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ABSTRACT

The Matching Efficiency of Regional Labour Markets A Stochastic Production Frontier Estimation, France 1990-1995*

We evaluate the determinants of matching efficiency changes through a stochastic Cobb-Douglas production frontier model extended to allow the efficiency coefficient to depend on variables meant to capture workers and firms characteristics. We apply this methodology to examine regional disparities in France over the period 1990-1995. About 30% of the efficiency changes observed over time and some 25% of the cross regional differences can be explained in terms of changes in firms and workers characteristics. Regional differences in matching efficiency are fairly stable over time and negatively correlated to the regional unemployment rates.

JEL Classification: J64, C24

Keywords: Matching efficiency, regional unemployment, stochastic frontier

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1 Introduction

Since the mid-seventies, unemployment rates have remained at abnormally high levels in many EU countries. Typically, the rise in unemployment coincided with a deterioration in the relationship between unemployment and vacancies (an outward shift of the so-called Beveridge curve). The magnitude of these increases and shifts varies substantially across countries, and even more so across regions (see EC (1999), part I, section IV).

Beveridge curve shifts can be analysed and interpreted in terms of search behaviours and the matching of unemployed workers and vacant jobs (Pissarides (1990); see also the survey of by Petrongolo and Pissarides (2001)). The matching process is usually represented by a *matching function*, typically a Cobb-Douglas with constant returns to scale. The flow of hirings is the output, the stock of job vacancies and of unemployed workers are the two inputs. The unemployment and vacancy rates remain unchanged from one period to the next if and only if hirings exactly compensates separations (quits and layoffs) and labour force growth. In this case, the matching function can be recast as a Beveridge curve. At given matching efficiency, a higher separation or labour force growth rate must be compensated by a higher hiring rate, which can be achieved if and only if there are more inputs in the matching process, *i.e.*, larger vacancy and unemployment rates. The Beveridge curve is like an isoquant that indicates all the combinations of the inputs (unemployment and vacancies) that yield a certain flow of hirings.

From this viewpoint, a Beveridge curve shift may either reflect a declining matching efficiency, or be the result of larger separation or labour force growth rates implying larger reallocation and matching efforts. It is thus interesting to try and evaluate whether changes in the matching efficiency may contribute to explain Beveridge curve differences observed over time and across regions. Several authors have examined this question by estimating aggregate or disaggregated (across regions or occupations) matching functions (see for instance Blanchard and Diamond (1989, 1990) and Anderson and Burgess (2000) for the US economy, Coles and Smith (1996) for England, Entorf (1998, chap.3) for Germany, Gorter and van Ours (1994) for the Netherlands, Maillard (1997) and Agullo (1999) for France, etc...). Our paper addresses the very same issue, with special emphasis on the regional dimension. We follow Warren (1991) and model the matching function as a *stochastic production frontier* model. Because the matching function is usually interpreted as a production function, this approach seems most natural. In Warren (1991), it was used to estimate the frictional unemployment rate in US manufacturing. More recently, Ibourk and Perelman (2000) used a more elaborated frontier model proposed by Battese and Coelli (1995) to identify the factors that may explain matching efficiency differences across regional labour markets in Marocco. We apply the same methodology to reexamine the issue of regional disparities in France over the period 1990-1995.

The contribution of matching efficiency changes to observed unemployment rate changes remains a debated issue. Blanchard and Diamond (1989, 1990) estimate a matching function on aggregate US data over the 1968:2-1981:12 period. They obtain a negative trend effect. The latter cannot be explained by long term unemployment. Their conclusion is that efficiency changes contribute to explain unemployment changes at low frequencies; at high frequencies, aggregate activity shocks rather than efficiency changes (reallocation shocks) dominate the movement of unemployment. van Ours estimates a matching function on Dutch data over the period 1961-1987. The estimated matching efficiency is negatively related to changes in the replacement ratio and long term unemployment. It remains quite stable over time, except for an unexplained decrease in the late sixties. Gorter and van Ours (1994) examine regional differences across the Dutch economy in the eighties. They obtain substantial regional differences (the normalised efficiency levels vary from 1 to 2). These differences seem to be barely significant though, and not related to long term unemployment or occupational mismatch. Maillard (1997) obtains similar results for France over the period 1974-1994. Over a smaller period (1990:1-1994:12) and with a richer data set, Agullo (1999) obtains regional differences that can be related to structural variables like long term unemployment, skill mismatch, proportion of old workers or permanent contracts, etc... These results suggest that regional differences do matter. The main difference between her paper and ours is methodological. The use of the stochastic frontier approach allows a more detailed analysis of the determinants of regional matching efficiencies.

We start in Section 2 with a brief presentation of the model and the estimation technique. The data are presented in section 3, the empirical results in section 4. Our main conclusions are gathered in section 5.

2 The Model

Let the matching process be represented by the following function:

$$H_{it} = F(V_{it-1}, U_{it-1}) \,.\, e_{it} \qquad \text{with } F_u, F_v > 0\,. \tag{1}$$

The flow of hirings in region i at time t, denoted H_{it}, is a positive function of the initial stock of job vacancies V_{it-1} and the initial stock of unemployed workers U_{it-1}, times the efficiency parameter e_{it}. With constant returns to scale, (1) can also be written as follows:

$$\frac{H_{it}}{U_{it-1}} = f(\frac{V_{it-1}}{U_{it-1}}) \,.\, e_{it}\,, \tag{2}$$

i.e. the proportion of unemployed workers hired per unit of time is a positive function of the tensions prevailing on the labour market, measured by the ratio of vacancies and unemployment, weighted by the efficiency parameter e_{it}. By definition, the rate of growth of employment is equal to the hiring rate $h_{it} \equiv H_{it}/N_{it-1}$ minus the separation rate s, that is:

$$\frac{\Delta N_{it}}{N_{it-1}} = h_{it} - s\,. \tag{3}$$

If function $F(.)$ displays constant returns to scale and employment growth is equal to labour force growth g (that is, the hiring rate is equal to the sum of the separation and the labour force growth rates: $h_{it} = s + g$), equation (1) can be recast as an inverse relationship between the unemployment and the vacancy rates, the so-called Beveridge curve. In this setup, the position of the Beveridge curve would depend on s, g and the value of the efficiency parameter e.

The matching process is usually compared to a production process. It seems most natural in this context to write the empirical model to (1) as a stochastic production frontier model. The concept of *technical efficiency* has been used for a long time in theoretical analyses of firms' behaviour. Debreu (1951) and Farrell (1957) define the technical efficiency of a firm as one minus the maximum equiproportional input reduction compatible with an unchanged output. If we let the production frontier be the envelope defined by these efficient input combinations, the technical efficiency of the firm is measured by the distance between the observed input-output combination and the one given by the production frontier (Shephard (1953)). These concepts are illustrated in figure 1. The efficiency at point A is equal to the ratio OB/OA.

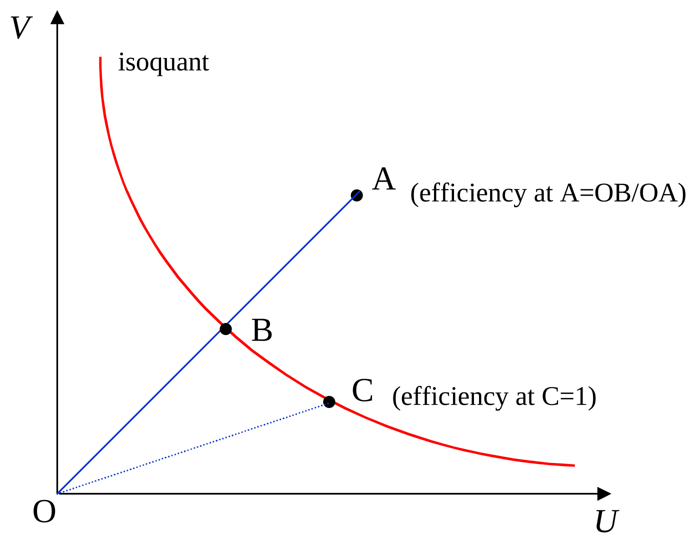

Figure 1: The efficiency frontier in the V-U space

If function $F(.)$ is, as it is usually assumed, a Cobb-Douglas function, a standard representation of the stochastic model to be estimated would then be:

$$\log H_{it} = [\alpha + \beta_1 \log V_{it-1} + \beta_2 \log U_{it-1} + \upsilon_{it}] + \log e_{it}\,. \tag{4}$$

The bracketed term corresponds to (the log of) function $F(.)$. The random term υ_{it} is assumed to be iid $N(0, \sigma_v^2)$. With a production frontier specification, the efficiency parameter e_{it} is constrained to be smaller than or equal to one. In many stochastic frontier models, the efficiency term (the log of e_{it}) is defined as a stochastic variable with half-normal distribution, as in Aigner et al. (1977). In our case, it seems more appropriate to allow the expected value of e_{it} to vary both over time and across regions as a function of observed characteristics. Efficiency can be seen as the product of two factors, one measuring the rate at which job-seekers and employers meet, the other the probability that a contact leads to a successful match (see for instance van Ours (1991), Anderson and Burgess (2000)). The former reflects search intensities and is affected by variables like the replacement ratio, unemployment duration, age and gender, etc... The latter depends on firms and workers choosiness and is affected by the same variables; it also depends on the degree of correspondence between workers and jobs characteristics, on skill requirements, firms size and type of activity (manufacturing vs services, e.g.), etc... Let Z_{it} represent the vector of variables capturing the characteristics of firms and workers in region i at time t, and assume that e_{it} can be written as a linear function of these variables[1]. The empirical model would then be written as follows:

$$\log H_{it} = [\alpha + \beta_1 \log V_{it-1} + \beta_2 \log U_{it-1} + \upsilon_{it}] + [Z_{it}\,\delta + \epsilon_{it}] \tag{5}$$

instead of (4). The second bracketed term corresponds to (the log of) the efficiency parameter e_{it}. To impose the constraint that e_{it} be smaller than or equal to one, we follow Battese and Coelli (1995) and define the random term ϵ_{it} by the truncation of the normal distribution with zero mean and variance σ^2, with truncation point at $-Z_{it}\,\delta$, that is we impose:

$$\epsilon_{it} \;\leq\; -Z_{it}\,\delta\,. \tag{6}$$

The half-normal distribution specification obtains as a particular case for $\delta \equiv 0$. The model with stochastic individual effects corresponds to the case where no truncation is imposed and Z_{it} is a set of regional dummies. If furthermore $\sigma \equiv 0$, one obtains the "fixed effects" model. The parameters of the stochastic frontier and those of the efficiency effect can be estimated jointly by maximising the log-likelihood of the model. The latter is expressed in terms of $\sigma_T^2 = \sigma_\upsilon^2 + \sigma^2$ and $\gamma = \sigma^2/\sigma_T^2$. The estimated parameters yield conditional estimates of the regional efficiency coefficient: $\hat{e}_{it} = \mathrm{E}\left[e^{Z_{it}\,\hat{\delta}+\hat{\epsilon}_{it}}|H, V, U, Z\right]$.

3 Data

We estimate the stochastic frontier model on French panel data, covering twenty-two regions over the period 1990:3 till 1995:2. Data sources are given in appendix 2. Variable H_{it} (hirings) is defined as the number of unemployed job seekers in region i who found a job in period t. V_{it-1} is the stock of all unfilled vacancies (including temporary jobs) at the end of period $t-1$ registered with the public employment agency (ANPE); U_{it-1} the stock of unemployed workers looking for a permanent full-time job at the end of period $t-1$ registered with ANPE. It is worth

[1]Differences in search behaviour between different groups of workers -for instance short term *vs* long term unemployed workers- is often taken into account by splitting total unemployment into its various components and writing the matching function as for instance $\log H_{it} = \alpha + \beta_1 \log V_{it-1} + \beta_2 \log \left(\sum_j (1 + c^j)\, U_{it-1}^j\right) + \upsilon_{it}$ for instance. This presentation is essentially equivalent to (5) when, in our example, Z_{it} is defined as the proportion of long term unemployed workers in total unemployment. See appendix 1 for details

emphasising that in February 1995 e.g. only one third of all filled vacancies were permanent full-time jobs, while most unemployed workers who found a job were registered as looking for a permanent job (more than 93%). In other words, it seems that although almost all unemployed workers apply for a permanent full-time job, a majority of them accepts temporary and/or part-time jobs. From this point of view, it seems preferable to include both temporary and permanent (part-time and full-time) job offers in the definition of V_{it}[2].

The across region average values of labour market tensions (measured by V/U) and of the proportion of unemployed workers who find a job during the month (H/U) are reproduced in the left panel of figure 2. Not surprisingly, both variables display wide seasonal fluctuations. From 1990:3 till 1993:2, there is a clear downward trend in the probability of finding a job (as measured by H/U). There is no similar trend for labour market tensions, at least after 1990. The contrast between the two suggests a declining "matching efficiency". The right panel of figure 2 gives some information about regional differences. It illustrates the correlation observed between (the log of) hiring probabilities ($\ln(H/U)$) and (the log of) labour market tensions ($\ln(V/U)$) across regions in February 1995. There is a slightly positive correlation and a slope coefficient approximately equal to 0.37. The regions that are above the line look *a priori* more efficient. This exercise of course remains much too simple. It imposes constant returns to scale; it fails to exploit the time-series information and to control for the many factors which may affect matching efficiency (the Z variables).

To explain matching efficiency differences both over time and across regions, we thus introduce variables meant to capture the characteristics and behaviours of firms and unemployed job seekers. Among unemployed job seekers, we distinguish young workers (< 25), older workers (> 50), immigrants, skilled workers (defined by their former occupation: supervisors, technicians and managerial workers), women and long-term unemployed workers (>1 year). The size of each

[2] We neglect interregional migration, which seems to play a modest role in France, at the region level (see Petrongolo and Wasmer (1999)). We also neglect the impact of on-the-job search. This is compatible with our definition of hirings -which does not include job-to-job flows-; it may however bias the parameter estimates if employed workers compete with unemployed ones for the vacancies posted at the national agency. See for instance Anderson and Burgess (2000), Broersma and van Ours (1999). Interregional comparisons remain unbiased as long as the relative importance of on-the-job search does not vary across regions or is accounted for by the turnover variable.

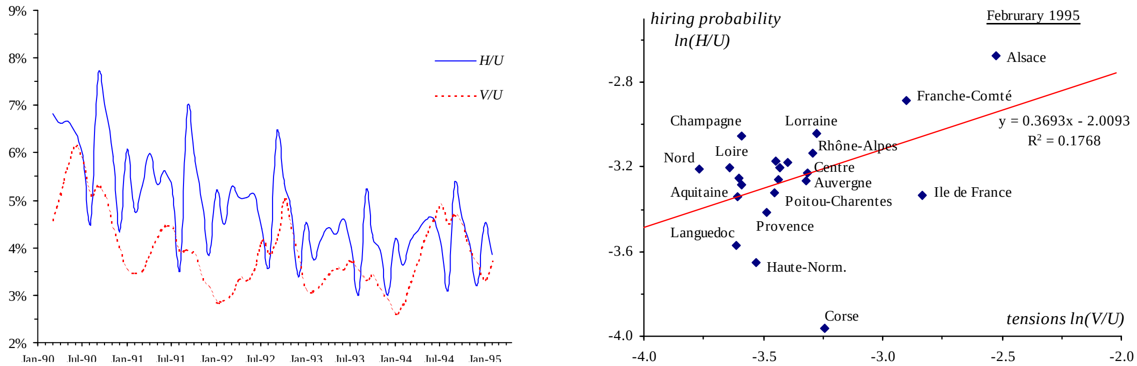

Figure 2: Labour market tensions (V/U) and hiring probabilities (H/U) over time (left; national averages) and across regions (right; February 1995)

group is measured in percentage points of total unemployment (see appendix for a brief justification). Differences between these groups may reflect different search intensities and/or willingness to accept received job offers (willingness to accept a temporary job, e.g.). Effects coming from firms size or type of activity will be proxied by the turnover rate and the proportion of permanent (as opposed to temporary) job offers. Firms behaviour may also change with growth (both across regions and over the cycle), for instance because growth may change the relative cost of screening job applicants. Such changes may affect short- and long-term unemployed workers differently (see for instance Lockwood (1991)). The net employment growth variable is meant to capture this type of influence. We control for direct effects of special employment programmes on the exit rate by introducing among the Z variables the proportion of unemployed workers going into special employment programmes (more specifically, *stages*; see appendix 1 for a brief justification). Finally, population density is meant to capture effects coming from the density of economic activities and the probability that a contact is established between the right employer and employee. The same variable may of course capture different effects simultaneously. For instance, the proportion of long term unemployment may capture both business cycle effects and more structural difficulties (firms behaviour, disenfranchisement and/or skill or occupational mismatch e.g.). To the extent that services will be relatively less important in rural areas e.g., the population density variable may capture effects related to the type of economic activity as well as effects coming from "market thickness".

The national average values of the most relevant variables are reproduced in figure 3. Some of

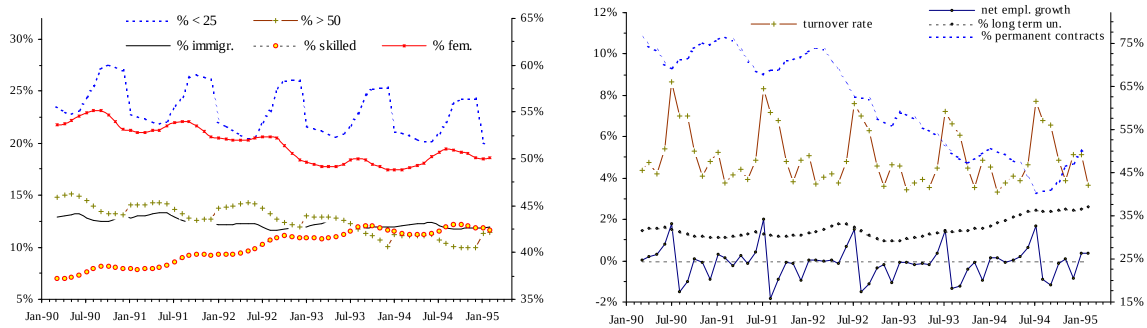

Figure 3: Unemployed worker characteristics (left) and other factors (right) potentially correlated with efficiency; the variables *% fem. workers* -left panel-, *% long term un.*, and *% permanent contracts* -right panel- are measured on the right scale; all values represent national averages

these variables have pronounced seasonal fluctuations. A few features are worth pointing out. The proportion of both young and older workers in unemployment decreases over time, which implies that the proportion of middle-aged unemployed workers increases. The proportion of unemployed female workers is first decreasing, next increasing. Quite surprisingly, the proportion of skilled workers has been steadily increasing in the early nineties (see Goux and Maurin (1993)) and remained high afterwards. The proportion of immigrants remains stable at the aggregate level (there may of course be substantial differences across regions). Finally, we observe after 1992-93 an increase in the share of long term unemployment and a pronounced decrease in the proportion of unfilled vacancies offering a permanent contract.

4 Results

The model is estimated with the *Frontier* programme of Coelli (1992), under the assumption that the residuals are *iid*. Monthly dummies are added alongside the constant term of the matching function, to capture the effects of purely seasonal fluctuations in the flows of hirings and the stocks of vacancies and job seekers. The estimated efficiency coefficient will thus be free of seasonal effects. For coherency, we must eliminate the purely seasonal components that may be present in the Z variables. This was done (for each region separately) by first regressing each Z variable on a time trend and monthly dummies and next eliminating the monthly effects when significant. The Z variables also include a constant term (on top of the one included in the frontier definition; see equation (5)) and a trend common to all regions. We further allow for non-linear population density effects by including a quadratic term.

Parameter Estimates

The main estimation results are reported in table 1. Model 1 gives the results obtained by unrestricted estimation over the entire sample (22 regions from 1990:3 till 1995:2). The elasticities of hirings with respect to unfilled vacancies and unemployment are both positive and quite significantly different from zero. As in other studies where hirings are defined as unemployment-to-job flows (see table 1 of Broersma and van Ours (1999)), the unemployment elasticity is estimated to be much larger than the vacancy elasticity (0.80 against 0.21). Most variables used to explain efficiency have *t-stat* values well above two, except for the time trend, the proportion of older workers, the proportion of skilled workers and net employment growth, which have small, statistically non-significant effects. The significant variables have a sign that is easily interpretable (a positive sign means a positive effect on efficiency). A larger proportion of young workers, of immigrants and/or of female job seekers increases the probability of matching. This may reflect different degrees of choosiness, for instance because these groups are more willing to accept temporary jobs, which represent a substantial fraction of total vacancies. In the same vein, one obtains that a larger percentage of permanent contract offers increases matching efficiency. The turnover variable has a positive significant effect, which may capture sectoral effects (firms size, type of activity and work organisation, ...). Long term unemployment has a negative effect, as expected. Special employment programmes have a positive effect on the flow of hirings. As in Coles and Smith (1996), geographic density seems to affect hiring probabilities. The estimated population density coefficients imply a concave relationship between efficiency and density. Except for the *Ile de France* region where the estimated effect is close to zero[3], population density has a positive, sizeable effect on efficiency: population density is estimated to generate an efficiency increase of about 33% in the *Nord-Pas de Calais* region (the most densely populated

[3]Population density (hundreds of inhabitants per square kilometre) reaches its lowest values in Corse (0.29), Limousin (0.42) and Auvergne (0.51), its largest values in Alsace (1.98), Nord-Pas-de-Calais (3.20) and Ile-de-France (9.01). Its average value is (1.3).

region after *Ile de France*) in comparison with the least densely populated areas.

The estimated vacancy and unemployment elasticities of Model 1 imply barely increasing returns to scale (1.01). The constant returns-to-scale restriction (Model 2) is easily accepted and leaves the parameter estimates almost unchanged. It is worth pointing out that removing the quadratic term from the specification of the density effect leads to a return-to-scale coefficient estimate that is statistically significantly larger than 1. Increasing returns to scale imply that *ceteris paribus* larger regions should have larger hiring-to-unemployment ratios, or lower matching efficiencies. Because the size (U and V) and density variables are strongly correlated (for instance the *Ile de France* region is by far the largest region -19% of total (un-)employment- and also the most densely populated one -about seven times the average density-), larger estimates of the return-to-scale parameter may well compensate an inappropriate representation of the density effect. In any case, disentangling return-to-scale and density effects is potentially problematic.

Model 3 in table 1 shows that when the *Ile de France* region is excluded from the sample, the return-to-scale coefficient increases to 1.03. Reestimating the constrained model shows that the constant return-to-scale hypothesis is rejected at the 5% level but accepted at the 1% level. Most parameter estimates remain essentially unchanged though. The population density effect has the same amplitude as before. With the *Ile de France* region excluded, the effect remains positive over the entire range of values considered, this time with a marked convex rather than concave shape. Comparing these results with those of Model 1 suggests that the relatively low matching efficiency of the *Ile de France* labour market is not be explained by our variables.

We pointed out when presenting the data that some of them have quite different patterns before and after 1993. To check for parameter stability, we reestimated the unrestricted model over the subperiod 1993:3 till 1995:2 (which reduces the number of observations from 1320 to 528). The results are presented as Model 4 in table 1. There are two main changes: (i) a significantly positive and sizeable trend effect, combined with a lower unemployment elasticity (the number of unemployed job seekers increases steadily over the entire sample period); (ii) a larger vacancy elasticity implying significantly increasing returns-to-scale, combined with a significantly negative density effect. These findings seem to reflect a multicollinearity problem that becomes especially acute in our reduced sample, as well as the difficulty to explain the low

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Unrestricted 1990:3-1995:2	CRS restr. 1990:3-1995:2	Ile de France excluded	Sub-period 1993:3-1995:2	Preferred 1990:3-1995:2
constant	−1.9368 (0.1210)	−1.8621 (0.0629)	−2.1179 (0.1218)	−2.5280 (0.1564)	−1.8852 (0.0545)
Vacancies (logarithm)	0.2096 (0.0208)	0.2020 (0.0183)	0.2241 (0.0216)	0.3759 (0.0276)	0.1948 (0.0167)
Unemployment (logarithm)	0.7995 (0.0188)	0.7980 –	0.8057 (0.0178)	0.6975 (0.0239)	0.8052 –
+ 11 *monthly dummies*					
constant	−3.0376 (0.2621)	−3.1158 (0.2379)	−3.0537 (0.2535)	1.9891 (0.8835)	−3.0211 (0.1754)
trend	0.0009 (0.0009)	0.0009 (0.0008)	0.001 (0.0009)	0.0198 (0.0042)	
% < 25 years[a]	0.0285 (0.0042)	0.0291 (0.0042)	0.0342 (0.0052)	0.0619 (0.0128)	0.0308 (0.0031)
% > 50 years[a]	−0.0012 (0.0098)	−0.0001 (0.0063)	0.0029 (0.0064)	−0.0279 (0.0208)	
% immigrants	0.0145 (0.0027)	0.0146 (0.0026)	0.0147 (0.0034)	−0.0141 (0.0086)	0.0138 (0.0024)
% skilled workers	−0.0051 (0.0037)	−0.0036 (0.0032)	0.0013 (0.004)	0.0277 (0.0104)	
% female workers[a]	0.0300 (0.0037)	0.0302 (0.0038)	0.0263 (0.004)	−0.0622 (0.0194)	0.028 (0.0031)
% long-term unemployment	−0.0140 (0.0024)	−0.0134 (0.0023)	−0.0128 (0.0026)	−0.0512 (0.0073)	−0.0127 (0.0021)
% permanent contracts	0.0017 (0.0007)	0.0016 (0.0006)	0.0024 (0.0007)	0.0036 (0.0022)	0.0015 (0.0005)
turnover rate[a]	0.0461 (0.0079)	0.0474 (0.0067)	0.0505 (0.0069)	0.0631 (0.0197)	0.0453 (0.0057)
net employment growth[a]	−0.0192 (0.0121)	−0.0191 (0.0125)	−0.0158 (0.0151)	−0.0053 (0.0346)	
% *stages*[a]	0.0813 (0.0152)	0.0809 (0.0155)	0.0726 (0.0153)	0.0335 (0.0174)	0.0772 (0.0108)
population density	0.1569 (0.0257)	0.1639 (0.0199)	−0.0908 (0.0474)	−0.2144 (0.1005)	0.1564 (0.0190)
squared pop.density	−0.0166 (0.0026)	−0.0172 (0.0019)	0.0522 (0.0110)	0.0191 (0.0095)	−0.0167 (0.0019)
σ_T^2	0.0269 (0.0012)	0.0269 (0.0012)	0.0260 (0.0013)	0.0184 (0.0018)	0.0275 (0.0013)
γ	0.5915 (0.1496)	0.5778 (0.1492)	0.5959 (0.1564)	0.2616 (0.0661)	0.6428 (0.1236)
log-likelihood	545.32	545.03	540.82	341.12	536.99 [b]

[a] Purely seasonal fluctuations are eliminated by regression on monthly dummies

[b] Model 5 includes five zero restrictions on the monthly dummies, and four on the efficiency coefficients

Table 1: Estimation results (dependent variable: log of hirings; standard errors between parentheses)

matching efficiency observed in the *Ile de France* region, which is likely to bias the returns-to-scale and population density coefficient estimates. Except for the proportion of female workers, the other explanatory variables have coefficient estimates that broadly support the earlier findings. Standard errors are of course substantially larger.

Matching Efficiency Estimates

The parameter estimates can be used to compute the conditional expectation of the efficiency coefficient e_{it}. We use the parameter estimates reported as Model 5 in table 1, that is, after imposing on Model 1 all the zero restrictions that are accepted by the data. The distribution of efficiency scores across regions is illustrated in figure 4.

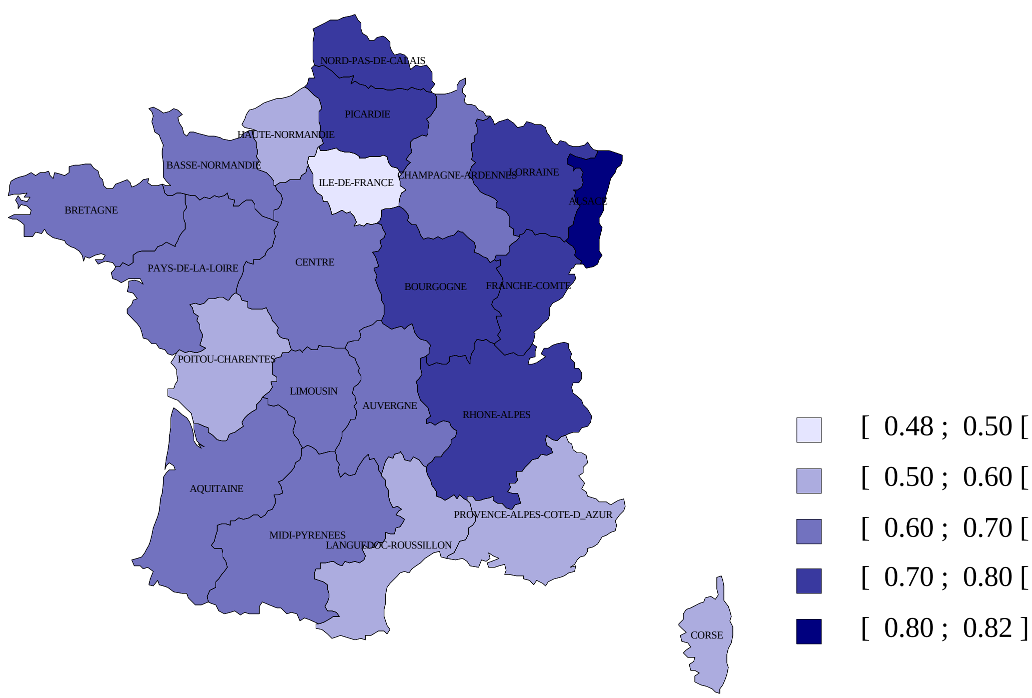

Figure 4: Regional distribution of efficiency scores (average over all observations)

The average, min and max values obtained in March of every year (February in 1995) are reproduced in the left panel of figure 5. The figure illustrates how large cross-regional differences can be and how average efficiency has changed over time. In 1990, matching efficiency values ranged from a minimum of around 0.63 in *Ile de France* to a maximum of around 0.95 in *Alsace* and *Franche-Comté*. From March 1990 till February 1995, the average matching efficiency decreased from 0.80 to 0.53. Half of this loss took place in the early nineties. The right panel of figure 5 gives more information on the ranking of regions. It also illustrates the relationship between efficiency and unemployment performance. The figure is drawn for February 1995. Similar figures can be constructed for the other periods. The ranking of regions remains actually extremely stable over time (the correlation between the 1990 and the 1995 rankings is 0.77)[4]. The figure suggests, as one would expect, a negative relationship between matching efficiency and unemployment (the absolute value of the correlation coefficient is 0.51, rising to 0.71 when *Ile de France* and *Corse* are not included).

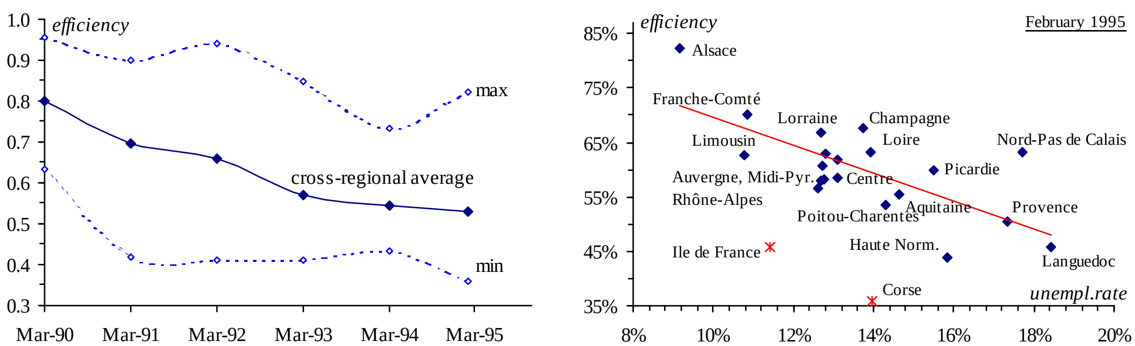

Figure 5: Efficiency changes over time (left) and across regions (right; February 1995)

In order to evaluate the extent to which our Z variables contribute to explain efficiency changes both over time and across regions, table 2 compares the values of gross *vs* net efficiency estimates. *Gross efficiency* refers to the value obtained when all Z variables take their actual values; *net efficiency* refers to the value obtained when the Z variables are set at a fixed value, equal to their sample (regions and months) average. Table 2 summarises the differences between gross and net estimates region by region and year by year.

We first compare regions. One way to evaluate the contribution of the Z variables is by comparing average gross and net efficiencies. The ratio of the two variables (x 100) is given in the

[4]The five regions with the best ranking (in terms of average gross efficiency) are (starting with the best): Alsace, Franche-Comté, Nord-Pas de Calais, Lorraine, Rhône-Alpes. The five regions with the worst average ranking are (starting with the worst): Ile de France, Haute-Normandie, Languedoc, Corse, Provence.

column “Ratio” of table 2. A value above 100 indicates that the region benefited on average from relatively good characteristics (Z values), and conversely for values below 100. The correlation between this ratio and average gross efficiency is 0.91, *i.e.*, the most efficient regions are those who on average benefit from the best characteristics. The value of the ratio varies between 106 in *Alsace* and 91 in *Ile de France*, which are also the regions with respectively the highest and the lowest efficiency record. Comparing gross and net average efficiency in these two regions shows that the Z variables explain about one third of the difference between the average gross efficiency of the two regions (.09 out of .33). In a given region, gross efficiency may of course vary over time, because of changes in the Z values themselves or because of changes in the unobserved residual (the residual term ϵ_{it} in equation (5)). The last three columns of table 2 give some information about the temporal variability in each region of the gross to net efficiency ratio, more precisely the difference between gross and net efficiency in percentage points of the former. The mean of that variable is approximately equal to that of the variable “Ratio” minus 100. A simple way to evaluate the contribution of the Z variables to the temporal variability of gross efficiency is by comparing the sample standard deviation of gross and net efficiency. The column “Variability” of table 2 shows that in all cases but one (*Corse*) fixing the Z variables reduces the temporal variability. The reduction is on average equal to 29% of the standard deviation of gross efficiency. Finally, one can easily check that the ranking of regions is about the same for gross and net efficiency (rank correlation coefficient 0.99). This suggests that the regions with the best characteristics (higher $Z\delta$ values) are also those who are “intrinsically” performing better in terms of matching efficiency (have higher mean ϵ values), as one would expect if the most dynamic regions are also those who have a larger proportion of young workers and /or a lower proportion of long term unemployment *e.g.*

If we now focus on differences observed over time rather than across regions (from 1990 till 1995; see lower part of table 2), we see (column “Ratio”) that the trend decrease in gross efficiency is in part due to trend changes in the Z variables (more precisely in the value of the linear combination $Z\delta$). Comparing changes in gross and net efficiency (the first two columns of table 2) from 1990 till 1995 suggests that about 30% of the decline (.053 out of .180) is related to changes in the values of the Z variables. The column “Variability” indicates that in every year some 25% of the cross-regional variability of efficiency is related to cross regional differences in

	Matching Efficiency Estimates				Difference Gross-Net Efficiency (in % of gross efficiency)			
	Gross (average)	Net (average)	Ratio gross/net	Variability $100(\sigma_g - \sigma_n)/\sigma_g$	Mean	Min.	Max.	sd
Regions								
Alsace	0.82	0.77	106	0.18	5.2	−1.0	10.6	3.1
Aquitaine	0.63	0.64	98	0.33	−2.1	−7.5	3.7	3.3
Auvergne	0.62	0.64	96	0.18	−3.8	−8.4	1.6	2.5
Basse-Normandie	0.66	0.66	100	0.34	−0.1	−7.0	5.5	3.3
Bourgogne	0.71	0.70	101	0.43	0.9	−6.7	6.7	4.0
Bretagne	0.7	0.69	101	0.32	0.4	−5.2	5.4	2.8
Centre	0.64	0.64	100	0.38	−0.3	−7.5	6.2	3.9
Champagne	0.69	0.70	99	0.33	−1.1	−7.9	4.7	3.9
Corse	0.56	0.60	93	−0.09	−7.2	−13.0	2.3	3.1
Franche-Comté	0.78	0.76	102	0.41	1.6	−5.6	9.8	4.2
Haute-Normandie	0.53	0.54	98	0.37	−2.8	−10.4	5.4	4.5
Ile-de-France	0.49	0.53	91	0.14	−9.7	−17.1	−3.0	3.8
Languedoc	0.53	0.56	95	0.32	−5.8	−12.1	2.6	3.8
Limousin	0.60	0.61	98	0.19	−2.0	−5.8	2.8	1.9
Lorraine	0.74	0.73	101	0.38	0.7	−5.9	6.7	3.6
Midi-Pyrénées	0.63	0.65	97	0.35	−3.5	−10.4	3.4	3.7
Nord-Pas de Calais	0.76	0.76	101	0.27	0.6	−5.9	5.0	3.2
Pays de la Loire	0.67	0.67	100	0.45	−0.3	−7.5	6.4	3.4
Picardie	0.73	0.74	99	0.24	−1.4	−7.4	2.9	3.4
Poitou-Charentes	0.59	0.61	96	0.27	−4.7	−11.5	1.9	3.2
Provence	0.58	0.61	95	0.30	−5.1	−11.4	2.5	4.0
Rhône-Alpes	0.73	0.72	102	0.38	1.6	−5.9	9	4.3
average	0.65	0.66		0.29				
Years								
1990	0.77	0.75	103	0.25	2.6	−7.3	10.6	3.5
1991	0.72	0.70	101	0.30	1.0	−8.8	10.0	3.8
1992	0.66	0.67	99	0.25	−1.4	−13.0	8.3	4.0
1993	0.58	0.60	96	0.25	−4.0	−14.3	9.8	3.8
1994	0.57	0.60	95	0.18	−5.7	−17.1	2.6	3.5
1995	0.59	0.62	95	0.17	−5.5	−14.8	1.6	3.3
All								
	0.65	0.66	99	0.32	−1.8	−17.1	10.6	4.8

Table 2: Estimated Efficiency Coefficients

the Z variables.

Table 3 gives information about the individual effects of the most important Z variables. The first three columns indicate the range of values taken by the variable (corrected for seasonal effects), the last five columns indicate its contribution to efficiency changes. The last column ("Variability") shows how much the variability (across regions and years) of the estimated efficiency coefficients is affected when the value of a Z variable is kept fixed at its sample mean. In all cases but one (proportion of immigrants) fixing the value of a Z variable reduces the variability of the estimated efficiency coefficients. Another and more interesting way of looking at the contribution to efficiency of a given Z variable is by computing marginal effects (see Frame and Coelli (2001)). Marginal effects calculated at the sample mean are reported in the fourth column of table 3. The marginal effect measures the efficiency change (in percentage points) obtained by increasing the corresponding Z variable by one percentage point. For instance, a 5 percentage points decrease in the proportion of young workers in the pool of unemployed job seekers (from 25% to 20% say, which is the order of magnitude of the change observed from 1990 till 1995) would *ceteris paribus* decrease efficiency by 3.35 percentage points (5x0.67); a 6 percentage points increase in the proportion of long-term unemployment (as observed at the national level from 1990 till 1995) would decrease efficiency by 1.68 percentage points. Similarly, the huge decrease observed in the proportion of permanent job offers after 1990 (from 75% to 45% at the national level) may have contributed about 1 percentage point (30x0.03) to the estimated efficiency decline.

Actual marginal effects are however non-linear and depend on the initial efficiency level. An increase in the proportion of young workers would thus have a much lower impact on efficiency in *Alsace* (where the initial efficiency level is already high) than in *Ile-de-France* (where it is low). The next two columns of the table (columns "Min" and "Max") report the range of variation of the estimated efficiency coefficient when the corresponding Z variable varies around its sample mean. For instance, observed changes (across regions and time) in the proportion of young unemployed workers (from 16.4% to 33.7%) generate up to 14.2 percentage points changes in the estimated matching efficiency. Altogether, Table 3 shows that the proportion of young workers and of female workers in the pool of unemployed workers as well as the turnover

	Explanatory Variables (values in percentage points)			Efficiency Effects			
				marginal	total		variability
	Mean	Min	Max	mean est.	Min	Max	$100(\sigma_g - \sigma_n)/\sigma_g$
% < 25 years	27.8	16.4	33.7	0.67	−9.6	4.6	0.11
% immigrants	9.8	2.3	30.4	0.30	−2.7	7.2	−0.02
% female workers	52.5	44.4	63.1	0.61	−6.2	7.2	0.10
turnover rate	4.7	1.0	11.0	0.99	−4.5	7.3	0.00
% long term un.	31.6	18.7	42.9	−0.28	−3.9	4.0	0.04
% perm. contracts	57.0	17.8	90.7	0.03	−1.5	1.2	0.03
% *stages*	1.3	0.0	3.5	1.68	−2.7	4.2	0.03
population density	1.3	0.3	9.0	3.41	−3.6	3.9	0.03
All variables					−17.1	10.4	0.32

Table 3: Individual variable contributions to estimated efficiency

rate have quite sizeable effects. The effect of the other variables, although smaller, is far from negligeable.

5 Conclusions

In this paper, we used a *stochastic production frontier* specification of the matching function to estimate regional matching efficiencies. The latter are a function of explanatory variables meant to capture workers and firms characteristics. Our empirical findings suggest that average matching efficiency has decreased in the early nineties; about 30% of this decrease can be traced back to changes in the composition of the pool of unemployed job seekers. There are also wide differences across regions, reflecting in part (for about 25%) differences in the characteristics of firms and workers. These regional differences in matching efficiency are fairly stable over time and negatively correlated to the regional unemployment rates.

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Appendix 1 Heterogeneity and Aggregate Matching

When different groups of workers have different search efficiencies, the aggregate matching function will be written as:

$$H_t = \alpha' \, V_{t-1}^{\beta_1} \left(\sum_j (1 + c^j) \, U_{t-1}^j \right)^{\beta_2} ,$$

where the c^j's can be interpreted as deviations from average search efficiency (if all groups of workers have identical search efficiency, $c^j = 0 \forall j$). Rearranging the terms will yields:

$$\begin{aligned} H_t &= \alpha' \, V_{t-1}^{\beta_1} \left(U_{t-1} + \sum_j c^j \, U_{t-1}^j \right)^{\beta_2} , \\ &= \alpha' \, V_{t-1}^{\beta_1} \, U_{t-1}^{\beta_2} \left(1 + \sum_j c^j \, \frac{U_{t-1}^j}{U_{t-1}} \right)^{\beta_2} . \end{aligned}$$

In logs:

$$\begin{aligned} \log H_t &\approx \alpha + \beta_1 \, \log V_{t-1} + \beta_2 \, \log U_{t-1} + \beta_2 \, \sum_j c^j \, \frac{U_{t-1}^j}{U_{t-1}} , \\ &\approx \alpha + \beta_1 \, \log V_{t-1} + \beta_2 \, \log U_{t-1} + \sum_j \delta_j \, \frac{U_{t-1}^j}{U_{t-1}} . \end{aligned}$$

The effects of special employment programmes on the flow out of unemployment will be taken into account by generalising the previous specification as follows:

$$\begin{aligned} H_t &= \alpha' \, V_{t-1}^{\beta_1} \left(\sum_j \left(1 + c^j + \varphi^j \, P_t \right) U_{t-1}^j \right)^{\beta_2} , \\ \log H_t &\approx \alpha + \beta_1 \, \log V_{t-1} + \beta_2 \, \log U_{t-1} + \sum_j \delta_j \, \frac{U_{t-1}^j}{U_{t-1}} + \delta_p \, P_t , \end{aligned}$$

where P_t measures the size of such programmes (for instance the number of workers taking training positions in percentage points of total unemployment) and φ^j its impact on the search efficiency of type j workers. The effect of P_t on total unemployment outflows ($\delta_p = \beta_2 \sum_j \varphi^j \, (U_{t-1}^j / U_{t-1})$) may vary over time with the composition of the unemployment stock.

Appendix 2 Data Definitions and Sources

The period covered by the analysis goes from March 1990 till February 1995. The data are published by the French National Institute of Statistics (INSEE). Except for population density (hundreds of inhabitants per square kilometre, regional population estimate of January 1, 1992), all data are available for each of the twenty-two regions of France on a monthly basis.

The stock of unemployed job seekers (U_{it-1}) is defined by the number of unemployed workers registered with the National Employment Agency (ANPE) at the end of the previous month and looking for a full-time permanent job (so-called *category 1* jobs). The flow of hirings (H_{it}) is measured by the number of these unemployed job seekers who found a job during the month, be it the seeked *category 1* job or a part-time and/or temporary job (so-called *category 2* and *category 3* jobs). To be consistent with this definition of hirings, the stock of unfilled vacancies (V_{it-1}) includes all three categories of jobs registered with ANPE at the end of the previous month. The ratio between the stock of unfilled vacancies of categories 1 and 2 and the total stock of unfilled vacancies defines the proportion of permanent job offers.

The monthly variables describing the regional composition of unemployment (by age, sex, skill, nationality and duration) and the size of special employment programmes (number of unemployed workers entering special employment programmes -*stages* for young or long-term unemployed persons- during the month) are collected by ANPE. These figures relate to *category 1* unemployed workers.

Information about hirings and separations (for various reasons : resignation, retirement, dismissal, end of contract, death) is obtained from an administrative source called *déclaration des mouvements de main d'œuvre* (DMMO). These administrative forms have to be filled by all private and semi-public firms employing at least fifty workers with a normal job contract. This category includes the so-called *contrats de qualification* and *contrats d'adaptation*; it excludes all interim workers as well as the beneficiaries of special professional training programmes (*stagiaires de la formation professionnelle*). They are used here to compute monthly hiring and separation rates on a regional basis. The sum of these two rates defines the turnover rate; their difference gives a measure of net employment growth (as a percentage of the total number of wage-earners at the beginning of the month).

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