The economic consequences of accidents at work

Abstract

This paper investigates the economic consequences of workplace accidents for workers in the UK labour market using data from the British Household Panel Survey (BHPS). Exploiting fixed effect estimators to control for time-invariant unobserved characteristics, we provide evidence supporting the hypothesis that following an accident at work both job opportunities and workers' earnings are negatively impacted. A state of injury reduces job opportunities in the short term, and this effect persists over time. For private sector non-unionized workers, a serious workplace accident is also associated with significant earnings losses, increasing in the accident's gravity, in the long term. In light of this evidence, high job and earnings protection and injured workers' rights contribute to reducing wage penalties for workers who suffered from accidents. Moreover, earnings losses may be reduced moving to a new job that better fits the worker's post-injury abilities.

1. Introduction

Accidents at work are random events that negatively affect the health status of workers involved, who will likely face illnesses, disabilities and, in the most serious cases, death. The majority of workplace accidents result in minor cuts, lacerations, contusions or bruising which entail only limited consequences for the workers' health status[1]. In more serious cases, however, workers suffer from long-term health problems or permanent disabilities. In these cases, they face both direct and indirect costs. Direct costs are related to the medical and rehabilitation care required to recover from minor health problems or to treat long-term illness and disabilities. Indirect costs can be measured in terms of a higher probability of unemployment, most likely resulting from a reduced ability to work in heavy duty jobs or for long hours. Moreover, accidents can also have effects later in the workers' life cycle, resulting in decreasing opportunities for promotion and earnings losses due to lower productivity.

This paper estimates the economic costs that accidents at work may entail for injured workers by focusing on labour market outcomes both in the short and in the long term. The empirical analysis is motivated by a general lack of evidence with respect to the economic consequences of an accident at work in the UK market, a topic largely ignored by the empirical literature on risk at work and occupational accidents. The evidence we provide highlights the presence of labour market failures which do not result in adequate compensation for injured workers. This may justify government interventions with an incentive compatible regulation aimed at minimizing costs associated with a workplace accident.

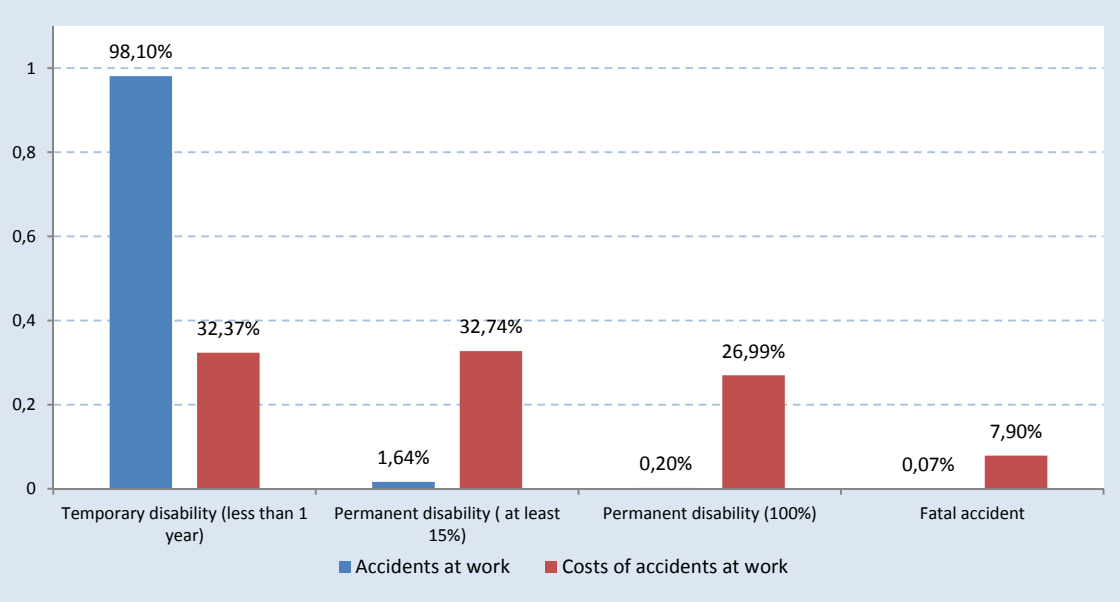
Although the costs resulting from occupational injuries are generally supported by the victim of an accident, the employer and society at large may also face significant losses. For the employer, an accident results in financial expenditures, damages and loss of resources that can be difficult to monetize. Costs are particularly high in the case of serious accidents. According to Eurostat (2004), minor occupational injuries represent the majority of all accidents at work but they account for only one third of total labour costs borne by the employers (Figure 1).[2] Conversely, more serious accidents represent relatively rare events but account for the largest share of total labour costs[3].

[1] Statistics by Eurostat (2007) indicates that prolonged sick leave (one month or more) was reported by 22 percent of workers who suffered an accident at work. In addition, only 1.8 percent of injuries entail disabilities for more than one year following the accident (Eurostat, 2004).

[2] In the EU, 98 percent of all accidents are classified as minor and accounts for 32.4 percent of total labour costs.

[3] Serious accidents represent relatively rare events: 1.6 percent of total accidents entail a 15 percent disability level, 0.2 percent result in 100 percent disability and 0.1 percent a fatal injury. Notwithstanding, they account for the largest part of the total labour costs: injuries that lead to 15 percent of disability account for 32.7 percent of the total labour costs, 100-percent of disability for 27 percent and fatal accidents for 8 percent. These statistics highlight the importance, in terms of labour costs, of accidents leading to long lasting or permanent injuries and to fatal consequences (Eurostat, 2004).

Figure 1: Distribution of accidents at work (resulting in more than 3 days of absence from work) and the incidence of each health consequence on the total of the labour costs supported by the firms.



Source: Eurostat (2004)

Despite the considerable economic consequences of an accident at work, the empirical literature has focused on estimating the value of statistical life (See Viscusi and Aldy, 2003, for a survey), on evaluating trade-offs between money and fatality risks for insurance companies and governments (Brown, 1980; Garen, 1988; Hamermesh, 1999; and Hwang, Reed and Hubbard, 1992) and on investigating the determinants of an accident at work, relatively to the impact of socio-demographic characteristics and of firm and job attributes. Conversely, only few studies deal with the consequences of accidents at work in US and New Zealand labour markets (Reville and Schoeni, 2001; Crichton, Stiliman and Hyslop, 2005; Boden and Galizzi, 2003a) and none of them is focused on estimating the costs of accidents at work in EU countries. This paper thus fills an important gap in the literature, focusing on the UK labour market.

Several examples of the negative relationship between injury due to a workplace accident and labour market outcomes can be found in the theoretical literature (Reville and Schoeni, 2001). While recovering, an injured worker might experience a reduction in human capital with respect to non-injured workers. Fewer employment opportunities and higher loss in job-specific human capital may result in earnings differences. This is particularly true if the employer and the local labour market cannot offer alternative jobs that fit worker's reduced abilities. Workers may also experience a loss in labour productivity if injuries result in fewer tasks accomplished, imprecise and unsatisfactorily outcomes or lower probability of reaching specific targets defined by pay-for-performance mechanisms. Moreover, moving from particularly risky jobs to safer activities, as a consequence of workplace accidents, may entail larger wage gaps due to losing compensating wage differentials assigned to compensate occupational risks. Finally, employment probabilities might be lower as a result of employers' discrimination against injured workers, such as refusal to offer employment opportunities to victims of accidents.

This paper offers three main contributions to the literature on risk at work and occupational accidents. First, we provide an empirical analysis of the economic consequences of serious occupational accidents on the UK labour market outcomes using the 1991-2007 waves of the British Household Panel Surveys. In particular, we exploit information on whether a worker receives the *Industrial Injuries Disablement Benefit (IIDB)*, a state aid for workers who are injured following a workplace accident. The main advantage of using the *IIDB,* rather than workers' self-reported assessments, consists of a significant reduction of measurement errors associated with identifying the nature and seriousness of an accident at work which naturally characterize self-reported workers' data. Second, we estimate the short-term and the long-term effects of a state of occupational injury using fixed effect estimators which control for workers' time invariant unobserved heterogeneity. The aim of our analysis is to highlight the economic costs of an occupational accident for the worker and to estimate their magnitude. To this end, we focus on employment probabilities and earnings losses for those injured workers who are still employed after an occupational accident. Finally, we argue that the effect of an occupational accident is heterogeneous across socio-economic groups of workers and across firms. In particular, we distinguish between injured workers on the basis of how personal characteristics (such as gender and age) affect employment probabilities and earning losses. With respect to firms, we analyse how wage penalties may vanish in firms where job and earnings protection are higher, such as in the public sector and in firms characterized by the presence of trade unions.

The paper is organized as follows. In Section 2 we present the institutional background on occupational health and safety regulations in the UK; in Section 3 we review the relevant literature on risk at work and workplace accident; Section 4 presents the dataset description and descriptive statistics; in Section 5 we introduce the empirical issues linked with estimating the effects of injury on labour market outcomes; Section 6 provides our results; in Section 7 we discuss how results may vary according to differences in socio-economic characteristics and firm and job attributes and concluding remarks follow.

2. The UK Occupational Health and Safety Regulation

In this Section, we present the main characteristics of UK institutional background focusing, in particular, on the provisions enacted with the aim of ensuring adequate compensations to injured workers. Government interventions to regulate occupational health and safety is necessary to guarantee less risk averse party, which is typically the employer, bears economic costs of a workplace (Shavell, 2007, for a survey). The economic consequences of an accident at work in the UK labour market can be appropriately analysed only by highlighting the main features of the institutional framework. In fact, variations in insurance systems and in work injury programmes may significantly alter the consequences of a workplace accident on labour market outcomes. For the purpose of our analysis, not appropriately accounting for the presence of state aid for injured workers may lead to overestimating the negative effects of accidents on employment probabilities whenever the

policy influences significantly the choice of not returning to work[4]. Conversely, the existence of such benefits may lead to underestimating earnings losses whenever injured workers can accept lower wages as a result of additional state compensations.

The UK occupational health and safety legislation is defined by the *Health and Safety at Work (HSW) Act* of 1974 and its subsequent amendments. These amendments were inspired by the *European Framework Directive 89/391* and by the *Management of Health and Safety and Work Regulations*, implemented in 1999. The fundamental principle defined by the *HSW Act* is the primary responsibility of the employer in assessing workplace risks, in adopting all appropriate measures and practices to avoiding them and in providing adequate occupational health services. When an occupational accident occurs, the employer is required to report injuries, diseases and dangerous occurrences in an *accident book* and to notify them to the *Health and Safety Executive* or to the local authorities. The *accident book* should contain all the detailed information on occupational accidents resulting in death or injuries that prevent workers from carrying out their normal work for more than three days.

When an accident at work occurs and the worker needs time off to recover, she is entitled to a sick pay provided by the employer. The employer can decide to arrange a discretional company sick pay scheme or to guarantee the *Statutory Sick Pay (SSP)*, which represents the legal minimum and is paid by the employer on behalf of the government[5]. If the worker suffers a physical injury and/or a mental disorder as a result of the non-compliance of the employer with respect to the duties highlighted in the *HSW Act*, she can claim for additional compensation on top of the sick pay mentioned above. Since the employer is legally responsible for health and safety at work, the worker can request that the employer pay an indemnity to compensate her injury. Employers' liability insurance, which is compulsory according to the *Employers' Liability (Compulsory Insurance) Act* of 1969, covers all the costs of claims for compensation related to relevant accidents at work: the insurer will pay the full amount of any compensation agreed between employers and employees or awarded to employees by a court.

The occurrence of a particularly serious occupational injury also allows the worker to claim for the *Industrial Injuries Disablement Benefit (IIDB)*. The *IIDB* is provided by the state with the aim to cover any costs for injuries resulting from accidents at work. The amount of the allowance granted to the worker is strictly dependent on the health consequences of the workplace accident. The nature and the seriousness of an occupational injury are determined, respectively, by the *Department for Work and Pensions* (*DWP*) with the *accident declaration*, and by a qualified doctor through an assessment of disability[6]. The *accident declaration*

[4] According to Boden and Galizzi (2003a), an injured worker may decide not to return to work in presence of significant state aid, especially whenever the accident is particularly serious and may lead to a significant reduction of potential earnings.

[5] UK work injury programmes are described in details on the *Directgov* website (http://www.direct.gov.uk).

[6] For the worker to receive the benefit, the *DWP* has to rule wither the accident can be considered an industrial accident. This is done by acquiring information from the *accident book* and, if necessary, requesting more details from the employer. When the *DWP* approves the *accident declaration*, thus

certifies whether the injury can be considered by law as an industrial accident. The medical examination certifies how serious the disability of the worker is and for how long the worker will be unable to work. The total revenue obtained from this claim by the worker is the product of the number of weeks needed to recover the pre-injury health status and the valuation of the disability, with a minimum qualifying disability of 14 percent[7]. In the case of temporary injury, at the end of the period covered by the allowance, the worker can ask for a renewal if the injury is still not resolved.

Other benefits available to the inured employees are the *Reduced Earnings Allowance (REA)*, assigned when the employee cannot do her usual job or other work with similar pay because of a disease or an injury caused by the job; the *Constant Attendance Allowance (CAA)* and the *Exceptionally Severe Disablement Allowance (ESDA)*, provided to employees who receive the *IIDB* at the 100 percent rate and need daily care and attention; the *Analogous Industrial Injuries Scheme (AIIS)*, paid exclusively to trainees who have an accident during a work-based training programme and, consequently, are not entitled to receiving *IIDB*.

In addition to financial aid for injured workers, the British government enacted the *Disability Discrimination Act* with the aim of avoiding any form of discrimination against injured workers in terms of employment. The *Disability Discrimination Act* guarantees that the employers do not discriminate injured individuals when offering an employment, through any arrangement, term of contract or deliberate refusal and that injured workers are granted the same on-job opportunities in terms of promotions, transfers, training programs and other benefits.

3. Literature review

Notwithstanding the great attention attributed in recent years to estimating the value of statistical life (see Viscusi and Aldy, 2003, for a survey) and to studying compensating wage differentials for risk at work (Brown, 1980; Garen, 1988; Hamermesh, 1999; and Hwang, Reed and Hubbard, 1992), only few contributions (Reville and Schoeni, 2001; Crichton, Stiliman and Hyslop, 2005; Boden and Galizzi, 2003b) deal with the issue of investigating how occupational injuries affect labor market outcomes, both in terms of earnings losses and employment opportunities.

The majority of the empirical literature on risk at work and occupational accidents is focused on the determinants of accidents at work, addressing two questions. First, a number of contributions study how workers' socio-demographic characteristics, as gender and citizenship, affect the rates of workplace accidents (Hersch, 1998; Leeth and Ruser, 2006; and Leombruni et al., 2009; Berger and Gabriel, 1991; Hamermesh, 1998; and Bauer et al., 1998).

confirming that the accident is due to work activities, the employee is entitled to receive, through *Job Centre Plus*, an allowance increasing in the seriousness of the injury, which is assessed by a qualified doctor.

[7] Injured workers are entitled to the benefit after the first 15 weeks of disability following an accident, independently of the moment in which the *IIDB* is certified.

Moreover, DeLeire and Levy (2004) and Grazier and Sloane (2006) investigate job sorting according to risk at work finding that occupational injury rates vary according to gender and family composition. Schaffner and Kluve (2007) show that part of gender wage differentials is explained by occupational segregation, which is in turn ascribable to gender differences in aversion to risk at work.

Second, an extensive literature investigates how firm and job characteristics impact the probability of accident. Some of the research questions addressed relate to the relationship between unionization and workplace accident rate (Litwin, 2000; Baugher and Roberts, 1999; and Fenn and Ashby, 2004); the existence of a pure "contractual effect" against workers employed with fixed term contracts (Guadalupe, 2003; Amuedo and Dorantes, 2002; Hernanz and Toharia, 2004; and Williamson et al., 2009); the relationship between working time and occupational accidents (Wilkins, 2004); how innovative work organization practices affect the occurrence of an accident at work (Fairris and Brenner, 2001; Brenner, Fairris and Ruser, 2004; Askenazy, 2001; and Askenazy and Caroli, 2006); and the relationship between macroeconomic conditions and cyclical fluctuations of the rate of occupational injuries (Ruhm, 2000; and Boone and van Ours, 2006; Boone et al., 2011).

Notwithstanding the extensive number of papers dealing with these issues, the empirical results are generally incomplete and not exhaustive due to three main reasons. First, the research questions are extremely heterogeneous and not very focused on testing the findings of the theoretical literature. Second, cross-country data availability is scarce, not allowing comparisons aimed at highlighting differences between countries. Third, endogeneity and selection problems are often not accounted for in cross-sectional studies and the lack of longitudinal dataset does not allow controlling for time-invariant unobserved heterogeneity that might lead to inconsistent estimates.

The most relevant strand of literature with respect to the research questions addressed in our analysis concerns the consequences of an accident at work. Investigating the return to work after a workplace accident in the US labour market, Boden and Galizzi (2003a) do not find robust evidences supporting the hypothesis that after-tax earnings, which may change the magnitude of income replacement, is a valid incentive to reduce the duration of absence from work. The authors show that time off work 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.

One of the major shortcomings in the literature is the absence of any studies investigating how occupational injuries affect labour market outcomes, in terms of earnings losses and employment opportunities, in EU labour market. With respect to the US labour market[8], Reville and Schoeni (2001), study the economic consequences of the *Permanent*

[8] The authors use a unique dataset obtained matching *1989 - 1995 Uniform Statistical Reporting Plan (USR)* database from the *Workers' Compensation Insurance Ratings Bureau (WCIRB)* with *Base Wage* file from the *State of California Employment Development Department (EDD)*

Partial Disabilities (PPD) finding significant earnings losses for injured workers (around 25 percent of earnings) four to five years after a serious occupational accident. The impact of injury on earnings losses is largely explained by a decrease of employment rate. Analyzing the determinants of earnings losses, the authors find a positive correlation with the severity of a workplace accident. Crichton, Stiliman and Hyslop (2005) use data on the New Zealand labour market[9] and show that injury duration and earnings losses are strongly correlated, without any decline of effects of longer-duration injuries over the first 18 months after leaving the insurance system. Their results indicate that employment rate and total income for injured workers are, respectively, 20 and 25 percent lower than for non-injured workers. Inspecting the US labour market, Boden and Galizzi (2003b) find significant differences in earnings losses between gender, especially in the long term (namely from three to sixteen quarters after injury). Using Blinder-Oaxaca Neumark decomposition, they show that employment and injury characteristics do not contribute to explaining gender differences in earnings losses. Half of gender gap in the long term is explained by higher probabilities of job loss for working women; while the rest is unexplained.

4. Data and descriptive statistics

The empirical analysis we present is based on an unbalanced panel from the British Household Panel Survey (BHPS), which provides information about every adult member of UK households from 1991 through 2007. For the scopes of our analysis, we restrict the sample to individuals aged 16-65 and eligible for work[10]. Our sample is thus composed of 24,901 individuals in 17 BHPS waves, for a total of 113,773 observations. Since accidents at work are rare shocks, we have to choose a large longitudinal dataset with many observations for a long time span, such as BHPS, to investigate their consequences both in the short and in the long term. In addition, relevant for our analysis, the questionnaire provides information on labour market outcomes.

We identify the effects of an occupational accident on labour market outcomes focusing both on variations in employment probabilities and on differences in earnings between injured and non-injured workers. The dependent variable used to analyse of employment probabilities is the dummy variables E, which is equal to 1 if the worker is employed at the time of the interview and to 0 otherwise. In our sample, employment rate is almost constant over time and around 78 percent[11].

Conversely, to estimate earnings losses caused by an occupational accident, we use the logarithm of hourly wage (ln_yhrl) as dependent variable. This variable is constructed using information on annual labour income and hours normally worked per week. We use the

[9] The authors use *1999 – 2004 New Zealand accident insurance system (ACC)*, together with data on earnings compensation provided by *Statistics New Zealand's (SNZ) Linked Employer-Employee Database.*

[10] We exclude full time students, individuals on maternity leave, involved in family care and in governmental training programmes.

[11] Our rate is slightly higher than aggregate statistics presented by UK Office for National Statistics.

hourly wage to eliminate any effects related to variations in working hours that could result whether the accident leads to a period of absence from work[12]. When focusing on earnings losses, we restrict our sample to individuals that are employed in time t and for which the variable (ln_yhrl) is observed. This sub-sample is composed of 15,022 individuals, for a total of 83,459 observations[13]. Mean hourly wage ranges from £ 6 (the first wave, 1991) to over £ 10.9 (2007, the last wave)[14].

To estimate the effect of an occupational accident on labour market outcomes it is necessary to correctly evaluate the nature and the seriousness of a workplace accident. Measurement problems in this respect usually characterize workers self-reported data. The problem is particularly important for minor occupational accidents leading to small and unsubstantial economic consequences. To minimize measurement error, we use information on whether a worker receives the *Industrial Injury Disablement Benefit (IIDB)*[15]. The *IIDB* consists in a significant reduction of measurement errors associated with identifying the nature and seriousness of an accident at work, with respect to workers' self-reported assessments, because the injury is certified by the *accident declaration* and assessed by a qualified doctor. A dummy variable is constructed indicating whether the worker was injured due to an occupational accident and, as a consequence, was received the *IIDB* in the previous 12 months. In addition, since we are interest in the long term consequences on the labour market outcome, we also introduce the lagged values of this variable, which capture whether the worker experienced a state of injury following an occupational accident in the five years before the interview (from time $t-1$ to time $t-4$).

Descriptive statistics presented in Table 1 suggest that a state of injury following a serious occupational accident has a negative impact on the probability of employment. Injured individuals seem to experience reduced job opportunities either in the short term (52.27 percent and 78.13 percent are respectively the employment rate of injured and non-injured individuals at time t) or in the long term. Indeed, disparities seem to increase over time, as shown by differences in employment rates between injured and non-injured individuals when we refer to injuries suffered in the previous periods and by in transition probabilities that highlight low probabilities of being re-employed among injured workers.

Focusing on effects of a workplace injury on earnings, the stylized facts presented in Figure 2 show that the hourly wages of workers injured at the time t are only 2.3 percent

[12] To check the sensitivity of our analysis to the definition of the income variable and to test the validity of our findings, in the subsection related to the robustness check, we perform various estimations using different definitions of earnings.

[13] We exclude non-employed individuals and workers without a labour contract. In addition, we eliminate the outliers in term of hours worked restricting the sample to individuals that work between 10 and 60 hours per week.

[14] Mean hourly wages are in line with the aggregate statistics provided by *Annual Survey of Hours and Earnings (ASHE)* for the UK labour market.

[15] The precise wording of the question used to construct the dummy variable is: *"Please tell me if, since September 1st of previous year, you have received any of the types of income or payments shown, either just yourself or jointly? Industrial Injury Disablement Allowance".* Details on the *IIDB* are provided in Section 2.

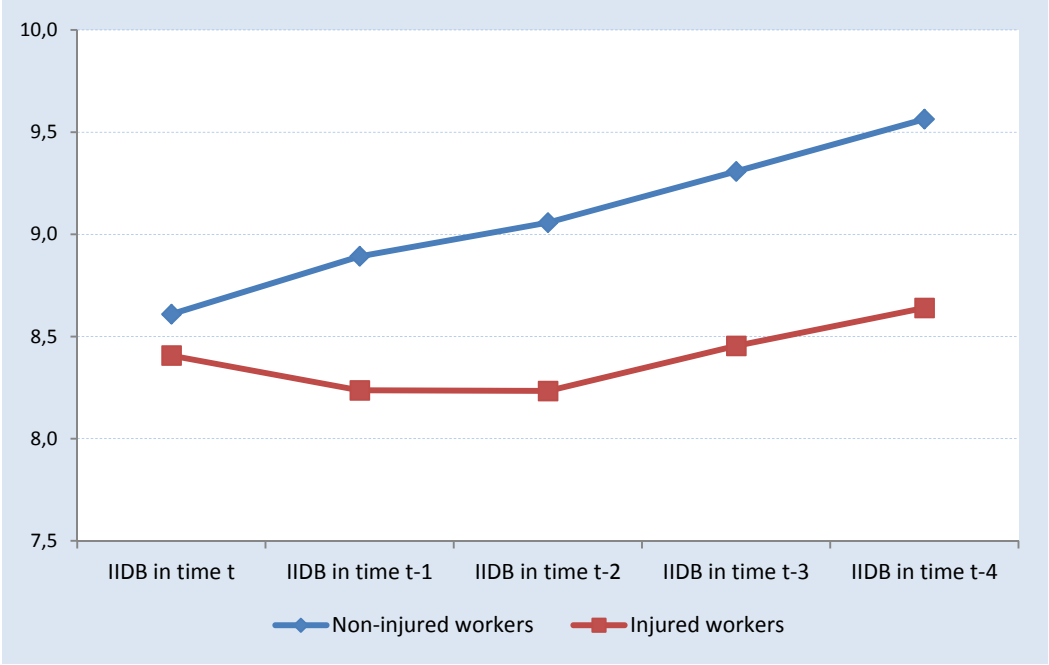
lower than those of non-injured workers. Conversely, earnings differences are larger (up to 9.7 percent) between non-injured workers and workers injured before time t. The descriptive statistics suggest that the effect of injury on earnings increases over the two years following the accident; after this time, the negative impact of injury on earnings seems to remain constant over time.

Table 1: Differences in employment probabilities according to a state of injury certified by *IIDB*

	Employment probabilities				
	IIDB in time t	IIDB in time $t-1$	IIDB in time $t-2$	IIDB in time $t-3$	IIDB in time $t-4$
Injured indiv.	52.27%	51.95%	51.95%	50.00%	49.21%
Non-Injured indiv.	78.13%	80.66%	82.08%	83.12%	83.94%

	Transition probabilities			
	IIDB in time $t-1$	IIDB in time $t-2$	IIDB in time $t-3$	IIDB in time $t-4$
Probabilities of employment	Non-employed in time $t-1$	Non-employed in time $t-2$ and $t-1$	Non-employed in time $t-3$. $t-2$ and $t-1$	Non-employed in time $t-4$. $t-3$. $t-2$ and $t-1$
Injured indiv.	4.55%	5.88%	3.23%	0.00%
Non-Injured indiv.	17.85%	11.48%	8.55%	6.94%
Probabilities of lossing employment	Employed in time $t-1$	Employed in time $t-2$ and $t-1$	Employed in time $t-3$. $t-2$ and $t-1$	Employed in time $t-4$. $t-3$. $t-2$ and $t-1$
Injured indiv.	7.64%	5.05%	1.43%	1.96%
Non-Injured indiv.	3.71%	2.57%	2.78%	2.70%

Figure 2: Differences in hourly wage (in time *t*) between injured and non-injured workers.



To control for all characteristics that could also affect labour market outcomes, in addition to a state of injury, we collect information on workers' demographic characteristics and firm attributes[16]. Demographic characteristics of the respondents include gender, age, race and family composition. To proxy for job attributes, we use information on the respondent's working qualifications (based on the International Standard Classification of Occupations - ISCO). Firm and job characteristics include information on sector (classified using

[16] A complete list of the variables used in our analyses and their means and descriptive statistics on their correlations with the dependent variables are available upon request.

International Standard Industrial Classification of All Economic Activities - ISIC), size of enterprise and presence of trade unions. We also add information on employment contracts: we introduce a dummy equal to 1 if the worker is employed part-time and two dummy variables indicating, respectively, if the worker is employed with a fixed-term contract or if she is a seasonal worker[17].

With the aim of including in the analysis a variable that captures whether the worker recently changed job, we construct to identify changes in stylized jobs. Since information on job changes cannot be found in the BHPS, which does not include any firm identifier, we use changes in stylized jobs to capture job changes. We identified stylized jobs within our sample by combining information about occupation, sector of activities and size of the firm for which the respondent works. We exploit differences in stylized jobs in different periods to capture job moves[18]. We thus construct four dummy variables, which assume the value 0 if the characteristics of the stylized job did not change or the value 1 if the stylized job is different between, respectively, time $t-1$, $t-2$, $t-3$ or $t-4$ and time t.

Finally, to eliminate from our empirical analysis the heterogeneous effects due to unobserved differences in UK regions and to time effects, we include a set of regional dummy variables and a set of time dummy variables.

5. Empirical model

A crucial problem that may characterize the estimation of the effect of occupational accidents, both in terms of employment probabilities and earnings, is the presence of unobserved heterogeneity in our data. The theoretical literature identifies several factors leading to heterogeneity. Differences in the propensity to suffering workplace accidents and in the ability to avoid occupational risks may lead workers to look for occupations according with their risk aversion: risk averse workers may look exclusively for low-risk jobs, while high-risk individuals may be willing to trade risk for wage, choosing jobs that provide high wage to induce employees to assume dangerous occupational risks. According with Lanoie (1991), endogenous selection might also be induced by the employer, who chooses an overprovision of safety precaution to compensate workers' hidden actions in exerting precaution effort.

Endogenous selection in risk at work may thus lead to a bias in determining the probability of accidents at work and, consequently, in estimating their economic consequences. Specifically, randomizing occupational sorting, we might observe more accidents at work, especially among low-risk individuals. This suggests particular care in choosing the appropriate estimation strategy to evaluate appropriately the effect of receiving the *IIDB* on labour market outcomes.

[17] We exclude the category of the permanent workers.

[18] Our hypothesis is that differences in occupation, sector of activities or size of the firm imply that the worker has changed her job with respect to the previous period. The disadvantage of this empirical strategy consists in the impossibility of capturing job moves that occur within occupations, sectors and size of the firm.

Indeed, evaluating the direction of bias introduced by the presence of heterogeneity is difficult because two opposing effects are at work. Unobserved heterogeneity may lead to underestimating the effect of serious accidents on labour market outcomes because low-risk individuals, who have higher probabilities of receiving *IIDB* without any job sorting, may also be the ones that experience the highest economic costs. This hypothesis is based on the assumption that individuals that are more risk averse as a result of their personal characteristics, such as health conditions or abilities to adapt to occupational risks, may be prone to recover more slowly to their pre-injury mental and physical conditions after a serious occupational accident.

Conversely, if low-risk individuals suffer less serious consequences with respect to high-risk individuals, the effects of a serious accident at work on labour outcomes would be overestimated. This is plausible if accidents at work affect more and with more serious consequences high-risk workers employed in jobs characterized by high occupational risks. This means that low-risk individuals might be affected less than high-risk individuals because they exert more precautionary effort to compensate their higher propensity to suffer an accident at work. In addition, the presence of wage compensation mechanisms may contribute to overestimate the effect of a serious accident: high-risk workers, who are more willing to accept contracts with wage compensation mechanisms, may support larger earnings losses because they may not be able to trade wage for risk.

Therefore, our empirical analysis of the effect of accidents at work on the probability of employment and on wage is specified as to control for unobserved heterogeneity that could affect our estimations. We first investigate employment probability. Given the dichotomous nature of the variable E_{it}, we use a binary outcome model, introducing the following specification:

$$E_{it}^{*} = \alpha_i + X_{it}'\beta + \delta IIDB_{it} + \varepsilon_{it} \qquad [1]$$

$$E_{it} = \begin{cases} 1 & if\ E_{it}^{*} > 0 \\ 0 & otherwise \end{cases}$$

where E_{it}^{*} is the latent variable which assumes a positive value if the individual i is employed at the time t and zero otherwise. The dummy variable $IIDB_{it}$ identifies if the individual i receives the $IIDB$ in time t as the consequence of a serious occupational accident, X_{it} is a vector of control variables, which are related to personal characteristics (gender, age, race, family composition and education, α_i are the random variables that capture unobserved heterogeneity and ε_{it} is the error term, which is logistic distributed.

The presence of time invariant unobserved heterogeneity suggests the use of a fixed effect estimators to isolate the causal effect of accidents at work from time-invariant unobserved heterogeneity between injured and non-injured individuals, which is captured by

the random variables α_i. We therefore use the conditional fixed effect estimator presented by Chamberlain (1980)[19].

Since we are also interest in estimating on the consequences of an occupational injury in the long term, we investigate the effect of an injury suffered in the past on the employment probability in the current period. The effect related to an injury in the previous period can be estimated including, in the standard specification [1], the lagged variable that capture an injury suffered in time $t-1$, in place of the variable $IIDB_{it}$. We use the same strategy to estimate the effect of an injury suffered in time $t-2$, $t-3$ or $t-4$: we include separately the corresponding lagged variables in [1], in place of the variable $\mathrm{IIDB_{it}}$.

The second empirical analysis we present estimates differences in earnings between injured and non-injured workers. We analyse whether an occupational injury may lead to variations in earnings at time t [20] using the following specification:

$$ln\_yhrl_{it} = \alpha_i + X'_{it}\gamma + \vartheta IIDB_{it} + \varphi_{it} \qquad [2]$$

where ln_yhrl_{it} is the hourly wage of individual i at time t, X'_{it} is the vector of control variables including both personal characteristics of the worker (gender, age, race, family composition and education) and firm and job attributes (occupation, sector and size of enterprise, characteristics of employment contract and presence of trade unions), along with regional and time dummy variables. As in specification [1], α_i are the random variables that capture unobserved heterogeneity; φ_{it} is the error term, which is i.i.d. over i and t. To account for time-invariant unobserved heterogeneity, we estimate earnings losses with a fixed effect estimator.

To estimate the long-term consequences of an injury on earnings, we also introduce lagged variables that identify a state of injury suffered in the previous periods. We estimate the effect on earnings of an injury suffered in time $t-1$ introducing the corresponding lagged variable in the specification [2], in place of the variable $IIDB_{it}$.

When we analyse the long-term effects on earnings, we have to take into account that our model may be wrongly specified if does not control for possible job moves. We can expect injured workers to change their jobs following an occupational accident. This can happen for two main reasons: first, they would not continue working in a firm where their accidents occurred; second, they are not able anymore to perform activities necessary for the fulfilment of their jobs description. Thus, referring to injuries suffered in time $t-1$, we include in [2] a variable that captures job moves from the previous to the current period. To investigate the effects on earnings of injuries suffered in time $t-2$, $t-3$ or $t-4$, we include separately the

[19] Given the large number of observations in our sample, restricting the sample size exclusively to individuals who transit from one labour status to the other does not constitute a serious problem. The main disadvantage of the conditional fixed effect estimator is the impossibility to estimate the marginal effects due to lack of information on individual heterogeneity (Wooldridge, 2001).

[20] To estimate earnings losses, we restrict our sample to workers in paid employment.

corresponding lagged variables and variables that capture job moves, from time $t-2$, $t-3$ or $t-4$, up to the current period.

Finally, we include in the estimation of equation [2], along with the variable $IIDB_{it}$, the lagged variables related to injuries suffered in time $t-1$, $t-2$, $t-3$ and $t-4$ and the corresponding variables that capture job moves from the previous to the current period. This analysis is performed with the aim of estimating the effect of a state of injury suffered for two or more periods. This empirical strategy is in line with Gannon (2005), Gannon and Nolan (2007), Kapteyn, Smith, van Soest and Banks (2010) and Oguzoglu (2010), who include in the model of interest both variables related to the current and to the previous periods to estimate the effect of disability.

6. Empirical Results

Effects of injury on employment probabilities

The results of conditional fixed effect logit estimations of equation [1] are presented in Table 2. The specifications presented differ in time lag of the $IIDB_{it}$ variable which is included in the analysis: column (I) reports the result relative to the effect of an injury at the time t on employment probabilities; in the other columns, we show results related to the lagged variables (times $t-1$, $t-2$, $t-3$ and $t-4$, respectively)[21].

We find a negative and statistically significant correlation between having suffered an injury and employment probabilities. In line with the descriptive statistics in Table 1, workers suffering an injury in the current period have a higher probability of being unemployed job with respect to non-injured workers. This evidence is consistent with the findings of Reville and Schoeni (2001) and Boden and Galizzi (2003b) relatively to US labour market and of Crichton, Stiliman and Hyslop (2005), about New Zealand labour market. Indeed, these studies argue that an accident at work affects significantly employment probabilities of injured workers in the short term.

In investigating the effect of an injury on employment probabilities in the long term, we do not find any statistically significant effect associated to lagged variables (times $t-1$, $t-2$, $t-3$ and $t-4$)[22].

[21] The table reports only the coefficients of interest, while the full set of results is available from the author upon request.

[22] These results are tested performing logit models with robust errors to gauge how ignoring unobserved heterogeneity it may affect the estimations. Comparing the results of logit and conditional fixed effect logit models, it can be shown ignoring unobserved heterogeneity leads to overestimating the effect of an accident at work on employment probabilities. This result suggests that high-risk individuals, who are more likely to support a serious accident at work, may support higher consequences in terms of lower employment probabilities with respect to non-injured workers. While the results are not reporter here, all estimations are available upon request.

Table 2: Effects on employment probabilities - Conditional fixed effect logit estimations

	(I)	(II)	(III)	(IV)	(V)
IIDB at time t	-0.827*** (0.335)				
IIDB at time $t-1$		-0.426 (0.381)			
IIDB at time $t-2$			0.156 (0.397)		
IIDB at time $t-3$				0.413 (0.444)	
IIDB at time $t-4$					0.701 (0.541)
Personal Characteristics	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes
Log likelihood	-10043.77	-7995.18	-6423.22	-5025.93	-3927.93
Observations	39222	30832	24408	19320	15135
Number of individuals	4866	3833	3114	2519	2054

Note: * Significant at 0.100; ** Significant at 0.50; *** Significant at 0.01. Standard errors are in parentheses. Personal characteristics are age, age squared and family composition.

Our analysis cannot as such inform on the cause of the negative relation between injuries and employment probabilities, but we can speculate on what is the most likely mechanism at work. As told in advance in Section 1, following an injury, a worker might be unable to carry out pre-injury tasks. Our results could be evidence that employers and local labour markets do not provide alternative jobs that are adequate to workers' limited abilities. Injured workers may be induced to leave their employments, especially in the case of heavy-duty jobs or long working hours, because accidents at work have reduced their productivity. Our results thus imply that employment probabilities are negatively affected by losses in human capital due to occupational injuries. The inability of the employers to provide an alternative job fit for injured workers' reduced abilities may be due to the firm's size or limited job protection.

The decrease in human capital puts injured workers at a disadvantage when looking for an employment in the local labour market, and it might turn out to be more difficult for them to find a job fitting their abilities. Moreover, employers are not willing to hire high-risk individuals that are injured too frequently and too seriously, since the costs associated with workplace injury for firms are high: for example, higher premiums paid to the national social security system, costs for replacements of workers and damages of products, structures or equipment. According to the theoretical literature on risk at work[23], one of labour market failures is due to asymmetric information on the heterogeneity in the worker's propensity to be injured and to ask for medical care. Employers may use the occurrence of a state of injury, certified by *IIDB*, as a signal that may drive them in not hiring injured individuals for responding to the adverse selection problem.

An alternative explanation of the negative relation between job accident and employment probabilities is related to economic incentives that injured workers face when deciding whether to return to work. The presence of several benefits, available in addition to *IIDB*, such the *Reduced Earnings Allowance (REA)*, the *Constant Attendance Allowance (CAA)* and the *Exceptionally Severe Disablement Allowance (ESDA)*, introduced in Section 2, may induce injured workers to postpone or not to return to work, affecting significantly their

[23] Rothschild and Stiglitz (1976); Wilson (1977); Grossman (1978) and Crocker and Snow (1985).

employment probability. Indeed, as argued by Boden and Galizzi (2003a), the existence of economic incentives may decrease the hazard of returning to work.

Effects on earnings

The results of estimations on hourly wages are presented in Table 3. In column (I), we report estimated differences in earnings between injured and non-injured workers at the time t; in columns (II-V), we present results related to the effects of being injured in the previous periods (from time $t-1$ to time $t-4$) to capture the long-term consequences, estimated in the current period (time t). In column (VI), we show the specification of the equation [2] that includes variables related to being injured either in the current period or in the previous four periods.

Results suggest that an occupational injury does not have statistically significant effects on earnings in the short term (column I). This result counters the hypothesis that an accident may lead to immediate costs in terms of hourly wages reduction of injured workers with respect to non-injured workers. However, we test whether injured workers support indirect costs in the long-term in terms of wage penalties. We find that suffering an occupational injury in time $t-1$ negatively affects earnings in time t: the reduction of hourly wage with respect to non-injured workers in the same period is statistically significant and is around to 8.6 percent. Referring to injuries suffered in the previous periods, earnings losses seem to increase over time. If the worker was injured in time $t-2$, she experiences earnings losses equal to 9.8 percent (column (III)) with respect to workers that in time $t-2$ were not injured. An injury results in 10.3 percent and 12.4 percent wage penalties if it occurs in time $t-3$ (column (IV)) or in time $t-4$ (column (V)), respectively[24].

The results of Table 3 highlight that workers who suffered an occupational injury in the recent past are penalized in the current period with respect to non-injured workers, without any evidence that the effect vanishes after five years. This hypothesis is confirmed by results of column (VI) which suggests that a serious accident may affect earnings in the long term, especially when it is particularly serious and the worker is injured for at least three consecutive periods.

[24] We test the robustness of our results estimating our model with different specifications of the dependent variable (hourly wages including also overtime hours worked in a normal week or annual earnings) not finding significant differences with respect the analysis performed with hourly wages. We also test our findings including in the equation [2] the variable that captures hours worked per week; results on the effect of *IIDB* do not change significantly. All these results suggest that differences in hours worked does not affect our findings. The robustness of our results is also checked investigating the presence of autocorrelation in the error terms. The test for serial correlation in the idiosyncratic errors of a linear panel-data model discussed by Wooldridge (2001) and implemented by Drukker (2003) is performed suggesting that the null hypothesis of no serial correlation is rejected. However, a fixed-effects linear model with autocorrelation provides similar results with respect what we present in Table 5 and the following. All other estimated coefficients are available upon request. Referring to the effect of unobserved heterogeneity, our analysis confirms the hypothesis discussed above: the presence of time invariant unobserved heterogeneity may overestimate the effect of being injured on earnings. This result seems to suggest that, in the occurrence of an accident at work, high-risk individuals may support more serious economic consequences, in terms of employment opportunities and of earnings losses.

Summarising our findings, we show that a serious accident leads to substantial differences between injured and non-injured workers. An accident at work resulting in a state of injury in time t and $t-1$ entails only a little and insignificant wage penalties but, considering an injury suffered in time t, $t-1$ and $t-2$, an injured workers may earn an hourly wage 15.8 percent lower with respect to the corresponding wage earned by workers who were not injured in at least one of these periods. Differences in earnings increase to 23.4 percent if we consider an accident occurred in time $t-3$, which results a state of injury for four periods (time t, $t-1$, $t-2$ and $t-3$). Finally, if we consider a worker who was injured for all 5 previous periods, we find that earnings losses are equal to 30.5 percent with respect to workers that were not injured in any of these five periods. In addition, the negative and statically significant effect of being injured in time $t-2$, $t-3$ or $t-4$ suggests that an accident at work has delayed effect on the earnings of an injured worker.

An alternative strategy to evaluate the effect of an accident at work on earnings is to analyzing separately the effects related to the persistency of the injury and to the delay of the injury. This strategy of analysis allows studying more precisely if increasing differences in earnings over time, as shown in columns (II-V) are due mostly to the persistency of injury or to the delay of injury. In addition, this estimation procedure provides a useful way to test the sensitivity of abovementioned analysis.

The persistency of the injury is captured by accidents that have led a state of injury for two or more consecutive years, up to the current period. For instance, the persistency of an injury suffered in time $t-1$ is estimated constructing a dummy variable equal to 1 if and only if injured workers receive $IIDB$ also in time t and 0 is conversely zero otherwise. Since we do not have any measure capturing the degree of disability certified by $IIDB$ we use persistency of injury as a proxy: the assumption we rely on is that the seriousness of an accident increases with the duration of injury.

The delayed effect of injuries can be captured considering accidents that led to a state of an injury only in the past, concluding their negative effects on health status before time t. For instance, to capture the delay of injuries suffered in time $t-1$ we define a dummy variable equals to 1 if and only if injured workers in time $t-1$ but do not receive $IIDB$ in time t.

The two dummy variables constructed to estimate the persistency of the injury and the delay of the injury in affecting earnings are introduced in [2], and replace the lagged variable capturing an injury suffered in time $t-1$. For each of the previous periods (time $t-2$, $t-3$ and $t-4$), we follow a similar strategy in constructing variables that capture the delayed effect of injuries and their persistence.

Table 3: Effects on hourly wage

	(I)		(II)		(III)		(IV)		(V)		(VI)	
IIDB at time t	0.0131	(0.0467)									-0.054	(0.0433)
IIDB at time t-1			-0.0869**	(0.0379)							0.033	(0.0415)
IIDB at time t-2					-0.0983**	(0.0382)					-0.137***	(0.0440)
IIDB at time t-3							-0.103***	(0.0400)			-0.076**	(0.0427)
IIDB at time t-4									-0.124***	(0.0422)	-0.071*	(0.0435)
Personal Characteristics	Yes		Yes		Yes		Yes		Yes		Yes	
Firm and job attributes	Yes		Yes		Yes		Yes		Yes		Yes	
Regional dummies	Yes		Yes		Yes		Yes		Yes		Yes	
Time dummies	Yes		Yes		Yes		Yes		Yes		Yes	
R-squared	0.290		0.329		0.319		0.302		0.287		0.291	
Observations	82425		65873		56493		46824		38625		37243	
Number of pid	14813		11455		9921		8548		7290		7024	

Note: * Significant at 0.100; ** Significant at 0.50; *** Significant at 0.01. Standard errors are in parentheses. Personal characteristics are age, age squared and family composition. Firm and job attributes are occupation, sector, public/private firm, size of enterprise, type of contract (part time/full time job and indefinite/temporary contract) and presence of trade unions

Table 4: Effects on hourly wage (distinguishing between the persistency of injury and the delay of an injury in affecting earnings)

		(I)		(II)		(III)		(IV)		(V)	
IIDB at time *t*		0.0131	(0.0467)								
IIDB at time *t-1*	*iidb_1_still*			-0.159***	(0.0518)						
	iidb_1_end			-0.0178	(0.0506)						
IIDB at time *t-2*	*iidb_2_still*					-0.254***	(0.0620)				
	iidb_2_end					-0.0197	(0.0454)				
IIDB at time *t-3*	*iidb_3_still*							-0.350***	(0.0718)		
	iidb_3_end							-0.0189	(0.0449)		
IIDB at time *t-4*	*iidb_4_still*									-0.438***	(0.0899)
	iidb_4_end									-0.0543	(0.0458)
Personal Characteristics		Yes		Yes		Yes		Yes		Yes	
Firm and job attributes		Yes		Yes		Yes		Yes		Yes	
Regional dummies		Yes		Yes		Yes		Yes		Yes	
Time dummies		Yes		Yes		Yes		Yes		Yes	
R-squared		0.290		0.329		0.319		0.302		0.287	
Observations		82425		65873		56493		46824		38625	
Number of individuals		14813		11455		9921		8548		7290	

Note: * Significant at 0.100; ** Significant at 0.50; *** Significant at 0.01. Standard errors are in parentheses. Personal characteristics are age, age squared and family composition. Firm and job attributes are occupation, sector, public/private firm, size of enterprise, type of contract (part time/full time job and indefinite/temporary contract) and presence of trade unions.

Estimation of the effect of the persistency of injury and the delay of injury on earnings are presented in Table 4[25]. Negative and statistically significant effects of the variables related to persistent occupational injuries suggest that wage penalties affect exclusively workers who suffered a state of injury for at least two years and are still injured in time t. The hypothesis that earnings losses depend on the delay of the injury in affecting earnings can be rejected since we do not find any statistically significant effect referring to these variables.

The negative and statistically significant effect of an injury increases according to its persistency, suggesting that there is a positive relationship between the seriousness of an occupational accident and earnings losses. Accidents at work that lead a state of injury for at least two years (time $t-1$ and time t) entail hourly wage penalties for injured workers equal to 15.9 percent. Annual earnings losses of a representative worker[26] are estimated equal to £3,526. This difference is more than the earnings penalty suffered by workers with fixed-term contract, with respect to permanent workers, and is equivalent to lose the wage increase that would result after one years and a half of experience. With one additional year of injury (time $t-2$, $t-1$ and t), the differential in hourly wage is equal to 25.4 percent and estimated annual earnings losses are calculated at £ 5,348. This is higher than the wage increasing resulting from three years of experience on the job. Receiving the $IIDB$ for four years (time $t-3$, $t-2$, $t-1$ and t) reduces hourly wage of injured workers of 35.0 percent (which correspond to lose more than five years of experience) Estimated annual earnings losses are equal to £ 6,956. Finally, extremely serious occupational injury (time $t-4$, $t-3$, $t-2$, $t-1$ and t) lead hourly wage penalties equal to 43.8 percent with respect to non-injured workers. Accidents with at least five consecutive years of injuries entail earnings losses equal to £ 7,743. The effect of such an injury results in very large earnings losses: comparing this differential with earnings penalty suffered by workers with fixed-term contract, with respect to permanent workers, we find that the latter is four times smaller. An alternative point of view to estimate the magnitude of earnings losses is to consider that wage penalties in the case of at least five consecutive years of injury are equal in amount to the wage increase a workers would obtain after seven years of experience. Although results of Table 4 are higher with respect to the corresponding effects summarizing estimations in column (VI) of Table 3, they define a similar trend and show that the effect of an accident at work increases according to the duration of the injury.

The existence of the relationship between earnings losses and seriousness of an occupational accident confirm the findings of Reville and Schoeni (2001) and Crichton, Stiliman and Hyslop (2005), investigating the US and New Zealand labour market, respectively. Indeed, we find that our estimated annual earnings losses are in line with results of Reville and Schoeni (2001), although our findings are not directly comparable with Reville and Schoeni (2001), because we refer to the seriousness of an accident in terms of the duration of the injury, instead of the degree of the disability.

[25] From column (II) to column (V), we report estimates related to injury from time $t-1$to time $t-4$.

[26] A representative individual is a married 40-year old worker, employed in a small firm of the private industrial sector, resident in Inner or Outer London. She is employed in a high-skill qualification with a full-time permanent labour contract.

Again, our empirical estimation does not inform on the reasons why injured workers experience earning losses, but there are in this respect a number of possible explanations. A worker may support a significant decrease of human capital, in terms of a reduction of productivity, due to occupational injury. The decrease in productivity may lead to higher earnings losses, especially when the employer adopts physically demanding pay-for-performance mechanisms, such as *HIWP*. The increasing use of *HIWP*s may explain part of this wage gap, since they imply effects on incentives and sorting of workers with different characteristics (Lazear, 1996 and 2000; Paarsch and Shearer, 2000). Injured workers may not be able to exert a sufficient effort to satisfy productivity targets required by incentive practices; moreover, injured workers may prefer to sort in firms that do not use *HIWPs* and with less occupational risks, obtaining in exchange lower hourly wages.

The existence of earnings losses also reflects the fact that the employers may discriminate injured workers either directly or indirectly. Direct effects of discrimination may concern differences in contracts: employers may supply less attractive contracts to injured workers. Moreover, employers may discriminate indirectly injured workers providing low safety at work standards. This effect consists in the need of injured workers to exert additional efforts in precaution activities, with respect to the other workers, to avoid accidents. In addition, the existence of excessively demanding productivity targets may result in an indirect form of discriminations. Injured workers may are not able to fulfil productivity targets, especially when they are demanding in terms of involvement and working hours.

Reductions in injured workers' human capital may distort job-worker matching, leading to earnings losses. A decline of job-worker matching may occur whenever injured workers are not anymore adequate to carry out pre-injury jobs, especially in the case of physically or mentally demanding tasks. Moreover, job-worker matching may not be efficient whenever the employer cannot supply an alternative job that fits injured worker's limited abilities. This may happen more often when injured workers are highly specialized or employers, due to sector or size of the firm, cannot provide suitable jobs. The existence of distortions in job-worker matching may drive injured workers to different jobs. More efficient job-worker matching may contribute to minimizing earnings losses providing more adequate jobs to fit better injured workers' limited abilities. Positive effects of job moves may be mitigated by losses in terms of firm-specific human capital or tenure accrued over time.

The validity of this latter explanation can be tested empirically providing a separate analysis for identifying earnings losses supported by workers who have moved to different jobs after the occurrence of occupational injuries and who are still employed in their pre-injury employments. Results are presented in Table 5[27].

[27] For this analysis, we use empirical strategy to estimate separately the effects related to the persistency of the injury and to the delay of the injury in affecting earnings. In Table 5, we report only estimations on the persistency of injury. We do not find any statically significant effect related to the delay of injury in affecting earnings.

Our findings suggest that leaving pre-injured job contributes to reducing earnings losses whenever an extremely serious accident occurs. Suffering a state of injury for at least two years leads to penalties of 17.4 and 17.7 percent of hourly wage for workers who stay in their jobs and those who move to other jobs, respectively. With one further year of injury, wage penalties are equal to 20.8 and 24.8 percent, respectively. When we consider more serious occupational accidents, which entail a state of injury for at least four consecutive periods, reductions are equal to 45.5 and 29.1 percent, respectively. When workers suffer a state of injury for at least five consecutive periods, wage penalties are equal to 56.8 and 33.7 percent, respectively.

These results confirm that distortions in job-worker matching may increase earnings losses that injured workers support as consequences a serious occupational accident. Moving to more adequate jobs that fit new and limited workers' abilities may reduce wage penalties supported by injured workers, especially when an accident leads to serious consequences for health status. Indeed, reductions in percentage points due to job moves may be estimated equal to more than 15 percent and 23 percent for at least four and five consecutive years of injury, respectively. In addition, results of this separate analysis may suggest that moving to a new and more suitable job can be interpreted as a voluntary decision of injured workers to improve post-injury job-worker matching.

Table 5: Effects on hourly wage (differences between stayers and movers – exclusively effects of the persistency of injury)

Persistency of injury	Stayers		Movers	
For at least one period	0.013		0.0133	
	(0.047)		(0.047)	
For at least two periods	-0.174	***	-0.177	**
	(0.059)		(0.090)	
For at least three periods	-0.208	**	-0.248	***
	(0.094)		(0.085)	
For at least four periods	-0.455	***	-0.291	***
	(0.143)		(0.089)	
For at least five periods	-0.568	**	-0.337	***
	(0.221)		(0.103)	
Personal Characteristics	Yes		Yes	
Firm and job attributes	Yes		Yes	
Regional dummies	Yes		Yes	
Time dummies	Yes		Yes	

Note: * Significant at 0.100; ** Significant at 0.50; *** Significant at 0.01. Standard errors are in parentheses. Personal characteristics are age, age squared and family composition. Firm and job attributes are occupation, sector, public/private firm, size of enterprise, type of contract (part time/full time job and indefinite/temporary contract) and presence of trade unions.

7. Discussion

In order to targeting policy interventions geared to prevent or to reduce labour market failures in employment opportunities and in earnings it is necessary to inspect how the heterogeneity across socio-economic groups may affect economic consequences of an

accident at work. With this purpose we perform separate analyses on employment probabilities and on earnings, whose results are presented in Table 6 and Table 7.

The presence of differences in risk aversion, as argued by Grazier and Sloane (2008) for UK labour market, may highlight the existence of gender gaps in the effects of occupational accidents. Higher risk aversion may drive more likely injured women to leave their employments and not to return to work; especially when they are employed in physically demanding occupations or their pre-injury employers and local labour market do not supply adequate alternative jobs. Differences in job and earnings protection may also lead to heterogeneous effects on labour market outcomes between young and old workers. Older workers, who are employed more likely with permanent contracts and have accrued more experience and tenure over time, might preserve more likely their jobs after an accident at work, with respect to younger individuals. Lower willingness to move to another job in the occurrence of an accident at work may explain differences in the effect of an occupational injury on earnings; older workers may not look for new jobs that fit their limited abilities, since they may fear to lose firm-specific human capital.

Reduced ability to work in heavy duty jobs or for long working hours may lead to larger earnings losses in physical labour-intensive industries, such as manufacturing and construction. Moreover, in the occurrence of an accident, small firms may not be able to supply valid alternative jobs for injured workers, who may lose firm-specific human capital moving to another job. The presence of trade unions, which are more likely in larger firms and in the industrial sector, may mitigate earnings losses with higher job and earnings protection and the defence of injured workers' rights. Although trade unions seem to fail in reducing workplace accident rates (Baugher and Roberts, 1999; Fenn and Ashby, 2004), they may play a crucial role in defending injured workers' rights, avoiding that injured workers support earnings losses due to occupational injuries. For similar reasons, in the public sectors, injured workers may support lower earnings losses thank to the presence of the *Disability Discrimination Act*.

Investigating differences in effects on employment probabilities (Table 6), our results highlight women and young (less than 40 years old) individuals, who suffered a serious accident at work, support a higher decrease of employment probabilities, with respect to injured old male individuals. The magnitude of these effects suggests women and young individuals may lose their employments more likely than injured old male individuals, who support only a weak or statistically insignificant decrease in employment probability.

Table 6: Effects on employment probabilities (distinguishing by personal characteristics)

	Female		Male		Young (less than 40 years)		Old (more than 40 years)	
	(I)		(II)		(III)		(IV)	
IIDB at time t	-1.633***	(0.702)	-0.630*	(0.377)	-1.746***	(0.702)	-0.533	(0.395)
IIDB at time $t-1$	-0.644	(0.752)	-0.411	(0.428)	-1.867***	(0.800)	0.939	(0.455)
IIDB at time $t-2$	-0.426	(0.742)	0.014	(0.453)	-0.420	(1.033)	0.482	(0.458)
IIDB at time $t-3$	2.353	(1.457)	0.291	(0.578)	0.376	(1.065)	0.488	(0.513)
IIDB at time $t-4$	-1.746	(0.702)	-0.532	(0.395)	13.900	(870.708)	0.631	(0.585)
Personal Characteristics	Yes		Yes		Yes		Yes	
Regional dummies	Yes		Yes		Yes		Yes	
Time dummies	Yes		Yes		Yes		Yes	

Note: * Significant at 0.100; ** Significant at 0.50; *** Significant at 0.01. Standard errors are in parentheses. Personal characteristics are age, age squared and family composition.

Table 7: Effects on hourly wages (distinguishing by personal characteristics and firm attributes – exclusively effects of the persistency of injury)

Persistency of injury	Female	Male	Young	Old	Industrial sector	Services sector	Small firms	Big firms	Private sect.	Public sect.	Unionized	Non-unionized
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
For at least one period	0.048	0.024	-0.091	0.010	-0.052	0.042	0.117	0.003	-0.008	0.060	0.063	0.058
	(0.135)	(0.047)	(0.132)	(0.041)	(0.061)	(0.099)	(0.085)	(0.055)	(0.055)	(0.087)	(0.063)	(0.072)
For at least two periods	-0.305 *	-0.124 **	-0.151	-0.183 ***	-0.120 *	-0.344 ***	-0.254 **	-0.077	-0.196 ***	-0.098	-0.014	-0.269 ***
	(0.176)	(0.050)	(0.203)	(0.047)	(0.068)	(0.107)	(0.101)	(0.058)	(0.059)	(0.111)	(0.066)	(0.089)
For at least three periods	-0.186	-0.242 ***	-0.107	-0.287 ***	-0.194 **	-0.500 ***	-0.296 ***	-0.182 **	-0.300 ***	-0.185	0.013	-0.372 ***
	(0.238)	(0.058)	(0.378)	(0.055)	(0.081)	(0.119)	(0.106)	(0.071)	(0.068)	(0.158)	(0.083)	(0.095)
For at least four periods	-0.006	-0.366 ***	---	-0.373 ***	-0.363 ***	-0.572 ***	-0.368 ***	-0.333 ***	-0.421 ***	-0.273	-0.041	-0.420 ***
	(0.306)	(0.067)	---	(0.065)	(0.101)	(0.124)	(0.119)	(0.083)	(0.079)	(0.189)	(0.108)	(0.103)
For at least five periods	---	-0.429 ***	---	-0.447 ***	-0.439 ***	-0.610 ***	-0.415 ***	-0.489 ***	-0.521 ***	---	0.078	-0.586 ***
	---	(0.082)	---	(0.082)	(0.127)	(0.129)	(0.184)	(0.104)	(0.098)	---	(0.143)	(0.116)
Personal Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: * Significant at 0.100; ** Significant at 0.50; *** Significant at 0.01. Standard errors are in parentheses. Personal characteristics are age, age squared and family composition. Firm and job attributes are occupation, sector, public/private firm, size of enterprise, type of contract (part time/full time job and indefinite/temporary contract) and presence of trade unions.

Focusing on gender differences in earnings losses (Table 7[28], column I and column II), we find that earnings losses are higher for women with respect to men when a state of injury is suffered for at least two years (30.5 percent for injured women versus 12.4 percent for injured men); otherwise, relatively to more serious occupational accidents, we find negative and statistically significant effects exclusively on male workers. For injured men, wage penalties increase according to the seriousness of the accident up to 42.9 percent (five or more consecutive years of injury). The lack of observations on female employees with long-term injuries[29] does not allow estimating their earnings losses. Moreover, a serious occupational accident may lead to statistically significant earnings losses only for older workers[30] (column IV), who suffer earnings losses from 18.3 percent for two or more years of injuries to 44.7 percent with at least five consecutive years of injury.

Inspecting heterogeneous effects according to firm and sector characteristics, we notice that workplace accidents may lead to higher wage penalties in the services sector[31] and in smaller firms. Results related to the industrial sector[32] (column V) suggest that, according to the persistency of injury, earnings losses increase up to 43.9 percent, for accidents leading to five or more consecutive years of injury; whereas, in the services sector (column VI), they are estimated equal to 61 percent for extremely serious occupational accident. In small firms (column VII), workplace accidents lead to negative and statistically significant effects, which increase from 25.4 percent, for at least two consecutive years of injury, to 41.5 percent for more serious injury (five or more consecutive years). Injured workers in large firms (column VIII) support earnings losses when they are affected by injuries that persist for at least three consecutive years. Only extremely serious occupational accidents that result in at least five consecutive years of injury lead to higher earnings losses in large firms with respect to corresponding losses in small firms.

With a separate analysis by workers in private and public firms (column IX and column X), we provide empirical evidence that, only in the private sector, persistent injuries lead to negative and statistically significant consequences on earnings. The magnitude of these effects may vary from 19.6 percent, for at least two years of injury, to 52.1 percent, referring to an injury that persists for five or more consecutive years. We do not find any statically significant effect on earnings for workers in the public sector, even when an accident results in a persistent injury (two or more consecutive years)[33]. Referring to unionized workers (column

[28] In Table 7, we report only estimations on the persistency of injury. We do not find any statically significant effect related to the delay of injury in affecting earnings.

[29] Injured women in time t are around 0.04 percent and there are only few of them with more than two years of injury (0.009 and 0.003 percent with three and four years of injury, respectively) and none with at least five years of injury.

[30] The lack of observations on young employees with long-term injuries (with at least four years of injury) does not allow estimating their earnings losses.

[31] Namely *Wholesale and retail trade, Hotel and Restaurants, Transport and communication, Financial and Real Estate*.

[32] Namely *Agriculture, Manufacturing, Electricity, gas and water supply and Construction*.

[33] Although we do not have enough information to test our hypothesis on workers employed in the public sector and that suffer a state of injury for at least five consecutive periods, results related to the persistency of injury for at least two, three and four years seem to confirm our hypothesis.

XI), we do not find any statistically significant effect on earnings, even when an occupational accident leads to a persistent injury (two of more years of injury). On the contrary, focusing on non-unionized workers (column XII), we find that earnings losses vary according to the seriousness of the occupational injury. The wage penalty for an occupational accident that leads to at least two years of injury is equal to 26.9 percent. Additional years of injury may entail higher earnings losses, which may amount to up to 58.6 percent for five or more years of injury.

Results on gender differences are in line with Boden and Galizzi (2003b) in highlighting that, in the occurrence of an accident at work, women support more negative economic consequences. Boden and Galizzi (2003b) suggest these differences can be motivated by gender discrimination that may rise more likely when a workplace accident occurs. Alternatively, we may explain these results by the presence of state benefits devised to aid injured workers: women may prefer to receive injury allowances, rather than returning to work, if they estimate that earnings losses could be consistent. Moreover, lower job and earnings protection, due to less stable contracts[34], may contribute to reducing labour market outcomes of injured women. Less stable contracts and lower experience and tenure accrued over time may also contribute to increasing probabilities of losing job across younger individuals, with respect to older workers. On the contrary, since older workers are less willing to move to alternative jobs, they may support higher earnings losses due to a decline in job-worker matching after returning to pre-injury employment. In addition, higher earnings losses may be motivated by lower ability of older workers to recover to pre-injury health conditions.

A lower presence of pay-for-performance mechanisms in the public sector may explain the absence of any effect on earnings. Burgess and Ratto (2003) and Prentice, Burgess and Propper (2007) argue that UK governments have achieved only small progresses in introducing pay-for-performance mechanisms in public firms. Moreover, the importance of the trade unions in rejecting contracts, which are characterized by pay-for-performance mechanisms that require exerting excessively high effort, may explain the lack of significative differences in earnings between injured and non-injured workers. Several studies (Brown, 1990; Heywood, Siebert, and Wei, 1997; and Barth, Bratsberg, Hægeland and Raaum, 2008) underline how unionized enterprises disfavours the use of pay-for-performance mechanisms by the employers. A decrease in human capital may be less effective in reducing injured workers' earnings in the public sector and in the unionized firms where pay-for-performance contracts and *HIWPs* are less often present. In addition, lower earnings losses in the public sector and in the unionized firms may be guaranteed by higher job and earnings protection. The existence of the *Disability Discrimination Act* and the presence of trade unions in the bargaining process may guarantee that job opportunities and promotions are not reserved exclusively to non-injured workers, reducing discrimination against injured workers. In addition, dissimilarities in earnings losses across socio-economic groups may be traced back to a correlation between the presence of trade unions and specific firm characteristics. Indeed, lower presence of trade unions may

[34] Women are employed more likely in part-time (31.24 percent against 2.84 percent for male workers) and in fixed-term or in temporary contracts (5.06 percent against 4.01 percent for male workers).

explain why earnings losses are higher in the services sectors and in small firms, with respect to the industrial sector and large firms.

8. Concluding remarks and policy implications

This analysis pointed to two possible effects of accidents at work on labour market outcomes. First, we show that, in terms of employment probabilities, injured workers have a higher probability of losing their jobs with respect to non-injured workers, in the short term, and only small opportunities of returning to work, in the long term. Possible explanations include workers' inability of carrying out pre-injury tasks, the absence of alternative jobs that may fit injured workers' new and limited abilities and the presence of economic incentives that may induce injured workers not to return to work.

Second, focusing on injured workers still employed after an accident, we find that earnings losses increase with the duration of the state of injury: summarizing different effects, wage penalties vary from 15.8 percent (considering injuries suffered in the current and the previous two periods) to 30.5 percent (when an accident leads to five periods of injury). Estimating separately the effects of the persistency of the injury, which can be considered as a good proxy for the seriousness of an occupational accident, we find similar, but higher, results: earnings losses vary from 25.4 percent, referring to at least three years of injury, to 43.8 percent, considering extremely serious accidents that lead to five or more years of injury. Various motivations are suggested to explain these disparities in earnings. A decline in productivity may increase wage penalties for injured workers, especially in firms that make large use of the *High Involvement Work Practice* (*HIWP*). Differences may also be attributable to discrimination, since injured workers may be disfavoured in employment opportunities and earnings. Reductions in human capital may distort job-worker matching leading to earnings losses for injured workers. We test this last explanation finding that injured workers' earnings losses may be minimized moving to new and alternative jobs that fit better their limited abilities.

Heterogeneous effects of an accident at work, according to different personal characteristics and firm attributes, are investigated with separate analyses. Results suggest that women and younger individuals are more likely to lose their jobs, with respect to men and to older workers, respectively. Earning losses are limited to private sector non-unionized workers. High job and earnings protection and the defence of injured workers' rights by trade unions contribute to reducing wage penalties for injured workers in large firms and in the industrial sector, where they are more present.

Our findings suggest various important policy implications. Such prominent costs of an occupational injury call for the government intervention with an incentive compatible regulation with the aim of preventing accidents at work and of minimizing their negative consequences for workers' health. Although accidents at work are unforeseeable random shocks, regulating safety at work, with stringent employers' and workers' duties or favouring *Workplace Health Promotion (WHP)*, may help to reduce occupational risks. Increasing safety

at work standards may help to prevent occupational accidents and their consequences in terms of the duration of absence.

In the occurrence of an accident at work, governments should intervene to avoid a substantial reduction in career opportunities and earnings due to a decline in human capital that injured workers may suffer. However, the costs and benefits of these interventions should be carefully assessed. One possible intervention concerns introducing financial aid with the aim of facilitating an adequate job placement, in line with workers' health conditions and productivity. Such policy would avoid long-term unemployment of injured workers and improve post-injury job-worker matching. This intervention may be effective whether the government contributes to employers' costs in hiring injured workers (higher insurance premium for medical care, costs for arranging workplace environments, providing special training courses, etc.). Moreover, the policy may result in a reduction of injured workers' unemployment probabilities and earnings losses, whether the government provides for injured individuals an allowance to inducing injured workers to move to more suitable jobs, with the aim of increasing post-injury job-worker matching.

Government interventions should be also aimed at making unlawful any employers' discrimination that may lead to differences in employment opportunities and in earnings between injured and non-injured workers. Disfavouring contracts that introduce pay-for-performance mechanisms with physically demanding *HIWP* may reduce earnings losses suffered by injured workers. Consequently, we can consider favourably UK governments' interventions in enacting acts and regulations to promote, also in the private sector, equality of opportunity for injured and non-injured individuals, such as the *Equality Act 2010* and the *Disability Equality Duty (DED)*.

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