pooled sample for technical convenience despite the economic consequences of the sampling technique. We are aware that in doing so we capture only one part of the labour demand, whereas two dimensions actually exist (Davis et al, 1996); labour demand through existing plants, and labour demand related to the birth or death of production plants. We end up with a sample of 1336 firms, composed of 658 urban firms, 162 periurban firms, and 516 rural firms. We focus our analysis on monoplant firms.

3.2 Some empirical issues

Before estimating production functions, simple statistics allow us to analyse the contribution of each factor to the productivity level, by observing in the case of each kind of area:

(1) the mean level of production growth during the period,

(2) the corresponding share between employment growth and a rise in labour-productivity levels.

If we first consider the whole population, from 1987 to 1992, production (measured by value added, in volume) increased by 17%. This led to a labour-productivity gap of 26%, while there was a 7% fall in employment. Capital intensity (in volume) rose by 68% over the same period. These major trends were common to industrial firms in the 1980s and 1990s: a significant upturn in activity being accompanied by a no less significant decline in employment. The obvious reason for this is the existence of high productivity gains (about 4% per annum), clearly resulting from substitution of capital for labour. This is not only a mechanical connection but also a strategic one; in some sense productivity gains and the associated cost reductions are presented as the only way to survive. In this light, the point of our investigation is to observe whether there was a difference in the way the firms coped with this 'productivity constraint'.

Looking now at the results by area, we find that activity grew a great deal in periurban and rural cases: both 30% against 11% in the urban area. At the same time, productivity increased dramatically in the urban and periurban areas (30% against 20% in the rural area), with, as a mechanical result, growth of employment in rural areas, stability in periurban areas, and a large decline in urban areas. Table 1 (over) summarises the situation. Case 3 (the urban area) correspond to a fall in employment, case 4 (the periurban area) to stability, case 2 (the rural area) to growth (8% in our sample area). Case 1 would correspond to the unpooled part of the sample, because these are firms with a high probability of going out of business. All cases other than case 1 concern firms that survived from 1987 to 1992, and this is perhaps the most interesting result: firms managed to survive by responding to the productivity – employment dilemma in different ways. It seems plausible to consider that several ways to produce can exist in different kinds of spatial area.

Table 1. The employment–productivity dilemma.

Productivity trend	Activity trend	
	low	high
Low	no survival 1	rural 2
High	urban 3	periurban 4

4 Input combination and firm location

The estimated form is

$$\ln Q_{it} = C + a_{\mathrm{K}} \ln K_{it} + a_{\mathrm{S}} \ln L_{it}^{\mathrm{S}} + a_{\mathrm{U}} \ln L_{it}^{\mathrm{U}} + a_{\mathrm{KK}} (\ln K_{it})^2 + a_{\mathrm{SS}} (\ln L_{it}^{\mathrm{S}})^2 + a_{\mathrm{UU}} (\ln L_{it}^{\mathrm{U}})^2 + a_{\mathrm{KS}} \ln K_{it} \ln L_{it}^{\mathrm{S}} + a_{\mathrm{KU}} \ln K_{it} \ln L_{it}^{\mathrm{U}} + a_{\mathrm{SU}} \ln L_{it}^{\mathrm{S}} \ln L_{it}^{\mathrm{U}} + e_{it} \ ,$$

for firm i observed at period t, where e_{it} is an error term. Although we use panel data, several econometric models can be estimated: the plain ordinary least squares (OLS) model, and between model, the within model, and the variance components generalised least squares (GLS) model (Matyas and Sevestre, 1992). For each we make appropriate assumptions as to the error term structure and the existence of an individual effect. In the within case we assume that there is an individual effect, which is a fixed one:

$$Y_{it} = a_i + bX_{it} + u_{it} \ .$$

In the GLS we assume that the individual effect is a random one, affecting the error term:

$$Y_{it} = bX_{it} + \alpha_i + u_{it} \ ,$$

where

$$u_{it} \cong \mathrm{N}(0, \sigma_u^2) , \qquad \alpha_i \cong \mathrm{N}(0, \sigma_\alpha^2) , \qquad \mathrm{E}(\alpha_i, u_{it}) = 0.$$

A number of tests have to be performed in order to verify the previous assumptions. These tests lead us to accept the assumption of a fixed individual effect, but to reject the assumption of a random individual effect. More precisely, the Hausman test concludes that the assumption of independence between the α_i and the X_{it} should be rejected. For these reasons, OLS, between, and GLS estimators are biased and inconsistent. We also use the Bhargava et al (1982) test for possible autocorrelation in the fixed-effect model and conclude that there is no autocorrelation.

We then complete the estimation by using instrumental variables. As instruments, we use the deviations from the mean of the capital, the labour, and of the crossed variables completed by some dummy variables. These variables indicate in particular the type of subsector of the firm, the existence of exportation (yes or no), the positive stock variation (yes or no). Our set of instruments is acceptable according to the standard Sargan test. Some other tests were carried out in relation to our functional form. These reject the assumption that crossed and quadratic terms are equal to 0. The translog form appears to be superior to the Cobb–Douglas.

4.1 The all-population estimation: classical results and a test of a spatial production structure

Before discussing the spatial differences, let us make some general comments on estimates using the whole population. Our estimates are in accordance with the related literature (see, for instance, Griliches and Mairesse, 1990; Mairesse, 1988). The capital

Table 2. Calculated elasticities from the all-population estimation.

	OLS	Between	Within	GLS	IV
C	6.491 (37.39)	6.424 (17.77)		6.700 (28.73)	7.124 (8.63)
σ_K	0.315 (56.55)	0.312 (28.43)	0.268 (21.28)	0.317 (39.50)	0.312 (11.51)
σ_S	0.303 (39.66)	0.330 (21.54)	0.102 (6.90)	0.226 (21.76)	0.411 (17.16)
σ_U	0.431 (53.67)	0.418 (26.67)	0.509 (27.45)	0.473 (40.10)	0.446 (18.58)
a_{KS}	0.006 (2.13)	0.010 (1.66)	−0.005 (−1.34)	−0.001 (−0.22)	−0.020 (−1.67)
a_{KU}	−0.070 (−8.34)	−0.068 (−3.83)	−0.050 (−3.67)	−0.070 (−6.56)	−0.314 (−5.64)
a_{SU}	−0.035 (−6.72)	−0.044 (−3.90)	−0.011 (−1.53)	−0.019 (−3.20)	−0.085 (−3.18)

$N = 1336$, $T = 6$. Statistical value of Sargan test for IV estimation 2.57 ($p = 0.28$).

Note. OLS—ordinary least squares. GLS—generalised least squares. IV—instrumental variables. t-statistics are given in parentheses. The calculated elasticity, σ, is directly presented for each input.

elasticity is about one third, while the labour elasticity (considered here as the sum of skilled and unskilled labour elasticities) is about two thirds (table 2). The scale returns appear to be slightly greater than 1. Comparison between the different estimators shows a certain stability, with the exception of one point: the skilled labour estimate significantly decreases in the case of the within estimator, and unskilled labour estimate significantly increases. Our explanation is that some unobserved variables are omitted in our model: for example, the manager's ability or the quality of management. These variables are probably correlated with our labour variables (positively with skilled, negatively with unskilled). The within estimator, introducing the individual fixed effect, is the only one that controls for the effect of such variables and then provides estimates that correct the corresponding biases.

Crossed terms must also be carefully analysed. The most robust result concerns the capital × unskilled labour parameter a_{KU}, which is significantly negative. This is a common result because those two inputs are clearly substitutable. The same situation prevails when we consider the skilled × unskilled labour combination, although the effect is not as marked. Our results do not allow a conclusion in the case of capital × skilled labour: the estimates are not significant, although some values suggest substitutability. With the exception of the last point, all these results are consistent with those surveyed in a classical reference such as Hamermesh (1993). Capital and unskilled labour, and skilled and unskilled labour are substitutable, and some forms of complementarity are observed between capital and skilled labour.

We provide a Chow test on the stability of parameters when spatial desegregation is introduced between urban, periurban, and rural firms. The comparison of the calculated statistic (3,43) to the tabulated value of $F(18, \infty)$ lead us to reject the assumption of parameter stability between subsamples. So we can consider the next step, which is devoted to estimations by area.

4.2 Estimation by area: urban versus rural firms

Introducing the comparison between the different spatial samples, we first consider the elasticity values (table 3, over). The skilled labour elasticity is much higher in the urban firm subsample than anywhere else, whichever estimator is considered. This is also the case for unskilled labour elasticity in the rural firm subsample. These results are consistent with our hypotheses: the urban production process is essentially based on skill labour, and the rural one on unskilled labour. As a result, a variation in skilled labour has a greater influence on the production of the urban areas, whereas a variation in unskilled labour has a greater impact on the production of the rural area. The case of

Table 3. Calculated elasticities: comparison of spatial samples

	OLS	Between	Within	GLS	IV
(a) Urban firms					
C	6.532 (28.47)	6.568 (13.66)		6.523 (20.02)	13.341 (8.65)
σ_K	0.325 (40.83)	0.324 (19.73)	0.255 (14.80)	0.319 (28.23)	0.444 (7.39)
σ_S	0.316 (29.31)	0.339 (15.01)	0.126 (6.18)	0.244 (16.66)	0.451 (10.88)
σ_U	0.396 (34.48)	0.375 (16.22)	0.477 (18.83)	0.450 (26.89)	0.306 (6.70)
a_{KS}	0.007 (1.53)	0.009 (0.88)	−0.004 (−0.53)	0.001 (0.28)	−0.147 (−5.50)
a_{KU}	−0.058 (−4.16)	−0.065 (−2.05)	−0.031 (−1.51)	−0.042 (−2.58)	−0.317 (−4.21)
a_{SU}	−0.036 (−4.15)	−0.039 (−2.04)	−0.019 (−1.61)	−0.026 (−2.56)	0.157 (3.23)
$N = 658$, $T = 6$					
Statistical value of Sargan test for IV estimation: 0.3454 ($p = 0.8414$)					
(b) Periurban firms					
C	7.045 (11.88)	6.84 (5.65)		7.545 (9.31)	6.094 (0.74)
σ_K	0.299 (18.97)	0.282 (8.74)	0.301 (10.14)	0.317 (14.99)	0.211 (3.45)
σ_S	0.263 (12.43)	0.306 (7.08)	0.048 (1.17)	0.169 (5.92)	0.445 (4.87)
σ_U	0.483 (22.86)	0.508 (11.78)	0.497 (10.37)	0.475 (15.90)	0.376 (4.90)
a_{KS}	−0.0009 (−1.13)	−0.001 (−0.44)	−0.021 (−1.50)	−0.018 (−1.86)	−0.064 (−1.07)
a_{KU}	−0.124 (−4.21)	−0.105 (−1.53)	−0.150 (−4.00)	−0.139 (−4.36)	0.078 (0.51)
a_{SU}	0.005 (0.43)	−0.015 (−0.58)	0.034 (2.08)	0.025 (1.88)	0.002 (0.03)
$N = 162$, $T = 6$					
Statistical value of Sargan test for IV estimation: 3.8179 ($p = 0.1482$)					
(c) Rural firms					
C	6.320 (19.31)	6.039 (8.87)		6.637 (15.70)	5.639 (5.83)
σ_K	0.315 (34.17)	0.312 (18.09)	0.255 (10.95)	0.311 (23.16)	0.309 (8.74)
σ_S	0.266 (19.74)	0.295 (11.21)	0.095 (3.75)	0.202 (11.28)	0.348 (6.24)
σ_U	0.476 (33.62)	0.461 (17.07)	0.611 (17.76)	0.525 (25.84)	0.609 (12.82)
a_{KS}	0.011 (2.32)	0.020 (1.74)	0.003 (0.57)	0.005 (1.02)	−0.002 (−0.20)
a_{KU}	−0.076 (−6.04)	−0.077 (−3.10)	−0.035 (−1.53)	−0.007 (−4.11)	−0.373 (−4.68)
a_{SU}	−0.057 (−5.31)	−0.072 (−2.95)	−0.037 (−2.84)	−0.044 (−3.86)	−0.116 (−5.07)
$N = 516$, $T = 6$					
Statistical value of Sargan test for IV estimation: 0.0056 ($p = 0.9402$)					

Note. OLS—ordinary least squares. GLS—generalised least squares. IV—instrumental variables. t-statistics are given in parentheses. The calculated elasticity, σ, is directly presented for each input.

capital elasticity is not so clear. By using the within estimator, we obtain the highest value in the periurban firm case, whereas the elasticity for urban firms is the greatest when we use instrumental variables. This suggests a distinction between equipment levels, where urban firms still dominate, and investment flows, where periurban firms tend to be more active.

If we now consider the crossed terms, we first obtain a very significant coefficient in the capital × unskilled labour case. All the estimates are significantly negative so the substitutability between those two factors can be assumed for all firms, wherever they locate. This is not the case for capital × skilled labour where we obtain nonsignificant crossed terms in all subsamples. The skilled × unskilled labour term is the only one to exhibit a spatial difference: substitutability appears for both the urban and the rural firms, but not for periurban ones.

Table 4 synthesises all these results. One has to remember that the elasticities are by far the most significant, whereas the crossed term coefficients are often weak, except for the capital × unskilled labour coefficient. In the urban area, skilled labour plays the main role, whereas in the rural case, unskilled labour is largely predominant. All these results are consistent with our starting assumptions. Periburban activity is a

Table 4. Synthesis of results for inputs and areas.

	Urban	Periurban	Rural
Major input contribution	skilled labour	capital	unskilled labour
Input combination			
capital × skilled labour	not significant	not significant	not significant
capital × unskilled labour	substitution	substitution	substitution
skilled × unskilled labour	substitution	not significant	substitution

particular case, and is more difficult to analyse. The firms located in these areas seem to be characterised by the importance of capital, especially in terms of trends. At the same time, the absence of substitution between the skilled and the unskilled population stresses the apparent specialisation within this area.

We explained all these spatial differences as being caused by differences in techniques of production. Nevertheless, another explanation, based on differences in products could be given. Some firms (remember we work on monoplant firms) can choose their location for reasons linked to market access, either to sell the outputs or to buy the inputs. For instance, a milk firm could have advantages in locating close to mile producers in a rural area. In practice, 49% of the food firms locate in urban areas but only 33% of milk firms, and only 43% of meat firms. By contrast, an industrial bakery is more likely to locate in an urban area, to be close to consumers: 73% of industrial bakeries locate in urban areas, and also 57% of beverage firms. These few figures suggest a difference by product. The question is now to find out if this difference leads to a difference in labour demand. Indeed, if one needs low-skilled workers and the other needs more skilled workers, then the spatial differentiation is a question of products and not of production techniques. The demand for skilled workers by meat firms is lower than the mean demand obtained in the whole sample (13% against 19%), and the demand by beverage firms is the highest (27%). But, at the same time, the demand by industrial bakeries is the lowest (11%), and the demand by milk firms is average. Grain firms, homogeneously spatially distributed, have a high demand for skilled workers (24%). It seems that the link between spatial difference in product and spatial difference in skilled worker demand is not so obvious and that the question of differences in production techniques also has to be considered.

5 The spatial differentiation of job structure

In the previous section, we used a robust but rough representation of labour, distinguishing only between skilled and unskilled labour. It was the price to pay in order to keep translog forms tractable. But labour demand (and by the way, its spatial differentiation too) has to be considered at a narrow level. In previous work (Huiban, 1994), we introduced the following idea: job structure must be analysed in two dimensions. The usual vertical differentiation according to skill level (for example, management versus workers) must be complemented by a horizontal differentiation. This is a functional differentiation: for example, production versus administrative management. It means that labour structure can also be used as an indicator of firm organisation, which is not captured by the single binary distinction between skilled and unskilled labour. The distinction between the (urban) firm head-office and the (rural or periurban) production plant, introduced by Ota and Fujita (1993) or Duranton and Puga (2001), could be captured by the use of our functional differentiation.

Consequently, one answer to our starting question is to identify within the different job categories the ones that play the main role inside an urban (rural) firm organisation.

We propose the following production function:

$$Q = f(K, L^*) .$$

In order to built L^* we first desegregate the labour factor:

$$L = \sum_{j=1}^{j=N} L_j ,$$

where L_j is the level of employment corresponding to job category j. Each job category corresponds to a skill level associated with a function. Then inside the production function we weight each job category with its relative marginal productivity (Griliches, 1969):

$$L^* = \sum_j p_j L_j , \qquad p_j = \frac{\partial Q}{\partial L_j} \Big/ \frac{\partial Q}{\partial L_0} ,$$

that is, the relative marginal productivity of the category with regard to the marginal productivity of the basic category (unskilled workers), which is equal to 1, by convention.

Indeed, because of the number of job categories, the translog form is no longer tractable. So, we use a Cobb–Douglas function, which is more restrictive, because it assumes a perfect substitutability between job categories. Algebraic transformations lead to the following form:

$$\ln \frac{Q}{L} = C + \alpha \ln \frac{K}{L} + (\alpha + \beta - 1) \ln L + \beta \sum_j (p_j - 1) a_j + \gamma t ,$$

where a_j is the proportion of job j in the overall employment level L. The relative marginal productivity of each job category can be written $p_j = 1 + \hat{b}_j / \beta_j \hat{b}_j$, where $\hat{b}_j$ is the estimated coefficient associated with the exogenous variable of the category a_j.

As in the previous estimations, we successively estimate the form on different samples composed of firms located in specific areas. To simplify the tables, we report in the appendix only the estimated coefficients for job structure, that is, $\hat{b}_j$.

A quite logical hierarchy can be observed in all econometric models except in the within one [table A1(a)]. Estimates are positive, that is, the relative productivity of the category is greater than the productivity of the basic category, unskilled workers. We also observe an increase with skill level, in the following order: skilled blue-collar workers, administrative office workers, administrative and commercial intermediate categories, administrative managers, engineers and technical managers, and salaried company heads. As we said before, the within estimator, introducing the individual fixed effect, shows a lower contribution from skilled workers and a higher combination from unskilled workers and leads to nearly homogeneous contributions to productivity from all categories.

The role of salaried company heads in production seems to be highest in rural firms [table A1(d), OLS, between, and within estimators]. In these firms, in addition to the boss, the technical manager (for example, engineer) holds a major role, whereas the contribution to productivity from administrative and commercial management is smaller. Tertiary functions are not developed inside an organisation design which looks hierarchical. Periurban firms display the opposite profile and the company head's contribution is much smaller [table A1(c), OLS, between, and within estimators]. Their production process seems to be built on engineers and technical management and on intermediate categories, such as technicians. Management appears to be a technical story devoted to highly skilled but also medium-skilled categories. At the same time, urban firms are in a different situation with a greater impact of tertiary functions, such as corporate administration [table A1(b), OLS, between, and within estimators]. A high

level of skill employed in a variety of functions characterises this kind of area. In an attempt to construct a comprehensive analysis, we could say that, between the different areas, a given function is not exerted at the same skill and hierarchical level. In rural firms, technical functions concern mainly the management level, whereas administration and commercial functions concern primarily intermediate categories, or even clerks, but are generally underdeveloped. In periurban firms the technical functions are the major ones and involve intermediate categories as well as management. Urban firms are those where tertiary functions are the most developed and exercised by the most highly skilled employees. The importance of skilled labour as emphasised in the previous section can be thus confirmed but has to be taken into account according to a set of functions.

The contribution of blue-collar workers to productivity also has to be considered: there is a significant difference between skilled and unskilled workers both in urban and in rural areas, but it is not the case in periurban areas. In this case, heavy equipment and a significant contribution of technical intermediate categories lead to a lack of skill differentiation within blue-collar workers. On the contrary, the relative contributions differ both in the urban areas, where high skill labour is most important, and in the rural ones, where low-skill labour plays a major role. Substitution between skilled and unskilled labours matters in the case of urban firms (where it has happened) and for rural firms (where it is still to come), but doesn not matter in the single case of periurban areas.

The introduction of the functional dimension completes the results of the previous section, concerning the use of factors. In rural firms unskilled labour plays the major role, devoted to direct production functions: the labour-intensive production process still dominates. We observe the opposite in urban areas, with a high skill level devoted especially to management and tertiary functions, while the human part has decreased in the direct production. Periurban still appears as a special case, where the intensity of capital is accompanied by the importance of technical functions, and where skill does not appear to play a discriminating role.

6 Conclusion

In this paper we have analysed the spatial heterogeneity of labour demand, on the basis of production functions, estimated at urban, periurban, and rural levels. We assumed that for each location there is a combination of factors which is the most suitable, given the endowment of this location and the relative cost of factors. Using spatial economics as a guide to analysis, we derived hypotheses about the spatial differentiation of firms' strategies. In a second step we introduced a detailed desegregation of the labour factor, that takes into account the functional distribution of jobs in the firm as well as the skill level.

Our results indicate that production process takes different forms according to the spatial context.

(1) In urban areas a massive technology effect appears through the part of it embodied in equipment and above all skill. The importance of nonproductive and especially tertiary functions reflects what looks like a *front-office effect*. The demand for this kind of job increases while the number of unskilled jobs decreases, particularly productive ones.

(2) It remains efficient to follow a different technical path in rural areas. Production is apparently more 'labour intensive', maintaining demand for unskilled labour, or even skilled labour, but within the blue-collar population.

(3) The question of the periurban firms still remains open. The different points developed in this paper suggest that this type of area has to be considered as a specific case,

more than an intermediary step between urban and rural cases. The installation of heavy equipment, mostly managed by technically intermediate categories, appears to be the major tendency. Surprisingly, this tendency is not accompanied by any kind of substitution between skilled and unskilled labour.

This paper could be improved in different directions, among which is the econometric specification. The first problem concerns a selection bias, especially if a balanced panel is used, because the firm decision to exit or to maintain its activity depends greatly on its performance and especially on its productivity level. The second problem is a simultaneity bias: the choice of input level affects the productivity level, but input demand also depends on the expected level of this productivity. Olley and Pakes (1996) give some interesting tracks to follow to solve these questions.

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APPENDIX

Table A1. Job structure estimation results (unskilled blue-collar workers are the reference category; *t*-statistics are given in parentheses).

	OLS		Between		Within		GLS	
(a) Total sample								
Salaried company heads	2.201	(9.45)	2.677	(5.39)	0.407	(1.25)	1.277	(4.69)
Administrative managers	0.890	(7.84)	0.905	(3.89)	−0.296	(−1.51)	0.670	(4.57)
Engineers and technical managers	1.326	(8.17)	1.537	(4.50)	−0.272	(−1.13)	0.821	(4.21)
Administrative and commercial intermediate categories	0.803	(14.47)	0.917	(8.19)	−0.187	(−1.83)	0.465	(6.27)
Technicians	0.968	(5.47)	0.978	(2.79)	0.060	(0.18)	0.904	(3.71)
Foremen	0.217	(2.05)	0.286	(1.30)	−0.335	(−2.003)	0.050	(0.38)
Administrative office workers	0.587	(6.63)	0.569	(3.13)	0.022	(0.15)	0.499	(4.42)
Skilled blue-collar workers	0.044	(2.02)	0.032	(0.73)	0.050	(1.30)	0.069	(2.37)
$N = 1336$, $T = 6$								
(b) Urban firms								
Salaried company heads	2.075	(6.49)	2.307	(3.21)	1.009	(2.41)	1.534	(4.24)
Administrative managers	0.920	(6.20)	0.943	(2.94)	−0.119	(−0.49)	0.684	(3.66)
Engineers and technical managers	1.116	(5.04)	1.179	(2.43)	0.118	(0.36)	0.871	(3.28)
Administrative and commercial intermediate categories	0.646	(8.54)	0.738	(4.59)	−0.138	(−1.08)	0.332	(3.39)
Technicians	1.165	(4.08)	1.179	(1.93)	0.234	(0.51)	1.020	(2.82)
Foremen	0.314	(2.10)	0.470	(1.48)	−0.460	(−1.96)	−0.073	(−0.39)
Administrative office workers	0.783	(6.47)	0.860	(3.26)	0.068	(0.37)	0.515	(3.46)
Skilled blue-collar workers	0.083	(2.48)	0.070	(1.08)	0.111	(1.86)	0.115	(2.54)
$N = 658$, $T = 6$								
(c) Periurban firms								
Salaried company heads	1.111	(1.82)	1.829	(1.45)	−1.408	(−1.57)	−0.162	(−0.22)
Administrative managers	0.569	(2.16)	0.580	(1.10)	−0.402	(−0.85)	0.419	(1.23)
Engineers and technical managers	1.296	(3.37)	1.622	(2.11)	−0.690	(−1.10)	0.583	(1.20)
Administrative and commercial intermediate categories	0.770	(4.48)	0.915	(2.77)	−0.829	(−2.07)	0.297	(1.21)
Technicians	1.016	(2.19)	1.044	(1.09)	0.111	(0.16)	0.865	(1.53)
Foremen	−0.279	(−1.06)	−0.410	(−0.78)	−0.029	(−0.07)	−0.011	(−0.04)
Administrative office workers	−0.252	(−1.04)	−0.371	(−0.79)	−0.153	(−0.32)	−0.09	(−0.03)
Skilled blue-collar workers	−0.182	(−3.36)	−0.193	(−1.86)	−0.115	(−1.08)	−0.151	(−2.03)
$N = 162$, $T = 6$								
(d) Rural firms								
Salaried company heads	2.584	(6.22)	3.552	(4.20)	−0.059	(−0.10)	1.12	(2.29)
Administrative managers	0.737	(3.08)	0.720	(1.55)	−0.599	(−1.40)	0.519	(1.67)
Engineers and technical managers	1.599	(5.35)	2.019	(3.26)	−0.541	(−1.27)	0.883	(2.55)
Administrative and commercial intermediate categories	1.064	(10.99)	1.236	(6.67)	−0.131	(−0.66)	0.669	(5.17)
Technicians	0.763	(2.94)	0.773	(1.64)	−0.401	(−0.66)	0.736	(1.90)
Foremen	0.233	(0.13)	−0.059	(−0.16)	−0.244	(−0.85)	0.086	(0.38)
Administrative office workers	0.475	(3.11)	0.360	(1.23)	−0.002	(−0.01)	0.496	(2.49)
Skilled blue-collar workers	0.071	(2.06)	0.051	(0.76)	0.048	(0.82)	0.096	(2.18)
$N = 516$, $T = 6$								