INSTITUT NATIONAL DE LA STATISTIQUE ET DES ETUDES ECONOMIQUES
Série des Documents de Travail du CREST
(Centre de Recherche en Economie et Statistique)

n° 2007-02

Innovation and Skill Upgrading : The Role of External vs Internal Labour Markets*

L. BEHAGHEL[1] **E. CAROLI**[2]
E. WALKOVIAK[3]

---

* We are grateful to Andrea Bassanini and Muriel Roger for Helpful comments and suggestions.

1 INRA-Paris School of Economics and CREST-INSEE.

2 Paris X University, EconomiX and Paris School of Economics

3 Orleans University, LEO and CEE.

Innovation and Skill Upgrading: The Role of External vs Internal Labour Markets

Luc BEHAGHEL
Eve CAROLI
Emmanuelle WALKOWIAK

Abstract

Following technical and organisational changes, firms may react to increasing skill requirements either by training (on the internal labour market) or hiring the new skills, or a combination of the two.
Using matched datasets with about 1,000 French plants, we assess the role 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, except for the adoption of the Internet which gives rise to both internal and external types of adjustments. We then consider the determinants of the strategies used by individual firms: do some firms mainly rely on one strategy while other firms prevalently choose another strategy, and why? We show that firms' size and localisation are critical in explaining such differences. Skill upgrading strategies relying on the external labour market seem to be prevalently adopted by small urban plants.

Résumé

Lors de l'introduction de changements technologiques et organisationnels, les entreprises font face à des besoins croissants en matière de compétences. Elles peuvent y réagir de plusieurs façons : soit par la formation continue (recours au marché interne du travail) soit par le recrutement externe des nouvelles compétences nécessaires, soit encore par une combinaison des deux stratégies.
Nous évaluons les rôles respectifs de ces stratégies interne et externe sur des données appariées portant sur 1000 établissements français. Suite aux changements technologiques et organisationnels, l'acquisition de nouvelles compétences passe essentiellement par des ajustements relevant du marché interne, sauf dans le cas de l'introduction d'internet qui débouche sur le recours simultané aux marchés interne et externe. Nous étudions ensuite les déterminants des choix réalisés par les différents établissements : certains établissements choisissent-ils une stratégie plutôt qu'une autre et, si oui, pourquoi ? Nous montrons que la taille des établissements et leur localisation sont déterminantes. Les stratégies d'acquisition de compétences reposant sur le recours au marché externe du travail sont en effet essentiellement utilisées par les petits établissements situés en milieu urbain.

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

JEL codes: J23; J24; J41.

Introduction

Changes in employment relationships have attracted a lot of attention in recent years, both in the popular press and in academic research. Following several downsizing episodes in the USA and in Europe, a widely shared view has developed according to which employment relationships have become more instable than they used to do be. Increasing product market competition and rising uncertainty in consumers' demand would have shortened firms' time horizon hence destabilised the traditional working of internal labour markets (Gautié, 2004). According to Doeringer and Piore (1971) internal labour markets are indeed characterised by the fact that wages and career paths are, to a large extent, determined by a set of administrative rules rather than by pressure arising from the external labour market. In contrast, in recent years, long-term employer-employee relationships have declined and the labour market seems to have been increasingly working like a "spot market" (see Atkinson, 1999). Correspondingly, the perception of job insecurity has increased in most OECD countries in the 1990s (OECD, 2003).

However, existing empirical evidence on rising job instability and the decline of internal labour markets is actually quite mixed. Regarding job instability, Neumark, Polsky and Hansen (1999) only find a limited decrease in 4-year retention rates[1] in the USA between 1983-87, 1987-91 and 1991-95, using CPS data: they fall slightly from 56.1% to 53.9%, and then rise slightly below the initial level, to 55.1%. Using the SIPP (Survey of Income and Program Participation) with 1-month and 1-year retention rates, Gottschak and Moffitt (1999) show that job instability has not increased on average between 1983 and 1995. Comparing snapshots of job tenure taken at the end of workers' career in 1969 and 2002, Stevens (2005) confirms these results: the attachment of workers and firms in the United States has remained roughly unchanged over the past several decades. However, job insecurity seems to have increased in America over the past decades. Using the Displaced Worker Survey between 1984 and 2002, Farber (2003) finds an increase in involuntary job loss in the mid-1990s. Similarly, using PSID data from 1976 to 1992, Valletta (2000) finds an increase in the probability of dismissal due to a sharp increase among workers with high tenure. On French data, Givord and Maurin (2004) find an upward trend in annual transition rates from employment to unemployment over the period 1982-2002. Using the same definition of job insecurity over a longer period of time (1975-1999), Behaghel (2003) finds that trends differ strongly with regard to tenure and age. Job insecurity remained remarkably stable for middle-

[1] i.e., the probability that a worker remains in the same firm during a 4-year span.

aged workers (aged 30 to 49 years old) with more than 5 years of tenure; but it increased strongly for older workers (aged more than 55), and for workers with less than 5 years of tenure.

Another way to characterise a potential destabilisation of internal labour markets is to investigate whether wages paid by firms have become more sensitive to changes on the external labour market. Using US data, Groshen and Levine (1998) find no evidence of a decline in the importance of internal labour markets in large firms, as measured by the magnitude or persistence of deviations in company wage policies from market averages. More recently, Bertrand (2004) finds that the elasticity of workers' current wages to the current unemployment rate is higher in more competitive environments, i.e. in industries where the level of importation penetration is higher.

So, evidence on the potential decline of internal labour market is far from being clear-cut. One reason for this may have to do with the rapid development of information and communication technologies and innovative workplace practices over the past 20 years. Though these changes have often been seen as potential causes of a decline in internal labour markets, this actually depends on how they impact human resource management, in particular through new and increasing skill requirements. The recent literature on the skill content of technological change shows that information and communication technologies substitute workers in routine tasks, be they manual or cognitive, whereas they complement workers in interactive and analytical activities (see Autor et al., 2003, and Spitz-Oener, 2006). This generates an increase in the demand for communication and analytical skills with which firms may cope in various ways. They may either hire the new skills on the external labour market or train their own workers, thus relying on the working of the internal labour market. Hiring the new skills from outside the firm may actually take two forms. Firms may hire more highly skilled workers and get rid of lower skilled ones, which generates an upward shift in the occupational structure. Alternatively, they may hire new workers within a constant occupational structure in order to bring "fresh blood", and presumably new skills, into their workforce.

A number of recent papers have investigated the impact of new technologies and innovative workplace practices on changes in the occupational structure within firms, worker flows or training. The positive impact of technical change upon the employment or wage-bill share of the more highly skilled occupations is now well documented in the literature (see Chennells and Van Reenen (2002) for a review). The same goes for new workplace practices which also tend to shift the occupational structure upward (see Caroli and Van Reenen, 2001;

Walkowiak, 2006 and Bresnahan et al., 2002). Regarding worker flows, Givord and Maurin (2004) find that the use of new technologies increases the annual transition rate from employment to unemployment, and that this is enough to explain the global trend toward greater job insecurity observed in France. Consistently, Di Prete et al (2002) find that returns to tenure are lower in high-tech industries in the USA, suggesting that the "freshness" of workers has become more valuable than their experience in innovative firms. Cappelli and Neumark (2004) find more mixed results with new work practices being positively associated with external churning only in non-manufacturing sectors. Looking at worker flows by skill levels in France, Askenazy and Moreno-Galbis (2004) find that ICT adoption is positively correlated with a higher turnover of clerks and manual workers whereas new organisational practices are positively correlated with a higher turnover of managers. For Germany, Bauer and Bender (2003) find that firms that introduce organisational changes have significantly higher job destruction and separation rates for the lowest skilled workers so that organisational change appears to be skill-biased. Moreover, they find that adjustments of the workforce following changes in workplace organisation mostly rely on external worker flows with the effect of internal flows being negligible. All these results suggest that firms meet the new skill requirements following the introduction of innovative workplace practices through adjustments on the external rather than internal labour market.

However, another strand of literature suggests that the adoption of information technologies and innovative workplace practices also raises firms' investment in training. On US data, Lynch and Black (1998) find that the proportion of workers receiving formal training is higher in firms that use high performance work practices such as Total Quality Management, benchmarking or self-managed teams. Zamora (2006) finds similar results for France using a first-difference specification: the introduction of new work practices increases the proportion of trained workers, especially for blue-collars and middle-managers, both in the short and medium run. In contrast, the impact of technological changes on training is significant only in the short run, while fading away in the longer run. Behaghel and Greenan (2005) use matched employer-employee data for France and also find that a more innovative organisation increases the probability that workers receive training, even once controlling for selection and potential endogeneity biases.

As underlined by this review of the literature, most works consider only one type of labour market response to technological and organisational innovations. They either study internal or external labour market strategies, but rarely both at the same time. However, as suggested by

Mincer (1989), these strategies are likely to be correlated with each other. Firms may react to increasing skill requirements either by combining in some way training with the hiring of new skills or they may, on the contrary, rely on one strategy at the expense of the other. The characteristics of this choice and its determinants are the focus of the present paper. We consider that following technological and/or organisational changes, firms have to upgrade the skill level of their workforce and we investigate the different channels through which they may do so. Three possible channels are considered here of which the first two correspond to external labour market strategies while the third one relies on the internal labour market. Firms may first upgrade their occupational structure by hiring workers in more skilled occupations and/or get rid of workers in less skilled ones. Second, they may increase labour turnover (while keeping constant their occupational structure) in order to acquire new skills by the adjunction of "fresh" workers. Third, they may train their own workers thus enhancing their skill level. We show that skill upgrading following technological and organisational changes takes place mostly through internal labour markets adjustments, except for the adoption of the Internet which gives rise to both internal and external types of adjustments. We then consider the determinants of the strategies used by individual firms: do some firms mainly rely on one strategy while other firms prevalently choose another strategy, and why? We show that firms' size and localisation are critical in explaining such differences. Skill upgrading strategies relying on the external labour market seem to be prevalently adopted by small urban plants.

The paper is organised as follows. Section 1 outlines the econometric model. Section 2 presents the data. Results are discussed in Section 3 and some concluding remarks are offered in Section 4.

1. The Econometric model

We build upon existing empirical models of skill biased technical/organisational change to develop a system of equations that describes how firms rely upon internal and external labour markets when they implement technical and organisational changes. This section describes the overall approach, the estimation method and the metrics used.

The overall approach

Theoretical models of skill biased technical/organisational change predict a positive correlation (all other things kept equal) between the use of more advanced technologies and/or workplace practices and the skill level of the workforce. A very simple test would rely on the following regression:

$$SKILL_i = x_i\beta + TECH_i\delta + ORGA_i\gamma + \varepsilon_i \qquad (1)$$

where *TECH* and *ORGA* are technology and organisation measures, *SKILL* is a measure of the workforce's skill, and *x* are control variables. One would then test whether δ and γ are positive.

Skills, however, can be acquired through a variety of channels. Denote $\Delta SKILL_{ic}$ the change in the skill level that takes place in plant *i* through channel *c* (channel 1 denotes upgrading the occupational structure through entries and/or exits; channel 2, increasing the turnover; channel 3: training the workers). Our approach is to study the partial correlations between changes in skills through these 3 different channels and organisational and technical changes. Consider the following three-equation SUR system:

$$\Delta SKILL_{ic} = x_{ic}\beta_c + \Delta TECH_i\delta_c + \Delta ORGA_i\gamma_c + \varepsilon_{ic}, \qquad c = 1,\ldots,3 \qquad \text{(system 1)}$$

where x is a vector of controls, $\Delta TECH_i$ a vector of technical change variables, $\Delta ORGA_i$ a vector of organisational change variables and ε_{ic} an error term.

Under the assumption that the error terms are not correlated with technical and organisational change, this system can be estimated by system OLS, or equivalently by OLS equation by equation. Feasible GLS are not more efficient given the fact that the same explanatory variables appear in each equation (the OLS and GLS estimators are in fact algebraically equal).

Equations in system 1 can be derived from the firm's optimisation program that implies that the demand for skills is a function of the technical and organisational capital being used (see in particular Caroli and Van Reenen, 2001). However, we do not try to make a structural estimation of this optimisation process which, as reminded by Athey and Stern (1998), would require instruments that are rarely available. Rather, we interpret positive estimates $\hat{\delta}_c$ and $\hat{\gamma}_c$ as reduced-form evidence of a complementarity between technical/organisational change and the demand for skills through channel *c*. This interpretation relies on the *ceteris paribus*

condition that we are able to observe plants that are similar in everything that is relevant for the demand for skills, and that differ only in their technology/organisational practices. To mitigate potential missing variable biases, we introduce a broad set of control variables from the REPONSE survey: firm characteristics (public/private, firm with one or several plants, listed on stock markets/non-listed), plant characteristics (rural or urban localisation, share of women, share of part-time workers), industrial relations (presence of union delegates), as well as a set of industry and plant size dummies. Though imperfect, this control approach rules out that the correlations we obtain are spuriously driven by these determinants.

The estimation method for each channel

The equations of system 1 are estimated separately for different occupational groups of different skill levels (managers, technicians and supervisors, clerks, blue collars, with a distinction, when available in the data, between skilled and unskilled clerks/blue collars).

First, consider channel 1 (upgrading of the occupational structure through entries/exits). Denote g_{ip} the growth rate of group *p* in plant *i*. $g_{ip} \equiv \frac{E_{ip} - S_{ip}}{L_{ip}}$, i.e. the difference between entries and exits from plant *i*, divided by the initial size of group *p*. In the same spirit as Aubert, Caroli and Roger (2006), we note that there is upgrading of the occupational structure through entries/exits, in a given plant *i*, if the growth rate of high-skill groups is higher than the average growth rate of the workforce. We follow their methodology and first estimate:

$$g_{ip} = x_i \varsigma + \Delta TECH_i \lambda_p + \Delta ORGA_i \mu_p + u_{ip},$$

by OLS equation by equation (for the same reason as above, there is no gain in implementing GLS). We then derive the predicted impacts of technical/organisational change on the average growth rate of the workforce in a representative plant:

$$\hat{\bar{\lambda}} = \sum_p k_p \hat{\lambda}_p; \ \hat{\bar{\mu}} = \sum_p k_p \hat{\mu}_p;$$

where k_p is the share of group *p* (we set the weights to be equal across groups and to sum up to 1). The predicted impacts on the relative growth of group *p* are then computed as:

$$\hat{l}_p = \hat{\lambda}_p - \hat{\bar{\lambda}} \text{ and } \hat{m}_p = \hat{\mu}_p - \hat{\bar{\mu}},$$

where $\hat{l}_p$ and $\hat{m}_p$ are the coefficients displayed in the tables. Though their construction is indirect, their interpretation is straightforward: a positive $\hat{l}_p$ implies that, for a representative plant, technical change is associated with an increase in the share of group *p*, through the increased entry rate (or lower exit rate) of this group relative to other groups.

Estimations for channels 2 and 3 are more immediate. However, they also need to be done separately for each group, in order to disentangle the three channels. Take channel 2 (increased 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 exceeds what is needed for a given level of job flows. We therefore use a measure of 'excess turnover', 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:

$$et_{ip} \equiv \frac{H_{ip} + S_{ip}}{L_{ip}} - \left| \frac{H_{ip} - S_{ip}}{L_{ip}} \right|$$

We estimate:

$$et_{ip} = x_i \xi + \Delta TECH_i n_p + \Delta ORGA_i q_p + v_{ip}$$

by OLS equation by equation. $\hat{n}_p$ and $\hat{q}_p$ are the estimates of interest; positive values indicate that technical/organisational change is associated with an increased turnover of group *p*, beyond what is mechanically implied by the upgrading of occupational groups.

Similarly, channel 3 (training) needs to be analyzed within each group. Indeed, training rates are higher in high-skill groups, hence upgrading of the 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:

$$T_{ip} = x_i \psi + \Delta TECH_i r_p + \Delta ORGA_i t_p + w_{ip}$$

which we estimate by OLS. $\hat{r}_p$ and $\hat{t}_p$ are the estimates of interest; positive values indicate that technical/organisational change is associated with an increase in training, once controlled for composition effects due to the upgrading of the occupational structure through

entries/exits. A possible difficulty is that training may increase as a mechanical consequence of excess turnover, if new hires systematically receive initial training. Our data does not allow us to distinguish between training of new hires and training of higher-tenure workers: this possible overlap of channels 2 and 3 will have to be kept in mind when interpreting the results.

Comparison across channels

Channels can be analyzed independently. However, to assess the relative role of each channel, we need a common metric. So far, $\hat{l}_p$ and $\hat{m}_p$ indicate the additional growth of group *p* compared to the overall workforce, in percentage points; $\hat{n}_p$ and $\hat{q}_p$ indicate increases in excess turnover; and $\hat{r}_p$ and $\hat{t}_p$ indicate increases in training incidence or average hours of training per year. These are not comparable metrics although they make sense to gauge the magnitude of the effects when looking at equations separately. A convenient way to make estimates comparable is to normalize variables on the left hand-side so that they have variance 1 in the estimation sample. Estimates are then expressed in standard deviations of the dependent variable. As both readings are possible – interpreting estimates within equations or comparing them across equations – our tables will display the two metrics.[2]

2. The Data

Measuring technological and organisational changes within establishments and skill upgrading through our 3 channels requires combining several databases.

Information on technological and organisational changes 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 reorganisations[3]. The questions on organisational and technological changes relate to the previous three years, so that the survey provides measures of changes within establishments over the period 1996 to 1998.

---

[2] Due to their indirect estimation, normalising the coefficients $\hat{l}_p$ and $\hat{m}_p$ by normalising the g_{ip} variables does not actually make sense. We rather compute the standard deviation of $g_{ip} - g_{.p}$ (the relative growth in group *p*, compared to average growth) for each group *p*, and use it to normalise the coefficients $\hat{l}_p$ and $\hat{m}_p$.

[3] The REPONSE survey was conducted in 1992, 1998 and 2005. Panels that result from the merging of the three waves contain few observations and thus can not be used. Moreover, other databases used in this paper (DMMO and "2483" records) are not yet available from 2005 onward.

Using this data, Askenazy and Moreno-Galbis (2004) constructed a vector of technological and organisational variables (computer use, net system, autonomous work teams, project groups, rotation between tasks, just-in-time production, quality controls, delayering) and studied its impact on job stability. Our organisational change variables are more synthetic although highly correlated to this vector.

The first variable we use is based on the following question: *"During the last three years, did your establishment experience an important organisational change?"* We define *organisational change* as a dummy variable equal to 1 when the manager answers yes and 0 otherwise. Our second variable captures functional changes within the establishment. The question asked to the manager is as follows: *"During the last three years, have you introduced the following changes in your organisation? (1) development of a marketing function, (2) development of a quality function, (3) development of R&D functions, (4) suppression of functions, (5) refocusing on specific competencies, (6) increasing subcontracting, (7) repatriation of subcontracted activities"*. The answers are coded as 1 if the manager answers yes and 0 otherwise. We then define *functional change* as the sum of all changes that took place so that our variable takes values from 0 to 7.

Regarding technological change, the REPONSE survey provides information on the proportion of workers using two main computerised equipments, i.e. computer and digital networks, and the Internet (less than 5%, 5 to 19%, 20 to 49%, 50% and more). Given that the number of firms which had already introduced these technologies by the beginning of 1996 was very small, 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 two dummy variables capturing technological changes: the first one is equal to 1 if 5% or more workers use the Internet. The second dummy variable is equal to 1 if 20% or more workers use computer and digital networks.

The REPONSE survey also provides information on establishments' characteristics which we use as control variables in the regressions.

In order to capture worker flows, we relied on two different sources. The DMMO 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, technicians and supervisors, skilled clerks and blue collars, unskilled clerks and blue collars. The EMMO has identical information on a representative sample of firms with less than 50 employees. We first used this data to compute the growth rate of employment through entries

and exits for each occupational group over 1996-1998. In order to do so, we divided net entries by the volume of employment in the corresponding occupational cell as of December 31st 1995. This information is provided by the French survey of employment structure: the ESE.

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[4]. This information is broken down into five occupational categories: managers, technicians and supervisors, clerks, skilled blue collars, and unskilled blue collars. This classification is not exactly the same as the one used in the DMMO-EMMO, but it is very similar and allows us to make some comparisons. 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 following technological and organisational changes.

Matching the five datasets and cleaning out establishments with implausible values for skill upgrading reduces our sample to 1,063 establishments. Table A1 summarises all the variables used in our models. Our sample consists mainly of large plants (76% have more than 100 workers) belonging to multi-establishment firms of the private sector. More than 75% have a union delegate and less than half of them are listed. Gender composition is quite balanced and one third of the plants employ more than 5% of part-time workers. Lastly, the manufacturing sector is over-represented (66% of the plants).

Over 1996-1998, net entry rates are on average negative in this particular sample, ranging from -0.17% for technicians and supervisors to -1% for unskilled workers. Technicians and supervisors have similar characteristics to managers in terms of training, whereas they appear to be more stable in terms of net entry rate and excess turnover. Unskilled clerks and blue collars face the worst conditions compared to other occupations: on average, their entry rate is the lowest (-1%), excess turnover is higher than for any other category (152%), they have less access to training (only 33% of them do) and benefit from a rather small number of training hours per worker (about 5 hours). The situation of unskilled workers is even worse in plants that implemented technological or organisational changes. In our sample, 39% of the plants

[4] "24-83" data relate to firm-level information rather than plant-level information. This is a form of measurement error that is likely to raise the standard errors in our estimates.

implemented some organisational change over the period 1996-1998 and the average number of functional changes is 2.28 (on a scale going from 0 to 7). In 1998, only 13% of the plants had introduced the Internet while 43% of them were using computer and digital networks.

3. Results

3.a Technological change, organisational change and skill upgrading strategies

We first investigate the impact of technological and organisational changes upon the strategies adopted by firms to upgrade the skills of their workforce. Table 1 presents the results for the three different channels we consider here: upgrading of the occupational structure through entries and/or exits, excess turnover and training.

The left hand-side panel of the table provides "non standardised coefficients" coming out of standard OLS regressions. Firms that have introduced the Internet for at least 5% of their workforce significantly upgrade their occupational structure by recurring to the external labour market. Specifically, they increase net entries of managers and decrease net entries of unskilled clerks and blue-collars more than average. However, the Internet is the only form of innovation to induce upward changes in the occupational structure. Computer and digital networks as well as organisational and functional changes do not generate any significant skill upgrading through this first channel. Results are pretty similar for excess turnover. Here again, the introduction of the Internet induces firms to recur to the external labour market in order to bring in new skills. But in this case, the effect is significant for one single category, namely skilled clerks and blue collars.

Turning now to the third channel, both technological and organisational innovations seem to generate skill upgrading through training. The incidence of training (measured as the number of trainees per 100 workers – Indicator 1) is positively affected by innovation for all occupational groups except unskilled blue-collars. Organisational change increases training incidence significantly for skilled blue-collars, clerks, and technicians/supervisors (at the 10% level for the latter). Computer and digital networks positively affect the training of clerks and managers and the adoption of the Internet increases the rate of training among clerks and skilled blue-collars. There are a couple of exceptions to this skill upgrading strategy: functional change has no significant impact on training and the Internet reduces the proportion of trainees among managers (at the 10% level). But overall, technological and organisational changes seem to raise the incidence of training in most occupational groups. Part of this effect

could, in theory, be due to increased turnover: as mentioned in Section 1, if firms react to innovation by hiring new workers and if these new workers are systematically trained, the effect of innovation on training may not only capture adjustments through the internal labour market. However, the scope of excess turnover as a skill upgrading strategy is very limited in our sample. As mentioned earlier, skilled clerks and blue-collars is the only group for which the introduction of the Internet accelerates turnover. So, the risk of confusion between the turnover and training effects is virtually nil except for the Internet and skilled blue-collars. For all other categories and forms of innovation, the positive impact on the incidence of training indeed captures an internal labour market strategy.

As regards the number of hours of training per worker (Indicator 2), it is also positively affected by technological and organisational changes. Organisational change increases the number of hours of training per worker for technicians/supervisors and clerks. The adoption of the Internet has the same effect on both groups and digital networks increase the average number of training hours for managers and clerks, as well as technicians/supervisors and unskilled blue collars (but only at the 10% level for the last two groups). In contrast, unskilled blue-collars are negatively affected in terms of training by the Internet (at the 10% level).

A first result coming out of our analysis is that firms use both external and internal labour market strategies in order to upgrade the skill level of their workforce, following the adoption of new technologies and innovative workplace practices. When introducing the Internet, they upgrade their occupational structure through entries of managers and exits of unskilled clerks and blue-collars. The use of turnover is limited to skilled clerks and blue-collars. In contrast, training is the most widespread upskilling strategy for all occupational groups. This is confirmed when looking at "standardised coefficients" provided by the right hand-side panel of Table 1. They are obtained by normalising our left hand-side variables and are hence expressed in standard deviations of the dependent variable (see Section 1). Following organisational change, firms upgrade their skill structure through training only. Clerks and technicians/supervisors are affected both through an increase in training incidence and in the average number of training hours whereas no other upskilling strategy is used. The same goes for the impact of computer and digital networks upon managers and clerks. In contrast, regarding the adoption of the Internet, the three channels are used. External labour market adjustments dominate for managers, whereas training is the most important skill upgrading strategy for clerks and technicians/supervisors. Interestingly, when the estimated coefficients are significant, their magnitudes are very similar, implying an effect of about one fifth of a

standard deviation. Moreover, technological and organisational changes tend to negatively affect workers in the lowest occupations, both through external and internal labour market adjustments. The proportion of unskilled clerks and blue-collars decreases following the adoption of the Internet through a negative effect on net entries in this group. This is consistent with results in the skill-biased technical change literature. Moreover low-skill workers also appear to be disadvantaged by the limited amount of training they receive: the impact of innovation on training is never significant at the 5% level and the positive impact of the introduction of computer and digital networks is smaller than the negative impact of the introduction of the Internet (both effects being significant at the 10% level only).

Overall, skill upgrading following technological and organisational changes seems to take place mostly through internal labour markets adjustments, except for the adoption of the Internet which gives rise to both internal and external types of adjustments. This raises the question of the determinants of the strategies used by individual firms. Do certain firms adopt specific skill upgrading strategies? And, if so, which firms adopt which strategy?

3.b Skill upgrading strategies according to firms' size and localisation

When coming to the determinants of firms' choices in terms of skill upgrading strategies, firms' size comes high up on the list of potential candidates. The main reason for this is that internal labour markets tend to be more developed in large firms than in small ones (see Groshen and Levine, 1998). Consistently, when adapting to new technologies and innovative workplace practices, small firms are more likely to rely on the external labour market because they do not necessarily have the right people to train internally. On the contrary, large firms have a larger pool of workers among whom some are probably able to acquire the required skills if properly trained. So, our first conjecture is that internal labour market strategies are more likely to be found in large plants than in small ones, and that the opposite holds for strategies relying on external flexibility. A second potential determinant of firms' strategies has to do with their localisation. When located in an urban area, firms benefit from a much larger external labour market than when located in a rural environment. As a consequence, our second conjecture is that urban establishments rely relatively more on external labour flexibility in order to upgrade the skill level of their workforce, whereas rural establishments rely more on the internal labour market.

Table 2 presents the results of simple OLS regressions including interaction terms between our innovation variables and establishments' size and localisation. The direct effects capture

the impact of innovation on the skill upgrading strategies of our reference category, namely small urban plants. Interaction terms capture the differential impact of size (resp. localisation). In order to make sure that our size effect does not capture sectoral differences, we introduce, as an additional control, the interaction between the innovation variables and a dummy variable indicating whether the establishment belongs to the manufacturing or service sector.

Results for channel 1 suggest that in small urban plants, organisational change and the introduction of the Internet bring about a substantial upgrading of the occupational structure by increasing net entries of all skilled categories and increasing net exits of unskilled clerks and blue-collars. From a quantitative point of view, the most important effect comes from the Internet (see the standardised coefficients), but organisational change goes in the same direction. As compared to this reference group, large plants rely relatively less on the external labour market when introducing organisational change and the Internet. This is consistent with our hypothesis that external labour adjustments are more widely used by small firms. Similarly, upgrading of the occupational structure through entries and exits seems to be less frequent in rural plants (even if our estimates are significant at the 10% level only). This is also consistent with our prior that the reduced size of the external labour market does not incite rural plants to rely on external forms of labour adjustments.

Small urban plants also use excess turnover as a skill upgrading strategy when they introduce organisational change and the Internet. However, the effect is less pervasive than in the case of channel 1: only clerks and blue-collars do face a higher turnover following both forms of innovation, but the effect is significant for both skilled and unskilled workers in those occupations. In contrast, functional change seems to reduce excess turnover in all occupations except managers, even if the results are significant at the 10% level only. As expected, large plants rely less on this form of external labour market. The same pattern of results holds for rural plants even if our estimates are rarely significant at conventional levels.

Overall, skill upgrading strategies relying on the external labour market seem to be prevalently adopted by small urban plants. In contrast, firms' size and localisation do not appear to be as critical when coming to adjustments based on the internal labour market. Training incidence increases in small urban plants following technological changes, but this is the case for a limited number of occupations (mainly managers and supervisors/technicians). Moreover, there is not much difference according to firm size. The only significant effect is for rural plants following organisational change: they rely more on training for managers and clerks. Results are stronger for the average number of hours per worker: small urban plants

tend to train clerks and managers more when introducing new technologies and innovative workplace practices. But the effects of innovation go in opposite directions for technicians/supervisors: negative for functional change and positive for the introduction of the Internet. Moreover, there does not seem to be much systematic contrast between the various types of plants: compared to small plants, large ones appear to increase the training received by skilled blue collars and technicians/supervisors but to reduce it for clerks when introducing organisational or functional changes. Functional and organisational changes also seem to foster training for managers and technicians/supervisors in rural plants as compared to urban ones, but no effects appear for the other occupational groups.

All in all, in contrast to external labour market strategies, training on the internal labour market does not seem to vary much according to firms' size and/or localisation. This suggests that training is relatively widespread across firms whatever their size and environment, while adjustments through the external labour market are characteristic of small plants, especially when located in an urban environment.

4. Conclusion

In this paper, we have taken a fresh look at the issue of skill-biased technical change, following Mincer's insight that it is important to know whether the skill upgrading of the firms' workforce takes place through hiring or training for the new skills. We believe that this approach sheds some light on two related issues that have attracted much of labour economists' attention over the past years: what is the impact of skill-biased technical and organisational changes on job stability and job security? And what is their impact on the employment and career perspectives of unskilled workers?

Assessing the responses of internal labour markets to changes in the technology and the organisation of firms seems indeed useful to understand recent evolutions in labour markets better than by modelling them as price and quantity adjustments on a spot market. Our empirical results for France in the mid '90s suggest that internal labour markets have dampened the impact of technical and organisational changes for most occupational groups. In plants with more than 100 workers, increased training seems to have made it possible to upgrade the skills of the workforce without relying heavily on the external market. Other things kept equal, turnover has remained roughly the same as in other large plants that did not introduce the changes. Such a role of internal labour markets is consistent with stylised facts

on the French labour market over the same period: it witnessed an unprecedented rise in training incidence (Behaghel and Greenan, 2005) and a remarkable stability of job security for workers with more than five years of tenure.

However, technological and organisational changes seem to have induced a net decline of internal labour markets for one specific category, namely unskilled workers. They actually cumulate handicaps in the sense that they bear the brunt of the upgrading of firms' occupational structure while receiving less hours of training per worker. This suggests that the negative impact of innovation upon unskilled workers affects both their employment and career prospects.

Clearly, this interpretation of the role of internal labour markets is still conjectural, and needs to be confronted with other pieces of evidence. Is it consistent with evolutions in other countries? The US seems a promising field of investigation, as job instability has remained roughly unchanged too, and the announced decline of internal labour market has found limited empirical support.

Last, as far as our empirical analysis is concerned, there is a need to go further in addressing causality issues. Besides using rich sets of controls as we did, using panel data on technical change is a promising venue.

References

Abowd J., P. Corbel, F. Kramarz (1999), « The Entry and Exit of Workers and the Growth of Employment, » *Review of Economics and Statistics* 81, 2, 170-187.

Askenazy P. and Moreno-Galbis E., 2004, "The Impact of Technological and Organisational Changes on Labour Flows. Evidence on French Establishments", mimeo GAINS-Le Mans University. http://www.univ-lemans.fr/~emoreno/papiers/EP6.pdf

Athey S. and Stern S., 1998, "An Empirical Framework for Testing Theories about Complementarities in Organisational Design", NBER Working Paper 6600.

Atkinson T., 1999, "Is Rising Inequality Inevitable? A Critique of the Transatlantic Consensus", *WIDER Annual Lectures* 3.

Aubert P., Caroli E. and Roger M., 2006, "New Technologies, Organisation and Age: Firm-Level Evidence", *The Economic Journal*, 116, pp. 73-93.

Autor D., Levy F. and Murnane R., 2003, "The skill content of recent technological change: an empirical investigation", *The Quarterly Journal of Economics*, 118(4), pp. 1279-1333.

Bauer T. and Bender S., 2004, "Technological Change, Organisational Change and Job Turnover", *Labour Economics*, 11(3), pp. 265-91.

Behaghel L., 2003 « Insécurité de l'emploi : le rôle protecteur de l'ancienneté a-t-il baissé en France ? », *Economie et statistique*, n°366, pp. 1-27.

Behaghel L. and Greenan N., 2005, "Training and Age-Biased Technical Change: Evidence from French Micro Data", CREST Working Paper 2005-6, Revised June 2005.

Bertrand M., 2004, "From the Invisible Handshake to the Invisible Hand? How Import Competition Changes the Employment Relationship", *Journal of Labour Economics*, 22(4), pp. 723-765.

Bresnahan T., Brynjolfsson E. and Hitt L, 2002, "Information Technology, Workplace Organisation and the Demand for Skilled Labour: Firm Level Evidence", *The Quarterly Journal of Economics*, 117(1), pp. 339-76.

Cappelli P. and Neumark D., 2004, "External Churning and Internal Flexibility: Evidence on the Functional Flexibility and Core-Periphery Hypotheses", *Industrial Relations*, 43(1), pp. 148-82.

Caroli E. and Van Reenen J, 2001, "Skill biased organisational change? Evidence from a panel of British and French establishments", *The Quarterly Journal of Economics*, 116(4), pp. 1449-92.

Chennells L. and Van Reenen J., 2002, "Has Technology hurt the less skilled workers? An econometric survey of the effects of technical change on the structure of pay and jobs", in L'Horty Y., Greenan N. and Mairesse J. eds, *Productivty, Inequality and the Digital Economy*, MIT Press, pp. 175-225.

DiPrete A., Goux D. and Maurin E., 2002, "Internal Labour Markets and Earnings Trajectories in the Post-Fordist Economy: An Analysis of Recent Trends", *Social Science Research*, 31, pp. 175-96.

Doeringer P. and Piore M., 1971, *Internal Labour Markets and Manpower Analysis*, Lexington MA, Heath.

Farber, H., 2003, “Job Loss in the United States, 1981-2001”, *NBER Working Paper n°9707*.

Gautié, J., 2004, “Les marchés internes du travail, l’emploi et les salaires”, *Revue Française d’Economie,* 18, pp. 33-62.

Givord, P. and Maurin E., 2004, “Changes in Job Insecurity and their Causes: An Empirical Analysis for France, 1982-2002”, *European Economic Review*, 48, pp. 595-615.

Gottschak P. and Moffitt R., 1999, “Changes in Job Instability and Wages for Adult Young Men”, *Journal of Labour Economics,* 17(4), pp. 91-126.

Groshen E. and Levine D., 1998, “The Rise and Decline (?) of U.S. Internal Labour Markets”, *Federal Reserve Bank of New-York Research Paper n°9819.*

Lynch L. and Black S., 1998, "Beyond the Incidence of Employer Provided Training", *Industrial and Labour Relations Review*, 52(1), pp. 6481.

Mincer J., 1989, "Human Capital Responses to Technological Change in the Labour Market", NBER Working Paper, n°3207.

Neumark, D., Polsky, D. and Hansen D., 1999, “Has Job Stability declined yet? New Evidence for the 1990s”, *Journal of Labour Economics,* 17(4), pp. 29-64.

OECD, 2003, "More and Better Jobs? Aggregate Performance during the Past Decade", Chapter 1, *Employment Outlook*, OECD, Paris, pp. 17-66.

Stevens A.H., 2005, “The more things change, the more they stay the same: Trends in Long-Term Employment in the United States, 1969-2002”, *NBER Working Paper* 11878.

Spitz-Oener A., 2006, "Technical Change, Job Tasks and Rising Educational Demands: Looking outside the Wage Structure, *Journal of Labour Economics*, 24(2), pp. 235-70.

Valletta R., 2000, "Declining Job Security", in Neumark D. ed*: On the Job: is Long-Term Employment a Thing of the Past?,* New-York : Russell Sage Foundation, pp. 227-56.

Walkowiak E., 2006, ‘Renouvellement de la main-d’œuvre et modernisation des entreprises ”, *Revue Economique*, 57(6), pp. 1205-33.

Zamora P., 2006, "Changements organisationnels, technologies et recours à la formation dans les entreprises industrielles", *Revue Economique*, 57(6), pp. 1235-57.

Table 1: Response to technical and organisational changes through the three upgrading channels (all plants together)

	Non Standardised coefficients				Standardised coefficients			
Channel 1: Upgrading of the occupational structure through entries/exits								
	Managers	Technicians and supervisors	Skilled clerks and blue collars	Unskilled clerks and blue collars	Managers	Technicians and supervisors	Skilled clerks and blue collars	Unskilled clerks and blue collars
Organisational change	2.65	1.92	3.26	-7.82	8.93	6.03	14.73	-10.75
	[1.85]	[2.11]	[2]	[5]	[6.26]	[6.65]	[9.04]	[6.87]
Functional change	0.19	0.47	-0.68	0.03	0.63	1.47	-3.08	0.04
	[0.58]	[0.66]	[0.63]	[1.57]	[1.97]	[2.09]	[2.84]	[2.16]
Introduction of computer and digital networks	-0.48	1.66	1.00	-2.17	-1.61	5.21	4.50	-2.99
	[1.87]	[2.14]	[2.02]	[5.06]	[6.33]	[6.72]	[9.14]	[6.95]
Introduction of the Internet	6.89	3.18	3.44	-13.50	23.26	9.99	15.55	-18.55
	[2.75]**	[3.14]	[2.97]	[7.43]*	[9.3]**	[9.88]	[13.44]	[10.21]*
Number of observations	1063	1063	1063	1063	1063	1063	1063	1063
R-squared	0.06	0.02	0.05	0.05	0.06	0.02	0.05	0.05
Channel 2: Excess turnover								
	Managers	Technicians and supervisors	Skilled clerks and blue collars	Unskilled clerks and blue collars	Managers	Technicians and supervisors	Skilled clerks and blue collars	Unskilled clerks and blue collars
Organisational change	0.38	-0.01	0.08	0.65	8.08	-2.22	3.77	7.77
	[0.308]	[0.039]	[0.143]	[0.542]	[6.594]	[6.547]	[6.514]	[6.451]
Functional change	0.07	-0.01	-0.01	-0.16	1.41	-1.34	-0.44	-1.94
	[0.097]	[0.012]	[0.045]	[0.170]	[2.071]	[2.057]	[2.046]	[2.026]
Introduction of computer and digital networks	0.43	-0.06	-0.01	0.52	9.30	-10.69	-0.55	6.24
	[0.311]	[0.040]	[0.145]	[0.548]	[6.667]	[6.619]	[6.586]	[6.522]
Introduction of the Internet	-0.23	0.06	0.59	1.20	-4.82	10.46	26.65	14.26
	[0.458]	[0.058]	[0.213]***	[0.805]	[9.802]	[9.731]	[9.683]***	[9.589]
Number of observations	1063	1063	1063	1063	1063	1063	1063	1063
R-squared	0.07	0.08	0.09	0.11	0.07	0.08	0.09	0.11

…/…

Table 1 (continued)

Channel 3: Training

Indicator 1: Number of trainees per 100 workers

	Managers	Technicians and supervisors	Clerks	Skilled blue collars	Unskilled blue collars	Managers	Technicians and supervisors	Clerks	Skilled blue collars	Unskilled blue collars
Organisational change	3.90	6.11	4.20	4.38	-8.76	11.44	12.90	13.21	14.69	-3.28
	[2.160]*	[3.144]*	[2.081]**	[2.083]**	[22.121]	[6.335]*	[6.642]*	[6.552]**	[6.984]**	[8.273]
Functional change	0.20	-0.72	-0.48	-0.13	-3.18	0.59	-1.51	-1.51	-0.42	-1.19
	[0.680]	[0.983]	[0.653]	[0.650]	[7.149]	[1.994]	[2.077]	[2.056]	[2.178]	[2.674]
Introduction of computer and digital networks	5.68	3.74	6.33	1.80	-0.80	16.66	7.90	19.93	6.02	-0.30
	[2.179]***	[3.195]	[2.098]***	[2.115]	[22.525]	[6.390]***	[6.750]	[6.605]***	[7.092]	[8.424]
Introduction of the Internet	-5.88	3.33	6.31	6.90	-5.48	-17.25	7.03	19.86	23.14	-2.05
	[3.198]*	[4.682]	[3.069]**	[3.141]**	[34.948]	[9.380]*	[9.889]	[9.663]**	[10.533]**	[13.069]
Number of observations	1055	1021	1031	910	703	1055	1021	1031	910	703
R-squared	0.15	0.09	0.12	0.11	0.03	0.15	0.09	0.12	0.11	0.03

Indicator 2: Hours of training per worker

	Managers	Technicians and supervisors	Clerks	Skilled blue collars	Unskilled blue collars	Managers	Technicians and supervisors	Clerks	Skilled blue collars	Unskilled blue collars
Organisational change	1.40	2.37	2.47	0.90	0.90	9.10	16.63	20.17	9.43	8.92
	[0.989]	[0.905]***	[0.797]***	[0.679]	[0.905]	[6.414]	[6.362]***	[6.505]***	[7.154]	[8.958]
Functional change	0.09	-0.10	0.01	0.26	-0.39	0.56	-0.69	0.10	2.77	-3.84
	[0.311]	[0.283]	[0.250]	[0.211]	[0.290]	[2.014]	[1.986]	[2.039]	[2.228]	[2.869]
Introduction of computer and digital networks	2.98	1.64	2.38	0.47	1.53	19.30	11.53	19.44	4.99	15.12
	[0.996]***	[0.919]*	[0.802]***	[0.688]	[0.903]*	[6.464]***	[6.461]*	[6.546]***	[7.255]	[8.942]*
Introduction of the Internet	-0.14	2.88	2.94	0.20	-2.64	-0.90	20.25	23.95	2.11	-26.09
	[1.462]	[1.342]**	[1.177]**	[1.021]	[1.404]*	[9.485]	[9.434]**	[9.601]**	[10.767]	[13.906]*
Number of observations	1054	1014	1029	909	593	1054	1014	1029	909	593
R-squared	0.13	0.18	0.13	0.07	0.07	0.13	0.18	0.13	0.07	0.07

Note:

Standard errors in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%

Separate OLS estimation for each occupational group and each channel / indicator. In the right hand-side panel, the dependent variables have been standardised so as to make coefficients' magnitude comparable between channels (see section 1 in text).

Additional controls: industry dummies (16 industries), plant size dummies, plant's share of women, indicators for single-establishment firm, public sector, listed company, rural localisation, presence of union delegates, presence of part-time workers.

Table 2: Response to technical and organisational changes through the three upgrading channels (by plants' size and localisation)

Channel 1: Upgrading of the occupational structure through entries/exits	**Non Standardised coefficients**				**Standardised coefficients**			
	Managers	Technicians and supervisors	Skilled clerks and blue collars	Unskilled clerks and blue collars	Managers	Technicians and supervisors	Skilled clerks and blue collars	Unskilled clerks and blue collars
Effect for reference category (small urban plants)								
Organisational change	14.45	12.91	17.82	-45.18	48.82	40.62	80.58	-62.09
	[4.67]***	[5.34]**	[5.04]***	[12.53]***	[15.76]***	[16.81]**	[22.8]***	[17.23]***
Functional change	-0.25	-0.13	-2.63	3.01	-0.85	-0.41	-11.90	4.14
	[1.38]	[1.58]	[1.5]*	[3.72]	[4.68]	[4.99]	[6.77]*	[5.11]
Introduction of computer and digital networks	0.79	0.46	3.13	-4.38	2.65	1.46	14.15	-6.02
	[4.69]	[5.37]	[5.07]	[12.59]	[15.83]	[16.89]	[22.91]	[17.31]
Introduction of the Internet	32.83	31.74	25.51	-90.09	110.89	99.89	115.35	-123.80
	[8.49]***	[9.72]***	[9.18]***	[22.81]***	[28.68]***	[30.59]***	[41.5]***	[31.35]***
Size-specific effet								
Organisational change x Large plant (>100 workers)	-13.19	-11.15	-16.29	40.64	-44.55	-35.10	-73.67	55.85
	[4.57]***	[5.23]**	[4.94]***	[12.27]***	[15.42]***	[16.45]**	[22.32]***	[16.86]***
Functional change x Large plant (>100 workers)	0.94	0.67	2.13	-3.74	3.17	2.12	9.64	-5.14
	[1.41]	[1.61]	[1.52]	[3.78]	[4.76]	[5.07]	[6.88]	[5.2]
Introduction of computer and digital networks x Large plant (>100 workers)	-3.42	-1.38	-3.59	8.38	-11.54	-4.35	-16.22	11.52
	[4.56]	[5.22]	[4.93]	[12.24]	[15.39]	[16.42]	[22.28]	[16.83]
Introduction of the Internet x Large plant (>100 workers)	-33.68	-32.23	-26.88	92.79	-113.77	-101.42	-121.51	127.52
	[7.78]***	[8.9]***	[8.41]***	[20.89]***	[26.26]***	[28.02]***	[38.01]***	[28.71]***
Rural specific effet								
Organisational change x Rural plant	-6.51	-6.87	-7.18	20.56	-22.00	-21.63	-32.44	28.26
	[3.96]	[4.54]	[4.28]*	[10.65]*	[13.38]	[14.28]	[19.37]*	[14.63]*
Functional change x Rural plant	0.14	0.65	1.28	-2.07	0.46	2.03	5.81	-2.84
	[1.04]	[1.19]	[1.13]	[2.8]	[3.52]	[3.75]	[5.09]	[3.85]
Introduction of computer and digital networks x Rural plant	3.55	1.50	-0.19	-4.86	11.99	4.72	-0.85	-6.68
	[4.05]	[4.63]	[4.38]	[10.88]	[13.67]	[14.58]	[19.79]	[14.95]
Introduction of the Internet x Rural plant	-9.56	-11.90	-5.01	26.47	-32.30	-37.44	-22.66	36.38
	[6.53]	[7.47]	[7.06]	[17.53]	[22.04]	[23.51]	[31.9]	[24.1]
Number of observations	1063	1063	1063	1063	1063	1063	1063	1063
R-squared	0.06	0.03	0.06	0.10	0.06	0.03	0.06	0.10

…/…

Table 2 (continued)

Channel 2: Excess turnover

	Managers	Technicians and supervisors	Skilled clerks and blue collars	Unskilled clerks and blue collars	Managers	Technicians and supervisors	Skilled clerks and blue collars	Unskilled clerks and blue collars
Effect for reference category (small urban plants)								
Organisational change	0.95	-0.07	0.75	3.34	20.27	-10.80	33.96	39.74
	[0.779]	[0.101]	[0.358]**	[1.365]**	[16.687]	[16.772]	[16.286]**	[16.248]**
Functional change	0.36	-0.05	-0.18	-0.67	7.72	-8.40	-8.01	-8.02
	[0.231]	[0.030]*	[0.106]*	[0.405]*	[4.951]	[4.976]*	[4.832]*	[4.821]*
Introduction of computer and digital networks	0.63	-0.17	0.15	0.57	13.47	-27.42	6.66	6.76
	[0.783]	[0.101]	[0.359]	[1.371]	[16.764]	[16.850]	[16.362]	[16.323]
Introduction of the Internet	-0.42	0.24	3.44	10.80	-8.93	39.72	156.58	128.60
	[1.418]	[0.183]	[0.651]***	[2.483]***	[30.369]	[30.524]	[29.640]***	[29.569]***
Size-specific effet								
Organisational change x Large plant (>100 workers)	-1.46	0.06	-0.89	-3.29	-31.30	9.28	-40.38	-39.15
	[0.762]*	[0.099]	[0.350]**	[1.335]**	[16.328]*	[16.412]	[15.936]**	[15.899]**
Functional change x Large plant (>100 workers)	-0.45	0.05	0.21	0.60	-9.72	8.47	9.53	7.12
	[0.235]*	[0.030]*	[0.108]*	[0.412]	[5.036]*	[5.062]*	[4.915]*	[4.903]
Introduction of computer and digital networks x Large plant (>100 workers)	-1.08	0.12	-0.21	-0.97	-23.16	19.63	-9.67	-11.60
	[0.761]	[0.098]	[0.349]	[1.333]	[16.300]	[16.383]	[15.908]	[15.871]
Introduction of the Internet x Large plant (>100 workers)	1.16	-0.15	-3.38	-10.67	24.83	-25.60	-153.88	-127.07
	[1.299]	[0.168]	[0.596]***	[2.275]***	[27.814]	[27.956]	[27.146]***	[27.082]***
Rural specific effet								
Organisational change x Rural plant	0.59	0.08	-0.05	-1.17	12.68	13.10	-2.16	-13.91
	[0.662]	[0.086]	[0.304]	[1.159]	[14.174]	[14.246]	[13.834]	[13.801]
Functional change x Rural plant	0.14	-0.01	-0.01	0.07	2.90	-2.40	-0.24	0.85
	[0.174]	[0.022]	[0.080]	[0.305]	[3.727]	[3.746]	[3.638]	[3.629]
Introduction of computer and digital networks x Rural plant	0.93	0.00	-0.01	0.90	19.86	-0.12	-0.64	10.70
	[0.676]	[0.087]	[0.310]	[1.184]	[14.478]	[14.551]	[14.130]	[14.097]
Introduction of the Internet x Rural plant	-1.27	-0.03	-0.95	-3.67	-27.12	-5.65	-43.03	-43.66
	[1.090]	[0.141]	[0.500]*	[1.909]*	[23.341]	[23.460]	[22.781]*	[22.727]*
Number of observations	1063	1063	1063	1063	1063	1063	1063	1063
R-squared	0.10	0.09	0.14	0.15	0.10	0.09	0.14	0.15

…/…

Table 2 (continued)

Channel 3: Training

Indicator 1: Number of trainees per 100 workers

	Managers	Technicians and supervisors	Clerks	Skilled blue collars	Unskilled blue collars	Managers	Technicians and supervisors	Clerks	Skilled blue collars	Unskilled blue collars
Effect for reference category (small urban plants)										
Organisational change	-8.48	5.61	6.89	-2.90	41.99	-24.88	11.85	21.69	-9.74	15.70
	[5.491]	[8.154]	[5.458]	[5.379]	[56.322]	[16.105]	[17.224]	[17.186]	[18.038]	[21.062]
Functional change	1.63	-3.57	-0.03	-0.32	-0.31	4.77	-7.55	-0.10	-1.08	-0.12
	[1.677]	[2.457]	[1.618]	[1.595]	[17.270]	[4.920]	[5.190]	[5.094]	[5.349]	[6.458]
Introduction of computer and digital networks	11.72	2.23	8.71	-0.95	9.83	34.36	4.72	27.41	-3.17	3.68
	[5.542]**	[8.280]	[5.397]	[5.544]	[56.396]	[16.255]**	[17.489]	[16.994]	[18.592]	[21.090]
Introduction of the Internet	6.44	32.45	3.94	15.32	4.51	18.90	68.55	12.39	51.36	1.69
	[9.958]	[14.783]**	[9.698]	[10.759]	[115.459]	[29.208]	[31.225]**	[30.535]	[36.080]	[43.177]
Size-specific effet										
Organisational change x Large plant (>100 workers)	7.65	2.41	-8.03	6.64	-39.45	22.45	5.08	-25.27	22.28	-14.75
	[5.364]	[7.971]	[5.282]	[5.306]	[55.599]	[15.732]	[16.836]	[16.633]	[17.793]	[20.792]
Functional change x Large plant (>100 workers)	-1.77	2.86	-0.34	0.08	-2.47	-5.18	6.04	-1.08	0.27	-0.93
	[1.658]	[2.437]	[1.596]	[1.602]	[17.328]	[4.863]	[5.148]	[5.026]	[5.371]	[6.480]
Introduction of computer and digital networks x Large plant (>100 workers)	-5.77	-0.20	-0.48	5.40	-8.04	-16.93	-0.42	-1.50	18.11	-3.01
	[5.350]	[8.026]	[5.189]	[5.432]	[55.889]	[15.692]	[16.954]	[16.339]	[18.217]	[20.900]
Introduction of the Internet x Large plant (>100 workers)	-3.40	-20.95	7.67	-7.82	-20.01	-9.97	-44.25	24.16	-26.22	-7.48
	[9.118]	[13.660]	[8.881]	[10.040]	[108.818]	[26.744]	[28.853]	[27.965]	[33.670]	[40.694]
Rural specific effet										
Organisational change x Rural plant	9.36	4.77	9.26	2.51	-13.33	27.45	10.08	29.16	8.40	-4.99
	[4.744]**	[6.915]	[4.570]**	[4.532]	[48.053]	[13.915]**	[14.607]	[14.390]**	[15.197]	[17.970]
Functional change x Rural plant	-0.47	0.04	0.40	-0.79	2.96	-1.37	0.09	1.26	-2.66	1.11
	[1.529]	[2.230]	[1.464]	[1.457]	[16.263]	[4.485]	[4.711]	[4.610]	[4.887]	[6.082]
Introduction of computer and digital networks x Rural plant	0.38	2.11	-4.55	0.24	2.34	1.10	4.45	-14.31	0.81	0.87
	[4.892]	[7.184]	[4.705]	[4.677]	[49.838]	[14.348]	[15.176]	[14.814]	[15.684]	[18.638]
Introduction of the Internet x Rural plant	-4.43	-6.09	-12.44	-6.35	24.45	-12.98	-12.86	-39.17	-21.30	9.14
	[7.648]	[11.174]	[7.343]*	[7.877]	[82.198]	[22.432]	[23.603]	[23.121]*	[26.415]	[30.739]
Number of observations	1055	1021	1031	910	703	1055	1021	1031	910	703
R-squared	0.17	0.11	0.13	0.12	0.04	0.17	0.11	0.13	0.12	0.04

…/…

Table 2 (continued)

Indicator 2: Hours of training per worker

	Managers	Technicians and supervisors	Clerks	Skilled blue collars	Unskilled blue collars	Managers	Technicians and supervisors	Clerks	Skilled blue collars	Unskilled blue collars
Effect for reference category (small urban plants)										
Organisational change	-1.87	2.74	4.77	-1.65	-0.29	-12.13	19.27	38.95	-17.39	-2.89
	[2.520]	[2.337]	[2.094]**	[1.745]	[2.386]	[16.346]	[16.423]	[17.085]**	[18.397]	[23.622]
Functional change	-0.72	-1.94	0.21	-0.12	-0.52	-4.67	-13.60	1.67	-1.23	-5.10
	[0.768]	[0.703]***	[0.620]	[0.517]	[0.719]	[4.984]	[4.940]***	[5.057]	[5.446]	[7.117]
Introduction of computer and digital networks	7.13	1.40	1.99	1.66	2.14	46.25	9.83	16.26	17.46	21.14
	[2.541]***	[2.371]	[2.068]	[1.801]	[2.358]	[16.486]***	[16.664]	[16.868]	[18.983]	[23.342]
Introduction of the Internet	1.56	10.52	2.41	0.84	-0.20	10.10	73.95	19.68	8.80	-2.02
	[4.566]	[4.227]**	[3.718]	[3.483]	[4.782]	[29.622]	[29.706]**	[30.333]	[36.712]	[47.349]
Size-specific effet										
Organisational change x Large plant (>100 workers)	1.07	-1.00	-4.33	3.05	0.36	6.95	-7.00	-35.31	32.13	3.51
	[2.470]	[2.293]	[2.035]**	[1.723]*	[2.375]	[16.025]	[16.118]	[16.598]**	[18.156]*	[23.512]
Functional change x Large plant (>100 workers)	0.60	1.47	-0.23	0.42	0.35	3.86	10.36	-1.84	4.42	3.49
	[0.760]	[0.698]**	[0.613]	[0.519]	[0.720]	[4.932]	[4.909]**	[4.997]	[5.468]	[7.131]
Introduction of computer and digital networks x Large plant (>100 workers)	-2.93	0.70	2.14	-0.68	-1.27	-19.00	4.89	17.44	-7.14	-12.61
	[2.454]	[2.303]	[1.990]	[1.766]	[2.316]	[15.921]	[16.184]	[16.230]	[18.619]	[22.930]
Introduction of the Internet x Large plant (>100 workers)	-0.19	-5.28	0.95	0.74	-2.14	-1.21	-37.14	7.77	7.75	-21.15
	[4.180]	[3.906]	[3.402]	[3.251]	[4.535]	[27.117]	[27.454]	[27.753]	[34.270]	[44.903]
Rural specific effet										
Organisational change x Rural plant	4.41	0.48	1.91	0.17	1.23	28.60	3.40	15.56	1.77	12.22
	[2.185]**	[1.995]	[1.758]	[1.467]	[1.946]	[14.172]**	[14.019]	[14.342]	[15.461]	[19.264]
Functional change x Rural plant	0.67	1.42	0.07	-0.60	-0.55	4.32	9.99	0.57	-6.28	-5.42
	[0.703]	[0.641]**	[0.562]	[0.472]	[0.652]	[4.559]	[4.503]**	[4.586]	[4.971]	[6.451]
Introduction of computer and digital networks x Rural plant	-1.55	-0.05	-2.40	-0.12	0.54	-10.05	-0.36	-19.58	-1.24	5.34
	[2.247]	[2.066]	[1.804]	[1.514]	[1.993]	[14.578]	[14.518]	[14.718]	[15.954]	[19.736]
Introduction of the Internet x Rural plant	1.00	-2.78	-0.91	-1.25	-0.36	6.45	-19.55	-7.39	-13.16	-3.51
	[3.508]	[3.197]	[2.816]	[2.548]	[3.231]	[22.756]	[22.470]	[22.971]	[26.861]	[31.988]
Number of observations	1054	1014	1029	909	593	1054	1014	1029	909	593
R-squared	0.15	0.19	0.14	0.09	0.07	0.15	0.19	0.14	0.09	0.07

Note:
Standard errors in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%
Separate OLS estimation for each occupational group and each channel / indicator. In the right hand-side panel, the dependent variables have been standardised so as to make coefficients' magnitude comparable between channels (see section 1 in text).
Additional controls: industry dummies (16 industries), plant size dummies, plant's share of women, indicators for single-establishment firm, public sector, listed company, rural localisation, presence of union delegates, presence of part-time workers, indicators of service sector interacted with: organisational change, functional change, introduction of computer and digital networks and introduction of the Internet.

Table A1: Descriptive statistics

		Subsample of plants that have...			
	All plants	... implemented organisational change	... implemented more than two functional changes	... introduced computer and digital networks	... introduced the Internet
Net entry rate (in %)					
Managers	-0.42	-0.52	-0.03	0.27	0.96
Technicians and supervisors	-0.17	-0.79	0.68	1.28	0.08
Skilled clerks and blue collars	-0.72	-1.15	-1.31	0.33	-1.34
Unskilled clerks and blue collars	-1.00	-8.36	-3.87	-3.75	-17.96
Excess turnover (in %)					
Managers	33.41	56.45	41.23	50.84	25.15
Technicians and supervisors	21.46	18.68	20.16	16.13	21.22
Skilled clerks and blue collars	37.38	40.15	36.32	38.31	79.97
Unskilled clerks and blue collars	152.60	188.17	153.30	191.07	267.37
Number of trainees per 100 workers					
Managers	59.30	63.58	61.78	64.58	60.80
Technicians and supervisors	59.27	64.90	60.17	64.42	65.94
Clerks	41.47	45.90	42.38	47.65	51.54
Skilled blue collars	34.47	37.97	35.25	38.15	41.96
Unskilled blue collars	33.03	28.47	24.72	28.10	21.46
Hours of training per worker					
Managers	21.53	23.51	22.92	24.39	24.02
Technicians and supervisors	19.11	21.64	20.04	21.66	23.32
Clerks	12.12	14.43	12.85	14.36	16.06
Skilled blue collars	6.03	6.96	6.52	6.80	6.47
Unskilled blue collars	5.42	6.18	5.26	6.25	3.98
Organisational change (dummy variable)	0.39	1.00	0.50	0.45	0.50
Functional change index (0 to 7)	2.28	2.95	3.22	2.65	2.96
Introduction of computer and digital networks	0.43	0.50	0.49	1.00	0.87
Introduction of the Internet	0.13	0.17	0.17	0.26	1.00
Indicator for plant with fewer than 100 workers	0.24	0.17	0.20	0.17	0.15
Indicator for multi-establishment firm	0.62	0.67	0.64	0.67	0.65
Indicator for public sector	0.03	0.02	0.03	0.04	0.04
Indicator for listed company	0.44	0.52	0.48	0.51	0.56
Indicator for presence of union delegates	0.76	0.81	0.79	0.81	0.72
Share of women	50.3	54.4	53.2	50.2	81.9
Indicator for part-time work (>5% of workforce)	0.33	0.31	0.30	0.34	0.35
Indicator for rural localisation	0.30	0.32	0.28	0.27	0.22
Indicator for service sector	0.34	0.28	0.29	0.31	0.37
Number of observations	1063	415	681	460	139