Safety at work and working conditions in Europe

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May 30, 2010

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This paper contributes to the analysis of the determinants of workplace accidents, using European Working Conditions Surveys data. We investigate the role of workplace conditions and safety at work in reducing the probability of workplace accidents and the cumulative duration of absence following an injury. Particular attention is given to the role of institutions and to differences in work organization practices. The main result shows evidence of an inverse relation between safety at work and accidents. When workers qualifications are analyzed separately, results suggest that lower safety at work is correlated with a higher probability of accident for low-skill jobs, as compared to high-skill jobs.

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This paper contributes to the analysis of the determinants of workplace accidents, using European Working Conditions Surveys data. We investigate the role of workplace conditions and safety at work in reducing the probability of workplace accidents and the cumulative duration of absence following an injury. Particular attention is given to the role of institutions and to differences in work organization practices. The main result shows evidence of an inverse relation between safety at work and accidents. When workers qualifications are analyzed separately, results suggest that lower safety at work is correlated with a higher probability of accident for low-skill jobs, as compared to high-skill jobs.

1 Introduction

In this paper we investigate how differences in working conditions and in safety at work affect workplace accidents both in terms of probability of suffering occupational injuries or cumulative duration of absence from work.

For the European Union and its Member States, the promotion of employment, the improvement of working conditions and the prevention of workplace accidents are amongst the primary objectives to pursue, as stipulated in Article 136 of the Treaty of Rome and confirmed by the EU Framework Directive 89/391. However, more than 27 thousands workers die every year due workplace accidents, resulting in a GDP loss of more than 4 percent of in the European Union. Workplace accidents, in fact, entail costs that are related to insurance indemnity, safety intervention, security devices and all the other expenditure related to workplace accidents. Consequently, the government should intervene for reducing workplace accident either on humanitarian or on economic grounds.

Although there is an extensive economic literature, developed widely by Viscusi, which focuses on the value of life for workers who suffer from workplace accidents, both theoretical and empirical literatures dealing with risk at work are limited and not exhaustive. Risk at work and the determinants of a workplace accident are investigated arising either macroeconomic or microeconomic issues. The macroeconomic literature is focused on testing the relationship between macroeconomic conditions and mortality due to hazardous working conditions (Ruhm; 2000 and Boone and van Ours; 2002, 2003). On the other hand, several articles contribute the microeconomic literature investigating the effect of risk at work on the labour demand (DeLoire and Levy, 2004; Grazier and Sloane, 2006; and Schaffner and Kluve, 2006), the determinants of an occupational injury (Litwin, 2000 and Fenn and Ashby, 2001; Bauer, Million, Rotte and Zimmermann, 1998; Guadalupe, 2003, Hernanz and Toharia, 2004 and García-Serrano, Hernanz & Toharia, 2008; Wilkins, 2004) and the consequences of a workplace accident, either for the return to work (Galizzi and Boden, 2003) or for earnings (Reville and Schoeni, 2001 and Crichton, Stiliman and Hyslop, 2005).

We argue that previous studies do not investigate the relation between safety at work and accidents, due to data limitations in providing measures of exposures to dangerous agents. The motivation of our empirical analysis is to provide evidence that investing in safety reduces the expected cost of workplace accidents, cost which depends on the probability that an accident occurs and on the consequences following an injury. The objective of this paper is to offer three main contributions to the previous literature. First, we provide a unique European cross-country comparison of the effect of working conditions and safety at work on workplace accidents using European Working Conditions Survey data. Second, we estimate the probability and the duration of absence accounting for the endogeneity in the provision of safety at work. Endogenous selection may be induced by the sorting of workers according to risk aversion. Firms' behaviour may also induce endogenous selection when they choose safety expenditures accounting for workers' hidden actions in exerting precaution effort. Finally, we highlight differences in the effect of safety at work between high-skill qualifications and low-skill jobs, where the former are characterized by better earnings, better working conditions and lower risk at work.

The paper is organized in the following way. In Section 2, we present the institutional background related to the effort of creating a common and unique legislative framework to safeguard occupational health and safety in the European Union; in Section 3, we review the relevant literature; Section 4 presents the dataset description; in Section 5 we introduce the main empirical issues related to investigating the probability and the duration of absence due to a workplace accident; Section 6 discusses the results and concluding remarks follow.

2 Institutional framework

Over the past two decades, the ratification of Framework Directive 89/391/EEC has led European countries to adopt measures and directives for the purpose of creating a common and unique legislative framework to safeguard occupational health and safety. However, there are still differences among European countries for what concerns the legislation enacted to avoid workplace accidents. In the 1990s, the implementation of the Framework Directive, particularly Articles 5, 6, 7 and 14, contributed to the development of tasks, methods and structures of occupational health services.

Occupational health services are defined in Recommendation n.112 (1959) of the ILO as *"service established in or near a place of employment for the purposes of (a) protecting the workers against any health hazard which may arise out of their work or the conditions in which it is carried on; (b) contributing towards the workers' physical and mental adjustment, in particular by the adaptation of the work to the workers and their assignment to jobs for which they are suited; and (c) contributing to the establishment and maintenance of the highest possible degree of physical and mental well-being of the workers."*

Several international bodies have a role in developing occupational health services, which support environmental and safety management practices in enterprises. The European Union, with the European Workplace Health Promotion Network founded on the Luxemburg Declaration in 1997, tends to increase occupational health services and to promote workplace safety. The European Foundation for the Improvement of Living and Working Conditions contributes to establish better living and working conditions by focusing on the organization of work and job design. The aim of the European Agency for Safety and Health at Work is to provide technical, scientific and economic information for promoting improvements in the work environment. Particularly important is the role of the International Labour Organisation (ILO) in ensuring international guidelines and legal frameworks for the development of occupational health policies and infrastructures as well as providing practical support for improving safety at workplace. Indeed, the ratification of the ILO Conventions concerning occupational health and safety can be used as a valid proxy to measure the effort of European governments towards avoiding workplace accidents over the last years[1]. Finally, the role of the World Health Organization (WHO) Regional Office for Europe is to identify environmental health priorities in the European Region and assessing health risks. Regulatory authorities are supported by the WHO Office which provides strategic guidance in developing occupational health services and assessments of environmental health risks.

The Framework Directive 89/391/EEC established the normative and practical development of the relationship between the employer and occupational health services. The aim of EU Directive is to emphasise the primary responsibility of the employer, which has the duty to organise preventive and protective services and to use best available technologies to avoid workplace accidents. Moreover, EU Directive states that the employer has the responsibility to control hazard at the source, investing in avoiding risk at work by either replacing dangerous tasks with non-dangerous or less dangerous ones or training and educating worker on how to reduce and eliminate the risks for their health and safety. The employer has the responsibility to inform workers on the protections and safety equipments required to avoid any workplace accident and to ensure that worker may give first aid when an occupational injury occurs.

The objective of occupation health services is to prevent traditional hazards

[1] A review of ILO Conventions concerning occupational health and safety is presented in the appendix.

related to the exposures to chemical agents (including lead, solvents and mineral dusts), to heavy physical work and noise. In addition, occupational health services have to identify and neutralize hazards due to technological improvements in production, such as new forms of radiations, chemical or biological agents, allergens, musculoskeletal disorders and, psychological and psychosocial problems. The enforcement of laws and regulations on occupational health and safety is entrusted to occupational safety and health authorities, in most of the Member States, or to a specific ministry. Occupational safety and health authorities and ministries must intervene to enforce legal provisions and to adopt a coherent system of inspections and monitoring of occupational health services for preventing and reducing hazards at work.

3 Background literature

Few empirical studies have dealt with the issue of investigating the determinants of workplace accidents. On the one hand, this topic arises macroeconomic issues, as argued by Ruhm (2000), who finds an inverse relationship between macroeconomic conditions and mortality due to hazardous working conditions. Boone and van Ours (2002, 2003) argue that variations in workplace accidents are due to the procyclicality in workers' absenteeism. Indeed, workplace accidents are affected negatively by both the level of unemployment and the change in employment status.

The microeconomic literature is focused on the effect of risk at work on the labour demand, on the determinants of an occupational injury and on the consequences of a workplace accident, either on the return to work or on earnings. DeLoire and Levy (2004), Grazier and Sloane (2006) and Schaffner and Kluve (2006) investigate the effect of risk at work on the demand function. Using family structure as a proxy for aversion to the risk of death, DeLoire and Levy (2004) find that, in the US labour market, individuals with strong aversion to risk of accidents, especially single who are raising children, choose safer jobs. In addition, gender is correlated with occupational risk choices and family structure explains only partially this correlation. Grazier and Sloane (2006) present similar findings investigating the UK labour market. Schaffner and Kluve (2006) argue that, in Germany, observed gender wage differentials are partly due to differences in the occupational injury risk of the jobs occupied by men and women and their corresponding compensation.

Several articles focus on the determinants of a workplace accident. Litwin (2000) and Fenn and Ashby (2001) investigate the effect of unionization in preventing workplace accidents. Litwin (2000) argues that, on the one hand, trade unions improve working conditions and that, on the other hand, there is no significant monotonic inverse relationship between union instrumentality and injury rates. Fenn and Ashby (2001) find that establishments with a higher proportion of unionized employees are associated with higher risk of reported injuries or illnesses; in addition, employees in larger establishments suffer lower probability of being injured. Focusing on the role of immigrant labour, Bauer, Million, Rotte and Zimmermann (1998) argue that foreigners face higher risks in terms of technological safety whereas there are no differences regarding workplace risks due to work organization. Focusing on the interaction between job risks of native and foreign workers, guestworkers employment has a positive effect on the workplace safety of natives. The relationship between fixed term contracts and workplace accidents has been investigated by Guadalupe (2003), Hernanz & Toharia (2004) and García-Serrano, Hernanz & Toharia (2008). Guadalupe (2003) identifies a systematic difference between accident rates of workers employed on fixed term contracts and those of workers employed on permanent contracts in the Spanish labour market. Hernanz & Toharia (2004) find that, both in Italy and in Spain, differences in the probability of workplace accident for workers with temporary and permanent contracts vanish either when job characteristics are controlled for. García-Serrano, Hernanz & Toharia (2008) argue that workers employed through Temporary Help Agencies (THAs) exhibit lower probability of suffering a serious/fatal accident and lower duration of an absence after a work-related accident, as compared to "direct" temporary contracts and permanent workers. Investigating the consequences of working hours, Wilkins (2004) does not find robust evidence that more hours worked per week affect workplace accidents rates.

Investigating the consequences of workplace accidents on the return to work, Galizzi and Boden (2003) find that the time off work following an injury is affected by workers' pre-employment history and that it is lower if workers return to their pre-injury jobs. If workers experience a long period off the job after the accident, they carry with them the burden of their injuries even after returning to work. Reville and Schoeni (2001) and Crichton, Stiliman and Hyslop (2005) investigate the consequences of workplace accidents in terms of their effects on earnings. Analysing the long-term labour market consequences of permanent partial disabilities, Reville and Schoeni (2001) estimate that earning losses are in the range of 25 per cent of the income of uninjured workers, mainly due to a decline in employment. Using the accident insurance scheme, Crichton, Stiliman and Hyslop (2005) argue that injuries have negative effects on future labour market outcomes if the workers receive more than 3 months of earnings compensation for injury. The effects are substantial for longer-duration injuries and increase with injury duration, without any evidence of declines over the first 18 months after leaving Accident Compensation Corporation.

4 Data and variables

We use a dataset which provides an overview of workers experience and working conditions across European countries based on the third (2000) and fourth (2005) European Working Conditions Survey. The questionnaires collect information on respectively 21,703 and 29,680 workers. The EWCS samples followed a multi-stage stratified and clustered design with "a random walk" procedure for the selection of the respondents at the last stage (expect for several countries). All interviews were conducted face-to-face in the respondent's own household.

The target number of respondents was around 1,400 in EU15 countries in the third wave and around 1,000 in EU27, Turkey, Croatia, Switzerland and Norway[2] in the fourth wave. The dataset includes information on personal characteristics and firm attributes, such as sector, size, working condition and work organization. Relevant for our analysis, the questionnaire presents questions on the relevance of the exposure to dangerous agents, working time and involvements of the job. Given the aim of our analysis, in this study we restrict the dataset to workers aged 18 to 65 and exclude from the analysis any workers who are still studying or employed in the military[3]. The final database selected for the analysis is composed of 37,147 observations, of which 17,530 are relative to third and 19,617 to the fourth wave of the EWCS.

For the analysis, we construct two dependent variables, accident and absence, using information reported by the worker on absences from work due to accident(s) at the workplace over the past 12 months. If the worker suffered a workplace accident, which entailed at least one day of absence from work, the variable accident is equal to one; otherwise, it is equal to zero. Only 3.53 per cent of workers considered suffered a workplace accident; 2.99 percent, if we consider exclusively over 3 day accidents. Our workplace accident rate is found to be rather in line with aggregate statistics[4] when we consider over 3 day accidents[5]. The discrete variable absence is constructed measuring the total number of days off work due to workplace accident(s) in the past 12 months. The outcome of the variable absence is equal to zero if the worker does not suffer any workplace accident; otherwise, the variable may assume any value in the interval 1 to 365 days. Among injured workers, the mean number of days of absence from work due to workplace accident is 25.07.

A complete list of the variables used in the analysis and their means is contained in Appendix Table A2.1. Personal characteristics of respondents include gender, age and working qualification (based on the International Standard Classification of Occupations (ISCO)). Firm attributes concern information on sector (classified using International Standard Industrial Classification of All Economic Activities (ISIC)), size of enterprise and firm's propensity to affect health by injury. We also include in the analysis a set of country dummy variables, which capture the citizenship of respondents, and time dummy variables, which identifies if observation is collected in the third or in the fourth wave of EWCS.

In addition, for estimating the effect of working conditions, we include variables related to working time and involvements of the job. Relating to working time, we use information on the arrangement of work time and on working overtime. Workers were asked to report whether they work at least once a month on

[2] Except in Cyprus, Estonia, Luxembourg, Malta and Slovenia, where the target number was around 600.

[3] We restrict the sample to estimate the probability of accident and the duration of absence for workers in the labour force.

[4] European Statistics of injuries At Work (ESAW) (2005) and OECD (2007).

[5] There are no available aggregate statistics on workplace accident that entails an absence lower than 3 days in EU.

a Saturday (49.44 percent of the workers interviewed) or a Sunday (28.77 percent). In addition, they were asked whether they had to work at least 2 hours between 6.00 pm and 10.00 pm (46.07 percent), or at least 2 hours between 10.00 pm and 5.00 am (18.77 percent) and more than 10 hours a day (35.36 percent). Involvements in the job are defined as working at very high speed for more than half of the time (46.57 percent) and working to meet tight deadlines for more than half of the time (47.03 percent).

For estimating the effect of safety at work, we create an index to evaluate the exposure to physical, chemical or biological agents. For this purpose, we use information on workers' evaluations of expositions to physical agents (noise, radiation, vibration, etc.), to chemical agents and to biological agents[6]. In the questionnaire, workers have to rate their exposures to dangerous agents on a scale from 1 to 7, with 1 meaning that he/she is exposed to risk all the time and 7 that he/she is never exposed. Principal component analysis is performed to combine seven variables into one single factor that evaluates the overall exposure to occupational risks.

5 Empirical Model

Focusing on the probability that a worker may suffer an occupational accident, we use a probit model to estimate the following equation:

$$\begin{aligned} P_i^* &= \alpha + X_i^{'}\beta + W_i^{'}\gamma + \theta s_i + \varepsilon_i \qquad (1) \\ P_i &= \begin{cases} 1 & if\ P_i^* > 0 \\ 0 & otherwise \end{cases} \end{aligned}$$

where P_i is the binary variable which captures whether a worker has suffered one or more workplace accidents, X_i is the vector of the variables that control for personal and firm-specific characteristics, W_i is the vector of the variables which provide information on working conditions, s_i is a safety at work index and ε_i is the error term, which is normally distributed, $\varepsilon_i \sim N(0,1)$.

The cumulative duration of absence because of occupational injuries is investigated using a negative binomial model[7]. The choice of the econometric technique is falling on a model for count data due to the peculiar characteristics of the dependent variable. Indeed, since the dependent variable measures the total number of days off work due to workplace accidents in the previous 12

[6] The specific risk considered are vibrations from hand tools or machinery, excessive noise, high and low temperature, breathing in smoke, fumes, powder or dust, handling or touching dangerous products or substances, either chemical or biological, and radiation.

[7] In ordered to estimate the equation of interest consistently and to predict conditional probabilities, Cameron and Trivedi (1986) suggest using the full maximum likelihood analysis of the NegBin I model, that satisfies the condition of overdispesion. In addition, NegBin II model provides a further generalization assuming that the amount of overdispersion is increasing with the conditional mean. In our estimations, NegBin II model is preferred to NegBin I because it entails a higher loglikelihood value with the same number of parameters.

months, it is necessary to use an econometric model which takes into account that this variable might be zero for a substantial part of the population (namely those workers that did not suffer any workplace accident in the last year) and that the values of the outcome have a cardinal rather than just an ordinal meaning. For these reasons, models for count data are preferred to an ordinary least square model or to order response models. In addition, we did not consider the option of carrying out a duration analysis because, given the nature of the data available, it is not possible to know if the number of days off work is due to a single workplace accident or to several injuries suffered during the year.

Therefore, the equation of interest on the total number of days off work due to a workplace is specified as follows:

$$A_i = \lambda + X_i^{'}\psi + W_i^{'}\delta + \vartheta s_i + \mu_i \tag{2}$$

where A_i is the discrete variable which measures the duration of absence because of a workplace accident in term of total number of days off work and all other variables as as in equation (1).

The issue of endogeneity in safety at work would entail that the empirical analysis may produce biased and inconsistent coefficients for the effect of safety at work index on both the probability and the cumulative duration of accident. We propose two different empirical strategies to deal with the endogeneity in safety at work[8].

When estimating the probability of injury on the workplace, we consider a set of adequate instrumental variables, and introduce the instrumental variable probit model. The instrumental variable probit model is used for fitting probit models with maximum likelihood estimation where one or more of the independent variables are endogenous. The endogenous regressors are treated as linear functions of the instruments and the other exogenous variables. Maximum likelihood estimator is computationally feasible in a large sample, as in our analysis, and it guarantees desirable properties. Indeed, it is asymptotically normally distributed and asymptotically efficient; in addition, approximate significance tests of parameters are statistically valid and the tests are easy to compute.

When estimating the cumulative duration of absence because of workplace accidents, we have use a two-step technique[9], which entails that the predicted value of safety at work index, $\hat{s}_i$, is estimated introducing a set of instrument, Z_i, in the auxiliary equation, as shown in the following model:

$$A_i = \varsigma + X_i^{'}\varphi + W_i^{'}\phi + \nu\hat{s}_i + \upsilon_i \tag{3}$$

$$s_i = \varpi + X_i^{'}\xi + W_i^{'}\varkappa + Z_i^{'}\varrho + \tau_i \tag{4}$$

[8] For accounting for the endogeneity, we need at least one additional moment condition derived from the availability of an instrumental variables, which is by definition correlated with the (endogenous) safety at work index but uncorrelated with the error terms ε_i or μ_i.

[9] We assume that the stochastic component of safety at work index is normally distributed and that it may estimate with ordinary least square model; see Woolridge (2002) for the assumption of efficiency of two-stage estimators.

The auxiliary equation is estimated by ordinary least square model and, then, the predicted value of the safety at work index is used in the negative binomial model (3).

6 Result

6.1 Descriptive analysis

Table A2.2 reports the workplace accident rate, in the first column, and the average duration of absence off work for workers who suffered a workplace accident, in the second column.

Focusing on differences in personal characteristics, we find that, on average, men suffer more workplace accident than women; on the contrary, differences in the duration of absence is limited, although women are absent from work on average for longer periods than men. Table A2.2 suggests that the probability of occupational accidents decreases with age; whereas the consequences of an occupational injury do not change significantly. Table A2.2 shows that low skill qualifications present a higher probability of a workplace accident as compared to high skill jobs; in addition, the consequences[10] for low skill workers are more serious in terms of days off work due to workplace accidents. Descriptive statistics confirms that workplace accidents occur more frequently in high-risk sectors[11], namely Manufacturing, Construction and Transport and Storage; in these sectors, moreover, an occupational injury entails more serious consequences. On the contrary, low-risk sectors, namely Financial Intermediation and Community Social and Personal Services, present either lower workplace accident rates or less serious consequences when an accident occurs. Raw differences in term of average workplace accident rate by size suggest that the dimension of enterprise is positively correlated with accident rate; on the contrary, the size of enterprise does not seem to be correlated with the duration of absence because of workplace accident. The firm's propensity to affect workers' health increases the probability and the cumulative duration of absence.

Investigating raw differences by country, Table A2.2 shows that Eastern European countries, namely Romania, Bulgaria and Czech Republic, present workplace accident rates always below of 1 percent; whereas, in Finland, one of the most involved country in regulating safety at work, more than 5 percent of workers was affected by an occupational injury in the last 12 months. This result arises a potential weakness of our dataset: differences in knowledge relatively to safety at work and workplace accident may induce workers in different countries to report misleadingly the consequences of a workplace accident. Consequently, the robustness analysis of our results are carried out separately for workers employed in EU15 countries and for workers employed in Eastern European countries. In addition, Table A2.2 suggests that the cumulative duration of

[10] We may assume that the cumulative duration of absence because of workplace accidents is a good proxy for the seriousness of occupational injuries.

[11] See OCSE (2007) for aggregate statistics on workplace accident rate by industries.

absence is not positively correlated with the probability of a workplace accident among EU countries.

Focusing on working conditions, descriptive statistics suggest that a more demanding job entails higher probability of suffering a workplace accident. On the other hand, there seems to be a negative relationship between more demanding working conditions and the cumulative duration of absence because of occupational injuries. However, this effect may be due to the presence of spurious effects related to work qualification and sector.

Table 1 shows how workers are exposed to each specific occupational risk. The dataset presents generally high levels of safety at work index: workers interviewed are generally never exposed to occupational risks. Indeed, for each occupational risk, more than half of workers interviewed are completely covered against the exposure to specific agent. In particular, the exposure to radiation is extremely limited: only 4.98 percent of workers are exposed to radiation for at least one quarter of the time. On the contrary, noise is the occupational risk that affects more frequently workers interview: 28.51 percent of workers are exposed to noise for at least one quarter of the time. Figure 1 shows the negative relationship between safety at work and workplace accident rate. Reducing the exposure to physical, chemical or biological agents, workplace accident rate decreases significantly. Figure 2 confirms that the safety at work index is correlated with the duration of absence and an decrese of exposures to dangerous agents reduces the days off work for an occupational injury.

6.2 Empirical evidences

In this section, we present results of our analysis of the effect of working conditions and of the safety at work index on the probability of injury and the cumulative duration of absence due to workplace accidents. Table 2 and Table 3 show, respectively, the estimates of the probit (equation 1) and the negative binomial regression (equation 2). We structure both the tables to show how the estimates of working conditions and safety at work index vary according to different specifications. Specification (I) includes only working conditions and safety at work index, controlling for time and country effects. In Specification (II), we introduce control variables related to personal characteristics of the worker and, in Specification (III), we also add variables to control for differences in firm characteristics.

Controlling for personal characteristics of the worker, we do not find any statistically significant difference in terms of gender and age either on the probability of accident or on the cumulative duration of absence. Results of the probit and negative binomial regressions confirm that there are statistically significant differences among qualifications. Low-skill qualifications are affected by higher probability of occupational injury and suffer less serious consequences from such accidents. In addition, there are statistically significant differences in the probability of suffering from an occupational injury and the cumulative duration of absence among industries, as shown in descriptive statistics. We find no statistically significant effect of firm size either on the probability of accident or on the cumulative duration of absence. We notice that the firm's propensity to affect health by injury has a positive and statistically significant effect both on the probability of a workplace accident and on the cumulative duration of absence.

In Table 2 and Table 3, we also show how characteristics related to working time and involvement on the job are correlated both with the probability of accident and with the cumulative duration of absence. Investigating the effects of differences in working time, we find that variations in the arrangement of working time do not influence the probability of workplace accident; on the other hand, working overtime seems to increase both the probability and the cumulative duration of absence because of an occupational injury. Indeed, positive and statistically significant correlation is highlighted between working more than 10 hours a day and both the probability of workplace accident and the cumulative duration of absence. This result is in line with our expectations: too long working hours result in overly tired workers, who experience a drop in promptness and less care in performing their tasks, thus increasing the probability that an occupational injury occurs. In addition, working for more than 10 hours induces more physical stress, which entails more serious consequences when an accident occurs. Results presented in Table 2 and Table 3 suggest that the level of involvement on the job is not associated with higher probability of workplace accident. Working at very high speed and to meet tight deadlines does not influence significantly the workplace accident rate.

Although the relationship between working conditions and the probability of workplace accident is limited to the effect of working overtime, we assume that a safer workplace reduces the probability of occupational injury. This assumption is reasonable if we consider that, in order to reduce workplace accident rates, safety regulation aims at reducing workers exposures to physical, chemical or biological agents on the workplace. Indeed, the estimates confirm this assumption (Table 2): higher values of the safety at work index are associated with a higher probability of a workplace accident. Less exposure to physical, chemical or biological agents contributes to a safer workplace and is associated with a lower probability of occupational injury. Moreover, the inclusion of a set of controls does not alter the negative relationship between the safety at work index and the probability of accident; indeed, the coefficient remains statistically significant at the 1 percent level. In column 1, we notice that reducing by 1 percent the exposure to dangerous agents decreases the probability of accident by 1.405 percent. Controlling for personal characteristics of the worker, such as gender, age and work qualifications, we find that the marginal effect of the safety at work index is partly reduced to -0.978 percent. Controlling also for firm specific characteristics, the marginal effect decreases further; indeed, an increase of 1 percent of safety at work decreases the probability of accident by 0.623 percent.

However, the empirical analysis we presented so far may produce a biased and inconsistent estimation of the effect of safety at work if exposures to dangerous agents are endogenously determined. Indeed, differences in aversion to risk at work may influence workers' career preferences entailing a selection effect.

Risk-adverse workers may look for occupations that minimize risk at work with more stringent safety regulation and innovations in work organization practices. The correlation between safety at work index and the probability of workplace accident, presented in Table 2, might not reflect the causal effect of reducing exposures to physical, chemical or biological agents but the consequences of differences in safety regulation and work organization practices.

In addition, firms' behaviour may also induce endogenous selection if the firm chooses safety expenditures according to workers' hidden actions in exerting precaution effort[12]. In a Stackelberg context where the firm does not observe workers' precaution effort, the problem of single moral hazard may arise: the firm proposes a contract to workers where wage and firm's safety expenditure are enforceable and, then, workers will choose the optimal precaution effort. The firm may decide to be over-prudent, investing more in safety expenditure than optimal, to reclaim the moral hazard implication that workers' precaution effort is lower than the optimal level[13]. We may assume that the safety at work can be endogenously determined by the firm's expenditure for innovating work organization practices.

In order to account for the endogeneity of safety at work, we introduce two types of instruments related to safety regulation and work organization practices. First, we propose an occupational health and safety index which captures the level of government intervention in promoting safety at work. The occupational health and safety index measures the number of ratifications of ILO conventions in 2000 for EU15 countries and in 2005 for EU27 countries, Turkey, Croatia, Switzerland and Norway. The government may intervene to induce the firms to exert the optimal level of safety expenditure modifying the accident liability system[14]. Accident liability affects incentives for the firm to engage activities that may cause an accident and to invest in precaution safety expenditure to reduce risk. Moreover, the liability system acts as an implicit insurer for victims of accidents compensating them with the fines paid by injurers. In this sense, the liability system moves the economic risk of an accident from the workers to the firms, which may be found guilty of lack of required safety precautions. Consequently, the identifying assumption is that more stringent regulation influences positively the safety at work index, inducing the firms to exert the optimal level of safety expenditure reducing exposures to physical, chemical or biological agents on workplace. On the contrary, the safety regulation does not affect either the probability that a worker may suffer from an occupational injury[15] or the cumulative duration of absence off work because of an occupational injury.

[12] This assumption is in line with Lanoie (1991) that argues that the probability of accident is influenced either by the precaution effort of workers or by the firm's safety expenditure. The workers' precaution level is related to the time spent in risk-preventing activities or the unpleasantness of these activities. The firm's safety expenditure is related to the safety equipment distributed to workers or investment in safer technology.

[13] Lanoie (1991)

[14] According to the tort literature, developed widely by Shavell (1983; 1984; 2005 for a review).

[15] Curington (1988) and Viscusi (1986) for a review.

Second, the firm's precaution expenditure is related to the adoption of work organization practices to reduce exposures to physical, chemical or biological agents. We introduce a variable which proxies for the adoption of high performance work organization practices in the safety at work equation. Several articles, such as Dertouzos et. al. (1989), Gittleman et al. (1998), Osterman (1994, 2000), Ramsay et al. (2000), Truss (2000) and Wood (1999), argue that improvements to the efficiency of work processes and the quality of products and services are directly related to the diffusion of innovations in organisational practices and arrangements. High-performance work organization is characterized by a series of practices aimed at increasing employee involvement, discretionary autonomy and responsibility for quality control. Following Arundel, Lorenz, Lundvall and Valeyre (2006), we select six binary variables that are related to high-performance work organization: responsibility for quality control (74.64 percent of workers interviewed), problem solving activities (82.36 percent), learning new things at work (72.91 percent), discretion in fixing order of tasks (66.92 percent), discretion in choosing methods of work (69.56 percent) and discretion in setting speed or rate of work (71.10 percent). We perform a principal component analysis to construct a factor which identifies, for each observation, the relative firm score in term of employee involvement, discretionary autonomy and responsibility for quality control. The relationship between high performance work organization and safety at work is depicted in Figure 3, where we show variations of safety at work increasing innovations in work organization practices. The slope of the trend line suggests that innovations in work organization for favouring employee involvement are positively correlated with safety at work.

In addition, inspired by Taylor's principles of task specialization, we also construct an index which captures the association between the variables related to the repetitiveness and monotonicity of working tasks. We use three variables: monotony of tasks (41.10 percent of workers interviewed) and repetitiveness of task, either if the task is repeated every minute or less (25.76 percent) or if it is repeated every 10 minutes or less (43.12 percent). Principal component analysis is used in order to construct the factor which measures, for each observation, the relative firm score in term of involvement in Taylor's principles of task specialization. Figure 4 shows that repetitiveness and monotonicity in working tasks are negatively correlated with the safety at work index, as shown by the negative slope of the trend line.

The identifying assumption is that workers involved in firms which introduce innovations in the work process are affected by better working conditions and, in particular, by higher levels of safety at work. On the contrary, the adoption of practices characterized by repetitiveness and monotonicity of tasks may induce higher exposures to physical, chemical or biological agents on workplace. Moreover, we notice incidentally that there is no evidence that practices adopted to modify work organization are correlated either with the probability that a worker may suffer from an occupational injury or with the cumulative duration of absence due to an occupational injury.

Table 4 presents the estimations of the OLS regression of the safety at work index on the set of control variables and instruments. Results suggests that there is a positive relationship between regulation and the safety at work index: where government intervention in ratifying ILO conventions is consistent, workers are employed in enterprises that guarantee higher reductions of exposure to physical, chemical or biological agents. This result is in line with our identifying assumption: ratifications of ILO conventions, which state the accident liability of the employer, induce firms to reduce exposures to dangerous agents. Variations in the liability system influence the expected costs that the firm may support if an occupational accident occurs. If the Court judges that the firm is found negligent, in the sense that it caused the accident distributing unsafe equipment or neglecting any investment in safer technology, the fines for compensating victims of accidents will be added to the cost of replacing injured workers. On the other hand, more stringent safety regulation may increase the expected cost of being monitored by the occupational health and safety authority. Thus, the firm may be induced to increase its safety precaution expenditure to avoid the payment of a fine for the insufficiency of occupational health services. In addition, innovation in work organization practices has a positive and statistically significant effect on the safety at work index, suggesting that, increasing employee involvement, firms tend to ensure higher levels of safety on the job. Increasing employee involvement and responsibility, the firm may drive workers to exert more precaution effort to reduce their exposures to dangerous agents. Moreover, we may assume that workers employed in firms that introduce innovations in work organization practices are better informed regarding the health and safety risks related to their performance of your job. More information on risk at work may help workers to avoid exposures to dangerous agents. On the other hand, the involvement in jobs characterized by repetitiveness and monotonicity of tasks has a negative and statistically significant effect on the safety at work index. The repetitiveness of risky tasks has the consequences of reducing safety at work because workers are not able to avoid being exposed to dangerous agents. The monotonicity of tasks induce a drop promptness and less care in exerting risky tasks that increase workers' exposures to dangerous agents.

In Table 5, we report estimates using the instrumental variable probit model, which accounts for endogeneity of safety at work, column (2), as well as using the analogous model in which safety at work index is treated as exogenous, column (1), in order to facilitate comparisons. Before comparing results of these estimations, we notice that Wald chi-squared test of exogeneity suggests that the safety at work index is indeed endogenous. Moreover, Amemiya-Lee-Newey minimum chi-squared statistic test of overidentifying restrictions[16] is in favour of the use of safety regulation and work organization practices as instruments for the safety at work index. Indeed, safety regulation and work organization practices affect the safety at work index, whereas they are not correlated with the probability of an occupational injury.

[16] Test of overidentifying restrictions is estimated by Newey's minimum chi-squared two-step estimator, which provides similar estimates of coefficients, as compared to maximum likelihood estimator.

The marginal effect of the safety at work index on the probability of workplace, presented in Table 5, reveals that the effect of exposure to physical, chemical or biological agents is drastically increased when accounting for variations of safety at work related to differences in safety regulation and innovations in work organization practices. A 1-percent increase in safety at work decreases a worker's predicted mean probability of accident by 1.846 percent. Controlling for endogeneity, the coefficient of the safety at work index is higher than the one of the exogenous regressor, suggesting that the analysis initial underestimated the effect of the safety at work index on the probability of workplace accident.

The economic intuition of the causal effect of the safety at work index on the probability of a workplace accident can be found in Lanoie (1991). According to Lanoie, the firm's precaution expenditure contributes with the worker's precaution effort in reducing the probability of a workplace accident. In addition, in the Stackelberg context, the firm's precaution expenditure influences the probability of a workplace accident independently from workers' behaviour in term of safety precaution effort: the firm may decide to be over-prudent to reclaim the moral hazard implication and to achieve the same probability that is ensured in the first best solution when firms and workers cooperate to minimize the probability of a workplace accident.

Focusing on the effect of the safety at work index on the duration of absence, we assume that exposures to physical, chemical or biological agents are positively correlated with the seriousness of consequences of accidents. Occupational injuries due to excessive exposure to dangerous agents may leave workers invalid or may entail fatal consequences. Results presented in Table 3 confirm our hypothesis: reducing the exposure to physical, chemical or biological agents has a negative effect on the consequences of workplace accidents. If firms provide increased safety at work, the consequences of a workplace accident will be less serious and the duration of absence will be significantly lower. The statistically significant effect of the safety at work index is robust to inclusion in the model of a set of controls related to personal characteristics, although controlling for gender, age and work qualifications reduces the marginal effect from -39.37 to -28.64 percent. Controlling also for firm specific characteristics does not alter the negative marginal effect of the safety at work index on the duration of absence, which is equal to -15.72. In all specifications, the coefficient of the safety at work index is statistically significant at the 1 percent level.

Table 6 reports estimates of negative binomial regression in which safety at work index is treated as exogenous, column (1), and results of the two-stage technique used to account for endogeneity in safety at work, column (2). Results reveal that, controlling for endogeneity, the effect of exposure to physical, chemical or biological agents is drastically increased. Accounting for differences in safety regulation and innovation of work organization practices, a decrease of exposures to dangerous agents of 1 percent reduces the duration of absence of 41.15 percent. Based on the empirical results presented, any attempt at reducing the exposure to physical, chemical or biological agents on workplace, either ratifying ILO conventions, which ensure a coherent enforcement of laws and regulations, or adopting work organization practices that increase employee involvement, induces, at the same time, a marginal decrease of workplace accident rate and the consequences that occur when workers suffer an occupational injury.

These results are particularly important because they show the existence of a trade-off, for the firm, between the precaution expenditure and the expected cost of a workplace accident. If a workplace accident occurs and the firm is found negligent, the firm has to pay the cost for replacing injured workers and the fine for compensating victims of accidents. Moreover, we may assume that the expected cost of a workplace accident increases either on the probability or on the duration of absence. Indeed, if the probability of accident and the duration of absence increase, the firm has to pay an increasing cost either for the fine, which is related to the seriousness of an injury, or for replacing injured workers. Cost/benefit analysis induces the firm to choose safety expenditure that minimizes the expected cost of a workplace accident. Consequently, government intervention, acting on the expected cost a workplace accident, may play a crucial role in inducing the firm to invest in safety expenditures. Indeed, the government may intervene increasing the monitoring activity of firms, with the purpose of checking the adequacy of their investment for supporting occupational health service. On the other hand, the government may adjust the fines that injurers must pay for compensating the victims of accidents. Both the possible interventions may induce the firm to increase the optimal safety precaution expenditure to reduce the expected cost a workplace accident.

6.3 Safety at work by work qualifications

In this section we focus on the different effects of the safety at work index based on the different qualifications of the workers in the sample. Analyzing separately high-skill and low-skill workers, we provide further evidence of the existence of asymmetries that do not concern exclusively the remunerations but also safety at work. Figure 5 shows how high-skill qualifications are characterized by net monthly income above the median; high-skill workers are distributed especially in the fourth and highest quartile (38% of high-skill workers) and in the third quartile (30%). On the contrary, the majority of workers employed in low-skill qualifications are overrepresented below the median, in the first and lowest quartile (29%) and in the second quartile (30%). Moreover, Figure 6 shows how high-skill qualifications present lower exposures to physical, chemical or biological agents than low-skill qualifications. In particular, high-skill workers in the first and in the fourth quartiles are exposed to the lowest level of exposures to dangerous agents. On the contrary, low-risk workers in the third and fourth quartiles are affected by critically low standards of safety at work.

The empirical analysis is focused on estimating differences in the effect of safety at work index on the probability and the duration of absence because an occupational injury between high-skill and low-skill qualifications.

In Table 7, we present results of probit regressions for the probability of a workplace accident conducted separately by work qualifications and accounting for endogeneity of the safety at work index. Column (1) and (2) show estimates for low-skill workers and high-skill workers, respectively. Comparing results for low-skill and high-skill workers, we find that the marginal effect of safety at work index on the probability of a workplace accident is equal to -1.935 percent for low-skill qualifications, whereas the corresponding effect for high-skill workers is lower and equal to -1.695.

Differences in the effect of the safety at work index are ascribed to the peculiarity of work qualifications. Generally, high-skill qualifications are characterized by high safety standards and the specific involvements of the job do not entail that workers be exposed frequently to physical, chemical or biological agents. Thus, reducing exposures to physical, chemical or biological agents has a limited negative effect on the probability of workplace accident. On the contrary, the exposure to physical, chemical or biological agents may be essential to finalize specific tasks for low-skill workers employed especially in the Manufacturing, Construction and Electricity, Gas and Water Supply sectors. Consequently, a marginal increase in the safety expenditure for reducing exposures to dangerous agents has a stronger effect on the probability of a workplace accident for low-skill individuals, as compared to the effect for high-skill individuals.

Table 7 also presents estimations of a negative binomial regression of the duration of absence because of occupational injuries accounting for endogeneity of the safety at work index: in column (3) and (4) we present results for low-skill individuals and high-skill workers, respectively. Results of negative binomial regressions confirm what revealed by probit estimates of the marginal effect of the safety at work index on the probability of injury for high-skill and low-skill jobs. Focusing on high-skill workers, the safety at work index has a statistically significant effect on reducing the cumulative duration of absence: an increase of 1 percent of the safety at work reduces the duration of absence of 11.04 percent. The corresponding effect for low-skill workers is stronger and equal to -69.42 percent.

Results suggest that a marginal decrease of exposures to dangerous agents, investing in safer technology or introducing innovations in work organization practices, has stronger effects either on the probability or on the duration of absence for low-risk workers, as compared to high-risk qualifications. Differences in the effect of the safety at work index between high-skill and low-skill qualifications confirm that between high-skill qualifications, characterized by better earnings, working constitutions and lower exposures, as compared to low-risk workers.

6.4 Sensitivity analyses

EU15 versus new entrants The existence of differences in the probability and the duration of absence because of a workplace accident among European countries, as shown in descriptive statistics, suggests to test the sensitivity of our results for EU15 countries and for countries that entered in the European Union later, namely in 2004 and 2007.

Table 8 shows differences in the effects of the safety at work on the probability of a workplace injury (column (1) and (2)) and on the duration of absence between EU15 countries and new entrants (column (3) and (4)). Comparing the results of the effect of the probability of workplace accident, we find that the safety at work has a statistically significant and negative effect for workers employed in EU15 countries, whereas this effect vanishes for new entrants. Analysing separately the duration of absence confirms that the safety at work index has a statistically significant and negative effect for workers employed in EU15 countries, whereas it does not affect the duration of absence in new entrants countries.

The lack of significance of the safety at work index in both regressions for those countries that joined the EU later can be explained by differences in knowledge relative to workplace accidents and their consequences. This might induce workers employed in new entrants to report misleadingly information on a workplace accident. Indeed, we may report that differences in the safety at work and workplace accident between EU15 countries and new entrants concern, in particular, the occurrence and the consequences of workplace accidents, which are significantly lower in new entrants; on the contrary, we do not find evidence that there is statistically significant difference in safety at work index.

7 Conclusion

The results revealed in the present analysis are consistent with the theoretical literature in finding that increasing safety at work reduces either the probability or the cumulative duration of absence because of occupational injuries. Our findings suggest that reducing exposures to physical, chemical or biological agents has a negative effect either on the probability or the cumulative duration of absence confirming empirically what assumed by Lanoie (1991). In addition, our analysis sustains that either innovations in work organization practices or more stringent safety regulation, as suggest by Shavell (1983; 1984), affect safety at work reducing exposures to physical, chemical or biological agents.

Investigating the effect of working conditions, we find that working overtime affects positively both the probability and the consequences of a workplace accident; on the other hand, variations in the arrangement of working time do not influence the probability and the duration of absence because of workplace accident. Finally, we report results of the analysis conducted to investigate the asymmetries in safety between low-skilled and high skilled agent. We notice that there exist wide differences either on earning or on risk at work. Results suggest that a marginal decrease of exposures to dangerous agents, investing in safer technology or introducing innovations in work organization practices, has stronger effects either on the probability or on the duration of absence for low-risk workers, as compared to high-risk qualifications.

Performing a sensitivity analysis between EU15 countries and countries that entered in the European Union in 2004 and 2007, we find that results are consistent considering workers employed in EU15 countries. On the contrary, in new entrants, the safety at work does not affect the probability and the duration of a workplace accident.

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A Appendix

A.1 ILO Conventions concerning occupational health and safety

The ratification of ILO Conventions concerning occupational health and safety can be used as a valid proxy to measure the effort of European governments towards avoiding workplace accidents over the last years.

Among the ILO Conventions concerning occupational health and safety, the *Occupational Safety and Health Convention (c.155)*, the *Occupational Health Services Convention (c.161)* and the *Protocol of 2002 to the Occupational Safety and Health Convention (p.155)* gain in importance for their general purpose. Indeed, the Convention 155 prescribes that each member state has to formulate, implement, enforce and periodically review a coherent set of laws and regulations concerning occupational safety, occupational health and the working environment. Moreover, an appropriate system of inspection has to be implemented in order to ensure adequate penalties for violations of the laws and regulations implemented. The Convention 161 advances these arguments mandating that each member state undertakes the development of progressively adequate and appropriate occupational health services for workers who suffer from specific occupational risks. The Protocol 155 ensures that the competent authority shall establish and periodically review requirements and procedures for the recording and the notification of occupational accidents, occupational diseases and dangerous occurrences, commuting accidents and suspected cases of occupational diseases.

In addition, International Labour Organization introduces the *Prevention of Major Industrial Accidents Convention (c.174)* to prevent major accidents involving hazardous substances and to limit the consequences of such accidents. The competent authority has to provide special policies to guarantee occupational health and safety by establishing a system for the identification of major hazard installations, consulting the major organizations of employers and workers, based on a list of hazardous substances and their respective threshold quantities. The *Promotional Framework for Occupational Safety and Health Convention (c.187)* sets the goal of promoting continuous improvement towards progressively achieving a safe and healthy working environment to prevent occupational injuries, diseases and deaths. This goal should be reached by developing national policies, systems and programs inspired by the promotional framework for occupational safety and health set out by ILO Conventions.

Most of the ILO Conventions related to occupational health and safety concern the enforcement of laws and regulations to ensure that any worker does not suffer an occupation accident due to a specific occupational risk. The *Radiation Protection Convention (c.115)* prescribes that all appropriate steps shall be taken to ensure effective protection, to restrict the exposure of workers to ionising radiations to the lowest practicable level and to avoid any unnecessary exposure. The *Benzene Convention (c.136)* provides the safety precautions to guarantee occupational hygiene and the technical measures to ensure effective protection of workers exposed to benzene or to products containing benzene. Moreover, the convention prescribes the replacement of benzene, or products containing benzene, with harmless or less harmful substitute products. According to the *Asbestos Convention (c.162)*, each member state has to prescribe the measures to prevent and protect workers against occupational exposures to asbestos and to review periodically the relative laws and regulations in the light of technical progress and of advances in scientific knowledge. The *Chemical Convention (c.170)* prescribes that each member state has to provide a coherent enforcement of laws and regulations to regulate the use of chemicals on the workplace and that, on safety and health grounds, the competent authority shall restrict the use of certain hazardous chemicals or require advance notification and authorization before such chemicals are used. The prohibition of using white lead, sulphate of lead and all products containing these pigments in the internal painting of buildings, is stressed by the *White Lead (Painting) Convention (c.13)*; exceptions are justified where the use of these products is considered necessary, as in the case of railway stations or industrial establishments. The *Occupational Cancer Convention (c.139)* prescribes that each member state has to periodically list the carcinogenic substances and agents to which workers should not be exposed or which use should be subject to authorization or control. Furthermore, the convention calls for the replacement by non-carcinogenic or less harmful substances of those carcinogenic substances and agents to which workers may be exposed. The *Working Environment (Air Pollution, Noise and Vibration) Convention (c.148)* and the *Hygiene (Commerce and Offices) Convention (c.120)* are implemented to prevent and control occupational hazards related to working environment, such as air pollution, noise and vibration, and to hygiene in the workplace, respectively. The *Maximum Weight Convention (c.127)* prescribes that no worker shall be required to engage in the manual transport of a load which, by reason of its weight, is likely to jeopardise health or safety. The *Guarding of Machinery Convention (c.119)*, on the other hand, sets out the conditions to deal with all machinery, either power-driven or manual, which present a risk of injury to the worker.

Finally, ILO Conventions concerning occupational health and safety call for the enforcement of laws and regulations to avoid occupational accidents in specific labour markets. The *Safety Provisions (Building) Convention (c.62)* and The *Safety and Health in Construction Convention (c.167)* concern the adoption of adequate provisions to preserve safety and health in construction and building work where the probability of serious accident is higher. The *Safety and Health in Mines Convention (c.176)* provides the adequate prescription to prevent any fatalities, injuries or ill health affecting workers which might arise from mining operations. The *Underground Work (Women) Convention (c.45)* prohibits that any female, whatever her age, be employed on underground work in any mine. Lastly, the *Safety and Health in Agriculture Convention (c.184)* prescribes that each member state shall provide a coherent national policy on safety and health in agriculture.

A.2 Data description

Table A2.1: Variables used in the analysis

	Obs.	Mean	Std. Dev.	Min	Max
Dependent Variables					
Workplace accident rate	37147	0,0353	0,1847	0	1
Cumulative duration of absence	1313	25,0731	43,6708	1	365
Explanatory Variables					
Safety at work Index	37147	0,0308	0,9808	-5,1345	0,8171
Working conditions					
Nights worked	37147	0,1877	0,3904	0	1
Evenings worked	37147	0,4607	0,4985	0	1
Sundays worked	37147	0,2877	0,4527	0	1
Saturdays worked	37147	0,4944	0,5000	0	1
More than 10 hours worked	37147	0,3536	0,4781	0	1
Working at high speed	37147	0,4657	0,4988	0	1
Working to tight dealines	37147	0,4703	0,4991	0	1
Personal Characteristics					
Male	37147	0,5102	0,4999	0	1
Age	37147	39,61	11,18	18	65
Age squared	37147	1693,78	907,72	324	4225
Work qualifications					
Managers	37147	0,0797	0,2708	0	1
Professionals	37147	0,1388	0,3457	0	1
Technicians and associate professionals	37147	0,1538	0,3608	0	1
Clerical support workers	37147	0,1465	0,3536	0	1
Service and sales workers	37147	0,1441	0,3512	0	1
Skilled agricultural, forestry and fishery workers	37147	0,0030	0,0546	0	1
Craft and related trades workers	37147	0,1453	0,3524	0	1
Plant and machine operators, and assemblers	37147	0,0755	0,2643	0	1
Elementary occupations	37147	0,1133	0,3169	0	1
Firm-specific Characteristics					
Sector					
Manufacturing	37147	0,1765	0,3813	0	1
Electricity, Gas and Water Supply	37147	0,0133	0,1144	0	1
Construction	37147	0,0707	0,2564	0	1
Wholesale and retail trade; repairs	37147	0,1610	0,3675	0	1
Hotels and resturants	37147	0,0433	0,2036	0	1
Transport and storage	37147	0,0472	0,2121	0	1
Post and Telecommunications	37147	0,0200	0,1399	0	1
Financial Intermediation	37147	0,0377	0,1905	0	1
Real estate, renting and business activities	37147	0,0730	0,2601	0	1
Community Social and Personal Services	37147	0,3573	0,4792	0	1
Size					
Work alone	37147	0,0896	0,2856	0	1
2 - 4 employee	37147	0,1317	0,3382	0	1
5 - 9	37147	0,1327	0,3393	0	1
10 - 49	37147	0,2866	0,4522	0	1
50 - 99	37147	0,1033	0,3043	0	1
100 - 249	37147	0,0930	0,2904	0	1
250 - 499	37147	0,0504	0,2188	0	1
More than 500	37147	0,1877	0,3904	0	1
Injury	37147	0,0798	0,2710	0	1
Countries Variables					
Belgium	37147	0,0551	0,2281	0	1
Czech Rep.	37147	0,0124	0,1105	0	1
Denmark	37147	0,0563	0,2305	0	1
Germany	37147	0,0506	0,2193	0	1
Estonia	37147	0,0097	0,0980	0	1
Greece	37147	0,0486	0,2151	0	1
Spain	37147	0,0500	0,2180	0	1
France	37147	0,0525	0,2231	0	1
Ireland	37147	0,0525	0,2230	0	1
Cyprus	37147	0,0134	0,1148	0	1
Latvia	37147	0,0182	0,1336	0	1
Lithuania	37147	0,0135	0,1155	0	1
Luxembourg	37147	0,0225	0,1482	0	1
Hungary	37147	0,0206	0,1420	0	1

Malta	37147	0,0116	0,1071	0	1
Netherlands	37147	0,0567	0,2312	0	1
Austria	37147	0,0433	0,2035	0	1
Poland	37147	0,0150	0,1217	0	1
Portugal	37147	0,0484	0,2146	0	1
Slovenia	37147	0,0116	0,1070	0	1
Slovakia	37147	0,0190	0,1365	0	1
Finland	37147	0,0526	0,2232	0	1
Sweden	37147	0,0598	0,2371	0	1
UK	37147	0,0513	0,2205	0	1
Bulgaria	37147	0,0181	0,1335	0	1
Croatia	37147	0,0173	0,1304	0	1
Romania	37147	0,0153	0,1229	0	1
Turkey	37147	0,0129	0,1127	0	1
Norway	37147	0,0197	0,1389	0	1
Switzerland	37147	0,0224	0,1481	0	1
Time Variables					
Year 2000	37147	0,4719	0,4992	0	1
Year 2005	37147	0,5281	0,4992	0	1
Instrumantal variables					
Regulation	37147	6,0837	2,8063	1	11
Innovation	37147	0,0021	0,9977	-2,5094	0,9497
Monotonous	37147	0,0028	1,0032	-0,9867	1,7753

Table A2.2: Descriptive statistics

	Workplace accident rate	Duration of absence (in days lost)
Personal Characteristics		
Gender		
Female	0,0241	26,60
Male	0,0462	24,31
Working activity (ISCO)		
High Skill qualifications		
Managers	0,0152	23,31
Professionals	0,0161	19,73
Technicians and associate professionals	0,0240	25,28
Low Skill qualifications		
Clerical support workers	0,0169	24,78
Service and sales workers	0,0413	26,68
Skilled agricultural, forestry and fishery workers	0,0360	6,25
Craft and related trades workers	0,0671	25,66
Plant and machine operators, and assemblers	0,0659	23,58
Elementary occupations	0,0437	26,72
Firm-specific characteristics		
Sector of the main paid job		
Manufacturing	0,0473	23,58
Electricity, Gas and Water Supply	0,0264	29,38
Construction	0,0700	28,55
Wholesale and Retail Trade; Repairs	0,0296	27,74
Hotels and Restaurants	0,0404	22,25
Transport and storage	0,0513	21,28
Post and Telecommunications	0,0404	33,87
Financial Intermediation	0,0100	13,29
Real estate, renting and business activities	0,0240	33,38
Community Social and Personal Services	0,0275	22,83
Size		
Work alone	0,0219	23,00
2 - 4 employee	0,0270	27,52
5 - 9	0,0365	21,66
10 - 49	0,0367	25,28
50 - 99	0,0378	24,70
100 - 249	0,0411	31,57
250 - 499	0,0459	21,36
More than 500	0,0441	23,53

Affect on Injury		
No	0,0281	24,79
Yes	0,1187	25,84
Country		
Belgium	0,0577	26,80
Czech Rep.	0,0065	26,67
Denmark	0,0368	28,06
Germany	0,0702	14,45
Estonia	0,0111	10,05
Greece	0,0127	43,43
Spain	0,0393	24,74
France	0,0476	31,32
Ireland	0,0375	15,34
Italy	0,0208	23,55
Cyprus	0,0161	53,88
Latvia	0,0104	38,86
Lithuania	0,0120	41,50
Luxembourg	0,0479	42,85
Hungary	0,0131	29,00
Malta	0,0325	28,93
Netherlands	0,0276	29,00
Austria	0,0466	19,80
Poland	0,0107	41,33
Portugal	0,0273	49,04
Slovenia	0,0442	20,53
Slovakia	0,0142	46,90
Finland	0,0737	21,23
Sweden	0,0333	24,27
UK	0,0446	12,48
Bulgaria	0,0059	46,25
Croatia	0,0171	36,91
Romania	0,0053	9,33
Turkey	0,0523	15,80
Norway	0,0219	34,50
Switzerland	0,0180	21,13
Working Conditions		
Working at night		
No	0,0322	26,19
Yes	0,0488	21,88
Working in the evening		
No	0,0314	26,30
Yes	0,0399	23,94
Working on Sunday		
No	0,0329	25,30
Yes	0,0414	24,62
Working on Saturday		
No	0,0295	26,41
Yes	0,0413	24,09
More than 10 hours per day		
No	0,0308	26,65
Yes	0,0436	23,04
Working at very high speed		
No	0,0294	25,67
Yes	0,0421	24,60
Working to tight deadline		
No	0,0285	26,33
Yes	0,0431	24,14

Figure 1: Workplace accident rate by safety at work index

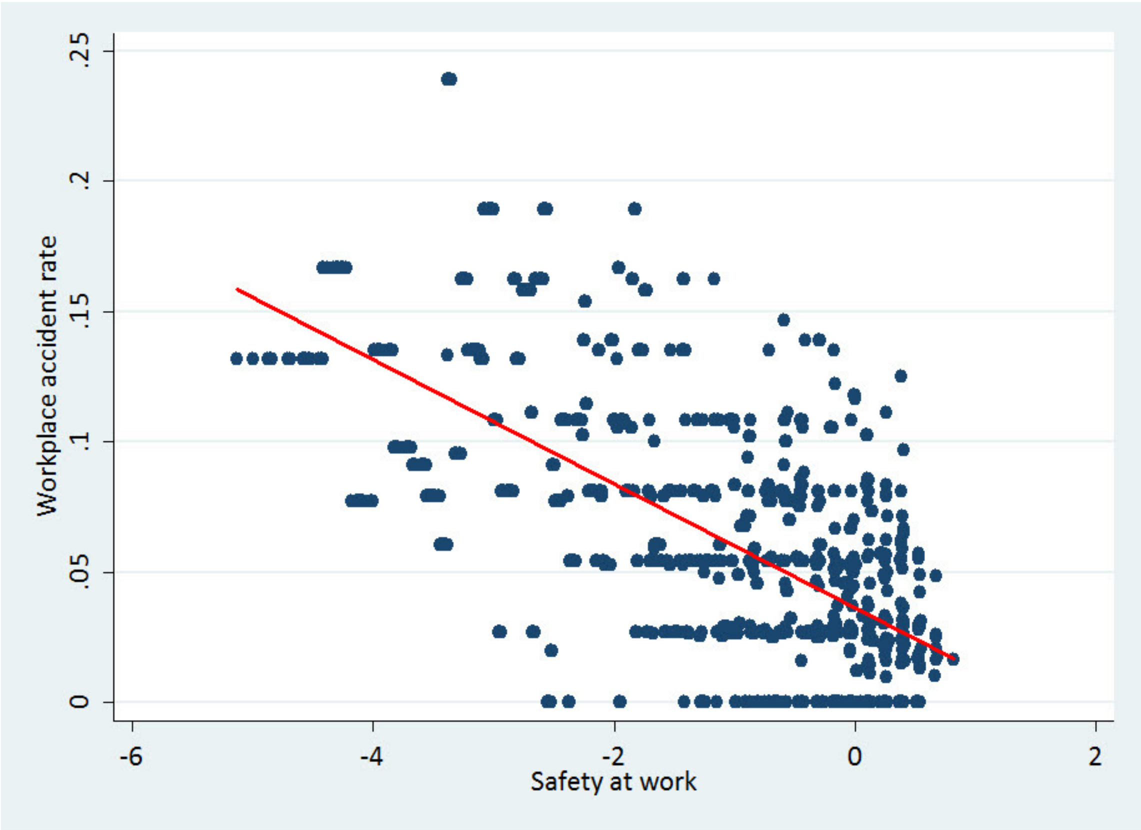

Figure 2: Duration of absence and safety at work index

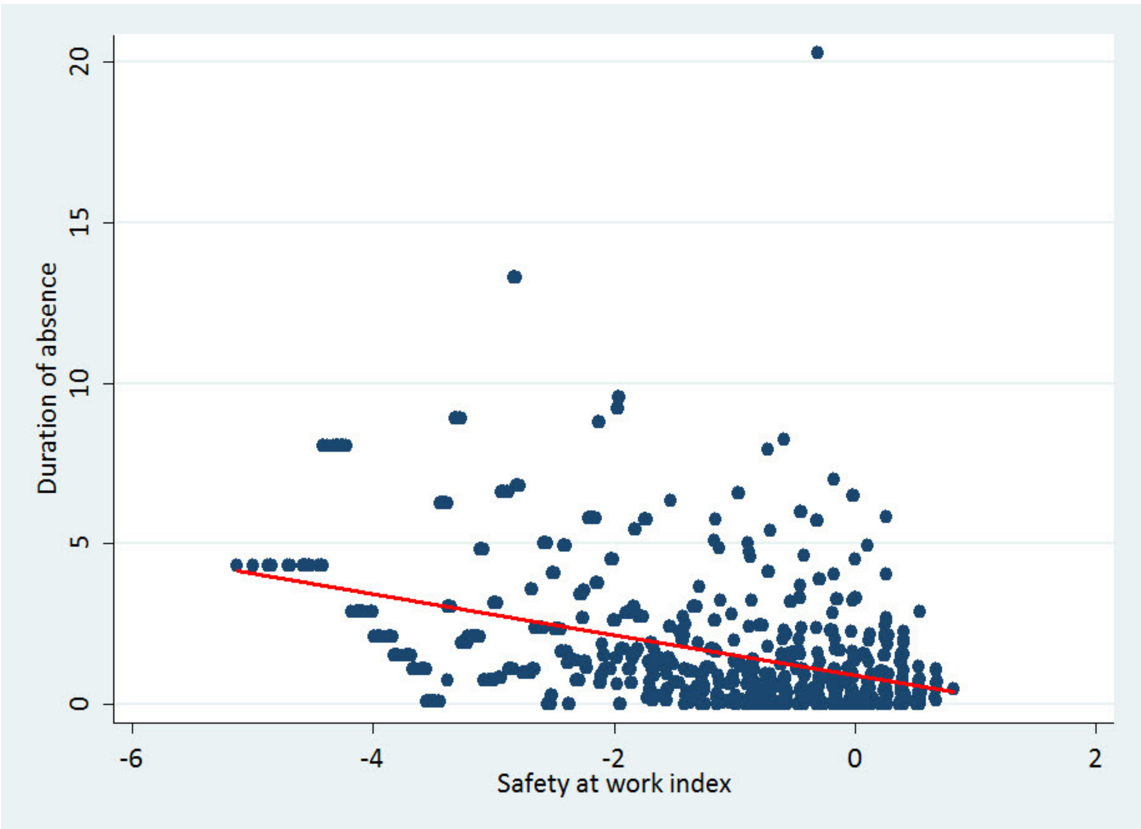

Figure 3: Safety at work index and high-performance work organization

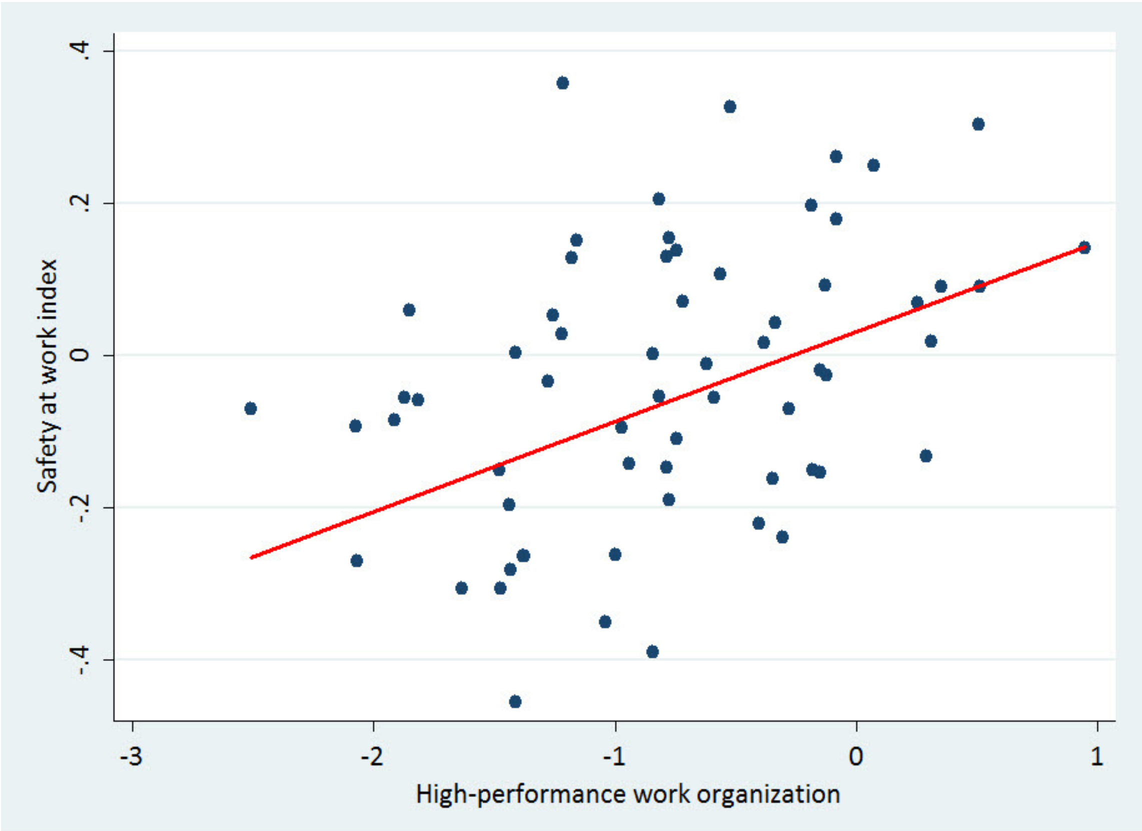

Figure 4: Safety at work index and Taylor's principles of task specialization

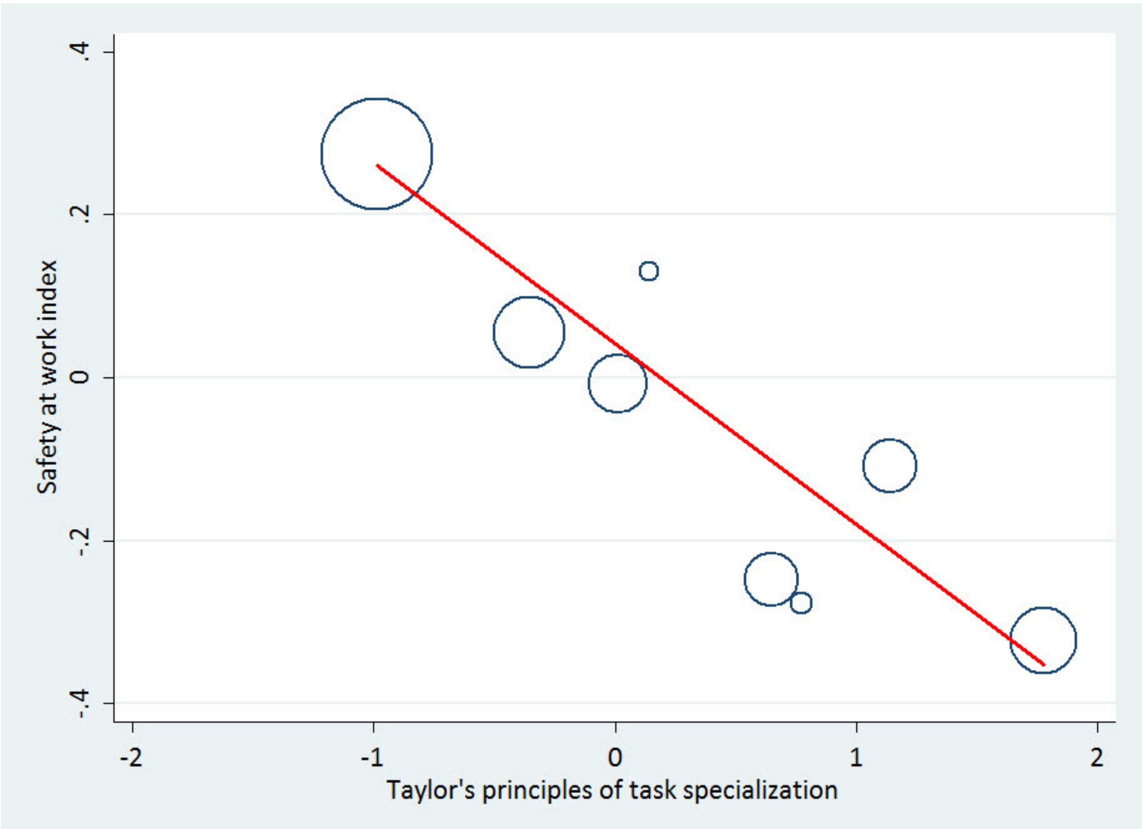

Figure 5: Frequency of high-skill and low-skill qualifications in net monthly income quartiles

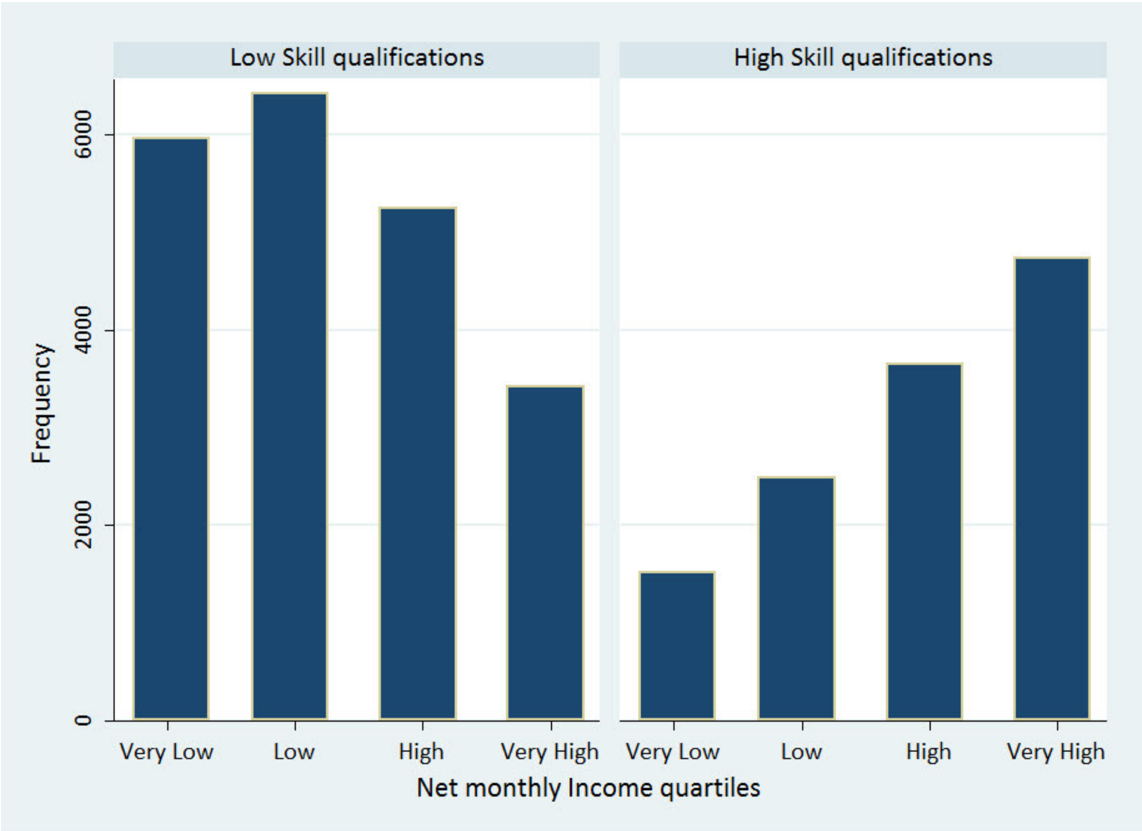

Figure 6: Safety at work for high-skill and low-skill qualifications (by net monthly income quartiles)

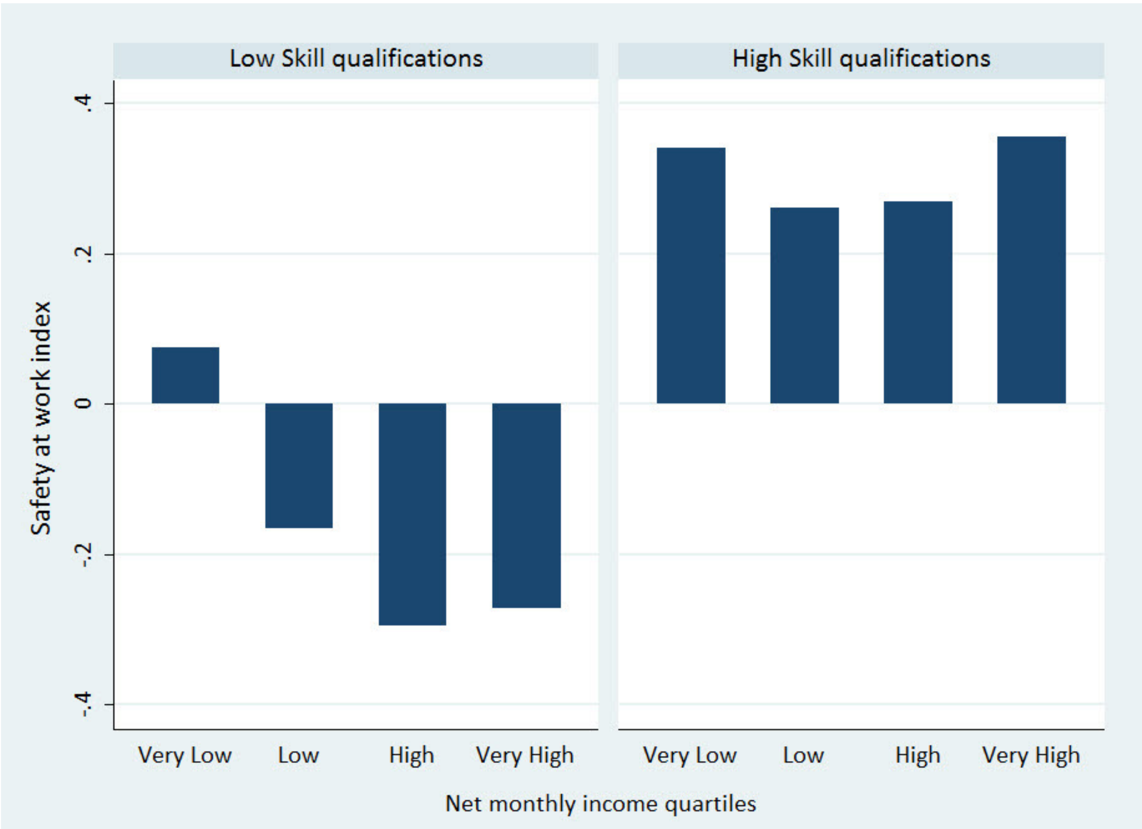

Table 1: Descriptive statistics of exposures to physical, chemical or biological agents

	Vibrations	Noise	High temperatures	Low temperatures	Breathing fumes	Handling chemicals	Radiation
All of the time	0,0497	0,0560	0,0303	0,0183	0,0473	0,0239	0,0090
Almost all of the time	0,0399	0,0526	0,0295	0,0193	0,0394	0,0234	0,0071
Around 3/4 of the time	0,0211	0,0311	0,0211	0,0173	0,0210	0,0135	0,0041
Around half of the time	0,0318	0,0518	0,0506	0,0526	0,0321	0,0229	0,0090
Around 1/4 of the time	0,0616	0,0936	0,0830	0,0862	0,0590	0,0538	0,0208
Almost never	0,1191	0,1708	0,1725	0,1747	0,1200	0,1329	0,0803
Never	0,6768	0,5441	0,6130	0,6317	0,6813	0,7296	0,8699

Table 2: Estimated marginal effects of safety at work and working conditions from the probability of workplace accident equation

Specification	(I)		(II)		(III)	
Safety at work	-0,0141	***	-0,0098	***	-0,0062	***
	(0,0007)		(0,0007)		(0,0007)	
Nights worked	0,0028		0,0004		-0,0011	
	(0,0023)		(0,0021)		(0,0020)	
Evenings worked	-0,0016		-0,0003		-0,0002	
	(0,0019)		(0,0018)		(0,0017)	
Sundays worked	0,0011		0,0030		0,0018	
	(0,0022)		(0,0021)		(0,0020)	
Saturdays worked	0,0056	***	0,0032	*	0,0034	**
	(0,0019)		(0,0018)		(0,0018)	
More than 10 hours worked	0,0059	***	0,0073	***	0,0069	***
	(0,0018)		(0,0018)		(0,0017)	
Working at high speed	0,0014		0,0009		0,0002	
	(0,0018)		(0,0017)		(0,0016)	
Working to tight deadlines	0,0014		0,0020		0,0012	
	(0,0018)		(0,0017)		(0,0016)	
Personal Characteristics	No		Yes		Yes	
Firm-specific Characteristics	No		No		Yes	
Time Effect	Yes		Yes		Yes	
Country effect	Yes		Yes		Yes	
Log pseudolikelihood	-5130,0513		-5042,2270		-4904,7562	
N° observations	37147		37147		37147	

Note: * Significant at 0.100; ** Significant at 0.50; Significant at 0.01. Standard errors are in parentheses

Table 3: Estimated marginal effects of safety at work and working conditions from the cumulative duration of absence because of workplace accidents equation

Specification	(I)		(II)		(III)	
Safety at work	-0,3938	***	-0,2864	***	-0,1239	***
	(0,0350)		(0,0323)		(0,0500)	
Nights worked	-0,0920		-0,1594	***	0,0392	***
	(0,0805)		(0,0609)		(0,0573)	
Evenings worked	-0,0189		0,0658		0,2202	
	(0,0843)		(0,0733)		(0,0853)	
Sundays worked	0,2531	**	0,3144	***	-0,0190	***
	(0,1164)		(0,1121)		(0,0606)	
Saturdays worked	0,1617	*	0,0249		0,1449	
	(0,0908)		(0,0739)		(0,0635)	
More than 10 hours worked	0,0630		0,1581	**	0,0554	***
	(0,0778)		(0,0764)		(0,0550)	
Working at high speed	0,0145		0,0163		-0,0649	
	(0,0735)		(0,0641)		(0,0519)	
Working to tight deadlines	-0,0465		-0,0298		-0,1572	
	(0,0701)		(0,0628)		(0,0267)	
Personal Characteristics	No		Yes		Yes	
Firm-specific Characteristics	No		No		Yes	
Time Effect	Yes		Yes		Yes	
Country effect	Yes		Yes		Yes	
Log pseudolikelihood	-10961,5750		-10903,9080		-10839,3460	
N° observations	37147		37147		37147	

Note: * Significant at 0.100; ** Significant at 0.50; Significant at 0.01. Standard errors are in parentheses

Table 4: Estimated coefficients of instrumental variables from the safety at work equation

	Safety at work	
Safety regulation	0,0030	**
	(0,0015)	
High-performance work organization	0,0300	***
	(0,0047)	
Taylor's principles of task specialization	-0,1149	***
	(0,0045)	
Personal Characteristics	Yes	
Firm-specific Characteristics	Yes	
Working conditions	Yes	
Year Effect	Yes	
Adj R-squared	0,36480	
N° observations	37147	

Note: * Significant at 0.100; ** Significant at 0.50; Significant at 0.01. Standard errors are in parentheses

Table 5: Estimated marginal effects of safety at work and working conditions from the probability of workplace accident equation – Exogenous versus Endogenous safety at work index specifications

	Exogenous safety at work		Endogenous safety at work	
Safety at work	-0,0062	***	-0,0185	***
	(0,0007)		(0,0078)	
Nights worked	-0,0011		-0,0027	
	(0,0020)		(0,0022)	
Evenings worked	-0,0002		-0,0002	
	(0,0017)		(0,0018)	
Sundays worked	0,0018		0,0019	
	(0,0020)		(0,0021)	
Saturdays worked	0,0034	**	0,0028	*
	(0,0018)		(0,0019)	
More than 10 hours worked	0,0069	***	0,0069	***
	(0,0017)		(0,0018)	
Working at high speed	0,0002		-0,0022	
	(0,0016)		(0,0023)	
Working to tight deadlines	0,0012		-0,0007	
	(0,0016)		(0,0021)	
Personal Characteristics	Yes		Yes	
Firm-specific Characteristics	Yes		Yes	
Time Effect	Yes		Yes	
Country effect	Yes		Yes	
Log pseudolikelihood	-4904,7562		-48224,3620	
N° observations	37147		37147	

Note: * Significant at 0.100; ** Significant at 0.50; Significant at 0.01. Standard errors are in parentheses. Wald test of exogeneity (/athrho = 0): chi2(1) = 3.23 Prob > chi2 = 0.0725. Test of overidentifying restrictions (Amemiya-Lee-Newey minimum chi-sq statistic): 3.163 Chi-sq(2); P-value = 0.2057

Table 6: Estimated marginal effects of safety at work and working conditions from the cumulative duration of absence because of workplace accidents equation – Exogenous versus Endogenous safety at work index specifications

	Exogenous safety at work		Endogenous safety at work	
Safety at work	-0,1239	***	-0,4116	**
	(0,0500)		(0,2108)	
Nights worked	0,0392	***	-0,1465	***
	(0,0573)		(0,0567)	
Evenings worked	0,2202		0,0422	
	(0,0853)		(0,0576)	
Sundays worked	-0,0190	***	0,1739	**
	(0,0606)		(0,0834)	
Saturdays worked	0,1449		-0,0413	
	(0,0635)		(0,0623)	
More than 10 hours worked	0,0554	***	0,1689	***
	(0,0550)		(0,0664)	
Working at high speed	-0,0649		0,0389	
	(0,0519)		(0,0724)	
Working to tight deadlines	-0,1572		-0,0971	
	(0,0267)		(0,0623)	
Personal Characteristics	Yes		Yes	
Firm-specific Characteristics	Yes		Yes	
Time Effect	Yes		Yes	
Country effect	Yes		Yes	
Log pseudolikelihood	-10839,3460		-10851,3880	
N° observations	37147		37147	

Note: * Significant at 0.100; ** Significant at 0.50; Significant at 0.01. Standard errors are in parentheses

Table 7: Estimated marginal effects of safety at work and working conditions from the probability and the cumulative duration of absence because of workplace accidents equations – High-Skill qualifications versus Low-Skill qualifications

	Probability of a workplace accident		Duration of absence	
	Low skill jobs	High skill jobs	Low skill jobs	High skill jobs
Safety at work	-0,0193 *	-0,0169 *	-0,6943 **	-0,1104 **
	(0,0116)	(0,0098)	(0,3484)	(0,0528)
Nights worked	-0,0023	-0,0039 *	-0,1485 *	-0,0536 ***
	(0,0034)	(0,0026)	(0,0995)	(0,0127)
Evenings worked	0,0011	-0,0023	-0,0504	0,0168
	(0,0027)	(0,0023)	(0,0908)	(0,0165)
Sundays worked	-0,0009	0,0065 **	0,1278	0,0636 ***
	(0,0031)	(0,0031)	(0,1252)	(0,0270)
Saturdays worked	0,0054 **	-0,0013	0,0635	-0,0051
	(0,0027)	(0,0027)	(0,1014)	(0,0174)
More than 10 hours worked	0,0087 ***	0,0049 **	0,3666 ***	0,0261 *
	(0,0028)	(0,0023)	(0,1141)	(0,0149)
Working at high speed	-0,0036	-0,0004	-0,1131	0,0135
	(0,0038)	(0,0024)	(0,1229)	(0,0169)
Working to tight deadlines	0,0005	-0,0020	-0,2543 **	-0,0152
	(0,0032)	(0,0025)	(0,1169)	(0,0152)
Personal Characteristics	Yes	Yes	Yes	Yes
Firm-specific Characteristics	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Log pseudolikelihood	-32767,0970	-14055,0760	-8461,0791	-2301,2631
N° observations	23316	13218	23316	13831

Note: * Significant at 0.100; ** Significant at 0.50; Significant at 0.01. Standard errors are in parentheses

Table 8: Estimated marginal effects of safety at work and working conditions from the probability and the cumulative duration of absence because of workplace accidents equations – EU15 countries versus new entrants

	Probability of a workplace accident		Duration of absence	
	EU15	New entrants	EU15	New entrants
Safety at work	-0,0301 ***	0,0122	-0,6736 **	-0,0050
	(0,0112)	(0,0199)	(0,3114)	(0,0113)
Nights worked	-0,0041	0,0023	-0,2683 ***	0,0022
	(0,0032)	(0,0044)	(0,0827)	(0,0036)
Evenings worked	0,0007	-0,0014	0,1040	-0,0039 *
	(0,0025)	(0,0033)	(0,0886)	(0,0023)
Sundays worked	0,0009	0,0044	0,2683 **	-0,0036 **
	(0,0030)	(0,0049)	(0,1325)	(0,0020)
Saturdays worked	0,0038	-0,0012	-0,0227	-0,0039 *
	(0,0026)	(0,0031)	(0,0933)	(0,0025)
More than 10 hours worked	0,0090 ***	0,0062	0,1891 **	0,0174 ***
	(0,0026)	(0,0060)	(0,0977)	(0,0058)
Working at high speed	-0,0041	0,0071	0,0075	0,0242 **
	(0,0032)	(0,0088)	(0,1054)	(0,0116)
Working to tight deadlines	-0,0020	0,0003	-0,1097	-0,0150 ***
	(0,0031)	(0,0025)	(0,0934)	(0,0039)
Personal Characteristics	Yes	Yes	Yes	Yes
Firm-specific Characteristics	Yes	Yes	Yes	Yes
Time Effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
Log pseudolikelihood	-36339,9740	-8087,3788	-9354,5893	-851,9671
N° observations	27835	6295	27835	6627

Note: * Significant at 0.100; ** Significant at 0.50; Significant at 0.01. Standard errors are in parentheses