The impact of technological and organizational changes on labor flows. Evidence on French establishments.

Philippe Askenazy*   Eva Moreno Galbis†

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Abstract

This paper investigates the effect of organizational and technological changes on job stability of different occupations. We first develop a basic matching model with endogenous job destruction. It predicts that new technologies should stimulate labor flows of low-skilled workers, but innovative work organization has ambiguous consequences. Second, we extensively exploit a unique French data set on a representative sample of French establishments. Empirical results globally corroborate our theoretical predictions. The adoption of information technologies increases flows of manual workers, employees and intermediary occupations. In addition, *tayloristic* organization reduces flows of employees and manual workers, while most of the new work practices raise employment variation of managers.

JEL classification: J23, J41, J63, L23, O33

Keywords: Job Flows; Information and Communication technologies; Organizational Change

*CNRS and CEPREMAP, 48 bd. Jourdan. 75014 Paris. philippe.askenazy@cepremap.ens.fr.

†Université Catholique de Louvain and IRES, Place Montesquieu, 3, B-1348 Louvain-la-Neuve (Belgique). E-mail: moreno@ires.ucl.ac.be, moreno@delta.ens.fr

1 Introduction

The consequences of the information and communication technologies (ICT) revolution have been largely analyzed by the economic literature. While authors like Berman, Bound, and Griliches (1994), Fitz Roy and Funke (1995), Machin, Ryan, and Van Reenen (1998), Krusell et al. (2000) and Moreno-Galbis (2002) claim that the capital-skill complementarity relationship has led to a skill-biased technological change, other authors, like Caroli and Van Reenen (2001) argue that it is the internal re-organization of firms following ICT adoption that has been skill-biased. Nowadays, there is an increasing agreement about the complementary relationship between ICT adoption, inside organizational changes of firms and skills (see Askenazy and Gianella (2000), Bresnahan, Brynjolfsson, and Hitt (2002) Cappelli (1996), Caroli and Van Reenen (2001) and Greenan (1996)). According to this argument, the introduction of ICT is necessarily associated with changes in the organizational and skill infrastructure of the firms.

In spite of the numerous works about the effects of the ICT revolution, there is no much evidence about its consequences on jobs quality. Our paper focuses on this issue, more particularly, we explore the effects of new technologies and new organizational practices (introduced by firms in order to efficiently exploit these ICT) on labor flows of different professional categories in France.

There are many articles analyzing labor and jobs flows, such as Burgess and Nickell (1990), who already in the beginning of the nineties developed a theoretical model distinguishing between the determinants of quits and layoffs and estimated it working with UK data on the manufacturing sector. Using Dutch data Hamermesh, Hassink, and Van-Ours (1996) describe the job flows within a firm, the job flows to and from the firm, the net employment changes within a firm and the patterns of hiring and firing. Burgess, Lane, and Stevens (2000), Neumark, Polsky, and Hansen (1999) or Valletta (1999) analyze the evolution job stability (job security in the last case) working with US data. Finally, using French data, Abowd and Kramarz (2003) address the extent of entry and exit of workers associated with job creation and destruction, the role of skill in simultaneous hiring and separation rates and the importance of short-term and long-term contracts in the adjustment process. None of these papers analyzes the sources of labor and job flows. The authors compute and describe flows without wondering about the effects that ICT adoption, introduction of high performance workplace organizational (HPWO) practices (such as *delayering*[1], team work, decentralization of decision making within firms, quality control, Total Quality Management) or other factors may have over these flows.

	ICT[1] investment in OECD countries			**HPWO[2] practices**			
	1980	**1990**	**2000**	**Task rotation**	**Working teams**	**Higher worker implication**	**Reduction in hierarchy**
Belgium	..	..	12	..	..	..	..
France	6.1	8.5	13.1	6	30	44	21
Germany	7.7	13.9	19.2	7	20	19	30
Italy	8.0	14.2	16.7	13	28	24	10
Netherlands	11.2	15.5	20.9	9	9	46	47
Spain	5.6	11.9	10.1	14	34	33	..
United Kingdom	5.6	13.8	22.0	13	33	48	45
United States	15.2	22.5	31.4	..	..	..	..

1. Percentage of non residual gross fixed capital formation, total economy. ICT equipment is defined as computer and office equipment and communication equipment; software includes both purchased and own account software.
2. Percentage of establishments stating in 1996 some of the HPWO practices adopted by their employers during the three previous years (concerning Italy data refers to the three previous months).
.. Unavailable data.
Source concerning ICT: OECD estimates based on national accounts.
Source concerning HPWO: OECD Employment Outlook 1999, table 4.4, page 206.

Table 1: ICT investment and adopted HPWO practices in some OECD countries.

When comparing the scarce available data about the introduction of ICT and HPWO practices with the also non abundant data concerning the workers' feeling on job stability[2], we observe that in most European countries new technologies and innovative organizational practices adoption

[1]Delegating responsibilities to lower hierarchical levels inside the firm by removing one or more managerial levels.

[2]It would be more interesting to compare the adoption of ICT and HPWO practices with the evolution of job turnover, however the available data on this variable concerns, for most European countries, the average values of job turnover between the mid-eighties and the beginning of the nineties (see OECD (1996) table 5.1 page 176), therefore we cannot analyze its evolution.

	Feeling[1] of job instability 1996	**Evolution[2] of job instability 1985-1995**
Belgium	71.5	-6*
France	78.7	-14*
Germany	71.8	-18*
Italy	69.6	-5*
Netherlands	60.3	-12*
Spain	71.2	..
United Kingdom	66.9	-22*
United States	..	..

1. Percentage of workers being in total disagreement with the statement *my job is ensure*.
2. Evolution in percentage points in the proportion of workers answering favorably to the question concerning the stability of their job.
.. Unavailable data. * Significant evolution.
Source: OECD Employment Outlook 1997, table 5.2, page 148, and table 5.3, page 149.

Table 2: Job instability in OECD countries.

has been associated to an increased feeling of job instability by workers (see tables 1 and 2). Using a unique French data set this paper tries to estimate the effects of ICT and HPWO practices on the labor flows of different professional categories.

Related theoretical literature concerns Michelacci and Lopez-Salido (2004). On the empirical side, Bauer and Bender (2002), working with a German employer-employee matched panel data set, examine the impact of ICT and HPWO practices on gross job and worker flows. The authors conclude that the organizational change is skill-biased since it leads to higher job destruction and separation rates for low- and medium-skilled workers, while employment patterns of high-skilled are not affected significantly. They also find that new technologies do not have significant effects on gross job and workers flows. Neumark and Reed (2004), working with US data, estimate a positive link between new economy jobs, defined either as employment in high-tech cities or as industry employment growth, and contingent[3] or alternative[4] employment relationships. Jones, Kato, and Weinberg (2003) implement a case study over ten US manufacturing establishments

[3]A contingent worker is defined as an individual holding a job that is temporary by its nature.

[4]Alternative employment arrangements are: independent contractors, on-call workers, temporary help agency workers and workers provided by contract firms.

in order to determine how the quality of jobs is affected by the managerial decision on business strategy. They conclude that in medium sized-establishment located in depressed areas and with workers of low-educational level, the proper adoption of HPWO practices can yield favorable worker outcomes: workers are more empowered, satisfied, committed, trusting, communicative and hardworking. Moreover, on the basis of the European Survey on Working Conditions, Bauer (2004) also finds that higher involvement in HPWO practices is associated with higher job satisfaction. Finally, Givord and Maurin (2004), using the French Labor Force Survey, develop an econometric analysis trying to identify the structural factors that have driven the upturn in the risk of involuntary job loss experienced by French workers over the last 20 years. They conclude that technological change seems to be at the origin of the increased job insecurity, but its effect may be mitigated by institutional changes. Our paper tests this hypothesis (impact of ICT) at the plant level.

This paper is divided in two interrelated parts. The first part develops a simple theoretical model that provides a structure for implementing the empirical analysis of the second part. Since we are concerned about the effects of new technologies and innovative organizational practices over the labor flows, we try to embed these features in a basic theoretical setup. Mortensen and Pissarides (1994) endogenous job destruction model provides an appropriate framework to do so. More particularly, we consider a perfectly segmented labor market where we distinguish between simple jobs, occupied by low-skilled workers, and complex jobs, occupied by high-skilled workers. Each type of job is characterized by a constant productivity component which is modified in case of biased technological or organizational changes.

In the second part of the paper we implement an empirical analysis. We use a database resulting from merging two French surveys conducted in 1999 and covering more than twenty-five hundred establishments: the REPONSE survey (RÉlations PrOfessionnelles et NégotiationS d'Entreprise), which describes the use of new technologies and innovative organizational practices by the establishment, and the DMMO survey (Déclaration Mensuelle de Mouvements de main d'Oeuvre), describing the labor flows in the establishment by gender, age, professional category, etc. We estimate the effects of ICT and HPWO practices on the labor flows of different categories of workers. Results reveal that, in France, labor flows of blue collars are increased by

ICT adoption while the turnover of white collars are stimulated by some of the HPWO practices. Our approach is focused on the total number of movements by professional categories while the analysis developed in Bauer and Bender (2002) estimated job creation and destruction patterns for different skill groups as well as worker replacement rates inside plants. Findings in both studies can, thus, be considered as complementary.

The paper is organized as follows. Section 2 presents a basic theoretical model providing the structure for our empirical analysis . The comparative static analysis reveals that the introduction of any technological or organizational change relatively favoring the productivity of white collars stimulates labor flows of blue collars. In contrast any change favoring the relative productivity of blue collar workers increases labor flows of white collars. Section 3 describes both, the data surveys and the data itself. Section 4 develops the econometric analysis and results are explained in Section 5. Section 6 concludes.

2 A simple model

2.1 Assumptions

We develop a basic model giving a theoretical foundation of the effects of ICT and HPWO practices on job stability. This theoretical setup is inspired in a discrete version of Mortensen and Pissarides (1994), developed in Cahuc and Postel-Vinay (2002) for the case of one firm offering different types of contracts to homogenous workers. Here we assume two types of competitive firms employing labor as a unique input:

- Firms producing a complex good only employ high-skilled workers since the production of these goods involves complex task requiring a high-skill qualification.
- Firms producing simple goods only employ low-skilled workers since their production process involves simpler tasks.

Therefore we have completely segmented labor markets, where high-skilled workers only occupy complex jobs and low-skilled workers simple jobs (no job competition).

When the firm opens a vacancy, it can be filled and start producing or remain empty and continue searching. Any job that is not producing or searching is destroyed (job destruction).

In contrast, a job is created when a firm with a vacant job and a worker meet and both decide to start producing (it is mutually profitable to produce). The number of complex and simple contacts per period (M_t^c and M_t^s) is respectively represented by the following linear homogeneous matching functions:

$$M_t^c = M^c(v_t^c, u_t^h) \qquad \text{and} \qquad M_t^s = M^s(v_t^s, u_t^l) \tag{1}$$

where v_t^c and v_t^s represent the number of complex and simple vacancies and u_t^h and u_t^l the number of high- and low-skilled unemployed normalized by the fixed labor force size (which is itself assumed equal to one).

We denote labor market tensions in the complex and simple segment by θ_t^c and θ_t^s, where:

$$\theta_t^c \equiv \frac{v_t^c}{u_t^h} \qquad \text{and} \qquad \theta_t^s \equiv \frac{v_t^s}{u_t^l}. \tag{2}$$

The probabilities of filling a complex and a simple job vacancy are respectively decreasing in θ_t^c and θ_t^s and they are defined as:

$$\frac{M_t^c}{v_t^c} = q(\theta_t^c) \qquad \text{and} \qquad \frac{M_t^s}{v_t^s} = q(\theta_t^s). \tag{3}$$

With linear homogeneous matching functions, the probabilities of finding a complex or a simple job can be respectively written as follows:

$$\frac{M_t^c}{u_t^h} = \theta_t^c q(\theta_t^c) \qquad \text{and} \qquad \frac{M_t^s}{u_t^l} = \theta_t^s q(\theta_t^s). \tag{4}$$

The complex job is associated to a fixed coefficients technology requiring one high-skilled worker to produce $\varepsilon + h_1$ units of output in period t. The simple job is associated to a fixed coefficients technology requiring one low-skilled worker to produce $\varepsilon + h_2$ units of output in period t. The term ε is a random idiosyncratic productivity parameter which is the same whether we are considering complex or simple jobs. All the values of ε are drawn from the distribution $\phi = \Phi'$ over the interval $[\underline{\varepsilon}, \overline{\varepsilon}]$, for both, complex and simple jobs. The process that changes this idiosyncratic term is Poisson with arrival rate $\lambda \in [0, 1]$. Therefore, there exists a probability λ that the job is hit by a shock such that a new value of ε has to be drawn from ϕ. The terms h_1 et h_2 addition to one ($h_1 + h_2 = 1$) and they can be interpreted as the constant productivity component specific to each production sector (complex sector or simple sector).

It is important to notice that all job contacts do not lead to a job creation, since the match may not be productive enough. The initial productivity level $\varepsilon + h_1$ (or $\varepsilon + h_2$) is revealed to the firm and the worker immediately after the match is formed. Because search and hiring activities are costly, the productivity level may be too low to compensate either party for their efforts. Therefore, there exists a productivity level, called reservation productivity and denoted ε^c for the complex segment and ε^s for the simple one, below which it is not in the interest of the firm and the worker to trade.

2.2 Concepts and notation

An open vacancy can remain empty and searching or be filled and start producing. The associated asset value to each of these situation is represented by Π^{v^c} (resp. Π^{v^s}) when the complex (resp. simple) vacancy is empty and by $\Pi^c(\varepsilon)$ (resp. $\Pi^s(\varepsilon)$) when the complex (resp. simple) vacancy is filled. In the same way, the value to the worker in a complex (resp. simple) job is denoted as $V^c(\varepsilon)$ (resp. $V^s(\varepsilon)$). Finally, the average expected return on the high-skilled (resp. low-skilled) worker's human capital when looking for a job is represented by V^{u^h} (V^{u^l}). Since search and hiring activities are costly, when a match is formed a joint surplus is generated:

$$\begin{aligned} S^c(\varepsilon) &= \Pi^c(\varepsilon) - \Pi^{v^c} + V^c(\varepsilon) - V^{u^h} \quad \text{Joint surplus in a complex job.} \\ S^s(\varepsilon) &= \Pi^s(\varepsilon) - \Pi^{v^s} + V^s(\varepsilon) - V^{u^l} \quad \text{Joint surplus in a simple job.} \end{aligned}$$

At the beginning of every period the firm and the employee renegotiate wages through a Nash bargaining process, that splits the joint surplus into fixed proportions at all times. Denoting as $\eta \in [0, 1]$ the bargaining power[5] of workers (whether they are in complex or simple positions), we have that:

$$\Pi^c(\varepsilon) - \Pi^{v^c} = (1-\eta)\, S^c(\varepsilon) \quad \text{or} \quad V^c(\varepsilon) - V^{u^h} = \eta\, S^c(\varepsilon)\,, \tag{5}$$

$$\Pi^s(\varepsilon) - \Pi^{v^s} = (1-\eta)\, S^s(\varepsilon) \quad \text{or} \quad V^s(\varepsilon) - V^{u^l} = \eta\, S^s(\varepsilon)\,. \tag{6}$$

When a firm producing a complex good opens a vacancy it has to support a cost a^c per unit of time. When a firm producing a simple good opens a vacancy it has to support a cost a^s per unit of time. There is a probability $1 - q(\theta^c)$ and $1 - q(\theta^s)$ that the complex and simple vacancy,

[5]For proofs we will exclude the extreme cases $\eta = 0$ and $\eta = 1$.

respectively, remain empty next period. On the opposite, there is a probability $q(\theta^c)$ and $q(\theta^s)$ that the complex and the simple vacancies get filled. The asset value associated to a searching vacancy is then:

$$\Pi^{v^c} = -a^c + \beta\,(1-q(\theta^c))\,\Pi^{v^c} + \beta\, q(\theta^c) \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[\Pi^c(x), \Pi^{v^c}]\; d\Phi(x)\;, \tag{7}$$

$$\Pi^{v^s} = -a^s + \beta\,(1-q(\theta^s))\,\Pi^{v^s} + \beta\, q(\theta^s) \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[\Pi^s(x), \Pi^{v^s}]\; d\Phi(x)\;. \tag{8}$$

where β is the discount factor.

When the vacancy is filled and actively producing, we know that there is a probability λ that the job is hit by a shock, so that a new value of ε is drawn from the distribution ϕ. The asset values associated to the complex and simple jobs are respectively:

$$\Pi^c(\varepsilon) = \varepsilon + h_1 - w^c + \beta\,(1-\lambda)\; Max[\Pi^c(\varepsilon), \Pi^{v^c}] + \beta\,\lambda \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[\Pi^c(x), \Pi^{v^c}]\; d\Phi(x)\;, \tag{9}$$

$$\Pi^s(\varepsilon) = \varepsilon + h_2 - w^s + \beta\,(1-\lambda)\; Max[\Pi^s(\varepsilon), \Pi^{v^s}] + \beta\,\lambda \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[\Pi^s(x), \Pi^{v^s}]\; d\Phi(x)\;, \tag{10}$$

where w^c and w^s represent, respectively, the wages paid to a high- and a low-skilled workers.

Independently of her skills, an unemployed worker receives a flow of earnings w^u including unemployment benefits, leisure, etc. The high-skilled job seeker comes in contact with a complex vacant slot at rate $\theta^c q(\theta^c)$ while the low-skilled comes in contact with a simple vacancy at rate $\theta^s q(\theta^s)$. The value to the workers of unemployment is given by:

$$V^{u^h} = w^u + \beta\,(1-\theta^c q(\theta^c))\; V^{u^h} + \beta\theta^c q(\theta^c) \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[V^c(x), V^{u^h}]\; d\Phi(x) \tag{11}$$

$$V^{u^l} = w^u + \beta\,(1-\theta^s q(\theta^s))\; V^{u^l} + \beta\theta^s q(\theta^s) \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[V^s(x), V^{u^l}]\; d\Phi(x)\;. \tag{12}$$

As just mentioned, a complex job with productivity $\varepsilon + h_1$ pays a wage w^c to the worker, while a simple job with productivity $\varepsilon + h_2$ pays w^s. Both types of jobs are hit by a shock with probability λ. The present value of a complex and simple job to the worker solve:

$$V^c(\varepsilon) = w^c + \beta\,(1-\lambda)\; Max[V^c(\varepsilon), V^{u^h}] + \beta\,\lambda \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[V^c(x), V^{u^h}]\; d\Phi(x)\;, \tag{13}$$

$$V^s(\varepsilon) = w^s + \beta\,(1-\lambda)\; Max[V^s(\varepsilon), V^{u^l}] + \beta\,\lambda \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[V^s(x), V^{u^l}]\; d\Phi(x)\;. \tag{14}$$

2.3 Job Creation and Job Destruction

We develop in detail the calculus of the steady state in appendix 1. This section presents the equilibrium job creation and job destruction rules obtained for each labor market segment. Job creation rules of the complex and simple segments are defined as:

$$\frac{a^c}{\beta(1-\eta)\, q(\theta^c)} = \frac{1}{1-\beta(1-\lambda)} \int_{\varepsilon^c}^{\overline{\varepsilon}} (1-\Phi(x))\, dx \;, \tag{15}$$

$$\frac{a^s}{\beta(1-\eta)\, q(\theta^s)} = \frac{1}{1-\beta(1-\lambda)} \int_{\varepsilon^s}^{\overline{\varepsilon}} (1-\Phi(x))\, dx \;, \tag{16}$$

As shown in appendix 1, both equations determine a negative relationship between market tightness and ε, meaning that the job creation curves are negatively sloped in the space (θ^i, ε) for $i = c, s$.

Complex and simple job destruction rules are given by:

$$\frac{\eta\, a^c\, \theta^c}{1-\eta} = \varepsilon^c + h_1 - w^u + \frac{\beta\, \lambda}{1-\beta(1-\lambda)} \int_{\varepsilon^c}^{\overline{\varepsilon}} (1-\Phi(x))\, dx \;, \tag{17}$$

$$\frac{\eta\, a^s\, \theta^s}{1-\eta} = \varepsilon^s + h_2 - w^u + \frac{\beta\, \lambda}{1-\beta(1-\lambda)} \int_{\varepsilon^s}^{\overline{\varepsilon}} (1-\Phi(x))\, dx \;. \tag{18}$$

It is proved in the appendix that both curves are positively sloped in the space (θ^c, ε) and (θ^s, ε), respectively.

2.4 Comparative Static Analysis

We analyze now the variations in job creation and destruction predicted by the model when some exogenous biased shocks modify the specific productivity component of each sector. The theoretical results described in this section permit to better understand the empirical findings presented afterwards.

Notice first, that depending on the values of $h_1, h_2, \theta^c, \theta^s, a^c$ and a^s, we might have an initial situation where the reservation productivity levels are such that: $\varepsilon^c > \varepsilon^s$ or $\varepsilon^c < \varepsilon^s$ or $\varepsilon^c = \varepsilon^s$. In any case, since the objective of the static comparative analysis we implement is to determine the evolution (increase or decrease) in the turnover of complex and simple jobs, the initial situation does not matter for the analysis . We focus on the effects of ICT and HPWO practices in each market segment separately.

Let's start the comparative static analysis considering the technological shocks:

- We assume first an exogenous shock consisting in a technological revolution. Evidence has shown that ICT adoption by an economy clearly favors the productivity of high-skilled workers since the efficient use of new machines requires qualified staff. Because complex jobs are always occupied by high-skilled workers we can imagine that their relative specific productivity component (h_1) is improved. In contrast the relative productivity in simple jobs (h_2) deteriorates since new technologies cannot be efficiently used. We can, thus, expect an upturn in the turnover of simple jobs with respect to the initial situation and the opposite evolution for complex jobs.

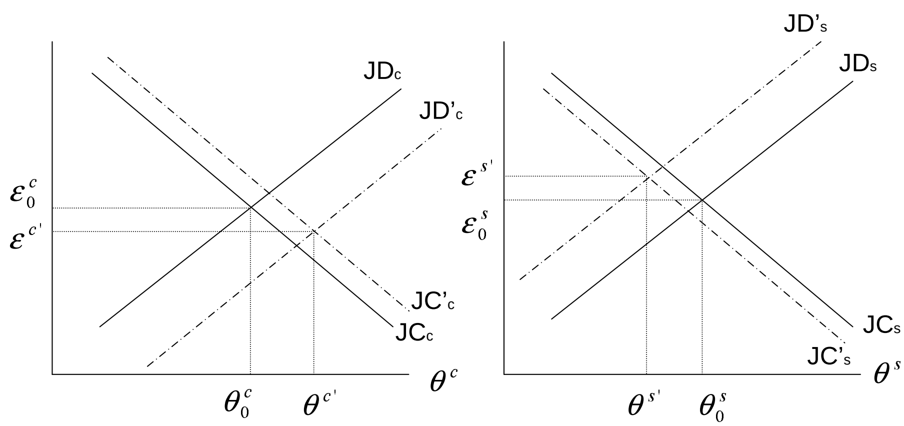

Figure 1: Shock increasing the specific productivity component of complex jobs.

More formally, the complex jobs destruction curve shifts down[6] (see figure 1) determining a lower reservation equilibrium value $\varepsilon^{c'}$ (that is, $\varepsilon^{c'} < \varepsilon^c$). As a result, the job creation curve shifts up increasing the labor market tightness for a given pattern of job destruction. In the simple sector the evolution is the opposite[7] leading to a higher equilibrium reservation productivity ($\varepsilon^{s'} > \varepsilon^s$). In this new situation, the turnover of complex jobs is necessarily reduced since in case of an idiosyncratic shock over ε, the new value $\widehat{\varepsilon}$ drawn from the distribution ϕ, might be such that $\varepsilon^{c'} < \widehat{\varepsilon} < \varepsilon^c$. That is, some jobs that would have been

[6] $\left.\frac{\partial \varepsilon^c}{\partial h_1}\right|_{\theta^c = Const} = -\frac{1-\beta\,(1-\lambda)}{1-\beta\,(1-\lambda\,\Phi(\varepsilon^c))} < 0$

[7] $\left.\frac{\partial \varepsilon^s}{\partial h_2}\right|_{\theta^s = Const} = -\frac{1-\beta\,(1-\lambda)}{1-\beta\,(1-\lambda\,\Phi(\varepsilon^s))} < 0$

destroyed in the initial situation, are not destroyed now that the specific productivity component of complex jobs has increased and the reservation productivity decreased. On the contrary, in the the simple segment job turnover is stimulated since the reduction of the specific productivity component determines a higher equilibrium reservation productivity, $(\varepsilon^{s'} > \widehat{\varepsilon} > \varepsilon^{s})$.

- We consider now a shock of a completely different nature. We assume that chain production systems (*tayloristic* systems) are introduced in both sectors of the economy. Such a change is likely to improve the relative marginal productivity of simple jobs (h_2) reducing their turnover. Because we are considering biased shocks ($h_1 + h_2 = 1$) an improvement in the marginal productivity of simple jobs implies a deterioration in that of complex jobs (fall in h_1). In graphical terms (see figure 2), the job destruction curve of the simple segment shifts right, determining a lower equilibrium reservation productivity in this market ($\varepsilon^{s'} < \varepsilon^{s}$), while in the complex segment the job destruction curve moves upward leading to $\varepsilon^{c'} > \varepsilon^{c}$. In this new situation, we require a stronger idiosyncratic shock over ε, with respect to the initial situation, to have simple jobs destroyed. On the contrary the idiosyncratic shock required to destroy complex jobs is now weaker.

In sum, technological shocks stimulate turnover in the labor market segment (complex or simple) whose specific productivity component is negatively affected by the shock, while turnover falls in the segment with an improved relative productivity. The static comparative analysis concerning the introduction of HPWO practices follows this same principle. We briefly comment the consequences on labor turnover of some particular HPWO practices:

- One of the main HPWO practices implemented by firms consists in introducing autonomous teams of production and multidisciplinary or project working groups. As Jones, Kato, and Weinberg (2003) show, these new organizational practices permit low-skilled workers to get more empowered with the firm, to be more satisfied, more committed and trusting in the managerial structure as well as more hardworking. Therefore, we can expect that such organizational practices improve the specific productivity component of simple jobs (h_2) while deteriorating that of complex jobs (h_1). Turnover is, thus, reduced in the simple segment and augmented in the complex segment (figure 2) .

- Another commonly used HPWO practice consists in implementing total quality control procedures. Evidently this control can only be implemented by qualified workers, which implies that the relative productivity of high-skilled workers is improved with respect to that of low-skilled (figure 1).

- The rotation of workers among different tasks or the just in time production practices inside firms are more likely to affect production workers (simple sector) rather than managers (complex sector). The main objective of such practices is not simply to form workers with more flexible abilities which permits firms to easily adapt to market demand changes, but also to avoid workers loosing motivation due to repetitive tasks. The adoption of the rotation or the just in time production systems is then likely to stimulate the relative specific productivity component of simple jobs, reducing in this way their turnover. On the contrary, the turnover of high-skilled workers is stimulated (figure 2).

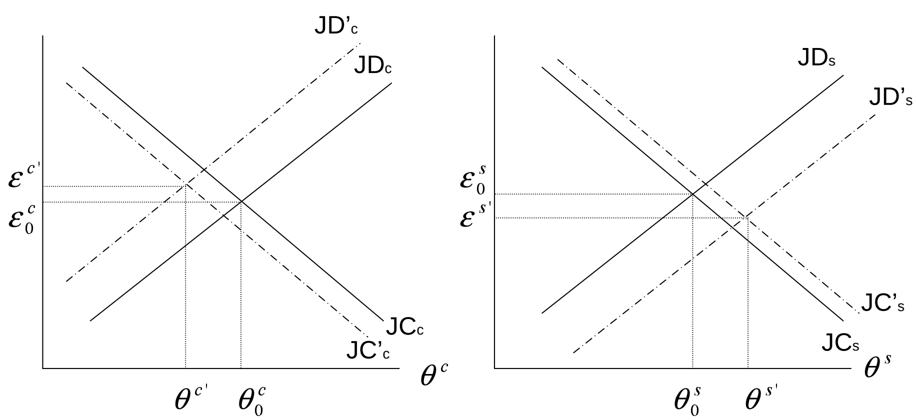

Figure 2: Shock increasing the specific productivity component of simple jobs.

- The introduction of the HPWO practice consisting in *delayering* (delegating responsibilities to lower hierarchical levels inside the firm by removing one or more managerial levels), stimulates the relative productivity specific component of production workers (simple jobs) deteriorating that of managers in the firm (complex jobs). This measure is then likely to raise the turnover of complex jobs and decrease that of simple jobs (figure 2). Indeed in Caroli and Van Reenen (2001) it is shown that, in the French case, the reduction in the number of hierarchical levels (*delayering*) has mainly favored skilled manual workers, whose wage bill share has been increased.

3 The data

The database used results from merging two French surveys conducted in 1999 and refereing to 1998: the REPONSE survey (RÉlations PrOfessionnelles et NégotiationS d'Entreprise) and the DMMO survey (Déclaration Mensuelle de Mouvements de main d'Oeuvre).

In REPONSE more than twenty-five hundred establishments were surveyed with senior managers being asked about the economic situation of the establishment, its internal organization, technological changes, the wage negotiation with unions and conflicts with workers. Only establishments with 20 or more employees were sampled and no public sector employees were included (except workers in state-owned industries). Concerning ICT and HPWO practices, managers were asked either about their presence in the establishment (1993 and 1998 waves) either about the proportion of workers benefitting from the corresponding technology or workplace practice (1998 wave). The REPONSE survey, which is also used in Caroli and Van Reenen (2001), contains, thus, very detailed information on the technological and organizational practices of a representative sample of French establishments.

In the DMMO survey, each establishment with at least 50 employees makes a monthly declaration of the beginning-of-the-month employment, end-of-the-month employment and the total entries and exists within the month. Furthermore, the respondent establishment reports the nature of the employment transaction (type of contract of the new entries and reasons for the exit), as well as the skill level, age and seniority of the employee involved in this transaction.

In the present paper we consider the effect that different technological and organizational variables have on the labor flows of five professional categories (all workers, managers, intermediary professions, employees and manual workers) as well as on women and men. We work with a cross section referred to 1998. Since the REPONSE survey and the DMMO survey were both conducted also in 1993, there does exist a small panel referring to 1993 and 1998. Unfortunately its reduced size and the highly probably presence of a bias leads to meaningless estimations. We explain below the variables used in the econometric analysis.

3.1 Labor flows

The variables capturing the workers flows of different professional categories are defined as follows:

- TOTAL=(Number of movements of all the workers in the establishment)/Total number of workers in the establishment.
- MANAGERS=(Number of movements of managers in the establishment)/Total number of managers in the establishment.
- INT. PROFES.=(Number of movements of intermediary professionals in the establishment)/Total number of intermediary professionals in the establishment.
- EMPLOYEES=(Number of movements of employees in the establishment)/Total number of employees in the establishment.
- WORKERS=(Number of movements of manual workers in the establishment)/Total number of manual workers in the establishment.
- WOMEN=(Number of movements of women in the establishment)/Total number of women in the establishment.
- MEN=(Number of movements of men in the establishment)/Total number of men in the establishment.

The number of movements is defined as the sum of entries and exits.

3.2 Technological variables

New technologies, specially ICT, are widely spread on French establishments, therefore we consider two technological variables:

- COMPUTER: It is a dummy variable taking the value 1 if 50% or more workers use a computer.

- NET: It is a dummy variable taking the value 1 if between 20 and 50% of the workers use the net system.

In addition, automated production is captured by the variable:

- CHAIN: It is a dummy variable taking the value 1 when the establishment still uses *tayloristic* production systems (robots, computer assisted systems, etc.).

3.3 Organizational variables

To measure the effects of HPWO practices we consider six different variables:

- AUTONOMOUS: It is a dummy variable taking the value 1 if between 20 and 50% of the workers participates in autonomous teams of production.

- PROJECT: It is a dummy variable taking the value 1 if between 20 and 50% of the workers participates in multidisciplinary working groups or project groups.

- ROTATION: It is a dummy variable taking the value 1 when a majority of workers rotates among tasks inside the firm.

- QUALITY: It is a dummy variable taking the value 1 when the establishment develops a total quality control procedure.

- HIERARCHY: It is a dummy variable taking the value 1 when the establishment has reduced the number of hierarchical levels.

- JUST TIME: It is a dummy variable taking the value 1 when the establishment practices just in time production methods.

3.4 Other variables

In the regressions we control for the size of the establishment, the economic sector, the relative importance of employees, technicians, short term contracts and women in the establishment and we also consider whether the establishment has already implemented the reduction in the number of working hours (35 hours per week). We define these variables as:

- Size: Dummy variable taking the value 1 if the number of workers in the firm is between 50 and 500.
- Hours: Dummy variable taking the value 1 if the firm has already implemented the reduction in the number of working hours.
- % Employees and % Technicians are the percentage of employees and technicians in the establishment.
- % Women is the percentage of women in the establishment.
- % Contract is the percentage of fixed duration contract in the establishment.
- Energy, Building, Finance, Services firms, Services individuals, Education and Administration are sectorial variables. They represent respectively the following sectors: energy sector (Energy); building sector (Building); financial activity sector (Finance); services to firms (Services firms); services to individuals (Services individuals); education, health and social action (Education); and administration (Administration).

3.5 Descriptive statistics

Appendix 3 summarizes the means and standard deviation of all variables used in our model. Remark that the category of workers having the relatively most important turnover are the employees, followed by the managers, the intermediate professionals and the manual workers. Even if the manual workers are those with the smallest labor flows, they have also the smallest standard deviation, which contrast with the high standard deviation of mangers or employees. Most of these labor flows correspond to women.

Notice also, the high presence of chain production systems and the importance of organizational practices such as the reduction of hierarchical levels, just in time production systems and the implementation of quality control procedures.

Appendix 4 presents the correlation matrix between labor flows, technological variables and organizational variables. In the upward part of the table we present the pairwise correlations between the labor flows and the technological and organizational variables of the model. In the downward part of the table we present the pairwise correlations between the technological and the organizational variables.

From the first part of the table, we remark the positive correlation between the labor flows of manual workers with respect to COMPUTER and NET. This contrast with the systematically negative correlation observed for labor flows and CHAIN. Organizational practices such as rotation of workers among different tasks, total quality control procedures or the reduction of hierarchical levels are negatively correlated with the turnover of intermediate professionals, employees and manual workers. In contrast, AUTONOMOUS and PROJECT are positively related to the managers' turnover.

From the second part of the table we remark that the use of new technologies and the introduction of new organizational practices are most of the times positively correlated (complementary relationship). However, the rotation of workers among task or the just in time production systems are negatively correlated with COMPUTER and NET. A negative correlation between the autonomous teams of production and COMPUTER is also observed.

4 Econometric modelling

According to our structural model, any technological or organizational change improving (deteriorating) the relative productivity of a particular professional category should reduce (increase) its turnover. More particularly we have seen that ICT adoption stimulates the turnover of production workers (simple jobs) while most HPWO practices increase the turnover of managers (complex jobs). We proceed now to estimated the following econometric model:

$$Y_{iet} = \alpha_1 \, I_{iet} + \alpha_2 \, O_{iet} + \alpha_3 \, X_{iet} + \upsilon_{iet} \tag{19}$$

where the dependent variables are the labor flows of all workers, of managers, intermediary professions, employees, manual workers, women workers and men workers. The vector I_{iet} contains all variables measuring the presence of information and communication technologies in the establishment. These variables are COMPUTER, NET and CHAIN. We expect $\alpha_1 > 0$ for intermediary professions, employees and manual workers, and $\alpha_1 < 0$ for managers. The vector

O_{iet} consists on all variables describing the introduction of HPWO practices by the establishment. It contains: AUTONOMOUS, PROJECT, ROTATION, QUALITY, HIERARCHY and JUST TIME. In this case, we expect $\alpha_2 > 0$ for managers and $\alpha_2 < 0$ for the rest of workers categories. Finally X_{it} is the vector of controls, where we introduce other variables that could affect the labor flows. More particularly, we control for the size of the firm, the number of hours worked in the establishment, the sector of activity, the percentage of employees, technicians and women in the establishment, as well as the percentage of workers with fixed duration contract. Because the percentage of workers with short term contract may be endogenous, we estimate the model twice, once controlling for this variable and the other without controlling for it.

Another econometric problem that we must solve concerns the selection bias that is likely to be present when considering the labor flows of manual workers. Indeed less than half of the establishments have manual workers employed. Furthermore, since many of these establishments belong to the service sector, it seems logical that those employing manual workers will present particular characteristics. Therefore the risk of a selection bias arises and applying the Heckman selection model for the labor flows of manual workers seems convenient. According to this method, in the relationship:

$$WORKERS_{et} = \alpha_1 \, I_{et} + \alpha_2 \, O_{et} + \alpha_3 \, X_{et} + \upsilon_{et} \tag{20}$$

the dependent variable is not always observed. Its observability will depend in a certain number of characteristics. Therefore, the Heckman selection model estimates first:

$$y_t^* = \beta \, Z_t + u_t \ , \tag{21}$$

where y_t^* is the probability to observe a manual worker labor flow and Z_t a vector containing technological and organizational variables, as well as variables concerning the economic situation of the firm, its size, its labor composition, its economic sector, its investment on training workers and its internal conflicts. Notice that,

$$WORKERS_t = 1 \quad \text{if} \quad y_t^* > 0 \tag{22}$$

$$WORKERS_t = 0 \qquad \text{otherwise} \ . \tag{23}$$

On the basis of this result the relationship (20) is re-estimated without selection bias this time. Indeed when $corr(\upsilon_t, u_t) = \rho > 0$, the Heckman selection model provides consistent, asymptotically efficient estimates for all parameters. Therefore we directly implement this procedure when dealing with manual workers turnover.

5 Results

5.1 Effect of ICT and HPWO practices

Final estimates from the regressions are reported in tables 3 and 4 (see table 7 in appendix 2 for reference on the set variables initially used, before eliminating the least significant variables). In the former table the percentage of fixed duration contracts in the establishment is introduced as a control variable, while in table 4 we do not control for this variable. Results are essentially the same in both cases, suggesting that there is not endogeneity problem with the variable % Contract.

This paper tries to shed some light regarding the deterioration or the improvement in the quality of jobs due to the introduction of ICT and/or HPWO practices. Empirical results obtained in this section reveal that the effects of these variables differ, and are even contradictory, depending on the professional category under analysis.

Consider first the labor flows of all workers (i.e: all professional categories confounded). Results suggest that the organizational practice consisting in the rotation of workers among different tasks inside the establishment stimulates workers' flows while the more traditional chain production systems (*tayloristic system*) reduce these flows. The analysis becomes more interesting when considering separately each professional category:

- The managers' turnover is stimulated by the just in time production systems and the organizational practices targeting to improve the workers and employees' empowerment and commitment to the firm, such as the autonomous teams of production or multidisciplinary groups. On the contrary, the organizational practice consisting in implementing total quality control procedures reduces the labor flows of managers, as this practice requires qualified staff to be developed.

- We look now results concerning intermediate professionals, employees and manual workers. Starting with the intermediate professionals we realize that the massive use of computers

Table 3: Determinants of labor flows for different categories of workers controlling for short term contracts.

	Dependent variable: labor flows for						
	TOTAL	MANAGERS	INT. PROFES.	EMPLOYEES	WORKERS	WOMEN	MEN
COMPUTER	0.102	-1.386	0.554	0.551	0.070	0.033	0.159
	(0.093)	(1.303)	(0.195)***	(0.292)*	(0.189)	(0.289)	(0.160)
NET	-0.054	-0.412	0.144	-0.070	0.286	-0.228	-0.191
	(0.091)	(1.247)	(0.183)	(0.283)	(0.175)*	(0.279)	(0.154)
CHAIN	-0.120	0.135	0.058	-0.418	-0.235	-0.364	-0.196
	(0.051)**	(0.698)	(0.102)	(0.156)***	(0.094)**	(0.154)**	(0.085)**
AUTONOMOUS	0.006	2.175	0.038	-0.161	-0.061	-0.242	0.126
	(0.089)	(1.220)*	(0.177)	(0.278)	(0.158)	(0.273)	(0.150)
PROJECT	-0.022	2.451	-0.127	0.044	-0.197	0.255	-0.117
	(0.087)	(1.190)**	(0.175)	(0.270)	(0.172)	(0.264)	(0.146)
ROTATION	0.116	-1.217	0.082	0.226	-0.113	0.176	0.101
	(0.081)	(1.123)	(0.163)	(0.253)	(0.147)	(0.247)	(0.137)
QUALITY	-0.023	-2.498	0.197	-0.011	-0.090	0.036	0.158
	(0.078)	(1.092)**	(0.161)	(0.244)	(0.159)	(0.240)	(0.133)
HIERARCHY	-0.045	0.774	-0.140	-0.345	0.039	-0.157	-0.076
	(0.051)	(0.708)	(0.104)	(0.160)**	(0.096)	(0.156)	(0.086)
JUST TIME	0.068	1.118	-0.044	-0.043	0.091	0.164	0.085
	(0.043)	(0.606)*	(0.088)	(0.136)	(0.079)	(0.134)	(0.074)
Size	-0.042	-0.220	0.149	-0.452	0.129	-0.410	-0.120
	(0.086)	(1.186)	(0.173)	(0.266)*	(0.164)	(0.263)	(0.145)
Hours	0.016	4.024	0.274	-0.306	-0.023	-0.109	-0.056
	(0.108)	(1.479)***	(0.215)	(0.337)	(0.192)	(0.330)	(0.182)
% Employees	0.623	2.954	0.523	-2.756	3.254	1.510	0.520
	(0.150)***	(2.084)	(0.309)*	(0.459)***	(0.451)***	(0.454)***	(0.250)**
% Technicians	-0.196	-0.472	-2.781	-1.195	0.820	-1.260	-0.075
	(0.246)	(3.464)	(0.525)***	(0.808)	(0.578)	(0.768)*	(0.423)
% Women	0.333	0.646	0.416	1.837	0.603	-3.976	1.948
	(0.156)**	(2.162)	(0.318)	(0.481)***	(0.306)**	(0.474)***	(0.261)***
% Contract	0.434	-4.730	0.570	2.351	1.185	0.616	-0.047
	(0.340)	(4.607)	(0.670)	(1.025)**	(0.689)*	(1.029)	(0.566)
Sectors (16)	YES	YES	YES	YES	YES	YES	YES
Constant	0.411	-1.153	0.257	1.486	-0.035	2.300	0.047
	(0.127)***	(1.780)	(0.264)	(0.396)***	(0.247)	(0.390)***	(0.215)
Adj. R^2	0.119	0.032	0.122	0.065		0.073	0.105
Observations	1645	1689	1575	1631	1140	1719	1722

*Significant at 10%.**Significant at 5%.***Significant at 1%.

by the establishment (when more than 50% of the staff uses them) is associated to a higher flows of this category of workers. In contrast, the HPWO practices seem to have no effect on this turnover. According to our model, these results indicate that, while the ICT deteriorate the intermediate professionals' relative productivity, the HPWO practices must not have so much effect on it.

The massive use of computers in the establishment also increases job instability of employees. In contrast, the use of the *tayloristic* production systems as well as the organizational practices consisting in removing managerial levels so as to delegate responsibilities to lower hierarchical levels improve the relative productivity, motivation, commitment and empowerment of this worker category reducing its turnover.

The labor flows of manual workers are increased by the use of ICT which negatively affect their relative marginal productivity. On the opposite, chain production systems permit manual workers to improve their relative productivity, reducing in this way their turnover. HPWO practices have no effect at all in manual workers' job stability.

In sum, the use of ICT is clearly associated to higher labor flows of intermediate professionals, employees and manual workers. On the contrary, because chain production systems improve the blue collar workers' relative productivity, they also reduce the turnover of these categories of workers. The progressive disappearance of the *tayloristic* systems would explain then the upturn in blue collars' labor flows. The HPWO practices do not seem be a key determinant on the labor flows of intermediate professionals and manual workers. In contrast employees have clearly benefited from the organizational practice consisting in delaying responsibilities to lower hierarchical levels.

- Equation (19) is also estimated for the women and men workers. Evidently, in this case all workers categories are confounded, that is, inside women workers there will be managers as well as manual workers and the same applies for men. Similarly to results concerning all workers flows (TOTAL), we conclude that the introduction of chain production systems is associated to lower labor flows of men and women.

Table 4: Determinants of labor flows for different categories of workers without controlling for short term contracts.

	Dependent variable: labor flows for						
	TOTAL	MANAGERS	INT. PROFES.	EMPLOYEES	WORKERS	WOMEN	MEN
COMPUTER	0.104	-1.287	0.559	0.537	0.099	0.038	0.168
	(0.093)	(1.291)	(0.193)***	(0.290)*	(0.187)	(0.287)	(0.158)
NET	-0.056	-0.360	0.143	-0.090	0.289	-0.224	-0.189
	(0.090)	(1.235)	(0.182)	(0.281)	(0.173)*	(0.276)	(0.152)
CHAIN	-0.120	0.116	0.051	-0.423	-0.229	-0.363	-0.192
	(0.050)**	(0.688)	(0.101)	(0.155)***	(0.093)**	(0.153)**	(0.084)**
AUTONOMOUS	0.001	2.156	0.044	-0.135	-0.061	-0.256	0.124
	(0.088)	(1.207)*	(0.176)	(0.276)	(0.157)	(0.270)	(0.148)
PROJECT	-0.023	2.364	-0.117	0.091	-0.194	0.247	-0.121
	(0.086)	(1.177)**	(0.173)	(0.268)	(0.171)	(0.262)	(0.144)
ROTATION	0.118	-1.116	0.086	0.213	-0.110	0.184	0.113
	(0.080)*	(1.110)	(0.162)	(0.251)	(0.146)	(0.245)	(0.135)
QUALITY	-0.107	-2.422	0.190	-0.015	-0.074	0.026	0.158
	(0.077)	(1.075)**	(0.159)	(0.241)	(0.157)	(0.238)	(0.131)
HIERARCHY	-0.046	0.786	-0.148	-0.360	0.033	-0.144	-0.077
	(0.050)	(0.699)	(0.103)	(0.158)**	(0.095)	(0.155)	(0.085)
JUST TIME	0.064	1.065	-0.040	-0.052	0.083	0.164	0.081
	(0.042)	(0.598)*	(0.087)	(0.135)	(0.785)	(0.132)	(0.073)
Size	-0.042	-0.206	0.141	-0.489	0.140	-0.425	-0.124
	(0.085)	(1.174)	(0.171)	(0.264)*	(0.163)	(0.260)*	(0.144)
Hours	0.007	3.851	0.276	-0.311	-0.004	-0.101	-0.064
	(0.106)	(1.457)***	(0.211)	(0.333)	(0.190)	(0.325)	(0.179)
% Employees	0.621	2.896	0.509	-2.785	3.078	1.530	0.515
	(0.148)***	(2.054)	(0.305)*	(0.454)***	(0.441)***	(0.448)***	(0.247)**
% Technicians	-0.194	0.511	-2.806	-1.300	0.647	-1.266	-0.077
	(0.243)	(3.417)	(0.518)***	(0.800)	(0.570)	(0.760)*	(0.418)
% Women	0.353	0.580	0.421	1.986	0.614	-3.938	1.942***
	(0.153)**	(2.122)	(0.313)	(0.474)***	(0.300)**	(0.465)***	(0.256)
% Contract	NO	NO	NO	NO	NO	NO	NO
Sectors (16)	YES	YES	YES	YES	YES	YES	YES
Constant	0.431	-1.427	0.303	1.625	0.037	2.310	-0.051
	(0.124)***	(1.735)	(0.258)	(0.387)***	(0.242)	(0.381)***	(0.209)
Adj. R^2	0.119	0.031	0.120	0.061		0.074	0.104
Observations	1669	1714	1595	1656	1156	1744	1747

*Significant at 10%.**Significant at 5%.***Significant at 1%.

To summarize, empirical estimates suggest that, since ICT are skill-requiring, its adoption results in higher turnover of intermediate professionals, employees and manual workers, who do not have these skills. At the same time, the turnover of these categories of workers falls when the establishment adopts *tayloristic* production systems. Because most HPWO practices try to stimulate motivation, participation and productivity of blue collar workers (production workers), its adoption is associated to higher labor flows of managers, whose relative productivity is negatively affected by these organizational practices. To conclude notice that, since ICT adoption is generally accompanied by changes in the internal organization of firms (HPWO practices), we can suggest that the labor flows of all workers categories must have been stimulated over the last years, either through the ICT for the blue collars, either by the HPWO practices for the white collars. Moreover, the reduction in the use of chain production systems has reinforced job instability of all workers categories.

5.2 Solving the Endogeneity Bias

The high degree of intercorrelation among the explicative variables (see table 9) indicates that the empirical model estimating the impact of the ICT and HPWO practices on the labor flows may yield biased coefficients. To solve this endogeneity problem a traditional approach used in the literature (e.g., Ichniowski, Shaw, and Prennushi (1997)) when only cross-sectional data is available, consists in defining sets of highly correlated practices. We consider in this paper two types of clusters differing in their economic interpretation:

- We analyze first the impact of what we will call "incremental organization" or "additive clusters". These sets of practices capture a kind of continuity in the technological and organizational changes.

- Second, we consider the effect of clusters including complementary technological and organizational practices ("multiplicative clusters"). There is an increasing literature (e.g., Ichniowski, Shaw, and Prennushi (1997) or Askenazy and Gianella (2000)) claiming that firms realize the largest gains in productivity by adopting clusters of complementary practices. It seems, thus, relevant to analyze the effect that these sets of interactive practices have on the labor flows.

5.2.1 The incremental organization

The incremental organization can be economically interpreted as measuring a continuity in the process of introduction of technological and organizational changes. We define five sets of variables capturing practices having a similar objective and being highly intercorrelated:

1. TECHNOLOGY: Cluster including the technological variables COMPUTER and NET. The presence of one of these practices is sufficient to guarantee the non nullity of TECHNOLOGY.

2. CHAIN: Dummy variable taking the value 1 when the establishment still uses systems of *tayloristic* production systems (robots, computer assisted systems, etc.).

3. TEAMWORK: Set of organizational variables including all practices tending towards the delegation of responsibilities and the promotion of working teams. The positivity of TEAMWORK is guaranteed by the presence of any of the following practices: AUTONOMOUS, PROJECT or HIERARCHY.

4. FLEXIBILITY: Cluster covering all organizational practices stimulating a flexible job assignment (ROTATION and JUST TIME).

5. QUALITY: Dummy variable taking the value 1 when the establishment develops a total quality control procedure.

Results in table 5 can be summarized as follows:

- The upturn in job instability of all workers (TOTAL) seems to be explained, rather than by the simple introduction of new technologies, by the combination of the progressive reduction in the use of *tayloristic* production system and progressive increase in the use of flexible job assignment practices.

- The workplace organizational practices favoring the delegation of responsibilities to lower hierarchical levels as well as the presence of working teams (TEAMWORK) are at the origin of the increased turnover observed for the managers. In contrast, quality control procedures continue to have an stabilization effect on their turnover.

Table 5: Effect of incremental organization over the labor flows.

	Dependent variable: labor flows for						
	TOTAL	MANAGERS	INT. PROFES.	EMPLOYEES	WORKERS	WOMEN	MEN
TECHNOLOGY	0.022	-0.767	0.330	0.248	0.179	-0.069	-0.030
	(0.050)	(0.693)	(0.102)***	(0.156)	(0.106)*	(0.154)	(0.085)
CHAIN	-0.120	-0.113	0.058	-0.418	-0.236	-0.367	-0.194
	(0.051)**	(0.699)	(0.102)	(0.157)***	(0.094)***	(0.155)**	(0.085)**
TEAMWORK	-0.030	1.497	-0.100	-0.217	-0.036	-0.076	-0.044
	(0.036)	(0.495)***	(0.072)	(0.111)**	(0.067)	(0.109)	(0.060)
FLEXIBILITY	0.078	0.542	-0.016	0.016	0.040	0.161	0.087
	(0.037)**	(0.507)	(0.073)	(0.115)	(0.066)	(0.112)	(0.062)
QUALITY	-0.112	-2.434	0.187	-0.024	-0.088	0.037	0.152
	(0.078)	(1.091)**	(0.161)	(0.244)	(0.160)	(0.241)	(0.133)
Size	-0.040	-0.246	0.148	-0.449	0.131	-0.410	-0.121
	(0.086)	(1.187)	(0.173)	(0.266)*	(0.164)	(0.263)	(0.145)
Hours	0.011	3.803	0.263	-0.336	0.000	-0.125	-0.068
	(0.107)	(1.471)***	(0.213)	(0.336)	(0.191)	(0.328)	(0.181)
% Employees	0.630	2.952	0.537	-2.719	3.243	1.542	0.537
	(0.149)***	(2.075)	(0.308)*	(0.457)**	(0.449)***	(0.452)***	(0.250)**
% Technicians	-0.179	0.346	-2.713	-1.085	0.718	-1.144	-0.063
	(0.245)	(3.445)	(0.520)***	(0.805)	(0.575)	(0.765)	(0.421)
% Women	0.338	0.531	0.427	1.863	0.591	-3.967	1.958
	(0.156)**	(2.161)	(0.318)	(0.481)***	(0.306)**	(0.473)***	(0.261)***
% Contract	0.436	-4.530	0.583	2.361	1.179	0.632	-0.050
	(0.339)	(4.608)	(0.670)	(1.025)**	(0.690)*	(1.028)	(0.566)
Sectors (16)	YES	YES	YES	YES	YES	YES	YES
Constant	0.403	-1.569	0.240	1.394	0.034	2.220	-0.053
	(0.125)***	(1.752)	(0.259)	(0.389)***	(0.242)	(0.384)***	(0.211)
Adj. R^2	0.120	0.032	0.123	0.064		0.074	0.105
Observations	1645	1689	1575	1631	1140	1719	1722

*Significant at 10%.**Significant at 5%.***Significant at 1%.

- The only professional category whose turnover seems clearly to have been stimulated by the ICT adoption is the intermediate professions.

- Regarding employees and manual workers, results in table 5 point to the progressive reduction in the *tayloristic* production systems as the main responsible of the increased job instability of these professional categories. On the other side, ICT adoption has stimulated labor flows of manual workers while the introduction of TEAMWORK practices has stabilized employees turnover.

- Finally, when considering separately all women workers and all men workers, the variable CHAIN appears again as the only practice having a significant effect.

Two general conclusions can, thus, be drawn from previous results. First, the progressive reduction in the use of *tayloristic* production systems, rather than simply ICT adoption, is at the origin of the generalized increase in job instability, more particularly in that of employees and workers. Indeed, only the upturn in the turnover of intermediate professions seems to be uniquely determined by the introduction of new technologies. Second, HPWO practices consisting in the reduction of hierarchical levels or in the promotion of autonomous working groups accelerate the turnover of managers and reduce the one of employees. In contrast, because quality control procedures require qualified staff, they promote stability in the manager's labor flows.

5.2.2 The complementary relationships

Ichniowski, Shaw, and Prennushi (1997) argue that the firms realize the largest gains in productivity by adopting clusters of complementary practices ("multiplicative clusters"). It seems, thus, relevant to analyze the effect these sets of complementary practices have on the labor flows. We consider two sets of variables[8]:

1. TEAMWORK*: Set of organizational variables including all practices tending towards the delegation of responsibilities and the promotion of working teams. The positivity of

[8] Alternative clusters of complementary variables have been considered, but they were non significant.

TEAMWORK is only guaranteed when the HPWO practices AUTONOMOUS, PROJECT and HIERARCHY are present in the establishment.

2. ICT FLEXIBILITY: This cluster combines technological and organizational variables. It tries to capture for the fact that the massive use of new technologies (COMPUTER) together with the introduction of flexible job assignment practices (ROTATION), normally act in the same sense over labor flows.

Results in table 6 suggest that the generalized increase in job instability (see TOTAL and MEN) is explained by both, reduction in the chain production systems and the introduction of ICT and flexible assignment job practices. The complementary effect of technological and organizational changes over the labor flows is, thus, well captured by the variable ICT FLEXIBILITY. The detailed analysis of the different professional categories reveals that:

- Regarding managers, the individual variables AUTONOMOUS, PROJECT and HIERARCHY loose their significance, while the variable capturing their interactions (TEAMWORK*) becomes significant and positive. The 3 HPWO practices reinforce, thus, each other, and it is this interaction the main responsible of the more important labor flows. The just in time production systems continue to accelerate the managers' turnover, while quality control procedures reduce it.

- As when considering incremental organization, job stability of intermediate professionals is uniquely affected by the massive use of computers and not by any other technological or organizational practices, or a combination of them.

- Concerning employees, the disappearance of the *tayloristic* production systems together with the combination of technological and flexible organizational practices (ICT FLEXIBILITY), is at the origin of the increased labor turnover. Only the HPWO practice consisting in delegating responsibilities to lower hierarchical levels (HIERARCHY) acts in the opposite sense, decreasing job instability.

- Finally, results regarding the manual workers turnover are not modified with respect to tables 3 and 4. The combined reduction in chain production systems and increased use of

Table 6: Effect of complementary practices over the labor flows.

	Dependent variable: labor flows for						
	TOTAL	MANAGERS	INT. PROFES.	EMPLOYEES	WORKERS	WOMEN	MEN
COMPUTER	-0.007	-1.314	0.541	0.170	0.140	-0.121	0.046
	(0.101)	(1.406)	(0.211)***	(0.315)	(0.210)	(0.314)	(0.173)
NET	-0.060	-0.500	0.144	-0.084	0.286	-0.228	-0.195
	(0.091)	(1.243)	(0.183)	(0.282)	(0.175)*	(0.279)	(0.154)
CHAIN	-0.122	-0.192	0.058	-0.426	-0.237	-0.363	-0.198
	(0.051)**	(0.697)	(0.102)	(0.157)***	(0.094)**	(0.155)**	(0.085)**
AUTONOMOUS	-0.049	-0.214	0.032	-0.276	-0.078	-0.182	0.043
	(0.102)	(1.389)	(0.204)	(0.318)	(0.178)	(0.312)	(0.171)
PROJECT	-0.073	0.503	-0.132	-0.050	-0.218	0.301	-0.187
	(0.095)	(1.306)	(0.194)	(0.297)	(0.198)	(0.291)	(0.161)
ROTATION	-0.012	-1.182	0.069	-0.211	-0.062	0.005	-0.028
	(0.093)	(1.277)	(0.185)	(0.287)	(0.162)	(0.283)	(0.156)
QUALITY	-0.106	-2.419	0.198	-0.008	-0.086	0.035	0.161
	(0.078)	(1.089)**	(0.162)	(0.243)	(0.159)	(0.241)	(0.133)
HIERARCHY	-0.055	0.344	-0.141	-0.372	0.037	-0.148	-0.092
	(0.052)	(0.716)	(0.106)	(0.161)**	(0.097)	(0.159)	(0.088)
JUST TIME	0.059	0.999	-0.045	-0.068	0.093	0.157	0.074
	(0.043)	(0.605)*	(0.089)	(0.136)	(0.080)	(0.135)	(0.074)
TEAMWORK*	0.130	5.341	0.012	0.264	-0.278	-0.124	0.191
	(0.107)	(1.497)***	(0.218)	(0.339)	(0.370)	(0.333)	(0.183)
ICT FLEXIBILITY	0.528	0.236	0.061	1.897	0.043	0.720	0.556
	(0.184)***	(2.553)	(0.378)	(0.588)***	(0.202)	(0.571)	(0.314)*
Size	-0.030	-0.164	0.150	-0.421	0.131	-0.402	-0.111
	(0.086)	(1.183)	(0.173)	(0.266)	(0.164)	(0.263)	(0.145)
Hours	0.013	4.201	0.273	-0.322	-0.016	-0.125	-0.058
	(0.107)	(1.476)***	(0.215)	(0.337)	(0.192)	(0.330)	(0.182)
% Employees	0.612	2.696	0.521	-2.817	3.242	1.502	0.501
	(0.149)***	(2.079)	(0.310)*	(0.458)***	(0.451)***	(0.455)***	(0.251)**
% Technicians	-0.196	0.645	-2.782	-1.220	0.832	-1.283	-0.078
	(0.246)	(3.455)	(0.526)***	(0.806)	(0.579)	(0.771)*	(0.423)
% Women	0.347	0.907	0.419	1.901	0.598	-3.964	1.973
	(0.155)**	(2.157)	(0.319)	(0.480)***	(0.306)**	(0.474)***	(0.261)***
% Contract	0.408	-5.224	0.566	2.238	1.176	0.591	-0.087
	(0.339)	(4.596)	(0.671)	(1.023)**	(0.690)*	(1.030)	(0.566)
Sectors (16)	YES	YES	YES	YES	YES	YES	YES
Constant	0.472	-0.358	0.264	1.683	-0.049	2.342	0.026
	(0.128)***	(1.799)	(0.268)	(0.400)***	(0.249)	(0.396)***	(0.218)
Adj. R^2	0.123	0.039	0.121	0.070		0.073	0.106
Observations	1645	1689	1575	1631	1140	1719	1722

*Significant at 10%.**Significant at 5%.***Significant at 1%.

net technologies explains the increased labor flows. In this case, the potential complementarities among technological and organizational variables are not significant.

To sum up, complementarities among HPWO practices (TEAMWORK*) or among technological and organizational practices (ICT FLEXIBILITY) must also be considered when analyzing labor flows issues. More particularly, the combination of ICT and flexible job assignment practices has led to a higher aggregate job instability (TOTAL, MEN and EMPLOYEES). In contrast, the combination of HPWO practices (TEAMWORK*) has mainly affected managers.

6 Conclusion

The main objective of this paper was to bring some light to one aspect for which the existent literature is not very abundant: the effect of ICT and HPWO practices on job stability (labor flows). We develop an empirical analysis based on a French database and covering more than twenty-five hundred establishments. Our estimations reveal that at the aggregate level, labor flows of all workers are accelerated by the combination of flexible job assignment practices and ICT. In contrast, the traditional systems of production (chain production systems) reduce the labor flows. In terms of job categories, we conclude that the labor flows of managers are stimulated by HPWO practices (more particularly by the presence of just in time production systems, reduction of hierarchical levels, autonomous teams of production or multidisciplinary groups) while new technologies accelerate labor flows of intermediate professionals, manual workers and employees. For the last ones, complementarities between ICT and flexible job assignment practices have been a key determinant in the increased job instability.

In order to provide a structure to these empirical results, we also develop a very simple theoretical model inspired in Cahuc and Postel-Vinay (2002). The comparative static analysis of the model reproduces the econometric estimations. That is, any technological or organizational change improving the relative productivity of one type of job will tend to reduce its turnover and increase the turnover of the other jobs.

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Appendix 1: Steady State.

At the equilibrium the firms open vacancies until no more benefit can be obtained, that is, all rents are exhausted and the free entry condition applies: $\Pi^{v^c} = 0$ and $\Pi^{v^s} = 0$. From equations (5), (6), (7) and (8) we derive the following expressions for each period:

$$\frac{a^c}{\beta(1-\eta)\, q(\theta^c)} = \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[S^c(x), 0]\, d\Phi(x)\ , \tag{24}$$

$$\frac{a^s}{\beta(1-\eta)\, q(\theta^s)} = \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[S^s(x), 0]\, d\Phi(x)\ . \tag{25}$$

We notice, that all jobs contacts will not lead to a job creation since, once the contact is made and the idiosyncratic productivity revealed, both parties may realize that the match is not productive enough to compensate for the search and hiring efforts. A contact will become a productive match if and only if the joint surplus (the one obtained by the firm plus the one of the worker) is positive. Therefore, for each type of job there exists a a critical productivity level, ε^c and ε^s, such that $S^c(\varepsilon^c) = 0$ and $S^s(\varepsilon^s) = 0$. Below these reservation productivity levels the joint surplus is negative and it is not profitable to create or continue a job.

To compute ε^c and ε^s, we first define the joint surplus of both types of jobs using equations (5)-(14) as well as the free entry conditions, (24) and (25):

$$S^c(\varepsilon) = \varepsilon + h_1 - w^u + \beta(1-\lambda) Max[S^c(\varepsilon), 0] + \beta\lambda \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[S^c(x), 0] d\Phi(x) - \frac{\eta a^c \theta^c}{1-\eta} \tag{26}$$

$$S^s(\varepsilon) = \varepsilon + h_2 - w^u + \beta(1-\lambda) Max[S^s(\varepsilon), 0] + \beta\lambda \int_{\underline{\varepsilon}}^{\overline{\varepsilon}} Max[S^s(x), 0] d\Phi(x) - \frac{\eta a^s \theta^s}{1-\eta} \tag{27}$$

At the threshold values ε^c and ε^s, equations (26) and (27) respectively become zero leading to:

$$\frac{\eta\, a^c\, \theta^c}{1-\eta} = \varepsilon^c + h_1 - w^u + \beta\, \lambda \int_{\varepsilon^c}^{\overline{\varepsilon}} S^c(x)\, d\Phi(x)\ , \tag{28}$$

$$\frac{\eta\, a^s\, \theta^s}{1-\eta} = \varepsilon^s + h_2 - w^u + \beta\, \lambda \int_{\varepsilon^s}^{\overline{\varepsilon}} S^s(x)\, d\Phi(x)\ . \tag{29}$$

From (26) and (27) we know that $S'^{\,c} = \frac{1}{1-\beta(1-\lambda)} > 0$ and $S'^{\,s} = \frac{1}{1-\beta(1-\lambda)} > 0$. Using these results and integrating by parts the integrals in (28) and (29) permits to determine the complex and simple job destruction rule:

$$\frac{\eta\, a^c\, \theta^c}{1-\eta} = \varepsilon^c + h_1 - w^u + \frac{\beta\, \lambda}{1-\beta(1-\lambda)} \int_{\varepsilon^c}^{\overline{\varepsilon}} (1-\Phi(x))\, dx\ , \tag{30}$$

$$\frac{\eta\, a^s\, \theta^s}{1-\eta} = \varepsilon^s + h_2 - w^u + \frac{\beta\, \lambda}{1-\beta(1-\lambda)} \int_{\varepsilon^s}^{\overline{\varepsilon}} (1-\Phi(x))\, dx\ . \tag{31}$$

Whether we consider the complex or the simple segment of the labor market we observe a positive relationship between the market tightness of the corresponding segment and its reservation productivity (see proof bellow). Therefore, the job destruction curves of the complex and simple segment of the labor market are positively sloped in the space (θ^c, ε) and (θ^s, ε), respectively.

Proof.

We analyze the slope of the job destruction curve for the complex segment of the labor market, but the procedure is identical for the simple segment.

$$\begin{aligned}
\frac{\eta\ a^c}{1-\eta}\ \frac{d\theta^c}{d\varepsilon^c} &= 1 + \frac{\beta\ \lambda}{1-\beta(1-\lambda)}\ \frac{d}{d\varepsilon^c}\int_{\varepsilon^c}^{\overline{\varepsilon}}(1-\Phi(x))dx\ , \qquad (32)\\
&= 1 + \frac{\beta\ \lambda}{1-\beta(1-\lambda)}\ \Big(-\frac{d}{d\varepsilon^c}\int_{\overline{\varepsilon}}^{\varepsilon^c}(1-\Phi(x))dx\Big)\ ,\\
&= 1 - \frac{\beta\ \lambda}{1-\beta(1-\lambda)}(1-\Phi(\varepsilon^c))\ .
\end{aligned}$$

From the previous expression we realize that:

$$sign\ \frac{d\theta^c}{d\varepsilon^c} = sign\ \Big(1 - \frac{\beta\ \lambda}{1-\beta(1-\lambda)}(1-\Phi(\varepsilon^c))\Big) \qquad (33)$$

We proceed then to determine the sign of the right hand side of equation (33). Because $0 < \beta < 1$ we know that $1 - \beta + \beta\ \lambda > \beta\ \lambda$. Therefore:

$$0 < \frac{\beta\ \lambda}{1-\beta(1-\lambda)} < 1\ .$$

At the same time, since $\Phi(x)$ is a probability distribution function we know that $0 \leq 1 - \Phi(\varepsilon^c) \leq 1$. Multiplying two numbers smaller than one leads to a positive number smaller than one, therefore:

$$1 - \frac{\beta\ \lambda}{1-\beta(1-\lambda)}(1-\Phi(\varepsilon^c)) > 0 \quad \text{which implies} \quad \frac{d\theta^c}{d\varepsilon^c} > 0\ . \qquad (34)$$

The job destruction curve in the complex segment is positive sloped. The positivity of the slope in the simple segment can be determined in a similar way. ■

We apply on equations (24) and (25) the same procedure developed to compute (30) and (31) so as to determine the job creation rule of each type of firm:

$$\frac{a^c}{\beta(1-\eta)\, q(\theta^c)} = \frac{1}{1-\beta(1-\lambda)} \int_{\varepsilon^c}^{\overline{\varepsilon}} (1-\Phi(x))\, dx \ , \tag{35}$$

$$\frac{a^s}{\beta(1-\eta)\, q(\theta^s)} = \frac{1}{1-\beta(1-\lambda)} \int_{\varepsilon^s}^{\overline{\varepsilon}} (1-\Phi(x))\, dx \ , \tag{36}$$

We prove now that both equations determine a negative relationship between market tightness and ε, meaning that the job creation curves are negatively sloped in the space (θ^i, ε) for $i = c, s$.

Proof.

We develop the proof for the complex case but, here again, the same procedure applies for the simple segment.

$$-\frac{a^c}{\beta\,(1-\eta)} \frac{q'(\theta^c)}{q^2(\theta^c)} \frac{d\theta^c}{d\varepsilon^c} = \frac{1}{1-\beta(1-\lambda)} \frac{d}{d\varepsilon^c} \int_{\varepsilon^c}^{\overline{\varepsilon}} (1-\Phi(x))dx \ , \tag{37}$$

$$-\frac{a^c}{\beta\,(1-\eta)} \frac{q'(\theta^c)}{q^2(\theta^c)} \frac{d\theta^c}{d\varepsilon^c} = -\frac{1}{1-\beta(1-\lambda)} \frac{d}{d\varepsilon^c} \int_{\overline{\varepsilon}}^{\varepsilon^c} (1-\Phi(x))dx \ ,$$

$$\frac{a^c}{\beta\,(1-\eta)} \frac{q'(\theta^c)}{q^2(\theta^c)} \frac{d\theta^c}{d\varepsilon^c} = \frac{1}{1-\beta(1-\lambda)} (1-\Phi(\varepsilon^c)) \ .$$

Because $0 < \beta < 1$, $0 < \eta < 1$ and $a^c > 0$ the first term on the left hand side, $\frac{a^c}{\beta\,(1-\eta)}$, is positive. At the same time, since $0 < \lambda < 1$ and $\Phi(x)$ is a probability distribution function, the right hand part of equation (37) is positive. Therefore:

$$sign \ \frac{d\theta^c}{d\varepsilon^c} = sign \ \frac{q^2(\theta^c)}{q'(\theta^c)} \tag{38}$$

As $q^2(\theta^c)$ is always positive and the probability of filling a vacancy is a decreasing function on the labor market tightness ($q'(\theta^c) < 0$), we find that $\frac{q^2(\theta^c)}{q'(\theta^c)} < 0$. The job creation curve is negatively sloped. ■

Finally, substituting the value functions into the surplus sharing rules (5) and (6) we obtain the following expression for the wages (see Pissarides (1990) chapter 2):

$$w^c = (1-\eta)\, w^u + \eta(\varepsilon + h_1 + a^c\theta^c) \ , \tag{39}$$

$$w^s = (1-\eta)\, w^u + \eta(\varepsilon + h_2 + a^s\theta^s). \tag{40}$$

Appendix 2: Original regressions

The variables included in the estimations of equation (19) (tables 3 and 4), have been chosen after successively eliminating the least significant variables among the following:

1. Explicative variables

    - COMPUTER: Dummy variable taking the value 1 if 50% or more workers use a computer.
    - NET: Dummy variable taking the value 1 if between 20 and 50% of the workers use the net system.
    - INTERNET: Dummy variable taking the value 1 if between 20 and 50% of the workers use the internet.
    - CHAIN: Dummy variable taking the value 1 when the establishment still uses systems of *tayloristic* production systems (robots, computer assisted systems, etc.).
    - AUTONOMOUS: Dummy variable taking the value 1 if between 20 and 50% of the workers participate in autonomous teams of production.
    - PROJECT: Dummy variable taking the value 1 if between 20 and 50% of the workers participate in multidisciplinary working groups or project groups.
    - ROTATION: Dummy variable taking the value 1 when a majority of workers rotates among tasks inside the firm.
    - QUALITY: Dummy variable taking the value 1 when the establishment develops a total quality control procedure.
    - HIERARCHY: Dummy variable taking the value 1 when the establishment has reduced the number of hierarchical levels.
    - JUST TIME: variable taking the value 1 when the establishment practices the just in time production methods either with the customer or with the supplier.

2. Control variables:

    - Tech. change: Dummy variable taking the value 1 if in 1998 there has been an important technological change in the establishment.

Table 7: Determinants of labor flows for different categories of workers.

	TOTAL	MANAGERS	INT. PROFES.	EMPLOYEES	WORKERS	WOMEN	MEN
COMPUTER	0.111	-1.069	0.252	0.632	0.086	0.079	0.188
	(0.102)	(1.417)	(0.209)	(0.317)**	(0.181)	(0.314)	(0.173)
NET	-0.027	0.032	0.024	-0.040	0.339	-0.225	-0.118
	(0.095)	(1.305)	(0.190)	(0.296)	(0.165)**	(0.291)	(0.161)
INTERNET	-0.171	-0.223	-0.225	0.070	-0.557	0.234	-0.410
	(0.167)	(2.307)	(0.336)	(0.531)	(0.351)*	(0.513)	(0.283)
CHAIN	-0.094	-0.298	0.053	-0.221	-0.193	-0.346	-0.159
	(0.057)*	(0.781)	(0.113)	(0.176)	(0.097)*	(0.174)*	(0.095)
AUTONOMOUS	0.029	2.177	0.084	-0.158	-0.024	-0.226	0.134
	(0.090)	(1.238)*	(0.180)	(0.282)	(0.147)	(0.277)	(0.152)
PROJECT	-0.000	2.678	-0.248	0.077	-0.201	0.261	-0.080
	(0.088)	(1.216)**	(0.178)	(0.275)	(0.151)	(0.270)	(0.149)
ROTATION	0.115	-1.404	0.132	0.321	-0.120	0.165	0.116
	(0.082)	(1.145)	(0.166)	(0.258)	(0.136)	(0.253)	(0.139)
QUALITY	-0.110	-2.597	0.191	-0.007	-0.075	0.106	0.154
	(0.080)	(1.111)**	(0.164)	(0.247)	(0.143)	(0.245)	(0.135)
HIERARCHY	-0.050	0.732	-0.160	-0.326	0.050	-0.143	-0.082
	(0.052)	(0.718)	(0.105)	(0.161)**	(0.089)	(0.159)	(0.088)
JUST TIME	0.065	1.098	-0.041	-0.067	0.075	0.185	0.068
	(0.044)	(0.613)*	(0.089)	(0.138)	(0.074)	(0.136)	(0.075)
Tech. change	-0.083	-1.065	0.137	-0.007	-0.283	0.139	0.006
	(0.091)	(1.251)	(0.182)	(0.281)	(0.163)*	(0.278)	(0.154)
Variation	-0.027	-0.366	-0.062	-0.003	-0.013	-0.236	0.074
	(0.084)	(1.163)	(0.171)	(0.259)	(0.146)	(0.257)	(0.142)
Increasing	0.043	-1.124	0.269	-0.114	0.271	0.437	0.087
	(0.404)	(4.919)	(0.798)	(1.083)	(0.598)	(1.098)	(0.626)
Decreasing	0.247	2.596	0.515	-0.220	0.138	0.347	0.509
	(0.411)	(5.033)	(0.813)	(1.110)	(0.611)	(1.123)	(0.639)
Stable	0.148	-1.154	0.158	-0.341	0.329	0.463	0.057
	(0.405)	(4.923)	(0.800)	(1.085)	(0.600)	(1.100)	(0.627)
Size 0-50	-0.003	0.683	0.352	-0.543	-0.162	-0.642	-0.132
	(0.392)	(5.278)	(0.843)	(1.164)	(0.718)	(1.179)	(0.629)
Size 50-500	-0.000	0.218	0.128	-0.418	0.033	-0.396	-0.127
	(0.095)	(1.314)	(0.192)	(0.294)	(0.160)	(0.291)	(0.160)
Size +500	0.094	1.044	0.018	0.035	-0.143	0.011	0.004
	(0.080)	(1.102)	(0.161)	(0.246)	(0.137)	(0.244)	(0.135)
Hours	0.005	3.898	0.275	-0.202	-0.042	-0.173	-0.029
	(0.109)	(1.493)***	(0.215)	(0.339)	(0.180)	(0.332)	(0.183)
% Employees	0.580	3.591	0.843	-3.902	2.400	1.248	0.353
	(0.176)***	(2.451)	(0.362)**	(0.534)***	(0.397)***	(0.532)**	(0.294)
% Technicians	-0.232	0.226	-2.820	-1.762	1.016	-1.428	-0.146
	(0.255)	(3.574)	(0.536)***	(0.827)**	(0.504)**	(0.792)**	(0.436)
% Managers	0.077	-2.318	2.734	-0.855	0.363	-0.680	0.058
	(0.312)	(4.323)	(0.651)***	(0.977)	(0.689)	(0.956)	(0.527)
% Women	0.354	1.097	0.363	1.925	0.644	-4.613	2.083
	(0.168)**	(2.341)	(0.344)	(0.517)***	(0.294)**	(0.512)***	(0.282)***
% Contract	0.464	-3.630	0.856	1.997	1.261	0.596	-0.034
	(0.346)	(4.690)	(0.680)	(1.040)*	(0.587)**	(1.045)	(0.575)
Agriculture							
Food industry	-0.307	1.630	-6.254	-0.738	1.291	0.975	0.593
	(0.406)	(5.472)	(0.967)***	(1.209)	(0.852)	(1.171)	(0.659)
Consumption industry	-0.528	0.736	-6.289	-0.930	0.927	1.425	0.294
	(0.397)	(5.376)	(0.958)***	(1.186)	(0.846)	(1.164)	(0.645)
Car industry	-0.572	1.061	-6.127	-0.621	1.167	0.130	0.543
	(0.441)	(5.986)	(1.028)***	(1.339)	(0.895)	(1.277)	(0.722)
Equipment industry	-0.427	1.869	-6.262	-0.272	0.988	0.256	0.620
	(0.401)	(5.398)	(0.958)***	(1.195)	(0.852)	(1.145)	(0.650)
Intermediary industry	-0.511	1.485	-6.252	-0.540	1.123	0.300	0.522
	(0.395)	(5.304)	(0.950)***	(1.172)	(0.842)	(1.125)	(0.637)
Energy	-0.584	1.637	-6.134	-0.059	3.947		0.745
	(0.517)	(7.021)	(1.150)***	1.629	(1.019)***		(0.854)
Building	-0.415	1.647	-6.116	-0.224	1.165	-0.363	0.898
	(0.414)	(5.582)	(0.978)***	(1.248)	(0.861)	(1.188)	(0.672)
Trade	-0.389	0.068	-6.393	1.151	1.187	1.073	0.797
	(0.391)	(5.230)	(0.941)***	(1.149)	(0.842)	(1.147)	(0.626)
Transport	-0.333	1.304	-6.312	-0.086	1.208	0.028	0.795
	(0.413)	(5.502)	(0.979)***	(1.210)	(0.852)	(1.191)	(0.661)
Finance	-0.545	1.862	-6.370	1.075	-0.767	2.018	-0.012
	(0.429)	(5.735)	(1.011)***	(1.271)	(1.123)	(1.258)	(0.690)
Housing	-0.573		-6.215		0.556	1.315	
	(0.510)		(1.172)***		(1.054)	(1.546)	
Services firms	0.127	1.644	-6.151	0.077	1.237	1.618	0.945
	(0.395)	(5.321)	(0.954)***	(1.170)	(0.859)	(1.157)	(0.637)
Services individuals	1.353	21.549	-4.852	4.953	2.173	4.580	3.187
	(0.435)***	(5.924)***	(1.020)***	(1.291)***	(0.988)**	(1.292)***	(0.705)***
Education	-0.127	-0.168	-3.792	1.644	-0.250	3.676	0.481
	(0.392)	(5.317)	(0.946)***	(1.168)	(0.832)	(1.184)***	(0.635)
Administration		1.407		2.371		1.822	1.949
		(6.931)		(1.540)		(1.523)	(0.829)**
Constant	0.700	-1.823	6.060	1.983	-1.342	1.434534	-0.833
	(0.571)	(7.235)	(1.250)***	(1.592)	(1.032)	(1.593)	(0.889)

*Significant at 10%.**Significant at 5%.***Significant at 1%.

- Variation: Dummy variable taking the value 1 if the economic activity of the establishment has suffered an unusual variation in 1998.
- Increasing: Dummy variable taking the value 1 if the economic activity of the establishment has been increasing in 1998.
- Decreasing: Dummy variable taking the value 1 if the economic activity of the establishment has been decreasing in 1998.
- Stable: Dummy variable taking the value 1 if the economic activity of the establishment has remained stable in 1998.
- Size 0-50: Dummy variable taking the value 1 if the number of workers in the firm is lower than 50.
- Size 50-500: Dummy variable taking the value 1 if the number of workers in the firm is between 50 and 500.
- Size +500: Dummy variable taking the value 1 if the number of workers in the firm is above 500.
- Hours: Dummy variable taking the value 1 if the firm has already implemented the reduction in the number of working hours.
- % Employees, % Technicians and % Managers are the percentage of employees, technicians and managers in the firm.
- % Women is the percentage of women in the firm.
- % Contract is the percentage of fixed duration contract in the firm.
- We control for the following economic sectors: agriculture and fishing (Agriculture); agricultural and food industry (Food industry); consumption industry (Consumption industry), automobile industry (Car industry); equipment industry (Equipment industry); intermediary goods' industry (Intermediary industry); energy sector (Energy); building sector (Building); trade sector (Trade); financial activity sector (Finance); housing activities (Housing); services to firms (Services firms); services to individuals (Services individuals); education, health and social action (Education); and administration (Administration).

Appendix 3: Means and standard deviations

Table 8: Mean and standard deviation of variables in cross section analysis.

Variables	Mean	Standard deviation
TOTAL	0.741	2.213
MANAGERS	0.764	18.800
INT. PROFES.	0.697	2.835
EMPLOYEES	0.921	4.323
WORKERS	0.574	2.149
WOMEN	1.081	4.338
MEN	0.845	2.536
COMPUTER	0.317	0.465
NET	0.252	0.434
CHAIN	0.778	0.805
AUTONOMOUS	0.192	0.394
PROJECT	0.244	0.430
ROTATION	0.251	0.433
QUALITY	0.606	0.489
HIERARCHY	0.924	0.726
JUST TIME	0.708	0.846
Size	0.189	0.392
Hours	0.106	0.308
% Employees	0.314	0.322
% Technicians	0.162	0.162
% Women	0.380	0.284
% Contract	0.058	0.114
Energy	0.007	0.086
Building	0.058	0.233
Finance	0.036	0.186
Services firms	0.101	0.301
Services individuals	0.0439	0.205
Education	0.126	0.332
Administration	0.013	0.115

Appendix 4: Correlation matrix

Table 9: Correlation matrix.

	TOTAL	MANAGERS	INT. PROFES.	EMPLOYEES	WORKERS	WOMEN	MEN
TOTAL	1.000						
MANAGERS	0.214 (0.000)	1.000					
INT. PROFES.	0.224 (0.000)	-0.003 (0.887)	1.000				
EMPLOYEES	0.452 (0.000)	-0.001 (0.959)	0.199 (0.000)	1.000			
WORKERS	0.270 (0.000)	0.036 (0.187)	0.089 (0.001)	0.160 (0.000)	1.000		
WOMEN	0.348 (0.000)	0.016 (0.516)	0.190 (0.000)	0.212 (0.000)	0.151 (0.000)	1.000	
MEN	0.727 (0.000)	0.301 (0.000)	0.444 (0.000)	0.486 (0.000)	0.251 (0.000)	0.272 (0.000)	1.000
COMPUTER	0.031 (0.163)	-0.016 (0.481)	-0.004 (0.854)	0.023 (0.337)	0.075 (0.005)	-0.026 (0.249)	0.014 (0.525)
NET	-0.044 (0.049)	-0.015 (0.533)	-0.024 (0.320)	-0.023 (0.328)	0.073 (0.007)	-0.057 (0.012)	-0.060 (0.007)
CHAIN	-0.149 (0.000)	-0.028 (0.234)	-0.122 (0.000)	-0.116 (0.000)	-0.118 (0.000)	-0.117 (0.000)	-0.152 (0.000)
AUTONOMOUS	-0.042 (0.056)	0.046 (0.049)	-0.039 (0.108)	-0.031 (0.193)	-0.047 (0.079)	-0.032 (0.153)	-0.013 (0.557)
PROJECT	-0.023 (0.304)	0.039 (0.092)	0.002 (0.932)	0.007 (0.765)	-0.037 (0.166)	0.008 (0.717)	-0.010 (0.666)
ROTATION	-0.029 (0.191)	-0.014 (0.540)	-0.039 (0.102)	0.001 (0.982)	-0.058 (0.033)	-0.020 (0.380)	-0.014 (0.541)
QUALITY	-0.103 (0.000)	-0.037 (0.113)	-0.045 (0.063)	-0.046 (0.049)	-0.058 (0.031)	-0.033 (0.147)	-0.034 (0.128)
HIERARCHY	-0.043 (0.051)	0.032 (0.173)	-0.101 (0.000)	-0.080 (0.001)	-0.028 (0.300)	-0.048 (0.033)	-0.064 (0.004)
JUST TIME	-0.039 (0.081)	0.032 (0.172)	-0.0890 (0.000)	-0.058 (0.013)	-0.033 (0.223)	-0.040 (0.078)	-0.057 (0.011)

	COMPUTER	NET	CHAIN	AUTONOMOUS	PROJECT	ROTATION	QUALITY
COMPUTER	1.000						
NET	0.496 (0.000)	1.000					
CHAIN	-0.012 (0.531)	0.086 (0.000)	1.000				
AUTONOMOUS	-0.038 (0.042)	0.036 (0.056)	0.171 (0.000)	1.000			
PROJECT	0.184 (0.000)	0.204 (0.000)	0.061 (0.001)	0.153 (0.000)	1.000		
ROTATION	-0.107 (0.000)	-0.049 (0.010)	0.134 (0.000)	0.098 (0.000)	-0.004 (0.822)	1.000	
QUALITY	-0.004 (0.841)	0.061 (0.001)	0.317 (0.000)	0.159 (0.000)	0.100 (0.000)	0.095 (0.000)	1.000
HIERARCHY	0.075 (0.000)	0.136 (0.000)	0.249 (0.000)	0.117 (0.000)	0.144 (0.000)	0.061 (0.001)	0.209 (0.000)
JUST TIME	-0.081 (0.000)	-0.002 (0.931)	0.316 (0.000)	0.135 (0.000)	0.007 (0.696)	0.169 (0.000)	0.242 (0.000)

	HIERARCHY	
HIERARCHY	1.000	
JUST TIME	0.210 (0.000)	1.000

() Significance levels.