**Couverture Orange CEPREMAP** **May 2001**

**N° 01 06**

# NEW ORGANIZATIONAL PRACTICES AND WORKING CONDITIONS: EVIDENCE FROM FRANCE IN THE 1990S

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This research has been funded by a grant from the French Ministry of Research. We are indebted to Bénédicte Reynaud and Muriel Roger for most valuable discussions. Thomas Coutrot, Sylvie Hamon-Cholet as well as participants to the French-German seminar on "Labour" in Berlin (January 2001), the REL conference in Metz on "The New Economy: Implications and Viability" (April 2001) and the seminar on "Labour Intensification" at Centre d'Etude de l'Emploi also provided useful remarks and suggestions. All remaining errors are our own.

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# PRATIQUES INNOVANTES DE TRAVAIL ET CONDITIONS DE TRAVAIL EN FRANCE DANS LES ANNEES 90

**Résumé :** Nous étudions l'impact des pratiques innovantes de travail sur les conditions de travail. Nous utilisons l'enquête française *Conditions de Travail* 1998 qui offre des données détaillées pour un échantillon représentatif de travailleurs. Les conditions de travail sont décrites à partir des accidents de travail et des indicateurs de charge mentale. Les nouvelles pratiques de travail qui jouent un rôle clef dans la réussite de la « nouvelle économie » incluent notamment la rotation de poste et les démarches de qualité. En exploitant le modèle causal de Rubin, nous montrons que, même après la correction des biais de sélection et le contrôle par les caractéristiques des travailleurs et de leurs postes, la main d'œuvre impliquée dans ces pratiques innovantes de travail supporte des conditions de travail significativement plus pénibles et dangereuses que celles des travailleurs non impliqués.

# NEW ORGANIZATIONAL PRACTICES AND WORKING CONDITIONS: EVIDENCE FROM FRANCE IN THE 1990S

**Abstract**: We investigate the impact of new work practices on working conditions. We use a unique French dataset providing information on individual workers for year 1998. New work practices which play a key role in the success of the new economy, include job rotation and the use of quality norms. Working conditions are captured by occupational injuries as well as indicators of mental strain. Using Rubin's causal model, we show that, even after controlling for employees and jobs characteristics and correcting for sample selection bias, workers involved in the new work practices still face working conditions that are significantly worse than those of non innovative workers.

**Mots clefs :** pratiques innovantes de travail, technologie de l'information, accidents du travail, conditions de travail

**Keywords:** new work practices, technology, occupational injuries, working conditions

**JEL classification: J28, L23**

## 1. Introduction

During the last decade, many firms have experienced a reorganization of their workplace. New workplace practices have been adopted such as job rotation, delayering, self-directed work-teams, just-in-time and total quality management. This phenomenon first appeared in the United-States and has then expended over to Europe (OECD, 1999). In 1998, in France 18% of establishments with more than 50 employees had at least one fifth of their workforce involved in autonomous teams - Coutrot (2000a;b) -, as compared to 38.4% in the USA having more than one half of their workforce involved in self directed teams in 1997 - Osterman (2000). The corresponding figures for job rotation are 22% for France and 55.5% for the USA.

An important literature, first developed in management and more recently in economics, has studied the consequences of these organizational changes on firms performance and skill requirements[1]. Using either industry or firm-level data, most of these work display a positive impact of new work practices upon productivity especially in connection with information technologies. On a small sample of steel finishing lines, Ichniowski et al. (1997) show that the introduction of new human resource management practices positively influences productivity. On a larger panel of US firms, Black and Lynch (2000) show that re-engineering, profit sharing and employees voice also have a positive impact on productivity. The same result is found by Caroli and Van Reenen (2001) for delayering on a panel of French firms. An exception is Cappelli and Neumark (1999) who do not find any effect of new work practices on labor efficiency. However their sample only includes US firms which already existed in 1977. It is therefore biased against finding any effect of new work practices if these are primarily introduced by newborn enterprises - as shown by Ichniowski et al. (1997). In relation to these works, a number of authors underline the importance of introducing clusters of complementary practices. Using US panel data, Black and Lynch (1997) show that the impact of total quality management on productivity is greater in unionized than in non-unionized firms. At the industry level, Askenazy and Gianella (2000) display some complementarities between technical and organizational change in

[1] See Caroli (2001) for a review.

the USA. Eventually, Bresnahan et al. (2001) find a three-way complementarity between skills, technology and new organizational practices in a sample of US establishments. In parallel, several papers provide evidence that, at least during the initial phase of reorganization, new work practices are biased against unskilled labor thus leading to an upskilling of firms' occupational structure[2].

Given the increasing diffusion of innovative work practices in the "new economy," another important issue has to do with their consequences on working conditions and, more specifically, on occupational health and safety. So far, this question has been largely neglected by economists. However, it appears to be potentially crucial for the viability of the "new economy". Should the new productive system noticeably increase the risk of work injuries or illnesses, this would raise absenteeism or social conflitcs and incur important costs both at the firm and macro levels. Moreover, it would probably affect workers' satisfaction at work which would, in turn, influence labour productivity. So, evaluating the impact of new work practices on working conditions appears as a key issue if one wants to draw a complete picture of the "new economy" and of its prospects of future development.

A number of works have been carried out on this issue by ergonomists and sociologists[3]. These essentially build upon a variety of case studies and yield conflicting conclusions[4]. For the sake of simplicity, they can be divided into two groups defending opposite, although not necessarily exclusive, views:

a) In the new production model, there is a synergy between firms' performance and workers' well-being.

- Because the new organization aims at optimizing the production process, safety should be a necessary objective for firms to pursue, in order to reduce one of the main sources of waste, i.e. absenteeism due to occupational hazards and the costs of related incidents.

[2] See Cappelli (1996) and Askenazy (2000) on US data, Greenan (1996) on French data and Caroli and Van Reenen (2001) on French and British data.

[3] See Gollac and Volkoff (2000) for evidence about France.

[4] See Askenazy (2001) for a survey of this literature.

- New work practices and, in particular, total quality management (TQM) and quality norms help reduce failures in the production process. To the extent that these failures imply risks of injuries in the workplace, TQM should mechanically result in an improvement of occupational safety, especially by reducing serious dangers.

- Moreover, job rotation and delegation of authority make work more diversified and therefore potentially more interesting. This is actually an objective in the new organization in order to enhance workers' motivation and thereby their productivity. Indeed, boredom reduces alertness thus contributing to raising the risk of injuries. Moreover, in the Karasek's (1998) control/demand model, a greater autonomy in an efficient organization reduces job strain hence health dangers (cardiovascular diseases etc...).

b) A second line of analysis stresses that new practices increase the pressure exerted on workers for performance.

- Job rotation and team work reduce slack time, thus raising the pace of work[5].

- The setting of safety procedures requires a stable work environment that was guaranteed in the tayloristic organization (Kramarz, 1986). Workers build up personal routines that improve their safety and limit their efforts through a long learning-by-doing process. Job rotation, continuous improvement and modifications in the production process, as well as frequent product changes, are therefore detrimental to the elaboration of such safety mechanisms.

- Quality control is another source of mental strain and, above all, requires a shift of attention from the work environment to the product.

This variety of arguments shows that the consequences of work practices on working conditions are connected through complex causality chains. Case studies in ergonomics, sociology or management, indeed corroborate this complexity. In

[5] See Cartron and Gollac (2001) for a study of the consequences of work intensity on workplace conditions.

particular they show that the above mentioned mechanisms play with extreme heterogeneity across firms. Results on Scandinavia are an exception in that the increase in workers' participation seems to have consistently improved the well-being and safety of workers (e.g. Gardell, 1991). This suggests that structural regulation should play a role in the observed connections between work and safety. However, by construction, case studies only provide limited evidence and their conclusions cannot easily be generalized to assess whether new work practices improve or damage working conditions and safety. Researchers in occupational medicine advocate quantitative explorations in this field through the use of large-scale databases (e.g. Tolsma, 1998).

The difficulty of this exercise is to find compatible and reliable sources on both workplace organization and working conditions. Three recent papers have tried to perform such work. Fairris and Brenner (1998) investigate the relationships between workplace transformation and the rise in cumulative trauma disorders (CTDs). They match Osterman's (1994) survey of private American establishments with sectoral data on CTDs and find no clear correlation between new work practices and the frequency of illnesses - except for quality circles where it is positive. Askenazy (2001) also uses Osterman's survey and a statistical treatment of 1.5 million articles from 1,000 management reviews to determine whether and when a sector[6] has reorganized. This index is matched with longitudinal OSHA[7] data on occupational injuries. He finds that new work practices (autonomous work teams, job rotation, TQM) increase by some 30% the frequency of injuries in the USA. Ramaciotti and Perriard (1999) use longitudinal data for 200 Swiss firms. They find that the rate of occupational injuries was initially *lower* in firms which subsequently implemented ISO 9000 norms, and that it is non-significantly different across firms, one decade later.

In this paper, we use an unique survey, "Conditions de Travail", covering 22,000 workers in France in 1998. It provides detailed information on working conditions, occupational injuries and the type of workplace practices workers are involved in. This survey has three main advantages. First, it is matched by construction to the French Labor Force Survey, "Enquête Emploi", which con-

[6] The study covers both manufacturing and tertiary activities.
[7] Occupational Safety and Health Administration.

tains a wealth of socio-demographic information on workers. Second, the sample is large and nationally representative. Third, France has balanced institutions somewhere between the "laissez-faire" American model and the Scandinavian regulation, which makes it an interesting country to study.

We primarily focus on the relationships between new organizational practices and work injuries. We first analyze the determinants of occupational injuries and show that, in addition to new work practices - namely quality norms and job rotation -, the usual factors such as education, seniority, occupation or industry come out. Due to the risk of sample selection bias, as a second step, we try and improve our estimates using Rubin's "causal model"[8]. Lastly, in order to get a more complete picture of working conditions in firms that have introduced new work practices, we focus on various indicators of mental strain. A consistent result over specifications and estimation methods is that workers involved in new organizational practices have a higher probability of occupational injuries than workers involved in a more traditional work organization. They are also subject to greater psychological discomfort, thus suggesting that the new organizational practices might be detrimental to working conditions. In order to make sure that the causality between new work practices and work injuries does not run from the latter to the former, we use longitudinal data from the French Social Security (CNAM[9]) over 1988-1998 in order to study the direction of causality between new work practices and injuries. Our conclusion is that it is most unlikely that the correlation runs from injuries to organizational innovation.

Section 2 presents the econometric method. Section 3 provides details about the data we use. Section 4 has the results and Section 5 concludes.

## 2. The Econometric Method

Estimating the pattern of occupational injuries conditional on whether workers are involved in new organizational practices raises serious selection problems. A

[8]The word "causal" is used by Rubin (1974) himself. Its use is quite inappropriate here given the cross-sectional nature of our data. Indeed, the model will yield correlation coefficients correcting for sample selection bias but will not allow, by itself, to assess the direction of causality given the lack of lagged instruments. We try and improve on this issue in Section 4.4.

[9]Caisse Nationale d'Assurance Maladie.

"naive" estimation of the impact of an innovative practice $P$ (e.g. job rotation) on a working condition indicator $Y$ (e.g. the rate of occupational injury) would consist in comparing the rates of occupational injuries for workers who are involved in the practice ($p = 1$) and workers who are not ($p = 0$). However, differences in the rate of injuries can result from particular characteristics of workers. For example, if clerical workers do not rotate among jobs while production workers do, a higher rate of injuries associated with job rotation may just reflect the fact that production workers face higher risks than clerks. Standard methods allowing to correct for such selection biases have been developed by epidemiologists and labor economists (see Heckman et al., 1999). In this paper, we implement the so-called Rubin's method of "causal estimation". This approach has been used recently by Crépon and Iung (1999) to estimate the impact of innovation on firms' performance and by Fiole et al. (2000) to study the impact of a reduction in working time on employment.

The impact of a work practice can be expressed in Rubin's (1974) framework as follows. The risk of injury (or mental strain ...) is described by two probabilities $(y_0, y_1)$ conditional on the realization of the variable $P$. Worker $i$ is thus characterized by the unobservable couple $(y_{0i}, y_{1i})$ where $y_{1i}$ is the qualitative variable of having an injury if the worker is involved in the practice $P$ ($p_i = 1$) and $y_{0i}$ is the variable if $p_i = 0$. We only observe $y_i$ :

$$y_i = p_i \times y_{1i} + (1 - p_i) \times y_{0i} \tag{2.1}$$

The "causal effect" $c_i$ of the practice $P$ on the risk of injuries (or mental strain...) is defined as:

$$c_i = y_{1i} - y_{0i} \tag{2.2}$$

This parameter is not identifiable since we do not observe simultaneously a realization of $y_{0i}$ and a realization of $y_{1i}$ (at a given point in time, a worker cannot both be involved in $P$ and not be involved in $P$). With these notations, the "naive" estimator of $c$ is:

$$\tilde{c} = E(y_i|p_i = 1) - E(y_i|p_i = 0). \tag{2.3}$$

Again, this estimator is biased because it does not take into account heterogeneity across workers nor across occupations or jobs. One way to correct for this bias is to estimate a probit or logit model of individuals' risk of having an occupational injury, including the $P$ variable along with all the characteristics of workers (education, marital status, age ...) and of their jobs. However, if the "causal" effect of workplace practices is not homogenous across the population[10], the coefficient associated to $P$ is again biased (see Crépon and Iung, 1999).

The construction of an unbiased, robust estimator follows Heckman, Rosenbaum and Rubin's (1983) work. If we want to estimate $E(c_i) = E(y_{1i} - y_{0i})$, we can directly estimate $E(y_{1i}|p_i = 1)$ and $E(y_{0i}|p_i = 0)$ but not $E(y_{1i}|p_i = 0)$ nor $E(y_{0i}|p_i = 1)$. The idea is then to find satisfying empirical equivalents for $E(y_{1i}|p_i = 0)$ and $E(y_{0i}|p_i = 1)$. In order to get an empirical distribution for $y_{0i}|p_i = 1$ - resp. $y_{1i}|p_i = 0$ -, one looks for a worker $j$ who is not involved in $P$ ($p_j = 0$) - resp. is involved in $P$ - and has similar characteristics to that of worker $i$. Crépon and Iung (1999) exploit this principle and provide a continuous estimator of the causal effect. This "weighted" estimator is defined as follows:

$$\hat{c}_w = E(c_i) = E[y_i\{\frac{p_i}{\pi(x_i)} - \frac{1-p_i}{1-\pi(x_i)}\}], \tag{2.4}$$

where $\pi(X_i) = P(p_i = 1|X_i)$ is the propensity score of being involved in $P$ given all the observable characteristics of the worker and of her position ($X$). Intuitively, this estimator puts an important weight on those workers who are not involved in $P$ (respectively are involved in $P$) while, because of their individual characteristics, the employer should assign them to $P$ (resp. should not). The crucial point is that this estimator is convergent and unbiased under assumption (H):

$$(y_{0i}, y_{1i}) \perp P \mid X, \tag{H}$$

i.e. when knowing $X$, the realization of variable $P$ does not provide any information about workers' characteristics but only about their work practices. This assumption is obviously never strictly verified; there is always some unobserved heterogeneity. However, given the very detailed nature of our data on workers and their job, the residual information revealed by the fact that a worker be or not assigned to $P$ should not be decisive, at least as far as her observable characteristics are concerned. We are thus left with the problem of unobserved heterogeneity

[10] E.g., intuitively, job rotation might not have the same consequences on safety for production and non-production workers.

which cannot be tackled at this point, due to the lack of adequate instruments. Another source of concern has to do with the lack of direct information about firms characteristics. Part of them is captured using sectoral dummies as well as a variety of post characteristics. A remaining problem is that of firms' human resource management practices. If these are correlated both with the adoption of new work practices and with working conditions, our estimates will be biased. The literature on organizational change indeed displays a positive correlation between "high performance" human resource management, based upon workers training by the firm, horizontal communication or profit sharing... and the adoption of new work practices such as job rotation or quality norms[11]. Given that the former are likely to be negatively correlated with occupational injuries - due to a better training and information of workers - our results will underestimate the true effect.

In practice, the estimation method consists in two steps: first, we estimate the probability that a worker $i$ be assigned to the work practice $P$, conditional on her characteristics and that of her job $X_i$: $\pi(X_i) = \Pr(p_i = 1|X_i)$ (using a properly specified logit model); second we use this estimate to compute $\hat{c}_w$ according to (2.4).

Crépon and Iung (1999) show that $\hat{c}_w$ is asymptotically normal. Its asymptotic variance is the variance of $\phi_i$ defined as:

$$\phi_i = y_i\{\frac{P_i}{\pi(x_i)} - \frac{1-P_i}{1-\pi(x_i)}\} - c_o \tag{2.5}$$

$$-E[\{\frac{P_i(1-\pi(x_i))}{\pi(x_i)} - \frac{\pi(x_i)(1-P_i)}{1-\pi(x_i)}\}y_i x_i]E[\pi(x_i)(1-\pi(x_i))x_i' x_i]^{-1}[(P_i-\pi(x_i))x_i'].$$

The weighted estimator yields an absolute risk. Let us assume, for example, that the "causal" impact (yielded by the weighted estimator) of job rotation on the risk of being injured is $\hat{c}_w = +0.05$. If a worker $i$ who does not rotate has a probability $z$ of being injured our estimation says that if she starts rotating, her risk of occupational injury should go up to $0.05 + z$. Therefore, the relative increase of individual risk is $0.05/z$. However, because of the selection bias, we cannot determine the true average value of $z$ and therefore, we cannot calculate

[11] See Osterman (1994) and Ichniowski and Shaw (1995).

the relative estimated causal effect. Nevertheless, in the case of a positive causal impact, the true value of $z$ should be lower than the average rate of injuries in the whole sample. Therefore, if $r$ denotes the average risk of injury (resp. mental strain) in the whole population, then $\hat{c}/r$ provides a lower bound estimate of the relative causal effect of the work practice on the risk of being injured at work. Obviously, this reasoning expands to other workplace practices and other indicators of working conditions.

## 3. Data

The data we use come from two different datasets: the Labor Force Survey (Enquête Emploi, EE) and a complementary questionnaire on working conditions, the Enquête Conditions de Travail[12] (CT). Both were conducted by the French statistical institute INSEE in 1998. The Enquête Emploi is an annual survey consisting of a three year rotating panel of a 1/300 sample of the active population. The questions on working conditions were asked only to individuals with a job in the outgoing third of the sample. Our database thus consists of a representative sample of the working population with about 22,000 individuals in it.

Questions on working conditions include work rhythm and working time, psychological stress and tensions in the relationships with other people in the working environment, physical stress or pain caused by work, including occupational injuries. Most of these questions rely to a large extent on the personal interpretation of the worker. For example, one of the questions relating to psychological strain is formulated as follows: "Do you need to cope on your own with difficult situations? Yes, quite often. Yes, it happens. No". What a difficult situation is is not indicated in the questionnaire, so that the respondent has to decide on her own what she should consider as such. Similarly, for physical stress, one question is: "Does your work require that you carry or move around heavy weights?", with no indication of any criterion according to which a weight should be considered as heavy. On the one hand, this is an obvious limitation on the information we have. On the other

[12] This survey has been designed by the Department of working conditions and industrial relations at the French Ministry of Labor (DARES), and conducted in 1998 by Catherine Rougerie, Lydie Vinck and Serge Volkoff.

hand, the data provide unique information on working conditions, as perceived by workers. We will particularly focus on indicators of psychological strain. A first group of variables captures *time pressure* as felt by workers. We define a binary variable coded as 1 if the individual declares that she has to hurry either all the time or often, and 0 otherwise ($HURRY$). We also have information on whether the individual feels she has enough time to do her job properly ($NO\_TIME$). A second group captures *stress due to uncertainty* about how to do the job. This contains a variable coded as 1 if the worker often has to drop one task for another one that was not anticipated and if she perceives this as disturbing for her work ($CH\_TSK$). It also includes a variable indicating whether the individual has to cope on her own with difficult situations ($COPE$) and whether she declares receiving contradictory prescriptions ($CONTRAD$). A third group has to do with the *consequences* the worker feels her mistakes may have on the production process: consequences on the quality of the product ($CSQ\_P$) and financial costs to the enterprise ($CSQ\_F$). Eventually a last group of variables captures the *social environment* at work, in particular tensions in the relationships with colleagues ($TENS\_COLL$) and with the hierarchical superiors ($TENS\_HIE$).

In addition to these variables, the questionnaire also asks workers about occupational injuries. This question was asked only to wage earners and formulated as follows: "*In the past 12 months, have you had, while working, any injury, even benign, that forced you to be nursed?*". The questionnaire then asks details about the nature of the injury as well as whether it forced the individual to stop working for at least one day. Due to the emphasis put on what happened in the past twelve months, we only kept those workers with more than one year of seniority. Indeed, for those with seniority less than a year, the risk of incident in their present job is mechanically lower than for the same type of individual with higher seniority, thus introducing measurement error. This brings our sample down to 16,089 individuals. Despite this precaution and due to the formulation of the question - i.e. have you had *any* injury over the past 12 months -, our injury variable ($OI$) will underestimate the true probability of injury. Indeed, individuals who have had more than one injury in the course of the past year will appear, in our data, as having only one. Given this limitation, the mean proportion of occupational injuries in our population, 8.5%, will have to be considered as a lower bound. We also define two other variables according to whether the injury has forced the worker to stop working for at least one day or not. The former captures what we regard as serious injuries ($SOI$) while the latter captures more benign hazards ($BOI$). They respectively account for 55 and 45% of all injuries.

The CT survey also provides information on the technology that is used by the worker and the type of work organization she is involved in. Technology variables include whether the worker uses a robot or any numerically controlled equipment ($ROBOT$), whether she uses a microcomputer ($COMP$) and is connected to the internet ($WEB$). Organizational practices include job rotation ($ROTA$) and the use of quality norms ($QNORM$). These variables are of particular interest since they appear as characteristics of the new organizational practices. Their use substantially increased in France over the 1990s while their incidence was virtually zero by the mid-80s. According to the REPONSE[13] survey, the share of private establishments using quality norms[14] went up from 12 to 34% between 1992 and 1998 while that of establishments not providing multitask training dropped from 44% to 26 % (the share of establishments providing such training to all categories of workers rose from 6 to 18%)

Following the estimation method presented in Section 2 implies controlling for the characteristics of workers and of their position. The EE provides information on individuals' characteristics such as education, seniority, sex, age, marital status, region of residence... We group this information by classes that are used as dummy variables in the statistical analysis.

In order to control for the job, we use the section of the EE dealing with workers' occupation and industry, as well as the size of the enterprise she works in. Moreover, the CT survey contains a wealth of information on the conditions in which the work is actually carried out. We have detailed information on working hours including how much control the worker has on them, whether she works at night or on weekends. We know whether work is repetitive, how the rhythm

[13] Relations Professionnelles et Négociations d'Entreprise survey conducted by the French Ministry of Labor in 1992. Unfortunately, this survey does not provide direct information on job rotation.

[14] These are figures for ISO norms.

of work is determined (either by the worker or by external constraints), whether the worker has to fulfill production norms or is subject to time constraints. We consider this information as characterizing the position of the individual and use it to control for features of the job that would not be captured by the occupation or the sector. However, one could argue that such variables at least partly reflect the kind of work organization the worker is involved in. For example, having to work on weekends is a characteristic of jobs in the trade sector. However, it may also correspond to an organization of work in which workers are required to be highly flexible on working hours. In order to check which of these interpretations is correct, we will use two different specifications: one including the conditions in which work is carried out and one excluding them.

A large number of descriptive statistics are contained in Appendix Tables I to III. Appendix Table I displays the mean and standard deviation of the main variables. Regarding the characteristics of individuals in our sample, 34% of workers have at least a high school degree as opposed to 25% with no diploma at all. The great majority of the population (89%) is between 25 and 55 years old. The 21 French regions have been reaggregated into 5 zones: North (West and East), South (West and East)[15] and Ile-de-France, i.e. Paris and the surrounding area.

The EE provides us with standard classifications for sectors. We use two of them which respectively contain 36 and 14 industries. Using the NAF700 - a 3-digit classification -, we also reaggregated the sectors into branches equivalent to those used by CNAM[16] (see Appendix Table I). CNAM is the Social Security institution in charge of compensating workers for work injuries. It collects exhaustive data on *reported* injuries (involving days away from work) and aggregates them into industrial branches that are defined on the basis of the risk of injury. Using the CNAM classification allows us to compare the data on injuries from our sample with the exhaustive data at the national level. The figures are reported in Appendix Table II. Given that CNAM only reports injuries that have led to some compensation, we restricted our sample to workers who declared having had a se-

[15]North-West includes Haute and Basse Normandie, Bretagne, Centre and Pays-de-la-Loire. North-East contains: Nord-Pas-de-Calais, Alsace, Lorraine, Franche-Comté, Picardie and Champagne-Ardennes. South-West is Limousin, Aquitaine, Midi-Pyrénées and Poitou. South-East includes: Bourgogne, Auvergne, Rhône-Alpes, PACA, Languedoc-Roussillon.

[16]Caisse Nationale d'Assurance Maladie.

rious occupational injury in the CT survey - i.e. an injury that forced her to stop working for at least one day. The global mean in our sample is very close to that in the CNAM database (4.68 as compared to 4.48%). One important difference is that CT does not take into account multiple injuries in the course of the year. We thus underestimate injuries in branches where multiple injuries are numerous - such as construction for example. However, our data is not likely to suffer from severe under declaration as is the case with CNAM data. Indeed, according to French Social Security rules, when occupational injuries are high in a firm, this is subject to financial penalty. As a consequence, employers tend to pressure workers into not declaring injuries. They often offer direct financial compensation in order to avoid declaration. This explains why CT injury rates may be higher than CNAM ones in some sectors. Overall though, our data is reasonably similar to that published by CNAM. Another interesting information regards the total rate of injuries by occupation (see Figure I).

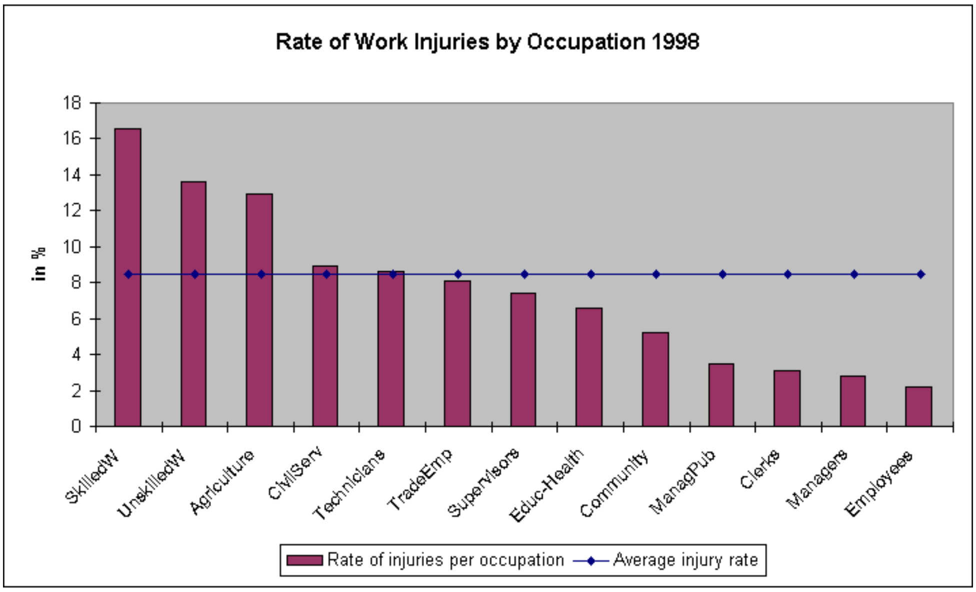



Figure I

As expected it varies a lot, from 16.6% for skilled workers to 2.2 for clerks. It is higher than the mean for skilled and unskilled manuals and for agriculture workers, and is much below it for clerks and managers.

Apart from injuries, a large proportion of workers in our sample appear to suffer from psychological discomfort. 25% feel they do not have enough time to do their work properly, 28% often have to change tasks unexpectedly and consider this as disturbing, 25% declare they have to cope on their own with difficult situations. Tensions with colleagues or with the hierarchy are quite frequent - respectively 25 and 34%. Eventually, the proportion of workers who are aware that their errors may have consequences on the quality of the product is very high (66%) as is the proportion of those who declare it may induce a financial cost to their firm (51%).

As regards organization, 21% of workers apply quality norms, while 31% rotate among jobs either regularly or when it happens to be necessary. Advanced technologies are quite widespread, at least for computers (53% of workers use them). They are of course more frequent among managers (91%) than among workers employed in agriculture (6.7%), but some 18% of unskilled workers and 35% of skilled workers use them in the manufacturing sector.

Appendix Table III breaks down the rate of occupational injuries according to whether workers apply any new work practices. Whatever the practice, work injuries appear to be much more frequent among workers involved in the new type of organization. 11.9% of workers rotating among jobs have had at least one occupational injury in 1998 as compared to only 7.1% for those who do not rotate. Similarly the proportion of injuries amounts to 12.8% in the group of workers who apply quality norms, as compared to 7.4% for those who do not. The next section essentially probes whether these correlations between new work practices and working conditions are robust to additional controls and to correcting for sample selection bias.

# 4. Results

## 4.1. The Determinants of Occupational injuries

In this section, we investigate the impact of new work practices upon occupational injuries when other possible determinants are taken into account[17]. Thus doing, we check whether our results are consistent with what is usually found in the literature

[17]Indeed, if such a test should display no incidence of new work practices, correcting for sample selection bias would be pointless.

regarding the socio-demographic factors influencing work injuries (e.g. ILO, 1998). We estimate a logit for all occupational injuries as well as for serious and benign injuries independently. The results are presented in Table I. All regressions include 3 groups of controls. First are the variables we are most interested in, namely the two work practices: the use of quality norms and job rotation. Second, in order to make sure that the impact of these practices does not actually capture characteristics of the individual or of her position, we introduce a full set of socio-demographic variables: age and seniority, education and occupation, nationality, marital status, region of residence... A last group of indicators controls for the characteristics of the job, such as the size of the firm, the industry, the technology used, as well as a large number of position characteristics.

Considering the total risk of injury ($OI$) our results are consistent with what is usually found in the literature. Education reduces the probability of injury, as do seniority. Regarding educational levels though, the biggest impact comes for those levels immediately above and below the reference. Having a high school degree rather than some technical secondary education does reduce the risk of occupational injuries, while some college makes little difference. Similarly, having only some general high school education increases occupational injuries[18] while having no diploma does not make much difference. Seniority does reduce occupational injuries with most experienced workers (the reference category) being less at risk than less experienced ones. Once conditioned on seniority, age has no significant impact. As expected, men have many more injuries than women which is due to the fact that, other things being equal, firms prefer to allocate a man rather than a woman to a dangerous task. Leaving with another person or having children does not reduce the probability of injuries, which means that these variables do not properly proxy for the unobserved propensity to take risks.

As for job characteristics, occupation is, as expected, an important determinant of the risk that is borne by individuals. The category more at risk is the reference one, namely skilled manual workers. An explanation for this pattern is that risky, hence sensitive, tasks are allocated to them rather than to unskilled manuals. Not surprisingly, being a manager strongly reduces the risk of injury,

[18] At the 10% significance level.

as do, to a lesser extent, being a middle manager or a clerk. Unskilled manuals are the category closer to skilled manuals in terms of risk, though with a probability of injury significantly lower. The size of the firm a worker is employed in does not seem to make much difference in terms of safety. In contrast, the effects of advanced technologies are quite diversified. Using a robot or a numerically controlled equipment is associated with a higher probability of injury while the opposite holds for using a computer. This probably reflects characteristics of the job that were not captured by occupations. As far as the position is concerned, doing a repetitive job is harmful, as is being subject to strict control of working time. Consistently, being able to decide on one's own working hours is associated with a lower probability of injuries. Not having a 48h break every week or having a short lunch break also drives up the risk of injury, while working on weekends does not. Surprisingly enough, working at night is associated with a lower risk of injury. This may be due to a strengthening of security rules so as to minimize the risk that could arise from weaker attention being paid to one's work. In fact, what might appear as a paradox is a standard result in epidemiology (Goldberg, 1998): the so-called "healthy worker effect". It is the consequence of "hidden" selection of workers: workers who cannot sustain the hard conditions of night work, are drifted away from their positions by their employers or voluntarily leave their jobs.

Another factor driving up the risk of injury is the fact of having one's work rhythm determined by external constraints, be they demand or technical constraints. Having to fulfill hourly production norms is also associated with the probability of occupational injury, while daily norms are not.

Overall, the picture of a high risk worker is that of a low-educated skilled manual with short tenure and who is subject to a strict control on her activity. In addition to these factors, the risk of injury is also strongly correlated with the use of new organizational practices, such as quality norms or job rotation. According to these first estimates, workers involved in new work practices have a 66 to 84% higher probability of being injured at work, *ceteris paribus.* These results are robust to various changes in specification. In particular, dropping variables such as education or age, which may be suspected of collinearity with occupation and seniority, does not change the coefficients on the remaining regressors. Job rotation and quality norms are still strongly correlated to the risk of injury. Their respective coefficients are 0.303(*0.073*) for $QNORM$ and 0.273(*0.063*) for $ROTA$, where standard errors are in italics. Similarly, dropping technology variables does not modify the results nor does dropping the socio-demographic variables which were insignificant in the first place[19]. The coefficients on the work practice variables are logically higher when the position characteristics are removed[20]. The coefficients on the various occupations also tend to go up, indicating that the former indeed capture some job characteristics.

The pattern of results is quite similar for serious occupational injuries ($SOI$). Here again, education and seniority reduce the risk of injury, although there is no longer any difference between a 5 and 10 year tenure. Being a man is still a factor of risk, with actually a higher coefficient than for total injuries. Turning to job characteristics, managers, middle managers and clerks do have a much lower probability of serious occupational injuries than skilled manuals. However, there is no longer any difference between the latter and unskilled manuals. Technology as well as most of the characteristics of the position essentially have the same effect as before. One difference though is that having no 48 hour break or having one's work rhythm determined by external constraints does not raise the probability of serious injuries. The same holds for having a short lunch break or not being able to interrupt one's work. But here again, job rotation and quality norms are strongly and positively correlated with the risk of injury.

In contrast, the determinants of minor injuries ($BOI$) seem to be quite different from what we found so far. Education beyond high school does no longer act as a guarantee of safety. However, the pattern of risk by occupation and by seniority is very similar to the one for total injuries. Most of the other job characteristics have no impact on benign injuries. Only the lack of a weekly 2 day break and the fact of being subject to a strict control on working hours positively influence the probability of minor injuries. Here again though, new work practices are associated with a higher probability of injuries.

Overall then, the risk of all types of injuries seems to be consistently and

[19] Coefficents are: 0.287(*0.072*) for QNORM and 0.251(*0.063*) for ROTA.

[20] Coefficents are 0.376(*0.070*) for QNORM and 0.310(*0.061*) for ROTA.

positively correlated to the use of new work practices. However, the method we used may suffer from sample selection bias. Indeed, as mentioned in Section 2, the vector of socio-demographic and job characteristics we have controlled for could well determine the probability that a worker uses new work practices. If a number of these controls are both positively correlated to the probability of injuries and to that of using either quality norms or job rotation, the coefficients that we estimate on the latter variables are upward biased. In order to solve this problem, the next section will provide estimates following Rubin's "causal" method.

### 4.2. Patterns of New Work Practices and Occupational Injuries

Our estimation method follows a two-step strategy. We first estimate the probability of adopting new work practices, in the form of a simple logit both for quality norms and job rotation. In a second stage, we compute the so-called "causal" estimator of the effect of both practices on the rate of injury. Given the importance of estimating properly the probability that a worker uses the new work practices, we will adopt several alternative specifications for the logits and compare the value of the causal estimators corresponding to each of them.

#### 4.2.1. The use of new work practices

We start from a very general specification of the logit equation which is identical for both practices. The regressors include most of the control variables we have used in the previous section. Indeed, our concern was that at least some of these might be correlated with the probability of using either $QNORM$ or $ROTA$. We therefore include age, education, seniority and all other socio-demographic controls, along with a full set of position characteristics, technology and firm size variables. In this first specification we include very detailed occupation and industry dummies. The occupation classification has 22 positions while the industry's has 36 positions. The reason for this is that we want to control as much as possible for job characteristics. Indeed, our data set provides little information on firms' characteristics. Apart from size and sector, we have no information on the enterprise. Conditioning on a very detailed industry classification is therefore the best we can do to capture those unobserved firm's features that may affect the probability that a worker uses new work practices. Similarly, controlling for detailed occupational categories hopefully allows us to capture a large part of firm's characteristics. However, the very detailed nature of these classifications raises the problem of potential collinearity between occupations and industries. We will therefore test different specifications using more aggregate occupational and sectoral dummies.

The results from the most general specification are reported in Table II. As for quality norms, the probability of using the practice is lower at very low education levels than for people having some technical education. It is also lower for those workers with very high educational levels. This is not surprising given that highly educated workers usually have high responsibility positions where quality norms are not explicit. The use of $QNORM$ does not seem to depend neither on age nor on seniority. Conversely, being a man raises the probability of using the practice. Not surprisingly, some important job characteristics appear to be correlated with the use of $QNORM$. Firm size has a positive impact on it with the maximum being in firms with 500 to 1,000 employees. Being on a part-time basis reduces the probability of using the practice if the number of hours worked per week is less than 14. This could be due to firms supporting fixed training cost when assigning a worker to a new work practice. In this case, it may not be profitable to involve workers with very few working hours in the new organizational system. As expected, new technologies are positively correlated to new work practices, both for robots and numerically controlled equipment and for computers. However, being connected to the internet has no significant impact. By the time of the survey (1998) a small fraction of the French labor force had access to the internet: no more than 6% of workers in our sample. These are essentially people employed in highly specialized or high responsibility jobs in which formal quality norms do not exist. Indeed 56% of workers using the web are private or public sector managers, and another 14% are high level clerks. This pattern is confirmed by the sign of the coefficients on the occupational dummies. As compared to skilled manuals employed in manufacturing, all managerial occupations and higher clerk positions have a lower probability of using $QNORM$. The same goes for unskilled manuals, though the impact is less than for highly skilled occupations. Quality norms therefore seem to be particularly frequent in the skilled manual category. Eventually, a number of position characteristics are positively correlated with this practice. Among them, having a repetitive job, facing time constraints, having to fulfill production norms and having one's work rhythm set by external constraints. Overall, quality norms seem to be associated with positions in which the level of prescription is quite high.

The pattern of results is somewhat different for job rotation. Higher levels of education reduce the probability of rotating but this time, seniority has the same effect and being a man does not make any difference. The influence of firm size is opposite to the one we had for quality norms: job rotation is more frequent in small firms and decreases as size goes up. As for $QNORM$, being on a part-time basis reduces the probability of being associated to the new work practice and the correlation with the technology variables is positive. This time however, being connected to the internet has a positive impact on job rotation. As far as occupations are concerned, job rotation is most frequent for unskilled manuals in manufacturing. Then come skilled manuals with all other categories being less likely to rotate. Position characteristics most correlated to job rotation are the fact of not having any weekly 48h break, facing flexible time constraints and having to fulfill production norms, as well as having one's work rhythm determined by technical constraints. So, the features of the rotating worker are not exactly similar to those of the worker who uses quality norms, although they are not completely different. Both work practices are particularly frequent in the skilled manual category and for rather low levels of education (excluding however people with no diploma at all).

As already mentioned other specifications were tested for both quality norms and rotation. We successively reaggregated occupations into 14 and then 5 categories. We also reaggregated industries in 18 categories for quality norms and 17 for job rotation. This did not change the general pattern of the results. Nor did aggregating the 21 regions into 5 zones and dropping the regressors which were insignificant in the first specification. One last attempt consisted in dropping the position characteristics. As will be made clear below, this sensibly affects the results, thus leading us to the conclusion that these variables do capture characteristics of the job rather than additional forms of new work practices.

### 4.2.2. New work practices and occupational injuries

As a second step, we estimate the correlation between quality norms (resp. job rotation) and occupational injuries, correcting for sample selection bias. Table III has the results for all injuries, as well as for serious and benign ones separately. For the sake of comparison, we present both the "naive" estimator (see equation 2.3) and the weighted estimator (see equation 2.4).

In Panel A, we use our most general specification for the logit - see Table II. Regarding quality norms, there still is a positive correlation with total work injuries, even after correcting for sample selection bias. The coefficient is 0.021 as compared to 0.055 for the "naive estimator". If it were necessary, this strongly supports the use of Rubin's method. Indeed, a naive estimation would greatly overstate the extent to which quality norms affect the risk of occupational injury. Essentially, it would predict a 65% difference in the probability of injuries between workers who use quality norms and workers who do not - with the probability being higher for the former -, while the weighted estimator only predicts a 25% difference. The gap between the two estimators is very large both for quality norms and job rotation. This indicates that part of the controls we had introduced in the regressions carried out in Section 4.1 were strong determinants, both of the risk of injury and of the probability of using new work practices. In such case, correcting for sample selection bias appears to be crucial.

However, a key result is that quality norms are clearly associated with a higher probability of occupational injuries. The coefficient varies from 0.021 to 0.032 according to the specification. Moreover, they are significant at conventional levels in all cases. Specification in Panel B. has dropped all insignificant regressors and has grouped occupational and sectoral dummies into respectively 14 and 18 groups[21]. In Panel C, we experiment with a third - quite extreme - specification in which we drop all position characteristics and technology variables, including those which were significant in the logit equations. Our concern is that these might capture some new work practices rather than job characteristics. Thus doing, the

[21] 17 sectoral dummies for $ROTA$.

coefficient on the weighted estimator goes up from 0.024 to 0.031. This indicates that these (significant) variables do actually capture characteristics of the position so that excluding them yields some sample selection bias. As a consequence, we regard Panel B. as providing the most satisfactory estimate of the true value of the correlation coefficient.

Our results indicate that using quality norms is associated with a 25 to 37% higher probability of work injury, which is decisively not negligible. Another interesting result is that this impact is essentially due to the fact that quality norms affect the risk of benign occupational injuries. Indeed, they have no significant impact on serious injuries when correcting for sample selection bias[22]. This is particularly interesting in the view of the results in Section 4.1. When estimating a simple logit equation, $QNORM$ seems to be positively correlated to all types of injuries. However, the results from the "causal" estimation show that this is due to common determinants of both the injury and the new practice variables. In contrast, quality norms do appear to be positively correlated to minor occupational injuries even after controlling for sample selection bias, with a percentage increase lying between 32 and 52% according to the specification.

As regards job rotation, the results are quite similar. This practice is associated to a 21 to 32% increase in the probability of work injuries, with the effect being due, again, to a positive impact on minor occupational injuries. These are 30 to 42% higher for workers who rotate. Here again, the coefficients are quite sizable.

Overall, even after controlling for sample selection bias, workers involved in new work practices appear to face a higher risk of occupational injuries with the difference with "non innovative" workers being more than 20%. Moreover, as evidenced below, new organizational practices are also associated with greater psychological discomfort.

### 4.3. New Work Practices and Psychological Strain

As mentioned in Section 3, beyond occupational injuries our database also contains information on mental strain. We use it to investigate the impact of new work

[22] Panel C is an exception but we have just seen that, due to dropping all positions characteristics, this specification does not properly correct for sample selection bias.

practices upon a number of indicators of psychological strain. Here again, we use Rubin's "causal" model in order to correct for potential sample selection bias. The results are presented in Table IV.

Let us first underline that, here again, for most of the dependent variables the coefficients on both quality norms and job rotation sharply drop when correcting for sample selection bias. An exception is the impact of $ROTA$ on the variable indicating that workers have to cope on their own with difficult situations ($COPE$), with the weighted estimator being 0.018 as compared to 0.005 for the naive estimator. This means that conditioning variables - i.e. workers and jobs characteristics - have opposite correlation patterns with the two variables. One reason for this may be that firms introduce job rotation only for those workers they think will be able to cope with it. If the ability to cope is positively correlated with some observable characteristics, once controlled for the latter, the impact of new work practices on $COPE$ is logically higher than it was in the "naive" estimation. However, apart from this specific case and, to a lesser extent, that of the $TENS\_COLL$ variable (tensions with colleagues), sample selection arises from positive correlations between the conditioning variables on the one hand, and new work practices and working conditions on the other hand.

The main result from this analysis is that both quality norms and job rotation appear to be associated with greater psychological strain. Workers using quality norms feel more *stress due to uncertainty.* They have to cope on their own with difficult situations more often that workers who are not involved in quality control processes. They also tend to receive more contradictory prescriptions ($CONTRAD$) and have to change task unexpectedly which they consider as disturbing ($CH\_TSK$). Therefore, quality norms and job rotation seem to be associated with a more confusing work organization rather than, as is often hypothesized, with a more efficient workplace.

Moreover, workers who apply quality norms are also more aware of the *consequences* of any error of their own, be it on the quality of the product ($CSQ\_P$) or as regards its financial implications for the firm ($CSQ\_F$). Eventually, their *social environment* is somewhat deteriorated. They more often experience situations of tensions with their colleagues ($TENS\_COLL$) and with their hierarchy

($TENS\_HIE$) than workers who are not involved in quality norms. However, the latter do not appear to be associated with greater *time pressure*: $QNORM$ is neither significantly correlated with the fact of having to hurry to carry out one's own work ($HURRY$), nor with the feeling of lacking time in order to do one's work properly ($NO\_TIME$). Despite this caveat, quality norms seem to be associated with greater stress on the part of workers, whatever the specification used - see Panels A and B. The proportion of workers answering "yes" to the psychological strain questions is from 9 to 21% higher in the quality norm group as compared to the reference group, with the precise figure depending on the type of stress.

The same pattern holds for job rotation. It is positively and significantly[23] correlated to all our indicators of psychological strain except the $HURRY$ variable. As for $QNORM$, workers involved in job rotation answer "yes" to the questions about stress more often than workers who do not rotate, with differences ranging from 4 and 27% according to the type of stress. The difference appears to be particularly important for some uncertainty indicators ($CH\_TSK$) as well as for the tensions experienced in the relationships with colleagues.

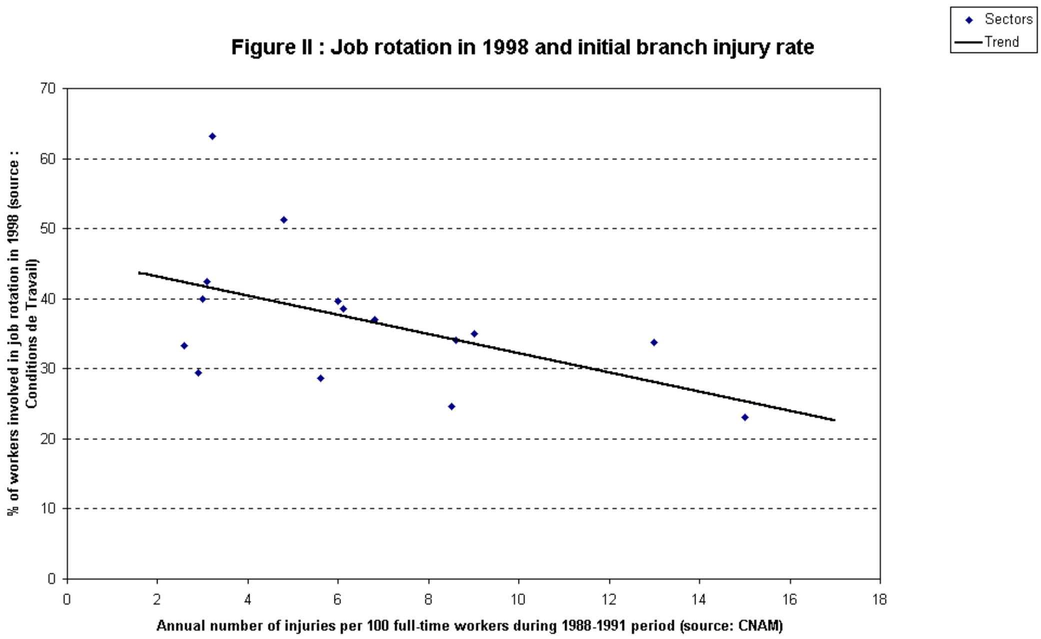
### 4.4. Discussion

Overall, the results concerning mental strain are consistent with those obtained for occupational injuries. Working conditions of employees involved in quality norms or job rotation appear to be noticeably worse than those of workers who are not. Obviously, given the lack of adequate instruments, one interpretation of these results could be that firms in which the rate of occupational injuries was high - and more generally, working conditions were bad - have reacted by introducing new work practices, which should result, in the future, in an improvement in safety and psychological comfort for their workers. However, such a mechanism appears to be quite unlikely for, at least, two reasons. First, by 1998, new work practices, especially quality norms, were already quite widespread in France and their introduction often dated back to the beginning of the 1990s. More precisely, as mentioned above, according to the REPONSE survey, 42% (resp. 12% and 12%)

[23] At the 10% level for $NO\_TIME$.

of private establishments with 20 or more workers already had quality groups (resp. ISO norms and autonomous work teams) in 1992; these proportions are respectively 54%, 34% and 35% in 1998. If such practices should improve working conditions, safety at work should have improved in an increasing number of firms. Figures on occupational injuries at the aggregate level do not provide any indication of such an evolution. On the contrary, according to CNAM data, the number of injuries have steadily increased by some 3 annual percents in France in the past 5 years while new work practices were becoming ever more widespread.

Second, there does not seem to be any positive relation between past rates of occupational injuries and the propensity to subsequently introduce new work practices, at the industry level. Using CT and CNAM data, we plotted the rate of use of $QNORM$ at the industrial branch level[24] in 1998 against the average rate of injuries in the corresponding branch over the 1988-1991 period - see Figure II.




If anything, the correlation between the two variables appears to be slightly negative, indicating that sectors with high rates of injuries did not react by introducing

[24]See Appendix Table I for the definition of these branches.

quality norms in a greater proportion than safer sectors. The same conclusion can be drawn from a similar exercise carried out for autonomy awarded to workers in case of incidents - see Figure III.

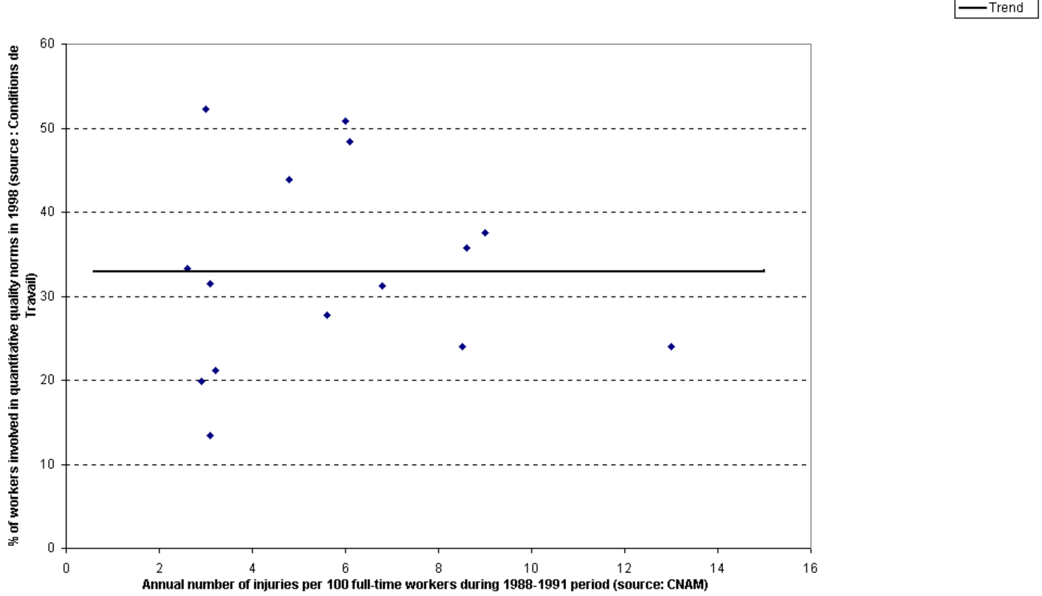



**Figure III : Quality norms in 1998 and initial branch injury rate**

In this case, there does not seem to be any correlation between the rate of injuries at the branch level at the end of the 1980s and the proportion of workers having some autonomy in that branch as of 1998.

Using CNAM data allows us to perform further investigations. CNAM also reports the number of injuries as splitted into 7 occupational groups: skilled manual workers, unskilled manual workers, managers, middle managers, clerks, apprentices and others (i.e. unknown occupations). Matching this data with that from EE yields 90 observations (15 branches $\times$ 6 occupations) for the rate of occupational injuries. The logs from the CNAM survey are workers' declarations in order to obtain social benefits in case of days away from work due to an occupational injury. As mentioned in Section 3, they are different from the claims in the CT survey and suffer from under declaration. This is due to the fact that CNAM logs are used to determine additional social security contribution[25] paid by employers with high level of occupational injuries so that the latter tend to exert pressure on workers and occupational physicians, or even compensate workers directly, in order to induce them not to declare the injury. Despite these limitations, we try and exploit this data in order to provide some additional insights into the causality between work practices and the risk of injury. The approach involves three steps:

1. We use CT to compute the share of workers[26], in each branch $\times$ occupation cell, involved in job rotation ($SROTA$) or in the use of quality norms ($SNORM$). We then regress the CNAM injury rate ($C$-$OI$) in each cell in 1998 on the proportion of workers involved in new work practices in that cell, checking that the correlation pattern is similar to the one we obtained using individual CT data.

2. We test whether the rate of injury dated 1988[27] "explains" the adoption of new practices in 1998, at the cell level.

3. The rate of injury in 1988 is introduced in step 1. regressions to correct for unobserved heterogeneity across cells.

Due to the lack of data, we only have 81 observations. Therefore, all the controls used in Tables I and II can not be included in the regressions. We choose to keep those which influence most strongly the risk of occupational injury and the adoption of work practice (see Tables I and II): $YOUNG$ (proportion of workers under 25), $DIPLOMA$ (share of workers with any high school or college degree),

[25] More precisely, the financial consequences incured by an injured worker (medical care, wage loss...) are always compensated for by social security. If the injury is declared and considered as an occupational one, thenfirms with 250 or more workers (resp. 10 to 250 employees), must, ex post, reimburse the whole of the costs to social security (resp. should pay a part of these costs depending on the number of occupational injuries in the firm compared to the mean in its industry and its trend).

[26] In this case, we do not restrict the sample to workers with tenure one year and above. Indeed, CNAM data report all occupational injuries during the reference year including those of short-tenure workers. Another difference is that the CNAM dataset reports all injuries including those of workers with several injuries in the reference year.

[27] 1988 is approximately at the same point as 1998 on the French business cycle.

$SENIORITY$ (proportion of workers with 10 years seniority or more), $SEX$ (share of women), and 15 branch dummies. Moreover, because the size of the cells vary dramatically, we correct for heteroskedasticity by weighting the tests (see Berman et al., 1994). This cannot be done in the Rubin's framework. Consequently, we only perform weighted LS regressions. According to the results in the previous section, this method should result in over-estimating the correlation between occupational injuries and innovative workplace practices.

Table V reports regression results for CNAM injury rates in 1998. The impact of sex, diploma and seniority is consistent with our previous results using the CT survey (Table I). We also find that job rotation is strongly correlated with a higher risk of injury (column 1); the coefficient is quantitatively similar to the one obtained in Table I. However, quality norms are not correlated with the CNAM rate of occupational injury (column 2). This result is clearly different from the findings in previous sections. This inconstancy might result from under-declaration of injuries by workers involved in quality control processes. A possible scenario is that a high rate of injury has a negative impact on firm's reputation. This is particularly likely to be the case for those firms involved in strict quality control. Indeed, the image they try and convey to both potential workers and clients is that failure is virtually absent from their production process. In such cases, the damage arising from a high rate of injury declaration may be particularly harmful. One important point is that job rotation and quality norms are correlated (with the correlation coefficient being +0.25): they are two faces of modern production. Consequently, if the under-declaration effect does exist, the introduction of $SROTA$ in the previous regression should result in a negative coefficient associated to $SNORM$. Specification (3) shows that this is indeed the case. Because of this problem, we focus in what follows on job rotation.

Regression (4) checks whether the reverse causality holds: high injury risk may have induced the adoption of "safe" new practices. We find no clear impact of the rate of injuries dated 1988 on the proportion of workers involved in job rotation as of 1998 (column 4)[28]. Finally, as shown by Crépon and Iung (1999), we can

[28] This regression includes the value of controls in 1998. We also experimented the same specification with lagged values of $YOUNG$, $SEX$, $DIPLOMA$ and $SENIORITY$ (i.e. dated 1988). The results were virtually unchanged (the coefficient associated to C-OI in 1988 was 0.09

correct[29] for unobserved heterogeneity by including the rate of injuries in 1988 in regression (1). Results in column (5) suggest that the introduction of job rotation is significantly associated with an increase in occupational injuries (between 1988 and 1998).

To sum up, preliminary evidence at the industry level does not support the idea that causality between new work practices and deteriorated working conditions might run from the latter to the former. The question is therefore raised of the impact of innovative organizational practices upon the worsening of safety at work and, more generally, of working conditions.

## 5. Conclusion

This paper has investigated the relationships between new work practices which are dramatically spreading in the new economy (namely quality norms and job rotation) and a series of indicators of working conditions. We first display that workers involved in any of these two innovative practices face a higher risk of work injuries than non innovative workers. This is robust to controlling for a large number of characteristics of the individual and her post, as well as for selection bias due to observable characteristics. One conclusion of the paper is that it is important to control for such a bias in order not to overestimate the correlation between work practices and working conditions. The pattern of results is quite similar for indicators of psychological discomfort. Workers involved in new work practices face more mental strain than their non innovative counterparts. In particular they declare having to cope on their own with difficult situations, receive contradictory orders, and face situations of tensions both with their hierarchy and colleagues. So, in France by the end of the 1990s, new work practices appear to be associated with harder working conditions.

This should of course be confirmed by further empirical analysis. Here, more than anywhere else, the call for better data is to be made. In particular, given the lack of time dimension in our dataset, we are not able to properly assess the

with standard error 0.15.

[29] Under the assumption that the unobserved heterogeneity is invariant between 1988 and 1998 "all other things being equal".

causality in the model. Part of our effort has been dedicated to tackling this issue, but tight limitations were imposed on us by the fact that lagged data was available only at the sectoral level. A related issue is that of firms characteristics. We attempted at capturing them using firm size, industry dummies as well as a large number of position characteristics. However, firm level data on work injuries would be of great help. Such data do exist but so far, the main obstacle lies in accessibility. Another line of investigation has to do with international comparisons. Our results seem to be consistent with studies on the U.S. On the contrary, it is quite far away from what Scandinavian experiences would suggest. More cross-country comparisons, in particular in Europe, would be useful in assessing whether the French pattern is to be found in some other EU countries where working conditions appear to have deteriorated in the recent past.

Despite the previous caveats, we feel our paper brings to the forth an important, though largely neglected issue in economics, i.e. that of working conditions in the new economy. This is a key element to take into account when assessing the performance of the new productive paradigms. In particular, a deterioration of working conditions be it in the form of rising work injuries or greater stress would bear important distributional consequences. In a number of countries, this would have a direct impact on public expenditure through health budgets. Moreover, work incentives are likely to be modified as taught by the growing literature on job satisfaction. Eventually, especially in Europe, damages to working conditions and confusion in the production process as felt by workers may even end up in the social rejection of the production model associated to the new economy, thus questioning its long-run viability. All these implications are complex and intricate and deserve more analysis in particular in relation with economic policy issues.

**Table I**
**Determinants of Occupational injuries**

| Dependent Variable | OI | SOI | BOI |
|---|---|---|---|
| Explanatory Variables | | | |
| *Work Practices* | | | |
| QNORM | 0.307 | 0.232 | 0.342 |
| | *0.074* | *0.098* | *0.104* |
| ROTA | 0.275 | 0.192 | 0.336 |
| | *0.063* | *0.083* | *0.090* |
| *Workers Characteristics* | | | |
| Age (ref: 25-40) | | | |
| age15-25 | 0.101 | 0.320 | -0.255 |
| | *0.155* | *0.189* | *0.244* |
| age 40-55 | -0.075 | -0.092 | -0.041 |
| | *0.070* | *0.093* | *0.101* |
| age >55 | -0.152 | -0.084 | -0.249 |
| | *0.134* | *0.167* | *0.210* |
| Education | | | |
| (ref: technical 2ndary) | | | |
| No diplome | 0.129 | 0.136 | 0.096 |
| | *0.076* | *0.095* | *0.113* |
| Lower general 2ndary | 0.209 | 0.064 | 0.362 |
| | *0.118* | *0.157* | *0.164* |
| High School degree | -0.293 | -0.447 | -0.100 |
| | *0.117* | *0.162* | *0.161* |
| College degree | -0.128 | -0.628 | 0.248 |
| | *0.131* | *0.207* | *0.169* |
| Graduate degree | -0.377 | -0.737 | -0.047 |
| | *0.193* | *0.294* | *0.253* |
| Student | 0.360 | 0.294 | 0.392 |
| | *0.242* | *0.309* | *0.352* |
| Seniority | | | |
| (ref: >10 years) | | | |
| seniority 1-5 | 0.484 | 0.355 | 0.577 |
| | *0.083* | *0.107* | *0.119* |
| seniority 5-10 | 0.338 | 0.174 | 0.492 |
| | *0.080* | *0.106* | *0.115* |

**Table I - continued 1**
**Determinants of Occupational injuries**

| Dependent Variable | OI | SOI | BOI |
|---|---|---|---|
| Sex (women=0) | 0.610 | 0.705 | 0.429 |
| | *0.082* | *0.111* | *0.115* |
| Couple | 0.091 | 0.207 | -0.065 |
| | *0.077* | *0.103* | *0.109* |
| Children | -0.011 | -0.121 | 0.134 |
| | *0.068* | *0.088* | *0.099* |
| Has moved | 0.304 | 0.418 | 0.117 |
| | *0.111* | *0.141* | *0.163* |
| *Job Characteristics* | | | |
| Occupation | | | |
| (ref: Skilled manuals) | | | |
| Managers | -0.869 | -0.799 | -0.803 |
| | *0.185* | *0.262* | *0.254* |
| Middle Managers | -0.500 | -0.522 | -0.401 |
| | *0.107* | *0.144* | *0.150* |
| Clerks | -0.570 | -0.421 | -0.639 |
| | *0.103* | *0.135* | *0.149* |
| Unskilled Manuals | -0.216 | 0.105 | -0.669 |
| | *0.107* | *0.130* | *0.172* |
| Size of firm | | | |
| (ref: <50) | | | |
| 50-100 | 0.107 | 0.312 | -0.234 |
| | *0.127* | *0.153* | *0.208* |
| 100-500 | 0.116 | 0.177 | 0.026 |
| | *0.095* | *0.122* | *0.140* |
| 500-1000 | 0.155 | -0.083 | 0.350 |
| | *0.138* | *0.198* | *0.182* |
| >1000 | 0.177 | 0.055 | 0.276 |
| | *0.093* | *0.125* | *0.130* |

**Table I - continued 2**
**Determinants of Occupational injuries**

| Dependent Variable | OI | SOI | BOI |
|---|---|---|---|
| *Job Characteristics* | | | |
| Technology | | | |
| ROBOT | 0.264 | 0.382 | 0.049 |
| | *0.104* | *0.134* | *0.147* |
| COMP | -0.283 | -0.384 | -0.144 |
| | *0.074* | *0.100* | *0.104* |
| WEB | -0.242 | -0.283 | -0.202 |
| | *0.188* | *0.293* | *0.241* |
| Position Characteristics | | | |
| Precarious job | -0.082 | -0.278 | 0.158 |
| | *0.148* | *0.199* | *0.204* |
| Repetitive job | 0.164 | 0.207 | 0.087 |
| | *0.069* | *0.088* | *0.100* |
| Production line | -0.165 | 0.063 | -0.375 |
| | *0.143* | *0.182* | *0.209* |
| Contact w. public | 0.063 | 0.164 | -0.056 |
| | *0.075* | *0.098* | *0.107* |
| Autonomy work. hours | -0.207 | -0.300 | -0.084 |
| | *0.088* | *0.123* | *0.122* |
| Control on work. hours | 0.083 | 0.055 | 0.109 |
| | *0.038* | *0.050* | *0.055* |
| Weekends worked | 0.002 | 0.000 | 0.003 |
| | *0.002* | *0.002* | *0.002* |
| Nights worked | -0.002 | -0.003 | -0.001 |
| | *0.001* | *0.001* | *0.001* |
| No 48h break | 0.239 | 0.074 | 0.407 |
| | *0.087* | *0.117* | *0.120* |
| Flexible time constraing | 0.111 | 0.022 | 0.207 |
| | *0.084* | *0.110* | *0.121* |
| Rigid time constraint | -0.010 | -0.063 | 0.060 |
| | *0.083* | *0.108* | *0.122* |
| Hourly prod. norms | 0.234 | 0.237 | 0.206 |
| | *0.081* | *0.106* | *0.116* |

**Table I - continued 3**
**Determinants of Occupational injuries**

| Dependent Variable | OI | SOI | BOI |
|---|---|---|---|
| Position Characteristics | | | |
| Daily prod. norms | 0.116 | 0.071 | 0.155 |
| | *0.084* | *0.110* | *0.121* |
| Demand→Rhythm | 0.136 | 0.140 | 0.104 |
| | *0.070* | *0.091* | *0.100* |
| Constraints→Rhythm | 0.134 | 0.118 | 0.142 |
| | *0.069* | *0.091* | *0.100* |
| Lunch break | -0.095 | -0.080 | -0.101 |
| | *0.051* | *0.066* | *0.074* |
| Break during work | 0.159 | 0.024 | 0.307 |
| | *0.070* | *0.093* | *0.098* |
| Can interrupt work | -0.095 | -0.213 | 0.069 |
| | *0.068* | *0.087* | *0.099* |
| Regional Dummies (5) | yes | yes | yes |
| Sectoral Dummies (16) | yes | yes | yes |
| Observations | 15,898 | 15,898 | 15,898 |
| Log Likelihood | -4205 | -2705 | -2385 |
| Pseudo $R^2$ | 0.093 | 0.101 | 0.079 |

*Notes: standard errors in italics. All specifications include controls for nationality and hours worked.*

**Table II**
**Determinants of New Work Practices**

| Dependent Variable | QNORM | ROTA |
|---|---|---|
| *Workers Characteristics* | | |
| Age (ref: 25-40) | | |
| age15-25 | -0.047 | 0.157 |
| | *0.146* | *0.113* |
| age 40-55 | -0.056 | -0.088 |
| | *0.054* | *0.044* |
| age >55 | -0.073 | -0.078 |
| | *0.100* | *0.082* |
| Education | | |
| (ref: technical 2ndary) | | |
| No diplome | -0.195 | 0.023 |
| | *0.064* | *0.051* |
| Lower general 2ndary | 0.002 | -0.019 |
| | *0.093* | *0.076* |
| High School degree | 0.044 | -0.049 |
| | *0.078* | *0.064* |
| College degree | -0.179 | -0.243 |
| | *0.091* | *0.079* |
| Graduate degree | -0.284 | -0.257 |
| | *0.117* | *0.105* |
| Student | 0.007 | -0.247 |
| | *0.247* | *0.188* |
| Seniority | | |
| (ref: >10 years) | | |
| seniority 1-5 | -0.104 | 0.129 |
| | *0.067* | *0.054* |
| seniority 5-10 | 0.010 | 0.130 |
| | *0.061* | *0.051* |
| Sex (women=0) | 0.203 | 0.016 |
| | *0.062* | *0.052* |
| Couple | 0.139 | -0.004 |
| | *0.061* | *0.048* |
| Children | 0.066 | -0.002 |
| | *0.053* | *0.043* |

**Table II - continued 1**
**Determinants of New Work Practices**

| Dependent Variable | QNORM | ROTA |
|---|---|---|
| Has moved | -0.101 | -0.63 |
| | *0.094* | *0.079* |
| *Job Characteristics* | | |
| Size of firm (ref: <50) | | |
| 50-100 | 0.265 | -0.263 |
| | *0.099* | *0.084* |
| 100-500 | 0.327 | -0.317 |
| | *0.074* | *0.063* |
| 500-1000 | 0.469 | -0.325 |
| | *0.103* | *0.091* |
| >1000 | 0.401 | -0.171 |
| | *0.074* | *0.060* |
| Hours worked (ref: 35-40h) | | |
| 0-14 | -1.384 | -0.598 |
| | *0.517* | *0.210* |
| 15-29 | -0.149 | -0.144 |
| | *0.104* | *0.073* |
| 30-34 | 0.003 | -0.066 |
| | *0.107* | *0.082* |
| >40h | 0.039 | -0.010 |
| | *0.059* | *0.051* |
| Technology | | |
| ROBOT | 0.525 | 0.528 |
| | *0.086* | *0.080* |
| COMP | 0.403 | 0.329 |
| | *0.061* | *0.050* |
| WEB | -0.137 | 0.164 |
| | *0.097* | *0.090* |

**Table II - continued 2**
**Determinants of New Work Practices**

| Dependent Variable | QNORM | ROTA |
|---|---|---|
| Occupations | | |
| (ref: Skilled manuals in manufacturing) | | |
| Public Managers | -0.973 | -1.785 |
| | *0.240* | *0.229* |
| University Professors | -1.076 | -1.658 |
| | *0.237* | *0.195* |
| Arts | -1.759 | -1.276 |
| | *0.549* | *0.313* |
| Higher Civil Servants | -0.533 | -1.460 |
| | *0.149* | *0.149* |
| Engineers | -0.212 | -1.360 |
| | *0.150* | *0.157* |
| Elementary Teachers | -1.130 | -1.341 |
| | *0.248* | *0.179* |
| Health | -0.612 | -0.883 |
| | *0.177* | *0.146* |
| Civil Servants | -1.348 | -1.294 |
| | *0.208* | *0.161* |
| Higher level Clerks | -0.603 | -1.248 |
| (adm. and trade) | *0.125* | *0.118* |
| Technicians | -0.255 | -0.887 |
| | *0.117* | *0.113* |
| Supervisors | 0.095 | -0.805 |
| | *0.119* | *0.116* |
| Janitors | -1.213 | -0.751 |
| | *0.140* | *0.112* |
| Police | -1.575 | -0.337 |
| | *0.219* | *0.139* |
| Clerks (private sect) | -1.144 | -0.915 |
| | *0.122* | *0.105* |
| Clerks (public sect) | -1.094 | -0.786 |
| | *0.182* | *0.143* |
| Community | -1.691 | -1.326 |
| | *0.242* | *0.151* |
| Skilled Craftsmen | -0.373 | -0.559 |
| | *0.111* | *0.100* |

**Table II - continued 3**
**Determinants of New Work Practices**

| Dependent Variable | QNORM | ROTA |
|---|---|---|
| Occupations | | |
| | | |
| Drivers | -1.501 | -1.294 |
| | *0.175* | *0.148* |
| Skilled manuals (moving) | -0.965 | -0.339 |
| | *0.159* | *0.138* |
| Unskilled manuals | -0.373 | 0.308 |
| (manufacturing) | *0.111* | *0.103* |
| | | |
| Unskilled Craftsmen | -1.223 | -0.977 |
| | *0.192* | *0.143* |
| Agriculture Workers | -0.337 | -0.551 |
| | *0.357* | *0.257* |
| Position Characteristics | | |
| | | |
| Precarious job | -0.115 | 0.256 |
| | *0.139* | *0.099* |
| Repetitive job | 0.341 | 0.052 |
| | *0.056* | *0.045* |
| Production line | 0.441 | 0.583 |
| | *0.113* | *0.106* |
| Contact w. public | 0.060 | 0.404 |
| | *0.057* | *0.049* |
| Autonomy work. hours | 0.165 | -0.200 |
| | *0.059* | *0.051* |
| Control on work. hours | -0.037 | -0.052 |
| | *0.031* | *0.025* |
| Weekends worked | -0.002 | 0.001 |
| | *0.001* | *0.001* |
| Nights worked | 0.001 | -0.002 |
| | *0.001* | *0.001* |
| No 48h break | -0.033 | 0.187 |
| | *0.075* | *0.058* |
| Flexible time constraint | 0.470 | 0.139 |
| | *0.067* | *0.051* |
| Rigid time constraint | 0.439 | 0.022 |
| | *0.068* | *0.051* |

**Table II - continued 4**
**Determinants of New Work Practices**

| Dependent Variable | QNORM | ROTA |
|---|---|---|
| Position Characteristics | | |
| Hourly prod. norms | 0.763 | 0.291 |
| | *0.059* | *0.051* |
| Daily prod. norms | 0.456 | 0.104 |
| | *0.061* | *0.053* |
| Demand→Rhythm | 0.180 | 0.055 |
| | *0.056* | *0.045* |
| Constraints→Rhythm | 0.378 | 0.350 |
| | *0.051* | *0.042* |
| Lunch break | -0.199 | 0.036 |
| | *0.043* | *0.032* |
| Break during work | 0.132 | 0.129 |
| | *0.058* | *0.048* |
| Can interrupt work | 0.043 | 0.140 |
| | *0.058* | *0.046* |
| Regional Dummies (21) | yes | yes |
| Sectoral Dummies (36) | yes | yes |
| Observations | 15,910 | 15,904 |
| Log Likelihood | -6332 | -8728 |
| Pseudo $R^2$ | 0.234 | 0.107 |

*Notes: standard errors in italics. Both specifications control for nationality.*

**Table III**
**Impact of New Work Practices upon Injuries**

| | QNORM | | ROTA | |
|---|---|---|---|---|
| | Naive Estimator | Weighted Estimator | Naive Estimator | Weighted Estimator |
| *Panel A.* Most general Specification | | | | |
| OI | 0.055 | 0.021 | 0.048 | 0.018 |
| | - | *0.008* | - | *0.005* |
| | (0.647) | (0.250) | (0.565) | (0.214) |
| SOI | 0.022 | 0.009 | 0.023 | 0.007 |
| | - | *0.006* | - | *0.004* |
| | (0.468) | (0.195) | (0.489) | (0.146) |
| BOI | 0.032 | 0.012 | 0.025 | 0.011 |
| | - | *0.005* | - | *0.004* |
| | (0.842) | (0.318) | (0.658) | (0.296) |
| *Panel B.* Only Significant Variables + Reaggregation of Categories for regional, occupational and industrial dummies | | | | |
| OI | 0.055 | 0.024 | 0.048 | 0.020 |
| | - | *0.007* | - | *0.005* |
| | (.647) | (0.286) | (0.565) | (0.234) |
| SOI | 0.022 | 0.010 | 0.023 | 0.007 |
| | - | *0.006* | - | *0.004* |
| | (0.468) | (0.215) | (0.489) | (0.147) |
| BOI | 0.032 | 0.014 | 0.025 | 0.013 |
| | - | *0.005* | - | *0.004* |
| | (0.842) | (0.372) | (0.658) | (0.340) |

*Notes: Standard errors in italics. In parantheses are the proportions explained by each estimator, computed as the ratio of the estimator to the mean value of the relevant injury variable. Specifications in Panel B. include only significant variables in the logit. They are thus different for QNORM and ROTA. Observations are 15,910 for QNORM and 15,904 for ROTA in Panel A. They are respectively 15,954 and 15,919 in Panel B.*

**Table III - continued**
**Impact of New Work Practices upon Injuries**

| | QNORM | | ROTA | |
|---|---|---|---|---|
| | Naive Estimator | Weighted Estimator | Weighted Estimator | Weighted Estimator |
| *Panel C.* Only Significant Variables + Reaggregation of Dummies + No Position Characteristics and No Technology | | | | |
| OI | 0.055 | 0.032 | 0.048 | 0.027 |
| | - | *0.007* | - | *0.005* |
| | (.647) | (0.369) | (0.565) | (0.316) |
| SOI | 0.022 | 0.012 | 0.023 | 0.011 |
| | - | *0.005* | - | *0.004* |
| | (0.468) | (0.248) | (0.489) | (0.228) |
| BOI | 0.032 | 0.020 | 0.025 | 0.016 |
| | - | *0.005* | - | *0.004* |
| | (0.842) | (0.518) | (0.658) | (0.423) |

*Notes: same as in the first part of the table. Observations are 16,043 for QNORM and 16,029 for ROTA.*

**Table IV**
**Impact of New Work Practices**
**on Psychological Strain**

| | QNORM | | ROTA | |
|---|---|---|---|---|
| | Naive Estimator | Weighted Estimator | Naive Estimator | Weighted Estimator |
| *Panel A. Most general specification* | | | | |
| HURRY | 0.099 | -0.007 | 0.051 | 0.010 |
| | - | *0.015* | - | *0.012* |
| | (0.189) | (-0.014) | (0.097) | (0.020) |
| NO_TIME | 0.053 | 0.010 | 0.022 | 0.015 |
| | - | *0.012* | - | *0.009* |
| | (0.210) | (0.040) | (0.087) | (0.059) |
| CH_TSK | 0.072 | 0.031 | 0.098 | 0.078 |
| | - | *0.013* | - | *0.009* |
| | (0.254) | (0.108) | (0.345) | (0.273) |
| COPE | 0.048 | 0.024 | 0.005 | 0.018 |
| | - | *0.012* | - | *0.009* |
| | (0.191) | (0.097) | (0.020) | (0.073) |
| CONTRAD | 0.116 | 0.050 | 0.104 | 0.068 |
| | - | *0.016* | - | *0.013* |
| | (0.253) | (0.109) | (0.227) | (0.148) |
| CSQ_P | 0.200 | 0.085 | 0.090 | 0.024 |
| | - | *0.018* | - | *0.012* |
| | (0.303) | (0.129) | (0.137) | (0.037) |
| CSQ_F | 0.278 | 0.107 | 0.109 | 0.035 |
| | - | *0.017* | - | *0.011* |
| | (0.548) | (0.211) | (0.215) | (0.068) |
| TENS_COLL | 0.059 | 0.042 | 0.048 | 0.048 |
| | | *0.014* | - | *0.009* |
| | (0.235) | (0.168) | (0.191) | (0.193) |
| TENS_HIE | 0.107 | 0.051 | 0.077 | 0.045 |
| | - | *0.014* | - | *0.010* |
| | (0.318) | (0.151) | (0.229) | (0.135) |

*Notes: Standard errors in italics. In parantheses are the proportions explained by each estimator, computed as the ratio of the estimator to the mean value of the relevant injury variable.*

**Table IV - continued**
**Impact of New Work Practices**
**on Psychological Strain**

| | QNORM | | ROTA | |
|---|---|---|---|---|
| | Naive Estimator | Weighted Estimator | Naive Estimator | Weighted Estimator |
| *B. Only Significant Variables + Reaggregation of regions, occupations and industries.* | | | | |
| HURRY | 0.099 | -0.010 | 0.051 | 0.014 |
| | - | *0.014* | - | *0.011* |
| | (0.189) | (-0.020) | (0.097) | (0.027) |
| NO_TIME | 0.053 | 0.006 | 0.022 | 0.016 |
| | - | *0.012* | - | *0.009* |
| | (0.210) | (0.022) | (0.087) | (0.065) |
| CH_TSK | 0.072 | 0.027 | 0.098 | 0.080 |
| | | *0.012* | | *0.009* |
| | (0.254) | (0.095) | (0.345) | (0.280) |
| COPE | 0.048 | 0.023 | 0.005 | 0.018 |
| | - | *0.012* | - | *0.009* |
| | (0.191) | (0.090) | (0.020) | (0.073) |
| CONTRAD | 0.116 | 0.050 | 0.104 | 0.076 |
| | - | *0.016* | - | *0.012* |
| | (0.253) | (0.109) | (0.227) | (0.166) |
| CSQ_P | 0.200 | 0.091 | 0.090 | 0.038 |
| | - | *0.017* | - | *0.012* |
| | (0.303) | (0.138) | (0.137) | (0.058) |
| CSQ_F | 0.278 | 0.101 | 0.109 | 0.043 |
| | - | *0.016* | - | *0.011* |
| | (0.548) | (0.199) | (0.215) | (0.086) |
| TENS_COLL | 0.059 | 0.037 | 0.048 | 0.053 |
| | - | *0.012* | - | *0.009* |
| | (0.235) | (0.146) | (0.191) | (0.213) |
| TENS_HIE | 0.107 | 0.044 | 0.077 | 0.047 |
| | - | *0.013* | - | *0.010* |
| | (0.318) | (0.130) | (0.229) | (0.141) |

*Notes: Standard errors in italics. In parantheses are the proportions explained by each estimator, computed as the ratio of the estimator to the mean value of the relevant injury variable.*

**Table V**
**Determinants of the 1998 rate of Occupational Injuries**
**(CNAM data)**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Dependent Variable in 1998 | C-OI | C-OI | C-OI | SROTA | C-OI |
| Explanatory Variables | | | | | |
| C-OI in 1988 | | | | 0.12 | 0.31 |
| | | | | *0.14* | *0.06* |
| QNORM | | 0.01 | -0.14 | | |
| | | *0.08* | *0.09* | | |
| ROTA | 0.20 | | 0.25 | | 0.16 |
| | *0.06* | | *0.07* | | *0.05* |
| *Worker Characteristics* | | | | | |
| YOUNG | 0.04 | 0.05 | -0.00 | 0.02 | -0.01 |
| | *0.04* | *0.05* | *0.05* | *0.09* | *0.04* |
| SEX | -0.06 | -0.07 | -0.09 | -0.05 | -0.03 |
| | *0.02* | *0.03* | *0.03* | *0.04* | *0.02* |
| DIPLOMA | -0.02 | -0.06 | -0.01 | -0.23 | -0.01 |
| | *0.03* | *0.02* | *0.03* | *0.04* | *0.02* |
| SENIORITY | -0.13 | -0.14 | 0.15 | 0.04 | 0.15 |
| | *0.07* | *0.07* | *0.07* | *0.14* | *0.06* |
| Branch Dummies | yes | yes | yes | yes | yes |
| Observations | 81 | 81 | 81 | 81 | 81 |
| $R^2$ | 0.65 | 0.59 | 0.66 | 0.74 | 0.76 |

*Notes: Standard errors are in italics. Specifications are LS weighted by the size of the occupation×branch cells. All specifications include $YOUNG$, $DIPLOMA$, $SEX$ and $SENIORITY$ dated 1998.*

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**Appendix Table I**
**Descriptive Statistics**

| Variable | Mean | Std Dev | Variable | Mean | Std Dev |
|---|---|---|---|---|---|
| *Working Conditions* | | | | | |
| Occupational injuries (OI) | 0.085 | 0.280 | Contradiction (CONTRAD) | 0.459 | 0.498 |
| Serious injuries (SOI) | 0.047 | 0.212 | Consequences on quality of product (CSQ_P) | 0.659 | 0.474 |
| Begnin injuries (BOI) | 0.038 | 0.192 | | | |
| Hurry up (HURRY) | 0.525 | 0.499 | Financial consequences (CSQ_F) | 0.507 | 0.500 |
| Not enough time (NO_TIME) | 0.252 | 0.434 | Tension with colleagues (TENS_COLL) | 0.251 | 0.434 |
| Change task unexpectedly (CHG_TSK) | 0.284 | 0.451 | Tension with hierarchy (TENS_HIE) | 0.336 | 0.472 |
| Cope with difficult situations (COPE) | 0.251 | 0.434 | | | |
| *Organization* | | | *Technology* | | |
| Quality norms (QNORM) | 0.214 | 0.410 | Robots (ROBOT) | 0.057 | 0.231 |
| Job rotation (ROTA) | 0.305 | 0.461 | Computer (COMP) | 0.526 | 0.499 |
| | | | Internet (WEB) | 0.064 | 0.245 |
| *Characteristics of position* | | | | | |
| Number of nights worked | 11.29 | 39.38 | Demand→Work rhythm | 0.641 | 0.480 |
| Number of weekends worked | 17.08 | 23.64 | Technical constraints →Work rhythm | 0.506 | 0.500 |
| No 48h break each week | 0.208 | 0.406 | | | |
| Repetitive job | 0.288 | 0.453 | Strict control of working hours | 1.653 | 0.804 |
| Worker on production line | 0.035 | 0.185 | Break during the day | 0.219 | 0.414 |
| Flexible time constraints | 0.361 | 0.480 | Duration of lunch break | 0.981 | 0.657 |
| Rigid time constraints | 0.328 | 0.469 | May interrupt own work | 0.721 | 0.448 |
| Hourly production norms | 0.235 | 0.424 | Precarious job | 0.043 | 0.203 |
| Daily production norms | 0.192 | 0.394 | Working time per week | 33.70 | 13.53 |
| Contact with the public | 0.627 | 0.484 | Worker sets working hours | 0.250 | 0.433 |
| *Workers' characteristics* | | | | | |
| Sex (ref: women) | 0.530 | 0.499 | Highest education level | | |
| Couple | 0.781 | 0.414 | no diplome | 0.252 | 0.434 |
| Has moved since last year | 0.063 | 0.243 | lower 2dary (BEPC) | 0.074 | 0.261 |
| Has at least one child | 0.674 | 0.469 | technical 2dary (CAP/BEP) | 0.316 | 0.465 |
| Age | | | high school diploma (Bac) | 0.128 | 0.335 |
| 15-25 years old | 0.032 | 0.175 | college degree | 0.117 | 0.322 |
| 25-40 years old | 0.434 | 0.496 | graduate degree and above | 0.100 | 0.300 |
| 40-55 years old | 0.453 | 0.498 | still a student | 0.013 | 0.113 |
| >55 years old | 0.082 | 0.274 | | | |

**Appendix Table I - continued**
**Descriptive Statistics**

| Variable | Mean | Std Dev | Variable | Mean | Std Dev |
|---|---|---|---|---|---|
| *Workers' characteristics* | | | | | |
| | | | Region of residence | | |
| Seniority | | | Ile-de-France | 0.168 | 0.374 |
| 1-5 years | 0.274 | 0.446 | North-West | 0.213 | 0.409 |
| 5-10 years | 0.231 | 0.421 | North-East | 0.233 | 0.423 |
| >10 years | 0.495 | 0.500 | South-West | 0.135 | 0.341 |
| Nationality | | | South-East | 0.251 | 0.433 |
| French | 0.955 | 0.207 | Size of firm | | |
| North-African | 0.013 | 0.115 | 1-50 | 0.270 | 0.444 |
| African | 0.003 | 0.053 | 50-100 | 0.061 | 0.238 |
| European Union | 0.020 | 0.139 | 100-500 | 0.152 | 0.359 |
| Europe non EU | 0.009 | 0.093 | 500-1000 | 0.058 | 0.233 |
| | | | > 1000 | 0.232 | 0.422 |
| Industrial Branches (CNAM classification) | | | | | |
| Metal working | 0.115 | - | Textile | 0.005 | - |
| Construction | 0.050 | - | Clothing | 0.004 | - |
| Wood work | 0.006 | - | Leather | 0.004 | - |
| Chemicals | 0.017 | - | Food | 0.090 | - |
| Stones | 0.012 | - | Transportation | 0.043 | - |
| Paper, Rubber | 0.020 | - | Water, Electricity | 0.011 | - |
| Books | 0.009 | - | Other | 0.539 | - |
| Trade | 0.076 | - | | | |

*Notes: CNAM is the Social Security institution in charge of compensating for work injuries. It collects exhaustive individual data that are aggregated into sectors as defined by the risk of injuries rather than with reference to the French ISIC classification.*

**Appendix Table II**
**Proportion of Occupational injuries 1998**

| Industrial Branch | CNAM data in % | CT data in % |
|---|---|---|
| Metal Working | 4.78 | 5.48 |
| Construction | 10.82 | 10.42 |
| Woodwork | 9.21 | 10.89 |
| Chemicals | 2.24 | 3.02 |
| Stones | 6.64 | 7.65 |
| Paper, Rubber | 5.51 | 6.71 |
| Books | 2.70 | 3.38 |
| Textile | 4.80 | 4.94 |
| Clothing | 2.65 | 4.55 |
| Leather | 2.94 | 1.82 |
| Food | 6.14 | 6.87 |
| Transportation | 7.30 | 6.80 |
| Water, Electricity | 3.69 | 2.25 |
| Trade | 2.73 | 5.03 |
| Other | 2.84 | 3.32 |
| Total | **4.48** | **4.68** |

**Appendix Table III**
**Occupational injuries and New Work Practices**

| Rate of Injuries % of population | Work Practices | |
|---|---|---|
| | Quality Norms | |
| | yes | no |
| Total OI | 12.8 | 7.4 |
| Serious OI | 6.4 | 4.2 |
| Benign OI | 6.4 | 3.2 |
| | Job Rotation | |
| | yes | no |
| Total OI | 11.9 | 7.1 |
| Serious OI | 6.3 | 4.0 |
| Benign OI | 5.6 | 3.1 |