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Do Internal Labour Markets Survive in the New Economy? The Case of France[♣]

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Abstract

Following the adoption of information and communication technologies (ICT), firms may react to increasing skill requirements either by training or hiring the new skills, or a combination of the two.Using matched datasets with about 1,000 French plants, we assess the relative importance of these external and internal labour market strategies. We show that skill upgrading following technological and organisational changes takes place mostly through internal labour markets adjustments. Consistently with the results in the literature, we find that the intensive use of ICT is associated with an upward shift in the occupational structure within firms. We show that about one third of the upgrading of the occupational structure is due to hiring and firing workers from and to the external labour market, whereas two-thirds are due to promotions. Moreover, we find no compelling evidence of external labour market strategies based on "excess turnover". In contrast, French firms heavily rely on training in order to upgrade the skill level of their workforce. When looking at potential heterogeneity across firms in skill upgrading strategies, we find that all firms rely much more on promotions than on external movements in order to shift their occupational structure upward. In contrast, different training patterns are found across sectors: the use of ICT is strongly correlated with training for all occupational groups in manufacturing sectors, whereas this is not the case in services. This difference is robust to controlling for other sources of heterogeneity and may be explained by the fact that labour turnover is much higher in services than in manufacturing.

Keywords: Technical change; labour turnover; skill bias; training; internal labour markets.

JEL codes: J23; J24; J41.

Introduction

It has been more than a decade now that the debate in the popular press and in the academic literature has suggested that the emergence of the "new economy" has deeply modified firms' human resource management practices. These would increasingly rely on the external labour market, at the expense of the internal one.

One alleged reason for this change is that the creation of value-added is increasingly based on the recombination of production factors in new ways, rather than on the accumulation of firm-specific competences (Reich, 2001). Regarding labour, this means that, in many instances, freshness becomes more valuable than seniority. This has had several consequences in terms of pay and human resource management practices, in particular lower returns to seniority in sectors that are intensive in information technologies (DiPrete et al, 2002); greater use of contingent work[1] and alternative employment[2] relationships in "new-economy jobs" (Neumark and Reed, 2004); and greater job insecurity (Givord and Maurin, 2004) and job instability (Bauer and Bender, 2004; Askenazy and Moreno-Galbis, 2007) in high-tech firms.

This literature suggests that, to some extent, new technologies are incompatible with long-term relationships between the firms and their workers, i.e. with the existence of internal labour markets. The question we ask in this paper is: are internal labour markets doomed to disappear in the new economy?

One key aspect of human resource management is the production of new skills within the firm. This function has become increasingly important in the new economy because, as is well established in the literature, new information and communication technologies (ICT) tend to be skill-biased (see Chennells and Van Reenen, 2002, for a review). So, ICT-intensive firms face strong incentives to upgrade the skill level of their workforce in order to fully exploit the potential productivity gains arising from the new equipment (Caroli and Van Reenen, 2001). Do they entirely rely on the external labour market in order to do that or do they also use the internal labour market, and to what extent?

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[1] Three definitions of contingent workers are used, going from more to less restrictive. The most stringent definition is wage and salary workers who expect their job to last 1 year or less and have been in the job for 1 year or less. The second definition adds in the self-employed and independent contractors for whom both 1-year criteria apply. It also adds in workers with temporary help agencies or contract companies for whom both 1-year criteria apply to their current assignment. Finally, the least restrictive definition drops the 1-year tenure criterion for wage and salary workers.

[2] Workers are said to be in alternative employment arrangements if they belong to any of the following categories: independent contractors (including consultants and freelance workers, and irrespective of whether they identify themselves as wage and salary workers or self-employed); on-call workers; temporary help agency workers; and workers provided by contract firms.

In order to investigate this issue, we build a unique data set providing information on technology use, occupations, labour flows and training for a sample of 1,100 French firms in the late 1990s. We consider three possible ways for firms to upgrade their skill structure.

1) They may shift their occupational structure upward, which can be done either by promoting incumbent workers from lower to higher skilled occupations (internal labour market strategy) or alternatively, by hiring workers in more highly skilled occupations and/or firing them in less skilled ones (external labour market strategy).

2) External labour market adjustments may also take the form of "excess turnover" (or churning) – i.e. turnover in excess to what is necessary to upgrade the occupational structure – if firms try to acquire new skills by the adjunction of "fresh" workers.

3) Eventually, firms may train their own workers, thus relying on the internal labour market.

Our empirical findings suggest that ICT-intensive firms largely rely on the internal labour market in order to upgrade the skill level of their workforce. We show that the intensive use of ICT is associated with an upward shift in the occupational structure within firms. About one third of this occupational upgrading is due entries and exits of workers from and to the external labour market, whereas two-thirds are due to promotions. We find no compelling evidence of external labour market strategies based on "excess turnover". In contrast, French firms heavily rely on training in order to upgrade the skill level of their workforce: ICT use is positively correlated with a greater access to training and more training hours for all categories of workers. This widespread use of internal labour market strategies is robust to controlling for potentially confounding factors such as the use of innovative workplace practices or industrial relations. When looking at potential heterogeneity across firms in skill upgrading strategies, we find that all firms rely much more on promotions than on external movements in order to shift their occupational structure upward. In contrast, different training patterns are found across sectors: the use of ICT is strongly correlated with training for all occupational groups in manufacturing sectors, whereas this is not the case in services. This difference is robust to controlling for other sources of heterogeneity and may be explained by the fact that labour turnover is much higher in services than in manufacturing.

Our work closely relates to a number of papers in the literature. Working on U.S. data, Neumark and Reed (2004) display a significantly greater use of contingent and "alternative" employment relationships in new economy jobs when these jobs are defined as jobs located in

cities classified as high-tech and in fast-growing industries. In contrast, they find evidence of a *lesser* use of this type of contracts when new-economy jobs are defined as jobs in high-tech industries. Our results are consistent with this in that they suggest that high-tech firms do not entirely rely on external turnover in order to upgrade the skill level of their workforce. Internal labour market strategies such as promotions and training are important tools used by firms to achieve this goal. Askenazy and Moreno-Galbis (2007) focus on France as we do. They find that firms that most intensely use new technologies and innovative work practices experience a higher turnover among most of the occupational categories. However, the bulk of the effect comes from innovative work practices rather than new technologies.[3] Our results suggest that when focusing on ICT and when considering the various skill upgrading strategies potentially used by firms, internal labour market strategies come out as dominant, for most occupational groups. This is consistent with findings in the training literature. Most papers indeed find that the adoption of information technologies raises firms' investment in training, which is a typical internal labour market response (see Lynch and Black, 1998; Behaghel and Greenan, 2005).

As underlined by this brief review of the literature, most works consider only one type of human resource strategy in relation with ICT adoption. They either study internal or external labour market strategies, but rarely both at the same time[4]. This is problematic as internal and external labour market strategies are likely to coexist, the key issue being their relative weight and whether they act as complements or substitutes (see Mincer, 1989). The main contribution of this paper is to develop and implement a simple statistical framework to systematically assess the relative importance of internal and external labour markets, in a context of technical change.

The paper is organised as follows. Section 1 outlines the econometric model. Section 2 introduces the data. The results are presented in Section 3 and some discussion and concluding remarks are offered in Section 4.

[3] One exception is the positive correlation between the use of the Intranet and churning for manual workers. We find a similar result when taking into account the potential role of firm size, labour market density and sector. In this case, a greater use of ICT is associated with higher excess turnover for blue-collars at least in the manufacturing sector.

[4] An exception is Bauer and Bender (2004) – see Section 4. for a more detailed discussion of their results.

1. The Econometric model

New technologies and skill upgrading

The existing literature on skill-biased technical change suggests that in order to fully exploit the potential of ICT, firms have to upgrade the skill level of their workforce when adopting them. The corresponding prediction is that there should be a positive correlation (all other things kept equal) between the use of more advanced technologies and an increase in the skill level of the workforce.

A very simple test is based on the following regression:

$$\Delta SKILL_i = z_i\beta + \Delta ICT_i\delta + \varepsilon_i \qquad (1)$$

where ΔICT is an indicator of adoption of new information and communication technologies, *SKILL* is a measure of the workforce's skills, and *z* are control variables.

ICT adoption is likely to be endogenous. In the absence of any good instrument for technological adoption, we interpret positive estimates $\hat{\delta}$ as evidence of partial correlations between the adoption of new technologies and upward changes in the skill structure of the workforce – see Section 4. for further discussion of endogeneity issues.

Skills, however, can be acquired through a variety of channels. In what follows, we consider three possible channels: firms may upgrade the occupational structure of their workforce (which can be achieved though entries and exits or, alternatively through promotions); they may rely on excess turnover in order to acquire fresh skills; and/or, they may train their own workers. We interpret upward changes in the occupational structure through entries and exits as well as excess turnover as indicators of external labour market adjustments. Conversely, skill upgrading through promotions and training are seen as indicators of internal labour market strategies.

Decomposing changes in the occupational structure

Changes in firms' occupational structure in relation with *ICT* adoption are usually estimated using standard labour share equations:

$$\Delta S_{ip} = x_i\beta_p + \Delta ICT_i\delta_p + \varepsilon_i \qquad (2)$$

where S_{ip} is the share of occupational group *p* in the workforce of firm *i:*

$$\Delta S_{ip} = \frac{L_t^{ip}}{L_t^i} - \frac{L_{t-1}^{ip}}{L_{t-1}^i}$$

Such changes are the outcome of two different movements: (i) entries and exits of workers at various levels of the occupational structure and (ii) promotions of workers from lower to higher occupations. In order to distinguish both effects, we construct counterfactual changes in labour shares ($\Delta\widetilde{S}_{ip}$) describing what would have happened to the occupational structure if there had only been entries and exits at the different occupational levels, but no internal movement (promotion or demotion):

$$\Delta\widetilde{S}_{ip} = \frac{L_{t-1}^{ip} + H_t^{ip} - E_t^{ip}}{L_{t-1}^i + H_t^i - E_t^i} - \frac{L_{t-1}^{ip}}{L_{t-1}^i} \qquad (3)$$

where L_{t-1}^{ip} is number of workers in occupation *p* in firm *i* at time *t-1*, H_t^{ip} is the number of entries in occupation *p* in firm *i* between time *t-1* and *t* and E_t^{ip} is the number of workers formerly employed in occupation *p* leaving firm *i* between time *t-1* and *t*. Similarly, L_t^i, H_t^i, and E_t^i respectively denote the total number of workers, entries and exits in firm *i* at time *t*.

Given that we do not have any direct information on promotions, changes in the occupational structure through promotions only ($\Delta\hat{S}_{ip}$) are defined as the changes in the occupational structure that would have occurred if there had been none of the entries or exits that we observe in the data:

$$\Delta\hat{S}_{ip} = \frac{L_t^{ip} - H_t^{ip} + E_t^{ip}}{L_t^i - H_t^i + E_t^i} - \frac{L_{t-1}^{ip}}{L_{t-1}^i} \qquad (4)$$

where L_t^{ip} is the number of workers in occupation *p* in firm *i* at time *t*. The number of workers in occupation *p* at *t* is computed as a counterfactual including only promotions, i.e. the number of workers observed at *t* in occupation *p* minus entries plus exits into that group between *t-1* and *t*. In other words, it includes all people that would have been in occupation *p* at date *t* if there had been only promotions and no entries nor exits at this level between *t-1* and *t*. The corresponding labour share is computed by dividing this number of workers by what employment would have been in the firm at year *t* if no entry nor exit had taken place over the period.

In the case where the total level of employment is constant, the observed changes are the sum of the two counterfactual changes. Indeed, we then have $H_t^i = E_t^i$ and $L_t^i = L_{t-1}^i$. Therefore,

$$\Delta S_{ip} = \frac{L_t^{ip} - L_{t-1}^{ip}}{L_{t-1}^i} = \frac{L_t^{ip} - H_t^{ip} + E_t^{ip} - L_{t-1}^{ip}}{L_{t-1}^i} + \frac{H_t^{ip} - E_t^{ip}}{L_{t-1}^i} = \Delta\hat{S}_{ip} + \Delta\widetilde{S}_{ip}.$$

We then estimate equation (2) separately for $\Delta\widetilde{S}_{ip}$ and $\Delta\hat{S}_{ip}$ by OLS, equation by equation.[5,6]

Upgrading skills through excess turnover and training

Another way to upgrade the skill structure of a firm when adopting ICT is through the addition of "fresh" workers by means of labour turnover. Turnover is, to some extent, a mechanical consequence of the upgrading of the occupational structure through entries/exits: there cannot be any upgrading of the occupational structure through entries/exits if there are no worker flows. However, as is well known from the literature on job and worker flows (for French firms, see Abowd, Corbel and Kramarz, 2003), worker flows (turnover) usually largely exceed what is needed for a given level of job flows. We therefore use a measure of 'excess turnover' – or churning -, i.e. turnover in excess to what is needed for a given change in the size of a group of workers. Specifically, excess turnover *et* in plant *i* and for group *p* is defined as:

$$et_{ip} \equiv \frac{H_{ip} + E_{ip}}{L_{ip}} - \left| \frac{H_{ip} - E_{ip}}{L_{ip}} \right| \tag{5}$$

We then estimate:

$$et_{ip} = x_i \xi_p + \Delta ICT_i \gamma_p + v_{ip} \tag{6}$$

by OLS equation by equation. $\hat{\gamma}_p$ is the estimate of interest; positive values indicate that ICT adoption is associated with an increased turnover of group *p*, beyond what is mechanically implied by the upgrading of occupational groups.

Similarly, skill upgrading through training needs to be analysed within each occupational group. Indeed, training rates are higher in high-skill groups, hence upgrading of the

[5] Although we are estimating a system of Seemingly Unrelated Regressions (SUR), feasible Generalized Least Squares (FGLS) are not warranted here, as the same regressors show up in each equation (see, e.g., Theorem 7.6 in Wooldridge, 2002).

[6] Note that the coefficients we obtain for $\Delta\hat{S}_{ip}$ and $\Delta\widetilde{S}_{ip}$ need not add up to those obtained when using ΔS_{ip} as a dependent variable: this is due to the effect that the decomposition is perfect only when total employment is constant. However, in practice, the estimated coefficients are not far to add up.

occupational structure through entries/exits mechanically generates an increase in training rates. Our data allows us to estimate training equations for a given occupational group:

$$T_{ip} = x_i \psi_p + \Delta ICT_i \eta_p + \upsilon_{ip} \quad (7)$$

which we estimate by OLS. $\hat{\eta}_p$ is the estimate of interest; positive values indicate that ICT adoption is associated with an increase in training, once controlled for composition effects.

2. The Data

Measuring technology adoption and skill upgrading through our 3 channels at the firm level requires combining several databases.

Information on ICT comes from the *REPONSE survey* (RElations PrOfessionnelles et NégocationS d'Entreprise). In 1998, 2978 establishments were surveyed with senior managers being asked questions about industrial relations, implementation of new technologies and reorganizations[7]. Regarding ICT, we have information on the proportion of workers using the Intranet[8] and the Internet in 1998 (no use, less than 5%, 5 to 19%, 20 to 49%, 50% and more). Given that these technologies were at the very beginning of their life cycle in France in the mid-1990s, we assume that the proportion of workers using them in 1998 provides a good approximation of technological *adoption* over 1996-1998. More specifically, we define a dummy variable equal to 1 if at least 5% of the workers use the Internet or at least 20% of the workers use the Intranet[9]. One advantage of this simple measure of ITC use is that it is relevant for the different sectors in the economy: as shown by table A1, in our sample, very similar proportions of firms in the manufacturing and service sectors are classified as "ICT-intensive" by this measure (about one third). Moreover, using another survey of French manufacturing firms, Greenan and Mairesse (2006) show that the use of the Internet (as measured in 1997) is highly correlated with a variety of other measures of technical change.

The REPONSE survey also provides detailed information on firms and establishments which we use as control variables in the regressions: firm characteristics (public/private, firm with one or several plants, listed on stock markets/non-listed), plant characteristics (share of women, share of part-time workers, presence of union delegates, local labour market density),

[7] The REPONSE survey was conducted in 1992, 1998 and 2005. Panels that result from the merging of the three waves contain few observations and therefore can not be used. Moreover, one of the databases used in this paper (ESE) is not available from 1999 onward.
[8] The exact phrasing is "Intranet and computer networks".
[9] We check that our results are robust to changes in these thresholds – see Section 3.a below.

as well as a set of industry and plant size dummies. We also have information on the use of innovative workplace practices and the quality of industrial relations (percentage of workers involved in quality circles, number of organisational devices used to stimulate workers' participation[10], whether there has been a strike in the past 3 years). We use them as additional controls in some specifications.

In order to capture worker flows, we rely on two different sources. The DMMO (Données sur les Mouvements de Main-d'Oeuvre) has exhaustive data on entries and exits of workers in and out of establishments with 50 employees or more. The data is broken down into four occupational categories: managers and professionals[11], technicians and supervisors, clerks and blue collars.[12] The EMMO (Enquête sur les Mouvements de Main-d'Oeuvre) has identical information on a representative sample of firms with less than 50 employees. We use this data to compute counterfactual changes in labour shares over 1996-1998, i.e. changes that are due only to entries and exits (resp. promotions) in the various occupations over the period. In order to do so – see equations (3) and (4) – we also use information on the level of employment in each occupational cell at the beginning and at the end of the period. This information is provided by the French survey of employment structure: the ESE (Enquête Structure des Emplois), as of December 31st 1995 and 1998.

The last channel we consider for skill upgrading is training. The so-called "24-83" fiscal records provide firm-level data on the number of workers receiving training and the volume of training hours[13]. This information is broken down into four occupational categories which are identical to those in the DMMO-EMMO database. For each occupation, we thus compute both the proportion of workers receiving some training and the average number of training hours per worker. These are averaged over 1996-1998 in order to account for the fact that training may take some time to be implemented after firms decide to invest in it.

Matching the five datasets and cleaning out establishments with implausible values for skill upgrading reduces our sample to 1,114 establishments. The low matching rate is primarily

[10] The devices that are considered are: existence of a suggestion box, a firm's newspaper, a visiting day, a firm's project or a quality action. The stimulation of workers' participation is considered to be strong if the establishment uses more than 3 of those devices.

[11] This category also includes engineers.

[12] In principle, the data allows to distinguish between skilled and unskilled blue-collars. We systematically ran the analysis with this distinction. The general picture remained unchanged (with some additional, expected shifts toward more skilled blue collars in ITC-intensive firms). However, we found evidence suggesting that, in some cases, training data reported by firms were incorrectly attributed to one category instead of the other, and therefore we chose to group all blue-collars together.

[13] The "24-83" records provide firm rather than plant-level data on training. Matching them with establishment-level data generates some measurement error that is likely to raise the standard errors in our estimates.

due to the fact that the EMMO and 24-83 sources are not exhaustive (respectively, not systematically coded) – see the Data Appendix for details.

Table A1 summarizes all the variables used in our models. Our sample consists mainly of large plants (53% have more than 200 workers) belonging to multi-establishment firms of the private sector. 77% have a union delegate and less than half of them are listed. The manufacturing sector is over-represented in our sample: it accounts for 80% of total employment, compared to only 20% in the whole French economy. As a consequence, women account for only 35% of the labour force. 37% of the plants employ more than 5% of part-time workers, 28% have more than one fifth of their workers involved in quality circles, and 35% strongly stimulate workers' participation. Lastly, 35% of the plants have experienced at least one strike in the three-year period covered by the survey.

Over 1996-1998, occupational changes have been substantial in our sample. The proportion of managers and professionals has increased on average in all plants, but the rise has been more important in establishments that have introduced ICT. The share of technicians and supervisors has also increased, especially in manufacturing plants. In contrast the share of clerks and blue-collars has decreased. This is particularly the case in establishments that have adopted information technologies. Finally, the reduction in the share of clerks has been much stronger in services than in manufacturing, while the opposite holds for blue-collars. Much of these changes seem to be due to internal movements of the labour force. Consistently, training appears to be frequent, although access is greater for more skilled occupations. In what follows, we use regression analysis in order to further investigate these changes.

3. Results

3.a ICT adoption and skill upgrading strategies

We first investigate the correlation between ICT adoption and the strategies used by firms to upgrade the skills of their workforce. Table 1 presents the results for the three different forms of skill upgrading we consider here: upward shift in the occupational structure through entries/exits versus promotions, excess turnover and training.

Panel A of Table 1 provides evidence of skill-biased technical change. The use of the Internet or the Intranet is positively correlated with an upward shift in the occupational structure and, more specifically with an increase in the proportion of managers, engineers and professionals

and a decrease in the proportion of clerks in the workforce. This occupational upgrading is essentially achieved through internal movements (promotions). These account for more than 70% of the increase in the proportion of managers – as compared to only 30% for external movements - and for almost all of the reduction in the share of clerks – see Panels B and C. This first set of results suggests that internal labour markets still play an important role when firms have to cope with increasing skill requirements. Most of the adjustment in the occupational structure takes place through promotions, whereas the relative importance of entries and exits to and from the external labour market remains limited. To gauge the economic significance of the effects, it is useful to compare them to the average changes in the occupational structure in our sample during the 1996-1998 period (Table A.1). For instance, the .80 percentage point increase in the share of managers and professionals occurring through internal movements and associated with intensive ICT-use (Table 1) is very close to the overall increase in the share of managers and professionals in the economy (+.77 percentage points). If we were to give a causal interpretation to the estimates, a back-of-the-envelop calculation would imply that about 35% of the overall increase in the demand for managers and professionals is due to the adoption of ICT that occurred in about 1/3 of firms over the period and which was satisfied through internal movements (0.33*.80/0.77=0.34); about 15% is due to the adoption of ICT but was satisfied by the external labour market (.33*.3/0.77=.13); and the remaining 50% is due to other causes. Of course, our estimates cannot necessarily be interpreted causally; but this suggests that the role of internal labour markets is far from negligible in the overall upgrading of the occupational structure.

However, firms may also try to upgrade the skill level of their workforce by bringing in "fresh workers" with new skills, beyond what would be necessary to upgrade the occupational structure through entries and exits. Panel D of Table 1 thus investigates the partial correlations between ICT adoption and excess turnover. We find no compelling evidence of such a correlation: the use of the Internet or the Intranet is not associated with excess turnover, whatever the category of workers we consider. Overall, the external labour market does not appear as a key provider of new skills when firms introduce new information and communication technologies.

In contrast, firms heavily rely on training in order to upgrade the skill level of their workforce. Panels E and F of Table 1 have the partial correlations between ICT adoption on the one hand and two different measures of training on the other hand. As evidenced by Panel E, the introduction of new technologies is correlated with a greater access to training for all

categories of workers except for managers and professionals - where the coefficient is positive but not statistically significant. In contrast, when considering the number of hours of training per worker, the correlation is positive and significant for all occupational groups, including managers. Again, it is useful to compare the effects to the average level of training in the sample displayed in Table A.1. Depending on the occupation, ICT adoption is associated with an increase in the incidence of training by 5 to 15%, and an increase in training hours by 10 to 15%. This strong association between training and ICT is slightly weaker when controlling for past levels of training but it remains significant for most occupations except blue-collar workers – see Table A2 – Panel 1. Although this specification permits to better control for unobserved heterogeneity in training investments, it is not our preferred one because it boils down to investigating the correlation between the adoption of ICT and the *acceleration* – rather than the change – in the skill level within firms. Training is indeed a flow that contributes to raise the skill level of workers, so that the change in training over time is nothing else than *the change in the change* in the skill level of workers, which is far from being easily interpretable.

Overall, our results suggest that the internal labour market still plays a key role in the adjustment of the skill level of the workforce in firms that intensely use new information and communication technologies. In order to check the robustness of these findings, we re-run our basic set of regressions, using alternative thresholds for ICT adoption (see Appendix Table A3). The general pattern of results is virtually unchanged: promotions account for the largest part of the upgrading in the occupational structure, and training is used as a complementary strategy to raise the skill level of workers in all occupations.

One may also be concerned that our results are driven by some differences in firms' characteristics that are likely to be correlated with ICT adoption. This is particularly likely to be the case for innovative workplace practices because they tend to be complementary with information technologies (see Bresnahan et al, 2002). This could also be the case for industrial relations if firms with more peaceful relations are both more willing to have internal labour markets and better equipped to introduce ICT. Table 2 presents the results when controlling for these possibly confounding factors. Specifically, we re-run our basic set of regressions adding a dummy variable for the use of quality circles (more than one fifth of the workforce involved), strong stimulation of workers' participation (more than 3 organisational devices used) and for strikes. Interestingly, external mobility does not seem to be a response to strikes (the correlation between strikes and excess turnover is even negative for most

occupational groups and significant for technicians and clerks at the 10% level). In contrast, strikes appear to be positively correlated with training, with significant effects for the number of training hours provided to blue-collars and (to a lesser extent) technicians. Unsurprisingly, the use of organisational devices aiming at stimulating workers' participation appears to be positively correlated with the provision of training, thus suggesting that firms that count more on their workers also choose to invest in them. However, despite these effects, the correlation between ICT adoption and the various skill upgrading strategies remains unchanged, suggesting that it is not entirely driven by differences in firms' organisation and/or industrial relations.

The important role of the internal labour market in upgrading the skill level of the workforce therefore seems to be quite resistant in France, even in the context of development of the new economy. One can wonder however whether this form of human resource management is to be found in all firms or whether there is some heterogeneity in firms' strategies and along which dimensions.

3.b Heterogeneity in firms' skill upgrading strategies

A first potential dimension of heterogeneity in our data has to do with industry. Skill upgrading practices are likely to be different across sectors, if anything because the needs and the relative cost of each strategy are likely to be different. Given the fact that our sample over-represents the manufacturing sector, our results may not be representative of the average trend in the French economy. A disaggregated analysis is therefore needed.

When splitting our sample across manufacturing and services, our results suggest that there are indeed some differences, in particular with respect to the use of training. Table 3.1 suggests that ICT-intensive firms in the manufacturing sector heavily rely on promotions in order to upgrade the skill level of their workforce. Excess turnover is used to a limited extent for clerks and blue-collars. But the dominant strategy is based on training with ICT-intensive firms providing significantly more training than others to all categories of workers. Regarding services (see Table 3.2), the same pattern is observed for changes in the occupational structure with promotions accounting for most of the skill upgrading. In contrast, firms in the service sectors appear to rely less on training when using ICT, the only significant correlation being for blue-collars. These differences in training patterns are robust to controlling for past levels of training (see Table A.2 – Panels 2 and 3).

This heterogeneity in skill upgrading strategies across sectors is, to a large extent, robust to taking into account other potential sources of heterogeneity (see Table 4). The skill upgrading strategies chosen by firms are likely to vary according a variety of dimensions. In particular, one would expect internal labour markets to be larger and better organised in large firms than in smaller ones. In contrast, the external labour market is potentially more attractive in high-density local labour markets because it is likely to offer a greater variety of skills. Eventually, skill upgrading strategies may be different between high and low-tech sectors[14] because the use of the Internet/Intranet is likely to be different in both types of industries.

Our results suggest that there is indeed some heterogeneity across several of these dimensions. The direct effects of the size and local labour market density variables suggest that these affect to a certain extent firm's skill upgrading strategies. Large firms essentially rely on promotions to upgrade the occupational structure of their workforce (in favour of technicians and supervisors and, to a lesser extent at the expense of clerks) and they rely less on excess turnover for both categories. More importantly, training is strongly correlated with size with large firms providing greater access and more training hours to all categories of workers. Interestingly, being located on a high-density local labour market is correlated with a lower turnover for technicians and clerks, which is not in line with the idea that high density on the local labour market should make external skill upgrading strategies more attractive to firms. Eventually, belonging to a high-tech sector does not seem to be strongly associated with firms' skill strategies. The only exception is that the high-tech variable is negatively correlated with excess turnover for blue-collars and positively correlated with the number of training hours for clerks (at the 10% level).

Moreover, the correlation between ICT adoption and skill upgrading strategies is sometimes quite different across firm size, type of local labour market and technological level of the sector. This is the message conveyed by the coefficients we get on the interaction terms between Internet/Intranet and our control variables. The density of the local labour market tends to increase the reliance of ICT-intensive firms upon promotion, in particular for managers and blue-collars (at the 10% significance level), contrary to what could be expected.[15] However, it also increases firms' reliance on excess turnover for technicians and

[14] Sectors are classified as being low or high-tech on the basis of the latest OECD 4-digit classification for manufacturing sectors (see Hatzichronoglou, 1997) and on the basis of the 4-digit classification proposed by the European Foundation for the Improvement of Living and Working Conditions for service sectors (see European Monitoring Center on Change, 2006).

[15] A tentative explanation could be that, if in dense local labour markets, firms are able to hire workers that match their needs more closely; these successful “matches” are then more likely to lead to promotions.

clerks when adopting ICT, which is consistent with the idea that denser labour markets offer a wider choice of skills and are thus likely to better fit firms' needs. In contrast, skill upgrading strategies associated with the use of ICT do not seem to be very heterogeneous across firm size, except for promotions which tend to be relatively more important for clerks and less so for technicians (at the 10% level). Similarly, being in high rather than low-tech sectors does not massively affect the skill upgrading strategies of ICT-intensive firms. One exception however, is that the latter provide more training hours (at the 10% level) to technicians and blue-collars in high-tech sectors.

The differences between manufacturing and services are essentially robust to the introduction of these additional controls. The increase in the share of managers and technicians is smaller in ICT-intensive service firms than in ITC-intensive manufacturing firms, but there is no difference in the respective roles of promotions versus external movements in achieving these changes. One important difference which was not striking when splitting the sample across sectors is that labour turnover is much higher in services than in manufacturing for all categories of workers. The specificity of services with respect to training is confirmed: ICT-intensive firms rely less on training for all categories of workers, with the coefficients being significant for managers and, to a lesser extent, for blue-collars (when considering training hours). One reason for this may well be the high level of turnover. If the type of training required when firms adopt ICT is more costly than usual, it may well be the case that service firms are more reluctant to train their workers given their higher probability to leave than in the manufacturing sector.

Overall, our results highlight some heterogeneity in the skill upgrading strategies of firms that have adopted ICT. Firms located in dense labour markets have mixed strategies in order to improve the skill level of their workforce: they use both promotions and excess turnover. Service firms tend to rely slightly less on training whereas the opposite goes for firms in high-tech sectors. Nonetheless, the message conveyed by our results is that the reliance on internal labour markets remains quite widespread in France even in firms that have adopted new information and communication technologies.

4. Discussion

In this paper, we have taken a fresh look at the fate of internal labour markets in the new economy. Our results suggest that they vividly resist in France even in firms that have introduced information and communication technologies.

As already evidenced by many papers in the literature, ICT adoption is associated with an upward shift in firm's occupational structure. But, in France, this is largely achieved through promotions rather than entries and exits from and to the external labour market. Moreover, when introducing new technologies, firms massively rely on training in order to upgrade the skill level of their workforce, whereas the use of excess turnover as a provider of new skills remains very limited. This resistance of internal labour markets even where ICT are intensely used is widespread across firms, whatever their size or technological level. It is slightly stronger in low-density labour markets and in manufacturing where training is more frequently used than in services to increase the skill level of workers.

We need to insist upon the fact that our estimates do not prove a causal relationship: although we introduce a rich set of controls to rule out some of the most likely sources of spurious correlations, the ICT variable remains potentially endogenous and we are not able to exhibit plausible instruments to solve that problem.[16] It is therefore important to distinguish between two possible interpretations of the results – a conservative one and a more daring one. The conservative reading of the results is simply that the intensive use of ICT does not preclude human resource management strategies based on internal labour markets: *internal labour markets and ICT can coexist*. This does not make any substantive statement on the causal impact of ICT on internal labour markets. Rather, *whatever this impact*, it has not been sufficient to cause the end of internal labour markets.

More boldly, we believe that our results make a large negative impact of ICT on internal labour markets rather unlikely. Indeed, reconciling a large negative causal impact with our finding of a robust, positive correlation would require that some unobserved variables create a large upward bias in our estimates. Let us consider two types of mechanisms that could generate such a bias, and examine whether they are consistent with the evidence we provide.

[16] Note that the instrument would need to be uncorrelated with human resource management practices, which is a strong requirement. Even relatively exogenous sources of technology adoption that have been put forward in the literature, such as immigration shocks (Lewis, 2005), would not be valid instruments here as they are likely to directly impact human resource management practices.

The first mechanism is one of spurious correlations due to unobserved shocks at the firm level. A first possibility would be that firms that are hit by unfavourable shocks (say, a falling demand for their product) have to cut costs. To that end, they adopt cost saving technologies; they also downsize, and the burden of the adjustment is disproportionately born by the unskilled. This sequence of events would generate a spurious correlation between ICT and upgrading of the occupational structure through entries and exits. Therefore, wrongly ignoring the potential role of unobserved shocks would make us overestimate the *external* labour market response to ICT adoption. This rather reinforces our result on the predominance of *internal* adjustments. However, unobserved shocks may also work the other way round. Firms that are hit by a positive shock may introduce new technologies (because they have more cash available for investment). They may also mechanically increase their training investment: The French regulation on the financing of continuous training is such that over the 1996-1998 period, all firms had to spend at least 1.5% of their wage bill on training. For the firms for which this constraint is binding, any positive shock that raises the wage bill will mechanically generate an increase in training expenditure. In this case, the positive correlation we find between new technologies and training may be spurious. In order to check whether this is the case, we re-ran our training regressions on the sub-sample of firms spending more than 2% of their wage bill on training. For these firms, the legal minimum is not binding so there is no reason that an increase in their wage bill should lead them to invest more in training. When doing this, our results are virtually unchanged[17]. Another way to control for positive shocks in our regressions is to introduce changes in firm's size over 1996-1998 as a control variable. Here again, the correlations between ICT and training are unchanged[18]. Of course, one can imagine other sources of unobserved heterogeneity that would drive the results spuriously. Bloom et al. (2008) suggest that the origin of capital could be one of them. They show that US multinationals operating in Europe are more IT-intensive than non-US multinationals (and get a higher productivity from IT) and that their IT advantage is primarily due to more efficient human resource management practices. In order to make sure that our correlation

[17] The coefficients (standard errors) of the Internet/Intranet variable in the regression for the proportion of trainees are: 4.15 (2.18) for managers and professionals, 8.61 (3.83) for technicians and supervisors, 4.87 (2.39) for clerks and 3.72 (2.97) and for blue-collars. The coefficients (standard errors) of the Internet/Intranet variable in the regression for the intensity of training are: 2.38 (1.13) for managers and professionals, 3.09 (1.11) for technicians and supervisors, 1.77 (0.95) for clerks and 2.45 (0.92) for blue-collars.

[18] The coefficients (standard errors) of the Internet/Intranet variable in the regression for the proportion of trainees are: 3.28 (2.07) for managers and professionals, 7.06 (3.03) for technicians and supervisors, 5.49 (1.94) for clerks and 3.69 (2.19) and for blue-collars. The coefficients (standard errors) of the Internet/Intranet variable in the regression for the intensity of training are: 2.87 (0.97) for managers and professionals, 3.23 (0.93) for technicians and supervisors, 2.07 (0.75) for clerks and 2.30 (0.71) for blue-collars.

between IT and internal labour market strategies is not driven by US-owned firms, we controlled for the origin of capital (US versus non-US) in our baseline regression. The results are left unchanged. Of course, this does not rule out other possible sources of unobserved heterogeneity. This is why we remain cautious in interpreting our results.

The second mechanism is related to a policy change that took place in France in the mid 1990s. Starting in 1993, successive governments have introduced fiscal measures to reduce the labour cost of low-wage workers. These payroll tax cuts have had the largest impact on firms employing a high proportion of low-skill workers. As a result, these firms were less induced to adopt new technologies (as long as they are substitutes to unskilled labour) while they had incentives to hire even more low-skill workers. Again, this would lead us to overestimate the impact of ICT adoption on external adjustments: the share of low-skill workers would increase through entries and exits in firms less prone to adopt ICT. The impact of the payroll taxes on internal adjustments is unclear. Low-wage firms might refrain from promoting and training their workers, by fear of increasing wages above the level eligible for the tax exemption. This, however, does not concern high-wage workers whose training appears to be highly correlated with new technologies in our data. Moreover, the additional contingents of low-wage workers paid at the minimum wage would probably not get much wage increase following training, given that their productivity would, most probably, remain below the minimum wage. Overall, it is unclear whether the payroll tax cuts should have induced lower training and fewer promotions in firms less likely to adopt ICT. Therefore, it is unclear why our finding of a positive correlation between ICT and internal labour market strategies should be driven by this policy change.

Overall, we view our results as providing evidence that internal labour markets have remained a viable human resource management strategy for French firms even when adopting new information and communication technologies. The negative impact of ICT, if any, has remained limited, or has been overcome by other factors.

This result is in contrast with Bauer and Bender's (2004) who also consider internal and external labour market strategies contemporaneously. Using German data, they find that new technologies increase churning rates for skilled and highly skilled workers and that most of the employment adjustment patterns associated with technological change are due to hiring and firing rather than to promotions or demotions. This suggests that firms' human resource strategies following ICT adoption may be quite different from one country to the other. As a matter of fact, this gap in behaviour between French and German firms is consistent with the

national labour market patterns described by Marsden (1999): France is characterised by widespread internal labour markets whereas in Germany, *occupational* labour markets are dominant, in particular for skilled workers. They are based on the certification of professional skills offered by the apprenticeship system. This allows firm to get reliable information on workers' skills before hiring them on the external labour market. By the same token, skilled workers are confident that if changing firm, their skills will be recognised in terms of pay and employment prospects. In such a system, it is not surprising that firms rely on external skill upgrading strategies when adopting new technologies. In France, the system of certification of professional skills is by far less developed so that firms face more uncertainty when hiring skilled workers on the external labour market. This may be one explanation for the fact that they rely much more on training and promotions than their German counterparts.

Where do we go from here? Another reason why internal labour markets have resisted in France, even in the context of development of a new economy, may be the existence of a protective employment protection legislation (see OECD, 2004): firms may rely on internal labour market adjustments because going on the external labour market would simply be too costly. This idea has long been put forward by Bishop (1991). However, recent evidence by Bassanini et al. (2007) suggests that the amount of training provided by firms would actually be negatively correlated to employment protection legislation. In order to get a better understanding of these relations, the direct comparison of France with other countries would be potentially very fruitful. The USA or the UK stand as particularly good candidates given that employment protection legislation is much less strict in these countries than in France. This would permit to check whether the introduction of new technologies has had a different impact on firms' labour market strategies in these countries. It would also permit to compare the various determinants of skill upgrading strategies across countries. An important avenue for future research is indeed to tie down the extent to which labour market institutions are likely to affect firms' strategies in terms of human resource management.

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Table 1
ICT Adoption and Skill Upgrading Channels

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
	A. Overall changes in the occupational structure			
Internet/Intranet	1,13***	-0,12	-0,65**	-0,36
	(0,22)	(0,30)	(0,30)	(0,34)
Obs	1 114	1 114	1 114	1 114
	B. Internal movements			
Internet/Intranet	0,80***	0,12	-0,58*	-0,34
	(0,20)	(0,31)	(0,30)	(0,32)
Obs	1 114	1 114	1 114	1 114
	C. External movements			
Internet/Intranet	0,30*	-0,26	-0,04	0,00
	(0,17)	(0,22)	(0,20)	(0,25)
Obs	1 114	1 114	1 114	1 114
	D. Excess turnover			
Internet/Intranet	1,18	3,15	9,52	-7,70
	(1,98)	(2,56)	(6,89)	(13,82)
Obs	1 090	1 094	1 104	1 046
	E. Number of trainees (per 100 workers)			
Internet/Intranet	3,40	7,43**	5,50***	3,81*
	(2,06)	(3,14)	(1,93)	(2,31)
Obs	1 097	1 052	1 087	909
	F. Training hours per worker			
Internet/Intranet	3,04***	3,31***	2,06***	2,24***
	(0,98)	(0,93)	(0,76)	(0,72)
Obs	1 095	1 042	1 083	907

Notes:
(1) Robust standard errors in parentheses
(2) *** p<0.01, ** p<0.05, * p<0.1
(3) A separate OLS regression is run in each panel and for each occupational category. Each regression includes controls for plant size (dummy variable for plants with more than 200 employees), being located on a labour market whose density is higher than the median, multi-establishment firms, public sector companies, listed companies, presence of union delegates, share of women in the labour force, part-time work (dummy variable for firms with more than 5% of workers being part-time) and 15 sectors.

Table 2
ICT Adoption, Work Organisation, Industrial Relations and Skill Upgrading Channels

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
	A. Overall changes in the occupational structure			
Internet/Intranet	1,11***	-0,11	-0,59**	-0,41
	(0,23)	(0,31)	(0,30)	(0,33)
>20% Quality circles	-0,23	0,17	0,07	-0,01
	(0,22)	(0,29)	(0,27)	(0,31)
Strongly stimulates workers' participation	0,26	-0,37	-0,04	0,14
	(0,20)	(0,28)	(0,28)	(0,32)
Strike in 96-98	0,08	-0,16	-0,26	0,35
	(0,21)	(0,28)	(0,25)	(0,34)
Obs	1 087	1 087	1 087	1 087
	B. Internal movements			
Internet/Intranet	0,78***	0,14	-0,52*	-0,40
	(0,21)	(0,33)	(0,30)	(0,31)
>20% Quality circles	-0,27	0,05	0,34	-0,12
	(0,22)	(0,31)	(0,28)	(0,30)
Strongly stimulates workers' participation	0,30	0,00	-0,11	-0,20
	(0,21)	(0,32)	(0,29)	(0,31)
Strike in 96-98	-0,10	-0,20	-0,18	0,49
	(0,20)	(0,29)	(0,28)	(0,30)
Obs	1 087	1 087	1 087	1 087
	C. External movements			
Internet/Intranet	0,31*	-0,27	-0,05	0,01
	(0,17)	(0,23)	(0,20)	(0,25)
>20% Quality circles	0,02	0,18	-0,19	0,00
	(0,15)	(0,21)	(0,19)	(0,25)
Strongly stimulates workers' participation	0,00	-0,39*	0,06	0,33
	(0,15)	(0,21)	(0,20)	(0,24)
Strike in 96-98	0,16	-0,03	-0,07	-0,06
	(0,16)	(0,21)	(0,19)	(0,27)
Obs	1 087	1 087	1 087	1 087

(…)

Table 2 - follow

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
		D. Excess turnover		
Internet/Intranet	1,22	2,55	8,49	-10,74
	(2,10)	(2,90)	(6,86)	(16,26)
>20% Quality circles	-5,79**	7,58	-6,43	-27,69
	(2,84)	(5,81)	(7,34)	(19,02)
Strongly stimulates workers' participation	4,95	4,20	11,80	38,54
	(3,59)	(6,02)	(10,90)	(31,49)
Strike in 96-98	-1,62	-6,18*	-13,33*	-21,03
	(2,39)	(3,48)	(7,41)	(17,97)
Obs	1 063	1 068	1 077	1 019
		E. Number of trainees (per 100 workers)		
Internet/Intranet	2,83	6,48**	4,93**	3,62
	(2,10)	(3,08)	(1,98)	(2,31)
>20% Quality circles	3,22	3,24	3,42	3,10
	(2,31)	(3,44)	(2,19)	(2,02)
Strongly stimulates workers' participation	9,35***	12,56***	5,21***	4,42
	(1,98)	(2,93)	(1,90)	(2,80)
Strike in 96-98	1,06	1,08	0,95	0,13
	(2,17)	(3,53)	(2,25)	(3,26)
Obs	1 070	1 027	1 060	885
		F. Training hours per worker		
Internet/Intranet	2,63***	3,06***	1,77**	1,91***
	(1,00)	(0,96)	(0,76)	(0,72)
>20% Quality circles	1,70	1,17	1,66**	0,42
	(1,11)	(1,02)	(0,82)	(0,69)
Strongly stimulates workers' participation	4,90***	3,25***	1,57**	2,06***
	(1,02)	(0,99)	(0,76)	(0,67)
Strike in 96-98	0,55	1,84*	0,48	1,95***
	(1,00)	(1,00)	(0,82)	(0,71)
Obs	1 068	1 017	1 056	883

Notes:
(1) Robust standard errors in parentheses
(2) *** p<0.01, ** p<0.05, * p<0.1
(3) A separate OLS regression is run in each panel and for each occupational category. Each regression includes controls for plant size (dummy variable for plants with more than 200 employees), being located on a labour market whose density is higher than the median, multi-establishment firms, public sector companies, listed companies, presence of union delegates, share of women in the labour force, part-time work (dummy variable for firms with more than 5% of workers being part-time) and 15 sectors.

Table 3.1
ICT Adoption and Skill Upgrading Channels in Manufacturing Sectors

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
	A. Overall changes in the occupational structure			
Internet/Intranet	1,05***	-0,42	-0,20	-0,43
	(0,26)	(0,35)	(0,26)	(0,39)
Obs	641	641	641	641
	B. Internal movements			
Internet/Intranet	0,80***	-0,16	-0,11	-0,53
	(0,23)	(0,35)	(0,25)	(0,36)
Obs	641	641	641	641
	C. External movements			
Internet/Intranet	0,24	-0,15	-0,13	0,03
	(0,19)	(0,23)	(0,17)	(0,29)
Obs	641	641	641	641
	D. Excess turnover			
Internet/Intranet	-1,07	4,04	10,31**	8,99*
	(1,33)	(3,16)	(4,27)	(5,20)
Obs	635	634	634	634
	E. Number of trainees (per 100 workers)			
Internet/Intranet	8,68***	13,04***	8,03***	4,10**
	(2,45)	(4,48)	(2,59)	(1,94)
Obs	633	625	624	629
	F. Training hours per worker			
Internet/Intranet	4,67***	4,40***	3,69***	1,85**
	(1,27)	(1,12)	(1,07)	(0,82)
Obs	631	620	622	629

Notes:
(1) Robust standard errors in parentheses
(2) *** p<0.01, ** p<0.05, * p<0.1
(3) A separate OLS regression is run in each panel and for each occupational category. Each regression includes controls for plant size (dummy variable for plants with more than 200 employees), being located on a labour market whose density is higher than the median, multi-establishment firms, public sector companies, listed companies, presence of union delegates, share of women in the labour force, part-time work (dummy variable for firms with more than 5% of workers being part-time) and 7 manufacturing sub sectors.

Table 3.2
ICT Adoption and Skill Upgrading Channels in Service Sectors

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
	A. Overall changes in the occupational structure			
Interintra	1,07***	0,40	-1,37**	-0,10
	(0,38)	(0,52)	(0,65)	(0,63)
Obs	473	473	473	473
	B. Internal movements			
Interintra	0,70*	0,53	-1,25*	0,03
	(0,38)	(0,58)	(0,67)	(0,61)
Obs	473	473	473	473
	C. External movements			
Interintra	0,30	-0,34	0,04	-0,01
	(0,30)	(0,43)	(0,43)	(0,44)
Obs	473	473	473	473
	D. Excess turnover			
Interintra	3,68	2,38	9,05	-32,38
	(4,91)	(4,52)	(15,73)	(33,71)
Obs	455	460	470	412
	E. Number of trainees (per 100 workers)			
Interintra	-3,65	-0,20	2,51	4,34
	(3,59)	(4,16)	(3,03)	(6,38)
Obs	464	427	463	280
	F. Training hours per worker			
Interintra	0,88	1,50	-0,27	2,93**
	(1,51)	(1,63)	(1,04)	(1,42)
Obs	464	422	461	278

Notes:
(1) Robust standard errors in parentheses
(2) *** p<0.01, ** p<0.05, * p<0.1
(3) A separate OLS regression is run in each panel and for each occupational category. Each regression includes controls for plant size (dummy variable for plants with more than 200 employees), being located on a labour market whose density is higher than the median, multi-establishment firms, public sector companies, listed companies, presence of union delegates, share of women in the labour force, part-time work (dummy variable for firms with more than 5% of workers being part-time) and 8 service sub sectors.

Table 4
ICT Adoption and Skill Upgrading Channels:
The role of size, labour market density and sector.

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
	A. Overall changes in the occupational structure			
Internet/Intranet	0,45	1,01	-0,26	-1,20*
	(0,51)	(0,69)	(0,64)	(0,70)
Large	-0,12	1,03***	-0,29	-0,62
	(0,20)	(0,30)	(0,33)	(0,40)
Internet/Intranet x Large	-0,09	-0,89	0,99	-0,01
	(0,49)	(0,64)	(0,63)	(0,66)
High Density	0,25	-0,03	0,11	-0,33
	(0,26)	(0,40)	(0,41)	(0,47)
Internet/Intranet x High Density	0,65	-0,58	-1,15	1,08
	(0,51)	(0,68)	(0,70)	(0,71)
Services	-0,46*	-0,77**	0,32	0,91
	(0,27)	(0,39)	(0,51)	(0,57)
Internet/Intranet x Services	0,15	0,27	-0,88	0,46
	(0,51)	(0,63)	(0,69)	(0,70)
Hightech	-0,20	0,18	0,71**	-0,69
	(0,33)	(0,38)	(0,35)	(0,47)
Internet/Intranet x Hightech	0,77	-1,22*	-0,72	1,17*
	(0,54)	(0,63)	(0,61)	(0,67)
Obs	1 069	1 069	1 069	1 069
	B. Internal movements			
Internet/Intranet	0,28	1,47**	-0,72	-1,02
	(0,46)	(0,72)	(0,61)	(0,70)
Large	-0,34	1,10***	-0,61*	-0,16
	(0,21)	(0,32)	(0,35)	(0,37)
Internet/Intranet x Large	0,13	-1,14*	1,14*	-0,13
	(0,45)	(0,67)	(0,66)	(0,65)
High Density	0,20	0,36	0,09	-0,65
	(0,20)	(0,41)	(0,42)	(0,47)
Internet/Intranet x High Density	0,89*	-1,02	-1,06	1,19*
	(0,47)	(0,74)	(0,74)	(0,71)
Services	-0,27	-0,46	-0,09	0,82
	(0,29)	(0,42)	(0,50)	(0,53)
Internet/Intranet x Services	-0,23	0,27	-0,67	0,64
	(0,44)	(0,67)	(0,69)	(0,67)
Hightech	-0,21	0,42	0,22	-0,43
	(0,31)	(0,40)	(0,34)	(0,42)
Internet/Intranet x Hightech	0,32	-1,12*	-0,12	0,92
	(0,46)	(0,65)	(0,61)	(0,63)
Obs	1 069	1 069	1 069	1 069

(…)

Table 4 – follow (1)

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
		C. External movements		
Internet/Intranet	0,03	-0,32	0,62	-0,33
	(0,38)	(0,53)	(0,43)	(0,55)
Large	0,16	-0,09	0,41*	-0,48
	(0,16)	(0,23)	(0,23)	(0,30)
Internet/Intranet x Large	-0,04	0,11	-0,34	0,27
	(0,35)	(0,47)	(0,41)	(0,50)
High Density	0,06	-0,24	0,30	-0,12
	(0,23)	(0,29)	(0,29)	(0,39)
Internet/Intranet x High Density	-0,16	0,23	-0,25	0,18
	(0,42)	(0,52)	(0,45)	(0,53)
Services	-0,10	-0,20	0,12	0,18
	(0,22)	(0,32)	(0,31)	(0,37)
Internet/Intranet x Services	0,31	-0,13	-0,04	-0,14
	(0,42)	(0,50)	(0,49)	(0,55)
Hightech	0,04	-0,25	0,40	-0,19
	(0,25)	(0,27)	(0,29)	(0,40)
Internet/Intranet x Hightech	0,44	-0,01	-0,66	0,23
	(0,40)	(0,45)	(0,43)	(0,53)
Obs	1 069	1 069	1 069	1 069
		D. Excess turnover		
Internet/Intranet	-1,84	1,38	-6,50	42,14*
	(4,11)	(9,41)	(14,16)	(24,06)
Large	-0,10	-12,14*	-22,73**	20,44
	(4,28)	(7,04)	(8,97)	(35,89)
Internet/Intranet x Large	-1,19	2,69	20,22	-49,99
	(4,51)	(7,45)	(15,98)	(38,67)
High Density	-3,47	-10,77**	-16,44*	-29,46
	(4,32)	(5,05)	(9,64)	(22,23)
Internet/Intranet x High Density	3,72	12,13**	43,37**	32,26
	(5,53)	(5,53)	(21,76)	(22,83)
Services	14,25**	19,60***	63,60***	49,40*
	(5,70)	(5,45)	(9,84)	(26,43)
Internet/Intranet x Services	3,55	-8,65	-18,48	-55,77*
	(4,92)	(7,11)	(14,73)	(30,87)
Hightech	1,18	1,10	0,61	-17,53**
	(2,34)	(2,57)	(5,72)	(7,95)
Internet/Intranet x Hightech	1,96	-2,74	-2,81	-2,98
	(3,19)	(5,17)	(13,32)	(16,68)
Obs	1 045	1 049	1 059	1 005

(…)

Table 4 – follow (2)

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
	E. Number of trainees (per 100 workers)			
Internet/Intranet	12,13**	8,03	9,26*	3,76
	(5,04)	(5,53)	(4,90)	(4,50)
Large	12,36***	15,48***	8,53***	9,04*
	(2,78)	(3,55)	(2,59)	(4,62)
Internet/Intranet x Large	-5,27	-4,76	-2,50	-2,54
	(4,36)	(5,30)	(4,32)	(5,51)
High Density	-1,75	-1,45	-1,93	-0,17
	(3,22)	(3,91)	(2,81)	(3,76)
Internet/Intranet x High Density	2,39	3,98	0,98	-0,65
	(4,56)	(5,50)	(4,41)	(4,94)
Services	4,52	2,80	-2,14	8,18
	(3,62)	(4,40)	(3,51)	(5,82)
Internet/Intranet x Services	-16,02***	-7,73	-4,81	-3,00
	(4,94)	(5,91)	(5,15)	(5,81)
Hightech	-5,26	-5,42	1,95	3,59
	(3,51)	(4,70)	(3,49)	(2,58)
Internet/Intranet x Hightech	1,26	2,69	-1,97	2,39
	(4,27)	(5,20)	(4,96)	(3,99)
Obs	1 052	1 009	1 043	871
	F. Training hours per worker			
Internet/Intranet	6,09**	2,91	3,79**	-1,19
	(2,47)	(2,03)	(1,74)	(1,57)
Large	6,73***	5,40***	3,59***	2,14***
	(1,33)	(1,25)	(0,91)	(0,74)
Internet/Intranet x Large	-1,91	-0,20	-1,52	2,07
	(2,13)	(2,06)	(1,72)	(1,47)
High Density	0,32	0,28	0,82	0,18
	(1,37)	(1,34)	(1,17)	(0,85)
Internet/Intranet x High Density	-1,40	-0,32	-1,87	0,33
	(2,12)	(2,18)	(1,67)	(1,84)
Services	1,03	2,51*	1,45	0,06
	(1,49)	(1,44)	(1,18)	(1,19)
Internet/Intranet x Services	-4,44*	-2,01	-2,88*	2,35
	(2,34)	(2,14)	(1,73)	(1,90)
Hightech	1,32	1,94	2,34*	-0,56
	(1,62)	(1,33)	(1,24)	(1,08)
Internet/Intranet x Hightech	0,63	3,63*	1,54	2,80*
	(2,14)	(1,95)	(1,85)	(1,62)
Obs	1 051	1 001	1 040	869

Notes: (1) Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
(2) A separate OLS regression is run in each panel and for each occupational category. Each regression includes controls for plant size (dummy variable for plants with more than 200 employees), multi-establishment firms, public sector companies, listed companies, presence of union delegates, share of women in the labour force, part-time work (dummy variable for firms with more than 5% of workers being part-time) and 15 sectors.
(3) High Density indicates that local labour market density belongs to the highest quartile.
(3) The coefficient for "Services" is computed as the difference between the coefficients for the eight 2-digit service sub sectors and the seven 2-digit manufacturing sub sectors, weighted by the shares of each sub sector.
(4) The "Hightech" indicator uses the OECD definition, applied to 712 4-digit sub sectors.

Appendix

Table A.1
Descriptive Statistics

	All plants	Internet/Intranet =0	Internet/Intranet =1	Manufacturing	Services
Change of labor share (in %)					
Managers and professionals	0,77	0,33	1,65	0,93	0,54
Technicians and supervisors	0,56	0,63	0,44	0,72	0,36
Clerks	-0,38	-0,15	-0,84	-0,27	-0,53
Blue collars	-0,95	-0,81	-1,24	-1,38	-0,37
Change of labor share through internal movements (in %)					
Managers and professionals	0,92	0,60	1,55	0,90	0,93
Technicians and supervisors	0,79	0,73	0,92	0,96	0,56
Clerks	-0,64	-0,38	-1,16	-0,41	-0,95
Blue collars	-1,07	-0,95	-1,31	-1,46	-0,55
Change of labor share through entries and exits (in %)					
Managers and professionals	-0,07	-0,18	0,15	0,07	-0,26
Technicians and supervisors	-0,13	0,00	-0,41	-0,17	-0,09
Clerks	0,18	0,13	0,29	0,14	0,25
Blue collars	0,02	0,04	-0,02	-0,04	0,10
Excess turnover (in %)					
Managers and professionals	24,12	25,04	22,29	18,54	31,89
Technicians and supervisors	25,13	27,38	20,67	13,95	40,55
Clerks	61,10	61,07	61,16	30,13	102,88
Blue collars	49,93	53,38	42,79	27,21	84,89
Number of trainees per 100 workers					
Managers and professionals	59,60	56,71	65,38	60,58	58,27
Technicians and supervisors	59,59	55,47	67,94	60,94	57,62
Clerks	41,27	37,88	48,06	43,82	37,83
Blue collars	34,18	32,04	39,14	34,17	34,22
Hours of training per worker					
Managers and professionals	21,45	19,54	25,24	22,70	19,75
Technicians and supervisors	19,45	17,55	23,30	19,97	18,69
Clerks	12,07	10,87	14,47	13,08	10,70
Blue collars	9,49	8,27	12,31	10,31	7,63
Internet/Intranet	0,33	0,00	1,00	0,34	0,32
>20% Quality circles	0,28	0,26	0,33	0,34	0,20
Strongly stimulates workers' participation	0,35	0,31	0,44	0,40	0,29
Strike in 96-98	0,35	0,34	0,38	0,46	0,21
Indicator for plant with more than 200 workers	0,53	0,48	0,62	0,62	0,40
Indicator for dense local labor market	0,25	0,21	0,34	0,20	0,32
Indicator for service sector	0,42	0,43	0,41	0,00	1,00
Indicator for multi-establishment firm	0,60	0,57	0,66	0,63	0,56
Indicator for public sector	0,03	0,03	0,05	0,02	0,05
Indicator for listed company	0,43	0,38	0,54	0,55	0,27
Indicator for presence of union delegates	0,77	0,76	0,81	0,84	0,69
Share of women (%)	35,13	35,91	33,54	25,98	47,53
Indicator for part-time work (>5% of workforce)	0,37	0,37	0,38	0,22	0,58
Number of observations	1114	747	367	641	473

Table A.2
ICT Adoption and Training
(controls for lagged training included)

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
		1. All firms		
		E. Number of trainees (per 100 workers)		
Internet/Intranet	1,78	5,57*	4,99***	2,05
	(1,85)	(3,30)	(1,76)	(2,10)
Obs	1 005	938	995	828
		F. Training hours per worker		
Internet/Intranet	1,66*	2,22**	1,70**	0,74
	(0,91)	(0,87)	(0,71)	(0,60)
Obs	1 001	924	990	824
		2. Manufacturing Sector only		
		E. Number of trainees (per 100 workers)		
Internet/Intranet	6,36***	9,76**	8,44***	2,64
	(2,21)	(4,85)	(2,27)	(1,73)
Obs	589	576	577	582
		F. Training hours per worker		
Internet/Intranet	3,19***	2,91***	3,86***	0,57
	(1,15)	(1,08)	(0,98)	(0,71)
Obs	585	567	575	582
		3. Service Sectors only		
		E. Number of trainees (per 100 workers)		
Internet/Intranet	-4,52	-0,37	0,71	1,41
	(3,24)	(4,15)	(2,83)	(6,14)
Obs	416	362	418	246
		F. Training hours per worker		
Internet/Intranet	-0,26	1,13	-1,40	1,03
	(1,46)	(1,52)	(0,98)	(1,14)
Obs	416	357	415	242

Notes: (1) Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
(2) A separate OLS regression is run in each panel and for each occupational category. Each regression includes controls for plant size, being located on a labour market whose density is higher than the median, multi-establishment firms, public sector companies, listed companies, presence of union delegates, share of women in the labour force, part-time work. All panels include industry dummies (15 in Panel 1, 7 in Panel 2 and 8 in Panel 3). Panel E controls for the average proportion of trainees among workers in 1993-1995 and Panel F for the number of training hours per worker in 1993-1995.

Table A.3
ICT Adoption and Skill Upgrading Channels
Alternative indicators of ICT
(Internet/Intranet = at least 20% of workers using the Internet and at least 50% using the Intranet)

	Managers and professionals	Technicians and supervisors	Clerks	Blue collars
	A. Overall changes in the occupational structure			
Internet/Intranet	1,84***	-0,14	-1,23***	-0,48
	(0,35)	(0,42)	(0,44)	(0,44)
Obs	1 114	1 114	1 114	1 114
	B. Internal movements			
Internet/Intranet	1,54***	-0,02	-1,21***	-0,32
	(0,32)	(0,46)	(0,45)	(0,44)
Obs	1 114	1 114	1 114	1 114
	C. External movements			
Internet/Intranet	0,25	-0,15	0,03	-0,13
	(0,24)	(0,30)	(0,27)	(0,32)
Obs	1 114	1 114	1 114	1 114
	D. Excess turnover			
Internet/Intranet	1,23	1,70	12,37	-10,25
	(2,29)	(2,60)	(11,12)	(13,94)
Obs	1 090	1 094	1 104	1 046
	E. Number of trainees (per 100 workers)			
Internet/Intranet	3,17	9,78**	7,41***	6,57*
	(2,54)	(4,77)	(2,45)	(3,82)
Obs	1 097	1 052	1 087	909
	F. Training hours per worker			
Internet/Intranet	2,09*	3,00**	1,54*	1,83*
	(1,16)	(1,20)	(0,87)	(1,05)
Obs	1 095	1 042	1 083	907

Notes:
(1) Robust standard errors in parentheses
(2) *** p<0.01, ** p<0.05, * p<0.1
(3) A separate OLS regression is run in each panel and for each occupational category. Each regression includes controls for plant size (dummy variable for plants with more than 200 employees), being located on a labour market whose density is higher than the median, multi establish-ment firms, public sector companies, listed companies, presence of union delegates, share of women in the labour force, part-time work (dummy variable for firms with more than 5% of workers being part-time) and 15 sectors.

Data appendix

In this appendix, we detail the key steps taken in preparing the data. The data sources are described in the data section in the text. In addition, the data on local labour market density (the number of employed and unemployed workers per square kilometres, computed over 348 local labour markets) comes from the 1990 population census.

Merging the different datasets

We start from a sample of 2,975 plants from the REPONSE (1998) survey, with information on ICT adoption as well as key firm and plant characteristics. Matching the RESPONSE sample with the DMMO-EMMO, ESE and 24-83 sources hence yields a sample of 1537 plants.

The relatively low matching rate (53%) is due, in particular, to the fact that the EMMO is not an exhaustive data source (plants are sampled at a rate that depends on their size) and that the 24-83 fiscal forms are not systematically coded.

In order to achieve this matching rate, we extrapolate some of the missing data, using the following procedures:

- when a plant is only present for 1 (resp. 2) of the 3 years in the 24-83 database, we compute the training variables as averages over 1 (resp. 2) years instead of 3;
- when a plant is missing for some quarters in a given year in the EMMO-DMMO data, we extrapolate the entries and exits in each occupation from the entries and exits observed during the rest of the year; if a plant is missing during one (or two) of the three years, we extrapolate entries and exits from the other years.

Though these extrapolations introduce measurement error in the movement and training variables, this does not bias the estimates as these are dependent variables in the regressions (it might, however, make them less precise). Moreover, we checked that restricting the sample to those plants that have complete DMMO-EMMO information does not significantly alter the results. Our results are indeed a little less precise when using extrapolated information. The point estimates are generally a bit smaller, but not significantly.

Outliers and consistency checks

It appeared that for some of the plants, the training information had been misreported (possibly inverted) for skilled and unskilled blue collars in 1997 and 1998, leading to implausible training rates. As we lacked information to correct the errors, we decided to aggregate the two categories in a single blue-collar occupation. In addition to this, a few observations had outlying values for the number of trainees for some years. We corrected these observations when possible, or set them to missing.

We then performed several consistency checks on this 1537 plant sample. First, we checked that the total plant size declared in the ESE does not differ too much from the

one declared in the DMMO-EMMO sources, at the beginning and at the end of our period (Dec 31, 1995 and Dec 31, 1998). We drop all plants for which the difference is more than 20% or represents at least 10 workers. We tested the robustness of our results to other thresholds; the main findings are not affected.

Second, we checked for outliers in the changes in the occupational structure. We dropped plants for which the sum of the absolute changes in the share of the different occupations is more than 60% and represents more than 10 workers. The results are not sensitive to using a stricter threshold.

With these filters, the benchmark sample has 1,114 plants. Dropping any kind of filter and using the 1537 observations does not significantly impact our results on training, but does affect those concerning internal and external movements. However, once a minimum level of consistency across data sources is required, the tightness of the filters we used does not matter.

Last, we also considered a sample where we restricted upward internal mobility for managers and professionals and downward internal mobility for unskilled blue collars. The idea is that managers cannot be downgraded and that no one can be promoted to an unskilled blue collar position. We first consider a strict limit, but as it appears that the median of internal promotion for unskilled workers was 0 (though obviously not symmetrically distributed), we eventually settle to a less strict limit (+/-2) allowing for measurement errors (in the first case the sample contains about 550 observations, and about 950 in the second case). When using the strict rule, results do shift a bit, but the sample size is also divided by 2. However, when using the less strict rule of +/-2, results are in line with our benchmark.