Empirical essays on occupational health and safety.

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EMPIRICAL ESSAYS ON OCCUPATIONAL HEALTH AND SAFETY

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SUMMARY

This thesis explores a number of aspects related to occupational health and safety. It discusses health and safety at work legislation and policy, and reviews trends in reported workplace accidents and illnesses. Empirically, it considers the impact that various labour market characteristics and policies have upon a workplace's injury and ill-health record, focussing especially upon arrangements common in today's workplace such as working more than 48 hours per week and flexitime policies. It also returns to Adam Smith's compensating wage differentials theory, and examines its relevance today in the context of whether workers receive a wage premium for being exposed to high accident risk. The impact that trade unions have upon the risk premium is reconsidered, given ambiguity in the earlier literature. As an emerging labour market institution, the role of the health and safety committee is also considered. It further investigates workers' aversion to accident risk, and whether personal characteristics, specifically gender and family composition, can be used to predict which workers will sort into relatively hazardous occupations. The contribution that differences in accident rates between occupations will make to occupational gender segregation is then explored. Following a similar hypothesis, it also examines if there is a relationship between smoking behaviour and the accident risk of a person's occupation.

DECLARATIONS AND STATEMENTS

DECLARATION

This work has not been previously accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed

Date..15/1/08......................

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed.

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STATEMENT 2

I hereby give consent for my thesis, if accepted, to be available for photocopying for inter-library loan, and for the title and summary to be made available to outside organisations.

Signed.

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ABBREVIATIONS AND DEFINITIONS

ASHE	Annual Survey of Hours and Earnings
BHPS	British Household Panel Survey
BLS	Bureau of Labour Statistics
CFOI	Census of Fatal Occupational Injuries
CPS	Current Population Survey
EC	European Commission
EODS	European Statistics on Occupational Disease
EPA	Environmental Protection Agency
EPIDERM	Occupational Skin Surveillance
EUROSTAT	European Union Statistical Office
GDP	Gross Domestic Product
GHS	General Household Survey
HSC	Health and Safety Commission
HSCER	Health and Safety (Consultation with Employees) Regulations
HSE	Health and Safety Executive
IDBR	Inter-Departmental Business Register
IER	Institute for Employment Research
IIA	Independence of Irrelevant Alternatives
LFS	Labour Force Survey
NES	New Earnings Survey
NIOSH	National Institute of Occupational Safety and Health
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
ONS	Office for National Statistics
OPCS	Office of Population, Censuses and Surveys
OPRA	Occupational Physicians and Reporting Activity
OSHA	Occupational Safety and Health Administration
RHS	Revitalising Health and Safety Strategy
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulation
RSI	Repetitive Strain Injury
SCELI	Social Change and Economic Life Initiative
SIC	Standard Industrial Classification
SOC	Standard Occupational Classification
SRSCR	Safety Representatives and Safety Committees Regulations
SWI	Self-Reported Work-Related Ill Health Survey
SWORD	Surveillance of Work-Related Occupational Respiratory Disease
THOR	The Health and Occupation and Reporting Network
UK	United Kingdom
US	United States
VSI	Value of a Statistical Injury
VSL	Value of a Statistical Life
WERS	Workplace Employment Relations Survey
WIRS	Workplace Industrial Relations Survey
2SLS	Two Stage Least Squares
3SLS	Three Stage Least Squares

CHAPTER 1

INTRODUCTION

Occupational health and safety research remains a priority for the government with the frequent launch of various United Kingdom (UK) and European Union (EU) strategies for improving workplace safety. This thesis examines the impact that modern day labour market characteristics and policies have upon workplace health and safety, thus providing a discussion of where policy needs to be directed. Given the many economic changes since Adam Smith published *The Wealth of Nations,* we also examine if his theory of compensating wage differentials, whereby workers receive a wage premium for sorting into occupations with a high accident risk, is still applicable today. Although there have been many papers examining the compensating wage differentials theory using US data, there has been comparatively little research using UK data. Furthermore, such investigations use accident data from the 1970s and 1980s. We further investigate if personal characteristics can be used to predict which workers are likely to sort into occupations with relatively low accident rates. Specifically, the hypothesis that aversion to risk will vary by gender and family composition, with the expectation that workers with dependent children will reveal themselves to prefer safer work, is tested. As smokers are potentially revealing themselves to be relatively less risk averse than non-smokers, we also consider if there is a correlation between smoking behaviour and the accident rate of a person's occupation.

The structure of the thesis is as follows. Chapter 2 examines occupational health and safety legislation and methods of enforcement so as to provide an introduction. The various sources that can be used for accident and illness data are then discussed, as such data will form the basis of the empirical work. Finally, trends in reports of workplace accidents and illnesses over a period of approximately 10 years are reported and analysed. An examination of the occupational health and safety literature then follows in chapter 3, based on empirical findings relating to influences on accident and illness rates. The theory of compensating wage differentials is then outlined, and the papers that have tested whether a wage premium is received for hazardous work are reviewed.

Chapter 4 uses the Workplace Employment Relations Survey (WERS) to examine what influences workplace safety, focusing upon workplace injuries and illnesses. Given the skewed nature of the dependent variable, with many firms reporting no accidents, the negative binomial regression model is used. The wealth of firm-level data is utilised to assess the impact that personnel policies, for instance flexitime and working over 48 hours per week, have upon occupational health and safety.

In an investigation of the compensating wage differentials theory, chapter 5 again uses WERS and accident data from the Health and Safety Executive (HSE) to test the applicability of the theory today, using an ordinary least squares regression model. The chapter specifically focuses upon the impact that trade unions have upon the risk premium, on which there is conflicting evidence in the earlier literature. As an extension to earlier studies and recognising the emergence of health and safety committees and safety representatives, it further considers their role in relation to the risk premium.

Chapter 6 investigates the proposition that workers sort into occupations based on their accident rate according to gender and family composition. Using HSE accident data and worker data from the Labour Force Survey (LFS), conditional logit models are estimated to compare the impact that accident risk has upon occupational choice between gender and different family structures. The hypothesis that such sorting contributes to occupational gender segregation is then examined, using the Duncan and Duncan (1955) Index of Dissimilarity. An amended version of this chapter, *Accident Risk, Gender, Family Status and Occupational Choice in the UK,* co-authored with Peter Sloane, is forthcoming in Labour Economics.

Using the British Household Panel Survey (BHPS) and HSE accident data, chapter 7 investigates whether there is a relationship between smoking behaviour and the accident rate of a person's occupation, using descriptive analysis and ordinary least squares regression models. The suitability of smoking behaviour as a potential instrument in two-stage estimation to proxy risk aversion is also considered.

Chapter 8 provides a summary of the empirical findings and discusses policy implications. Unresolved issues are also highlighted, pointing towards potential for further research.

As three out of the four empirical estimations rely on accident data from the HSE, the Accident Risk Appendix discusses the main issues arising from trying to capture accurately work accident risk. Accident rates using various methods are considered and compared.

CHAPTER 2

WORKPLACE INJURY AND ILL-HEALTH: LEGISLATION, DATA AND TRENDS

2.1 Introduction

Davies and Teasdale (1999) estimated the cost of work-related accidents and illness to society to be substantial, equating to between £9.9 billion and £14.1 billion in 1995/96, which is equivalent to between 1.4 per cent and 2 per cent of total British GDP[1] (p.53). Reducing work-related accidents and illnesses therefore, remains a priority in the UK, with the government and Health and Safety Commission (HSC) introducing the *Revitalising Health and Safety (RHS)* strategy in 2000. The 10 year strategy outlines a number of action points through which the government and HSC aim to reduce the incidence rate of fatal and major injury accidents by 10 per cent and the incidence rate of work-related ill-health by 20 per cent by 2010. In doing so, they also aim to reduce the number of working days lost from work-related injury and ill-health by 30 per cent.

Lee (1987) outlines three general approaches to reducing workplace risks: limiting exposure, legislating for safer exposure, and changing attitudes so that exposure is reduced voluntarily. The Department of the Environment, Transport and Regions (2000) sets out an action plan for achievement of the RHS targets, which centres on

[1] The study calculated direct costs only, which included costs arising from loss of output, from a HSE investigation, and resource costs arising from damage, administration, and medical treatment.

changing and improving attitudes towards hazards rather than modifying existing legislation (p.53). The plan includes engaging with small firms more effectively, with sector-specific guidance upon how to improve safety within the workplace.

Recently Davies and Jones (2005) have suggested that setting and monitoring progress towards reaching targets to reduce the incidence of workplace accidents may not be an appropriate way to measure progress in improving workplace safety. Many labour market factors impact upon the number of injuries; Davies and Jones (2005) for instance, find "the dominant influence that contributes to an individual's risk of injury is their occupation" (p.102). Any changes in occupational composition over time therefore, will have a large effect upon the number of workplace injuries. Any monitoring of rates of workplace injury over time, therefore, needs to be in the context of any changes in labour market composition.

In order to monitor progress, there must be adequate occupational health and safety reporting mechanisms. It is through accident and illness reports, in addition to the use of self-reported surveys, that we are able to monitor and capture the level of risk associated with particular employment, enabling policy both to be devised and evaluated. There are however, many issues to consider when using health and safety reports. For instance, it is important to distinguish between accidents and ill-health. A workplace with a particular accident record can potentially have a very different record with regard to cases of work-related ill-health. One must also consider the specific requirements of reporting, such as what accidents and illnesses are reportable, and which specific circumstances warrant being classed as a workplace incident.

This section outlines health and safety legislation and enforcement in the UK and elsewhere. It also considers accident and illness reporting legislation, and specifically the accuracy of health and safety data. Finally, using accident and illness reports, trends in workplace safety over time are considered.

2.2 Health and Safety at Work Legislation and Enforcement

The workplace health and safety strategies and enforcement record of the UK is compared to that of other EU countries. This is particularly relevant given that the EU is attempting to ensure harmonisation of legislation and reporting methods relating to work safety across member states. The enforcement record of the UK is also compared to that of the United States (US).

2.2.1 UK and EU Legislation and Enforcement

Prior to the 1970s, health and safety legislation was governed by many legislative provisions and administered by several government departments and independent inspectors. With no downward trend in accident rates, the Robens Committee was formed in 1970, charged with the task of reviewing occupational health and safety legislation. The committee reported its findings in 1972, and had many concerns. Specifically, the committee called for more emphasis on self-regulation by employers and employees, believing that legislation was too prescriptive. Drawing upon many of the committee's recommendations, the Health and Safety at Work Act 1974 was established. The Act places duties upon employers to safeguard the welfare of workers as far as is reasonably practicable, and to inform employees on issues related to occupational health. Workers also have a duty to take reasonable care and to co-operate with their employer over safety matters (James and Walters, 1999).

Communication between the employer and employee is of central importance to the Health and Safety at Work Act, with the belief that "the standard of protection accorded to workers would be higher where employees, through their representatives, had a more significant voice and involvement in the consultative process" (Robinson and Smallman, 2006, p.88). To achieve such consultation, under the Safety Representatives and Safety Committees Regulations (SRSCR) 1977, safety representatives can be appointed by a trade union recognised by the employer. Safety representatives have the role of investigating possible dangers at work, causes of accidents, general health and safety welfare issues, and consulting with employers. If two or more safety representatives request that the employer set up a health and safety committee, the employer must do so within three months. Managers and representatives must agree on who chairs the meetings, how regularly they should be held, and what they hope to achieve.

In an effort to achieve convergence and harmonisation of health and safety legislation across member states, six new regulations came into force in Britain on the 1st January 1993, as part of an EU Framework Directive. Commonly known as the 'Six-Pack' Regulations, the Management Regulation in particular, places specific duties upon employers[2]. This regulation requires employers to conduct a risk assessment, with workplaces employing five or more workers required to record findings. Employers must ensure the safety of its workers as far as is reasonably practicable. The Health

[2] Further regulations introduced by the Directive are: Workplace Regulations, Manual Handling Regulations, Display Screen Equipment Regulations, Work Equipment Regulations, and Personal Protective Equipment Regulations.

and Safety Executive (HSE) emphasise that this means "an employer does not have to take measures to avoid or reduce the risk if they are technically impossible or if the time, trouble or cost of the measures would be grossly disproportionate to the risk" (HSE, 2003, p.2). Thus, employers have the freedom to decide how to control risk in the workplace. However, in particularly hazardous industries, specific regulations place more obligations upon employers. For example, the Personal Protective Equipment at Work Regulations requires protective clothing and equipment to be made available. In an investigation into the awareness of the new regulations, HSE (1998) found that only half of British workplaces had heard of all six (p.1).

In terms of consulting with employees, the Management Regulations extended employers' duties. Safety representatives have to be provided with appropriate facilities and assistance; employers must also ensure they consult with representatives in good time over any safety issues. In 1992 the European Court of Justice found in two separate cases that the UK failed to fully implement the regulations[3]. This was due to the fact that consultation was only required in firms with a recognised trade union. The Health and Safety (Consultation with Employees) Regulations (HSCER) 1996 was therefore introduced, which requires employers to consult with all employees who are not represented by a recognised trade union on health and safety issues, either directly or indirectly through a representative. However, James and Walters (2002) suggest that non-unionised workplaces may still be at a disadvantage because of "the difficulties that workers in non-unionised workplaces face in gaining access to representation" (p.154). In addition, there is evidence[4] that worker representation is most effective when trade unions are present, leading to further

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[3] Commission of the European Communities v United Kingdom (C-383/92)
Commission of the European Communities v United Kingdom (C382/92)

[4] See for example Litwin (2000) and Reilly et al. (1995).

disadvantages for workers in non-unionised firms. James and Walters (2002) conclude that "a much more radical approach is needed" to "increase worker access to representation" (p.154).

Health and safety inspectors have a significant role to play in enforcing the legislation. In the UK, inspectors have statutory powers, and can enter work premises without prior notice. If dissatisfied with the level of health and safety in a workplace, inspectors have a number of options to obtain improvements, depending upon the scale of the breach. They can offer advice to an employer about how safety should be improved to prevent prosecution. If the breach is more serious, they can issue an improvement or prohibition notice, which prevents workplace activity from continuing until the breach is corrected. If workplace safety does not improve, or if the breach is particularly serious, an employer can be prosecuted in the criminal courts. In England and Wales, magistrates can impose a maximum fine of £20 000. The case could however, be referred to a higher court, where there is no limit on the fine that can be imposed (HSC, 2004, p.18). In the case of a fatality at work, there may also be a manslaughter investigation. The names of all firms that are convicted of a health and safety offence are listed in a publicly available Offender's Database. Investigations by the HSE, which sent out questionnaires to businesses of all sizes, found that 82 per cent of respondents felt that complying with health and safety regulations was important to protect their business's reputation. Furthermore, 90 per cent felt health and safety improvements were important for productivity and morale (HSE, 2004a, p.3). The cost of failing to comply with occupational health and safety legislation can therefore, be large not just in monetary terms, but in the case of lost business through a damaged reputation.

2.2.2 US Legislation and Enforcement

The main piece of legislation governing workplace health and safety in the US is the Occupational Safety and Health Act 1970. Similar to the UK Health and Safety at Work Act 1974, this places duties upon both employers (to provide a safe working environment) and employees (to comply with all regulations and standards).

The Occupational Safety and Health Administration (OSHA) are responsible for enforcing health and safety at work policy in the US. The main method of enforcement is through the workers' compensation system. Firms pay workers' compensation insurance, with the amount dependent upon their accident record. Firms with a high accident rate pay the most insurance, which for high-risk firms can typically amount to over 10 per cent of their total wage bill (Wei et al., 2005, p.324). In the UK, insurance is only used to cover liability if employees sue their employer for negligence; it is not used to pay employee compensation. Furthermore, a high level of proof is required in such liability cases, and any pay-outs are often small (Wei et al., 2005, p.323). Wei et al. (2005) compare the occupational health and safety experiences of Hong Kong, US and UK, in an attempt to inform policy in Hong Kong where the "workplace safety record lags behind leading industrial countries" (p.321). Inspections are carried out in the UK and the US, although data in Table 2.1 show this to be comparatively less important in the US than in the UK.

Table 2.1: US and UK Work Safety Enforcement Record 1995

	US	**UK**
Inspections	94,539	88,571
Inspections resulting in citations	31,198 (33.9%)	1,499 (1.7%)
Average fine per Inspection	US$955	US$4,597
Probability of Inspection	0.09	0.31

Source: Wei et al. (2005) p.323

Wei et al. show that although the total number of inspections in 1995 was higher in the US than in the UK, this number does not take into account the number of firms. Comparatively, UK firms are much likely to have an inspection than US firms, as shown by the probability of inspection figure. The average fine per inspection was calculated as $4,597 for the UK compared to $955 for the US. Furthermore, a greater percentage of inspections in the US resulted in a citation notice. Wei et al. note that the OSHA was criticised due to the fact that inspectors had quotas for issuing citations and as a result, trivial errors often resulted in prosecution. Inspections are now focused in establishments with high injury rates, similar to the UK's system of inspections, which are "highly targeted and cover 100 per cent of high-risk firms" (Wei et al., 2005, p.324). Despite such changes, the worker compensation system remains the primary enforcement method in the US, with it placing "relatively little reliance in its systems of fines and inspections" (p.324).

Through devising a simulation model to assess the effectiveness of different safety policies, Wei et al. find that although increasing the amount of workers' compensation would encourage employers to improve workplace health and safety, it would at the same time encourage workers to take riskier jobs (p.351). Increasing fines for violation of safety regulations was found to have a significant impact, but "the required increase in fines would have to be very substantial" (p.351). The differences in the enforcement systems of the US and UK should be considered later when health and safety records of the two countries are compared.

2.3 UK Work-Related Accident Reporting

Accident data refer to cases in which a person has an accident at work that results in fatality or an injury of a specific degree of severity (the details of which vary between sources). When an accident at work occurs, we would expect attribution to the working environment to be relatively straightforward. When an accident results in a fatality, the degree of severity of an accident is also unambiguous. Due to the accuracy that is assumed for existing sources therefore, there is no need for several data sources.

Statistics available from the HSE on work fatalities, major injuries and over 3-day injuries are compiled from reports made to them and local authorities. The Reporting of Injuries, Diseases and Dangerous Occurrences Regulation 1995 (RIDDOR 95) came into effect on the 1st April 1996, and places a legal requirement upon employers in Britain to report specific incidences of fatalities and injuries at work. Specifically, RIDDOR 95 states that employers must report incidences of an accident resulting in death or major injury arising out of, or in connection with, work. Employers are also required to report incidences of an accident that results in an employee being incapacitated from work for more than three consecutive days; these three days exclude the day of accident but include days which would not have been working days, such as weekends. Injuries to members of the public that occur at a business premises must also be reported if the person has to be admitted to hospital.

Incidences that are not reportable under RIDDOR 95 include road traffic accidents that involve people travelling in the course of work, which is covered by road traffic legislation[5]. Accidents to members of the Armed Forces are also excluded. In addition, injuries to the self-employed due to an accident at their own premises are not reportable.

RIDDOR 95 replaced RIDDOR 85, and made a number of changes to reporting requirements. For example, under RIDDOR 95 injuries to members of the public need only be reported if the person is taken to hospital for treatment. The definition of an injury, to be discussed in detail later, was also widened. RIDDOR 95 also extended the definition of an accident to include acts of non-consensual violence at work, and acts of suicide occurring on transport systems, such as railways, that result in the death or injury of a worker on that transport system. The HSE stress that statistics on fatalities compiled from reports made under RIDDOR 95 are comparable with earlier figures, but other injury statistics from 1996/97 cannot be compared with previous years.

As a result of incidences reported under RIDDOR 95, statistics are divided into fatalities, major injuries, over 3-day injuries, injuries to members of the public and dangerous occurrences. The regulation specifically defines a major injury for its purposes, which includes some differences from the RIDDOR 85 definition. Table 2.2 reports.

[5]Some accidents that occur in occupations that involve mostly travel are reportable. For instance, if a lorry driver had a road accident and was injured by the substances he was transporting this would be reportable. If he were injured whilst carrying or unloading the substances he was transporting, this would also be reportable.

Table 2.2: RIDDOR 95 Major Injuries

MAJOR INJURY	RIDDOR 95 DEFINITION	COMPARISON WITH RIDDOR 85
Fractures	Any fracture other than to the fingers, thumbs and toes.	RIDDOR 95 now includes fractures of the hand and foot
Amputations	Any amputations.	Unchanged
Loss of Sight	Includes permanent and temporary loss of sight.	RIDDOR 85 excluded temporary loss of sight.
Electric Shocks	Injury resulting from electric shock or electrical burn leading to unconsciousness, resuscitation, or admittance to hospital for more than 24 hours.	Unchanged
Exposures	Loss of consciousness caused by asphyxia or exposure to a harmful substance or biological agent.	New to RIDDOR 95
Absorption of Substances	An acute illness requiring medical treatment, or loss of consciousness, caused by the absorption of any substance by inhalation, ingestion, or through the skin.	Unchanged
Exposure to Toxins	Acute illness requiring medical treatment resulting from exposure to a biological agent or its toxins of infected material.	Unchanged
Other Injuries	Injury leading to hypothermia, heat-induced illness or unconsciousness. Injury requiring resuscitation or admittance to hospital for more than 24 hours.	Extended from any other injury resulting in the person being admitted to hospital for more than 24 hours.

Source: UK Legislation

To examine the rate of reported injuries under RIDDOR, the HSE also use the LFS as a source of information on workplace non-fatal injuries. Since 1993, the LFS has annually included a limited set of questions on workplace injury. Respondents are asked if they have suffered an injury at work in the 12 months before the interview. Workplace injury estimates obtained from the LFS can be used in conjunction with reported rates of injury under RIDDOR to give an estimate of the level of reporting of injuries. As rates obtained from the LFS can be subject to sampling error fluctuations, they are presented as 3-year moving averages. Use of the LFS enables reporting trends to be examined, and hence is an important complement to injury data obtained from reports made under RIDDOR.

2.4 Accident Reports under RIDDOR 95

Reports that use RIDDOR 95 data are usually restricted to employees, as accidents to the self-employed are only reported if the person was not working at the premises they own or occupy at the time of the accident. Table 2.3 reports fatality rates that are calculated by the HSE, who use LFS employment data.

Table 2.3: Fatal Injuries Reported Under RIDDOR

	Employees		Self Employed		Workers	
Year	Number	Rate*	Number	Rate*	Number	Rate*
1986/87	355	1.7	52	2	407	1.7
1987/88	361	1.7	84	3	445	1.9
1988/89	529	2.4	80	2.7	609	2.4
1989/90	370	1.7	105	3.3	475	1.9
1990/91	346	1.6	87	2.7	433	1.7
1991/92	297	1.4	71	2.3	368	1.5
1992/93	276	1.3	63	2	339	1.4
1993/94	245	1.2	51	1.6	296	1.2
1994/95	191	0.9	81	2.5	272	1.1
1995/96	209	1	49	1.5	258	1
1996/97	207	0.9	80	2.3	287	1.1
1997/98	212	0.9	62	1.8	274	1
1998/99	188	0.8	65	1.9	253	0.9
1999/00	162	0.7	58	1.7	220	0.8
2000/01	213	0.9	79	2.4	292	1
2001/02	206	0.8	45	1.3	251	0.9
2002/03	183	0.7	44	1.3	227	0.8
2003/04	168	0.7	67	1.8	235	0.8
2004/05	172	0.7	51	1.3	223	0.8
2005/06	160	0.6	52	1.4	212	0.7

*rate per 100 000
Workers = Employees + Self-employed
Source: HSC (2006); HSE (online)

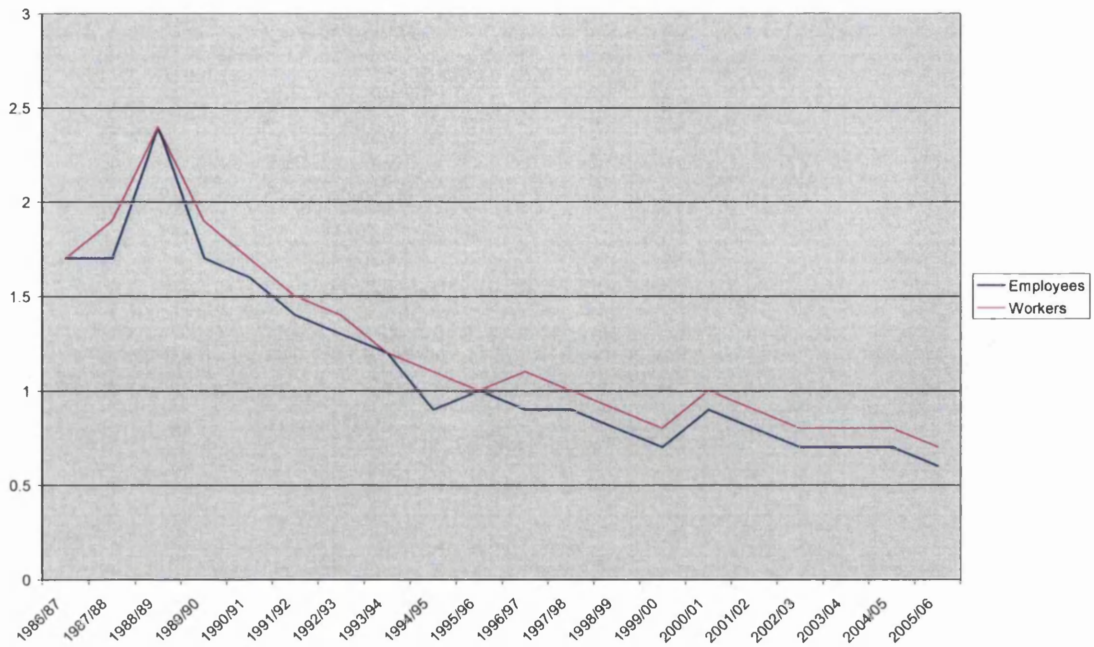


Figure 2.1: Rate of Fatal Injury per 100 000 Employees and per 100 000 Workers

Table 2.3 and Figure 2.1 illustrate a general downward trend in the rate of reported fatal injury. Since 2002/03, the rate of fatal injuries per 100 000 employees has remained fairly stable at around 0.7, falling to 0.6 in 2005/06.

As outlined, the definition of a major injury was extended in RIDDOR 95 from RIDDOR 85, and so major injury data from 1996/97 are not comparable with earlier data. Table 2.4 and Figure 2.2 show the number and rate of major injuries to employees and workers fell between 1996/97 and 2000/01. After increasing slightly between 2001/02 and 2003/04, the rate has now started to fall steadily.

Table 2.4: Major Injuries Reported Under RIDDOR

	Employees		Self-employed		Workers	
Year	**Number**	**Rate***	**Number**	**Rate***	**Number**	**Rate***
1986/87	20695	99.1	690	26.9	21385	91.2
1987/88	20057	94	867	31	20924	86.7
1988/89	19944	91.4	1152	39.4	21096	85.3
1989/90	20396	91.8	1310	41.2	21706	85.5
1990/91	19896	89.9	1326	41.2	21222	83.7
1991/92	17597	81.7	1101	35.9	18698	76
1992/93	16938	80.3	1115	35.8	18053	74.6
1993/94	16705	79.3	1274	40.6	17979	74.2
1994/95	17041	80.4	1313	40.4	18354	75.1
1995/96	16568	77.1	1166	36	17734	71.7
1996/97	27964	127.5	1356	38.4	29320	115.1
1997/98	29187	127.6	815	23.3	30002	113.8
1998/99	28368	121.7	685	20.3	29053	108.8
1999/00	28652	116.6	663	19.7	29315	104.9
2000/01	27524	110.2	630	19.2	28154	99.6
2001/02	28011	110.9	929	27.8	28940	101.2
2002/03	28113	111.1	1079	32.3	29192	101.9
2003/04	30689	120.4	1283	33.9	31972	109.2
2004/05	30451	117.9	1251	33.0	31702	107.1
2005/06	28605	110.1	1251	32.9	29856	100.3

*rate per 100 000
Black line denotes inability to compare 1995/96 reports with later data
Workers = Employees + Self-employed
Source: HSC (2006); HSE (online)

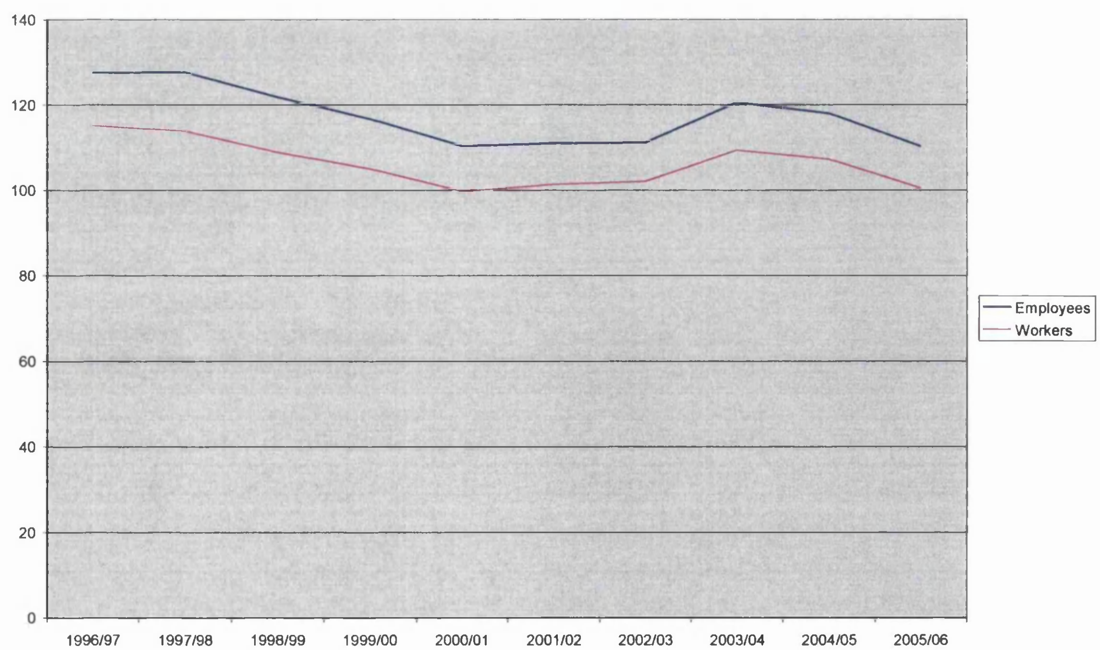


Figure2.2: Rate of Major Injuries per 100 000 Employees and 100 000 Workers

Table 2.5 and Figure 2.3 show that the rate of over 3-day injuries, when a person is incapacitated from work for more than 3 consecutive days because of a work-related accident, has gradually fallen from 1997/98. The rate increased in 2003/04, for the first time since 1997/98, from 506.5 to 514.2 per 100 000 employees, but has since fallen to 452.2 per 100 000 employees.

Table 2.5: Over 3-Day Injuries Reported Under RIDDOR

	Employees		**Self-employed**		**Workers**	
	Number	**Rate***	**Number**	**Rate***	**Number**	**Rate***
1986/87	159011	761.1	1029	40.1	160040	682.2
1987/88	159852	748.9	1169	41.4	161021	666.5
1988/89	163119	747.7	1503	51.4	164622	665.4
1989/90	165244	743.4	1865	58.6	167109	657.7
1990/91	160811	726.5	2077	64.5	162888	642.3
1991/92	152506	708.5	1832	64.5	154338	633.3
1992/93	141147	669	2136	68.5	143283	591.8
1993/94	134928	640.2	2531	80.7	137459	567.7
1994/95	139349	657.2	2869	88.4	142218	581.6
1995/96	130582	607.4	2394	73.8	132976	537.5
1996/97	127286	580.1	2282	64.6	129568	508.7
1997/98	134789	589.2	984	28.1	135773	514.8
1998/99	132295	567.3	849	25.2	133144	498.8
1999/00	135381	550.9	732	21.8	136113	487.3
2000/01	134105	536.9	715	21.8	134820	477.1
2001/02	129655	513.5	917	27.5	130572	456.7
2002/03	128184	506.5	951	28.4	129135	450.7
2003/04	131017	514.2	1114	29.5	132131	451.6
2004/05	121779	471.7	1143	30.2	122922	415.2
2005/06	117471	452.2	1174	30.8	118645	398.4

*rate per 100 000
Black line denotes inability to compare 1995/96 reports with later data
Workers = Employees + Self-employed
Source: HSC (2006); HSE (online)

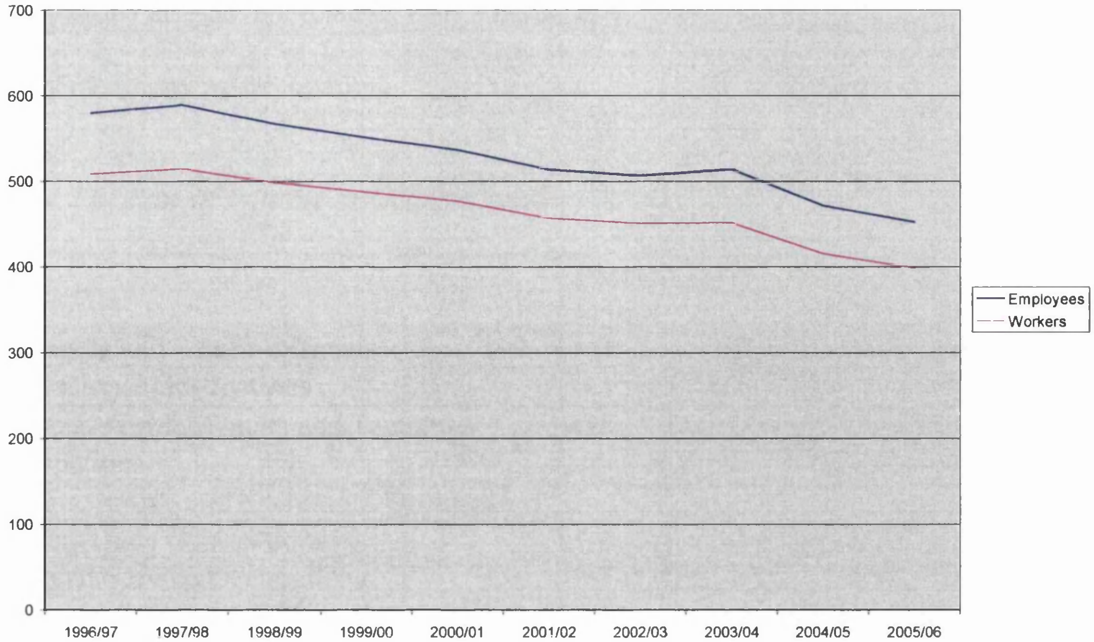


Figure 2.3: Rate of Over 3-Day Injuries per 100 000 Employees

2.5 Context to Changes in Accident Rates

Any comparison of accident rates over time needs to take account of any changes to the composition of employment over the same period. Davies and Jones (2005), in a report to the HSE, investigate the attribution of various factors that have contributed to the fall in accident reports between 1986 and 2003. Using an Analysis of Variance (ANOVA) model, they find occupation is the key explanatory factor, contributing approximately 40 per cent in predicting the occurrence of a workplace injury[6] (p.69). Table 2.6 reports injuries to employees by occupation in 2005/06 using 1 digit Standard Occupational Classification (SOC) 2000, using reports made under RIDDOR 95. Process, Plant and Machine Operatives have the highest rate of fatal injury, with 2.9 fatal injuries per 100 000 employees in 2005/06. This occupation also has the highest rate of non-fatal injury. Skilled Trade occupations and Elementary

[6] The industry a worker is employed in accounts for less than 2 per cent of the probability of experiencing an injury.

occupations also have a relatively high injury rate. This highlights the extent of which injury rates vary by occupation.

Table 2.6: Rate of Injuries by Occupation per 100 000 Employees 2005/06

	Fatal Injury	**Major Injury**	**Over 3-day Injury**
Managers and Senior Officials	0.3	45.8	99.8
Professional Occupations	0.3	55.5	141.1
Associate Professionals and Technical Occupations	0.2	74.2	353.5
Administrative and Secretarial Occupations	0	31.3	86.5
Skilled Trade Occupations	1.9	235.0	774.8
Personal Service Occupations	0.1	116.5	569.8
Sales and Customer Service Occupations	0.1	89.3	356.5
Process, Plant and Machine Operatives	2.9	386.8	1753.0
Elementary Occupations	1.3	205.7	1010.8

Rates per 100 000 employees
Source: HSE (Online)

Table 2.7: Employment by Occupation (1982, 1992, 2002)

	Share of Total Employment (%)		
Occupation	**1982**	**1992**	**2002**
Managers and Senior Officials	10.7	12.6	14.9
Professional Occupations	8.0	9.4	11.3
Associate Professionals and Technical Occupations	9.6	11.3	14.0
Administrative and Secretarial Occupations	15.5	15.8	13.2
Skilled Trade Occupations	17.0	14.6	11.4
Personal Service Occupations	3.7	4.9	7.3
Sales and Customer Service Occupations	6.1	6.7	7.9
Process, Plant and Machine Operatives	11.8	9.7	8.4
Elementary Occupations	17.7	15.0	11.6

Source: Davies and Jones (2005) Table 2.2 p.9

Davies and Jones (2005) further consider the contribution changes in occupational composition have made to the decline in accident rates between 1986 and 2003. Table 2.7 highlights a fall in the share of manual occupations, such as Process, Plant and Machine Operatives and Skilled Trade Occupations. In contrast, the share of white-collar jobs such as Professional Occupations and Managers and Senior Officials, has increased.

Considered in conjunction with Table 2.6, which highlights the declining manual occupations as the most likely to experience an accident at work, we would expect a general downward trend in injury rates since the 1980s, as has been the case. Davies and Jones (2005) report the rate of major injury was 45 per cent higher in 1986 compared to 2003. Given changes in occupational composition only, we would have expected it to be 23 per cent higher in 1986. In terms of attribution therefore, approximately half of the fall in the major injury rate would have been expected given occupational change, with the remaining half due to other factors (p.75). Such factors include other changes in the workforce such as gender composition and changes in patterns of hours worked. It also includes however, improvements in health and safety within occupations, possibly due to policy. The fact that occupation is a key determinant of the probability of experiencing a workplace accident has important implications for the empirical analyses that follow. Not only does it stress the importance of controlling for occupation in any investigation of workplace health and safety, but also suggests accidents are best classified according to a person's occupation[7].

As many changes in workforce composition will impact upon the workplace accident rate, it is difficult to quantify the effect that health and safety policy has had upon injury rates. Davies and Jones create a statistical model that controls for numerous personal, establishment and economic characteristics and developments over time, to

[7] Chapter 3 and the Accident Risk Appendices further discuss the relative advantages of classifying accidents by occupation as opposed to industry.

generate predicted injury rates. When compared to actual injury rates, they find "the series of predicted injury rates closely followed the series of actual injury rates" (p.102). The challenge for the HSE therefore, is to prove "a direct link between workplace injury rates and the regulatory activity" (p.104) by separating the policy contribution from that due to evolving market conditions. They stress that when assessing progress towards meeting the RHS strategy targets, they should be at the very least, considered in conjunction with occupational composition.

2.6 International Work-Related Accident Comparison

As reported, incidences of fatality at work in Britain are very low with just 0.6 fatalities at work per 100 000 employees in 2005/06. This point is emphasised by comparing the number of work-related fatalities in Britain with the number in other European member states. In an attempt to give consistency to workplace accident statistics, the European Union Statistical Office (EUROSTAT) calculated accident statistics for all member states based on common definitions. Standardised incidence rates of fatal and over 3-day injuries were calculated for member states, and as an EU average. This rate takes into account variation in employment by industrial sector, as the profile of employment in member states will affect the incidence rate of industrial accidents.

Table 2.8: EU Standardised Rates of Fatal and Over 3-Day Injury per 100,000 Workers 2003

Member State	**Standardised Rate of Fatal Injury**	**Standardised Rate of Over 3-Day Injury**
Great Britain	1.1	1614
Sweden	1.2	1252
Denmark	1.8	2443
Finland	1.9	2847
Netherlands	2.0	1188
Germany	2.3	3674
Belgium	2.4	3456
EU Average	**2.5**	**3334**
Italy	2.8	3267
France	2.8	4689
Greece	3.0	2090
Ireland	3.2	1262
Luxembourg	3.2	5033
Spain	3.7	6520
Austria	4.8	2629
Portugal	7.6	4054

Source: HSE (online)
Note: All rates of fatal injury exclude road traffic and transport accidents. Rates of over 3-day injury for Britain and Ireland exclude road traffic and transport accidents, but are included for other member states

Table 2.8 reports that the standardised rate of fatal accidents in 2003 in Britain was calculated to be the lowest in the EU, with 1.1 fatalities per 100 000 workers, compared to an EU average rate of 2.5 per 100 000 workers. Similarly for over 3-day injuries, the British standardised rate was calculated as 1614 per 100 000 workers, compared to an EU average of 3334. Compared to the rest of Europe therefore, Britain has a below average work-related accident rate.

EUROSTAT also calculated standardised accident rates for 2000, and included an equivalent measure for the US. Table 2.9 shows the rate of fatal injury of 2.2 per 100 000 workers was higher than the rate of 1.7 per 100 000 for Britain, but lower than the EU average. These rates can be considered in conjunction with the earlier section on differences in health and safety at work enforcement policy between the US and the UK, as displayed in Table 2.1. As noted earlier, the UK places more emphasis on inspections and fines as a deterrent rather than an experience-related workers' compensation insurance system as in the US.

Table 2.9: EU Standardised Rates of Fatal and Over 3-Day Injury per 100,000 Workers 2000

Country	Standardised Rate of Fatal Injury	Standardised Rate of Over 3-Day Injury
Great Britain	1.7	1607
EU Average	2.8	4016
USA	2.2	2780

Source: HSE (2000)

The HSE also undertook an analysis to compare injury statistics in Great Britain, Germany, France, Italy and Spain, over a five year period. Similar to the analysis undertaken by EUROSTAT, the statistics were adjusted to make them comparable, which involved excluding road traffic accidents. As shown in Table 2.10 and Figure 2.4, the average rate of fatal injury in Britain between 1999 and 2003 has consistently been below the EU average.

Table 2.10: Standardised Rates of Fatal Injury per 100 000 Workers

	Great Britain	Germany	France	Italy	Spain	EU Average
1999	1.4	2.4	3.4	3.4	5.0	2.9
2000	1.7	2.1	3.4	3.3	4.7	2.8
2001	1.5	2.0	3.2	3.1	4.4	2.7
2002	1.4	2.5	2.6	2.1	4.3	2.5
2003	1.1	2.3	2.8	2.8	3.7	2.5

Source: HSE (Online)

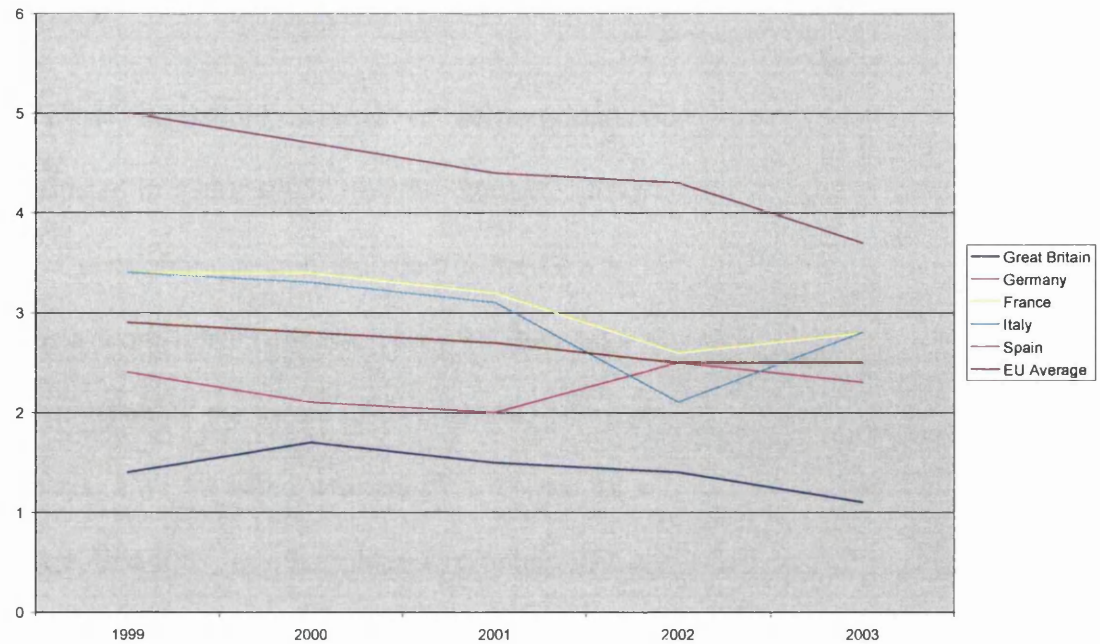


Figure 2.4: Standardised Rates of Fatal Injury per 100 000 Workers

2.7 UK Work-Related Ill-Health Reporting

Occupational ill-health and disease cover a wide range of disorders, some of which are easier to attribute to work than others. Illness risk is cumulative, and attribution will differ between workers, reflecting their own perspectives, knowledge and awareness. Unlike workplace fatalities and injuries, ill-health does not always occur immediately after exposure to the hazard, there is likely to be some delay: reporting the number of cases of occupational ill-health is therefore difficult. The HSE use a range of sources on occupational ill-health, unlike cases of occupational fatalities and injuries, where reports made under RIDDOR 95 coupled with LFS data are sufficient. Selections of the main sources of ill-health data are considered.

2.7.1 Surveys of Self-Reported Work-Related Ill-Health (SWI)

SWI are household surveys of self-reported occupational ill-health that were conducted in 1990, 1995, 1998/99, 2001/02, 2003/04, 2004/05 and 2005/06. Surveys use a screening question included in the LFS to isolate workers who have suffered from a work-related illness. The SWI then asks these particular individuals further questions about the nature of their illness. The screening question has varied between surveys. SWI 90 asked workers if in the last 12 months they had suffered from any illness, disability, or other physical problem that was caused or made worse by work, including work done in the past. SWI 90 covered workers in England and Wales only. SWI 95 asked the same screening question, but covers workers in Great Britain. SWI 98/99 was commissioned by EUROSTAT and included most member states; data are therefore available at the UK level. The screening question was re-worded slightly to include mental illness, asking respondents if within the last 12 months they had suffered from any illness, disability, or other physical or mental problem that was caused or made worse by their job. However, unlike all of the other surveys, coverage is restricted to people working in the past 12 months rather than to people ever employed. In other surveys, people who no longer work but may still have experienced an illness caused by work done in their previous job are included. This is important given the cumulative nature of illness, as in some cases it may be many years after initial exposure before a person has symptoms. Later surveys have used a screening question that includes mental illness like SWI 98/99, but also includes past workers. SWI 01/02, 03/04, and 04/05 cover workers in Great Britain, and are the most comparable (Jones et al., 2006, p.xxv).

Respondents who indicated in the screening question that they had suffered a work-related illness in the last 12 months, took part in a follow-up questionnaire which asked for more details. This included the nature of the illness, the job which caused it, the number of work-days lost, other characteristics of the illness, and the nature of the person's job. If more than one illness was reported, follow-up questions concentrated on the most serious. As the survey is based only on peoples' perceptions, the doctor or specialist who treated the illness was contacted and asked to confirm the diagnosis. They were also asked if they thought a link with work was likely. Responses were excluded if there was a poor link with work, and also if the illness was as a result of an accident.

The responses are used by the HSE to code the illnesses based on the International Classification of Disease. Jones et al. (2006) list the broad categories of disease used in the surveys as follows:

- Stress, depression or anxiety
- Headache or eyestrain
- Hearing problems
- Heart disease/attack, other circulatory system
- Breathing or lung problems
- Skin problems
- Musculoskeletal disorders
- Infectious diseases (virus, bacteria)

2.7.2 Reports under RIDDOR 95

In addition to requiring employees to report incidences of work accidents, RIDDOR 95 also requires employers to report cases of a defined list of diseases occurring amongst their employees'. Employers have to report cases when an employee has received a doctor's written diagnosis and when there is a clear link with the disease and the employee's work activity. In addition to a list of reportable diseases, RIDDOR 95 includes a list of work activity that is associated with each disease. The following main categories of diseases are reportable (the full list of which is available from UK Legislation):

- Conditions due to physical agents and the physical demands of work
- Infections due to biological agents
- Conditions due to substances

Stress-related illnesses are not reportable, with the regulation more concerned with reporting occupational disease. Similar to accident reports, the list of reportable diseases is slightly different from RIDDOR 85, the main difference being that RIDDOR 95 includes specified musculoskeletal disorders and occupational dermatitis. The HSE stress there is significant under-reporting of occupational diseases under RIDDOR 95. Due to this, 2002/03 is the last year for which RIDDOR disease reports have been compiled by the HSE.

2.7.3 Voluntary Reporting by Specialist Doctors under The Health and Occupation and Reporting Network (THOR)

The Reporting Network THOR has operated since 2002, and brought together seven schemes concerned with reporting specific types of work-related disease. The main schemes that will be considered are the Surveillance of Work-Related Occupational Respiratory Disease (SWORD), the Occupational Skin Surveillance (EPIDERM) and the Occupational Physicians Reporting Activity (OPRA). The network relies on specialist doctors and physicians reporting voluntarily cases of work-related disease. However, as not all workers will have access to such specialists at their work-place, figures reported under THOR should be regarded as minimum estimates.

2.7.4 Industrial Injuries Disablement Benefit (IIDB) Scheme

The IIDB compensates workers that have a disease that has been prescribed to be as a direct result of his or her occupation, and has resulted in disability. Although it does vary for different diseases, the benefit is usually paid to those whose extent of disability is assessed at being 14 per cent or more compared to a non-disabled person. The HSE stress IIDB data will not be a true reflection of workplace illnesses for many reasons. It may be difficult to identify and prove that a person's occupation caused the disease and this is especially true when there is a long latency period. Individuals may also be unaware that they are able to claim the benefit, and also that their condition is as a direct result of their work. The HSE stress that a large proportion of claimants' suffer from ailments that are as a result of poor past working conditions that would, in many cases, be illegal by today's health and safety standards. Data is rounded to the nearest 5 cases to maintain anonymity.

2.8 Ill-Health Statistics

Reports of ill health over time using the sources discussed are now considered.

2.8.1 SWI Surveys

The previous section highlighted the many differences between the six surveys, and stressed that the HSE advise that SWI 01/02, 03/04, 04/05 and 05/06 are the most comparable. Therefore, data are compared between these four surveys only. When interpreting the data, a distinction between incidence and prevalence rates must be made. Annual incidence refers to the estimated new cases of work-related ill-health occurring in the 12 month period, whereas annual prevalence is the number of people with a work-related illness at any time during the 12 month reference period. Only prevalence rates can be compared between surveys. Prevalence is also arguably the most appropriate measure of work-related ill-health, because of the likelihood of persistence of symptoms after initial diagnosis.

Table 2.11: SWI Surveys Ill-Health Prevalence Rates

Rate per 100 ever employed	**2001/02**	**2003/04**	**2004/05**	**2005/06**
Male	6.4	6.2	5.5	5.3
Female	4.3	4.3	3.9	3.8
All persons	5.3	5.2	4.7	4.5

Source: HSE (2007)

Table 2.11 reports a fall in the prevalence of workplace illnesses between 2001/02 and 2005/06 for both men and women. The prevalence rate per 100 ever employed of people suffering from a work-related illness equated to an estimated 2 million people in 2004/05, with 576 thousand first aware of their illness in the previous 12 months

(Jones et al. 2006). Decomposing the total illnesses by type of complaint (Table 2.12 and Figure 2.5) illustrates that bone, joint or muscle problems are by far the most prevalent.

Table 2.12: SWI Surveys Ill-Health Prevalence Rates by Type of Complaint

Rate per 100 ever employed	**2001/02**	**2003/04**	**2004/05**	**2005/06**
Bone, joint or muscle problem	2.6	2.6	2.4	2.4
Breathing or lung problem	0.39	0.43	0.32	0.36
Skin problem	0.088	0.071	0.067	0.062
Hearing problem	0.21	0.19	0.17	0.16
Stress, depression or anxiety	1.3	1.3	1.2	0.97
Headache and/or eyestrain	0.12	0.087	0.073	0.075
Heart disease/attack, other circulatory system	0.19	0.15	0.13	0.15
Infectious disease	0.074	0.065	0.065	0.063
Other type of complaint	0.39	0.32	0.29	0.33

Source: HSE (2007)

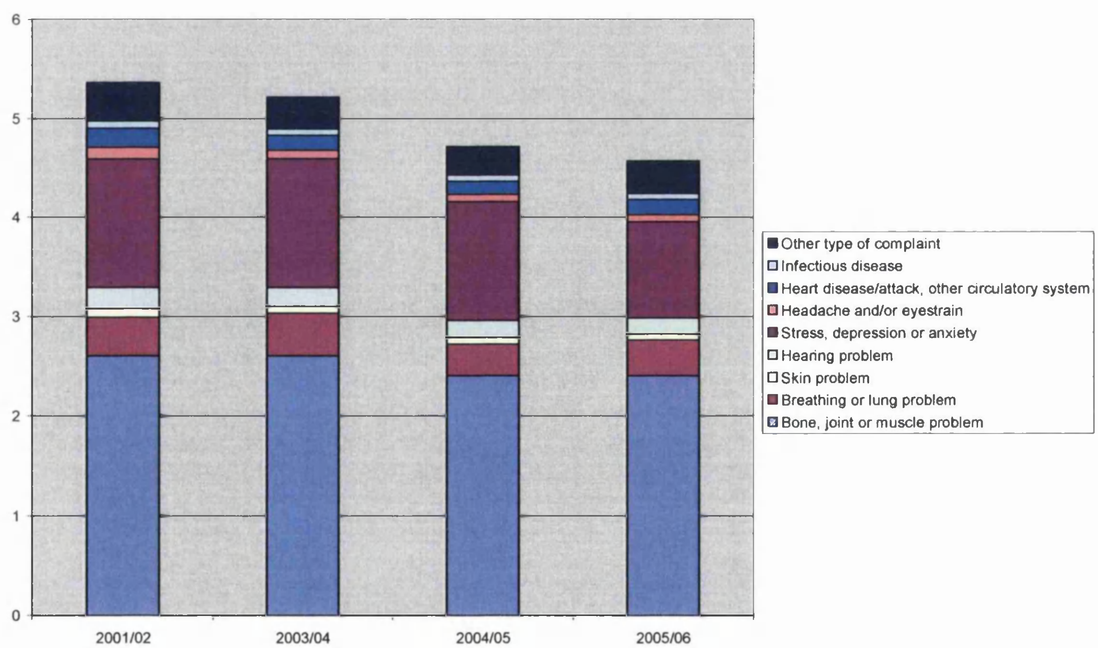


Figure 2.5: SWI Surveys Ill-Health Prevalence Rates per 100 Ever Employed

<u>2.8.2 RIDDOR 95</u>

As discussed, HSE have stressed there is significant under-reporting, and so statistics are unavailable after 2001. Statistics reported under RIDDOR refer to new incidences of work-related ill-health, rather than its prevalence. For completeness, Table 2.13 reports the number of new incidences of each category of occupational disease from 1996/97-2000/01.

Table 2.13: Incidences of Work-Related Ill-Health Reported Under RIDDOR 95 (Numbers)

	1996/97	1997/98	1998/99	1999/00	2000/01
Conditions due to physical agents and the physical demands of work	1019	1123	1389	1703	1697
Infections due to biological agents	160	131	105	94	93
Infections due to substances	465	633	702	737	588
TOTAL	1644	1887	2196	2534	2378

Source: HSE (2001), Table A2.11

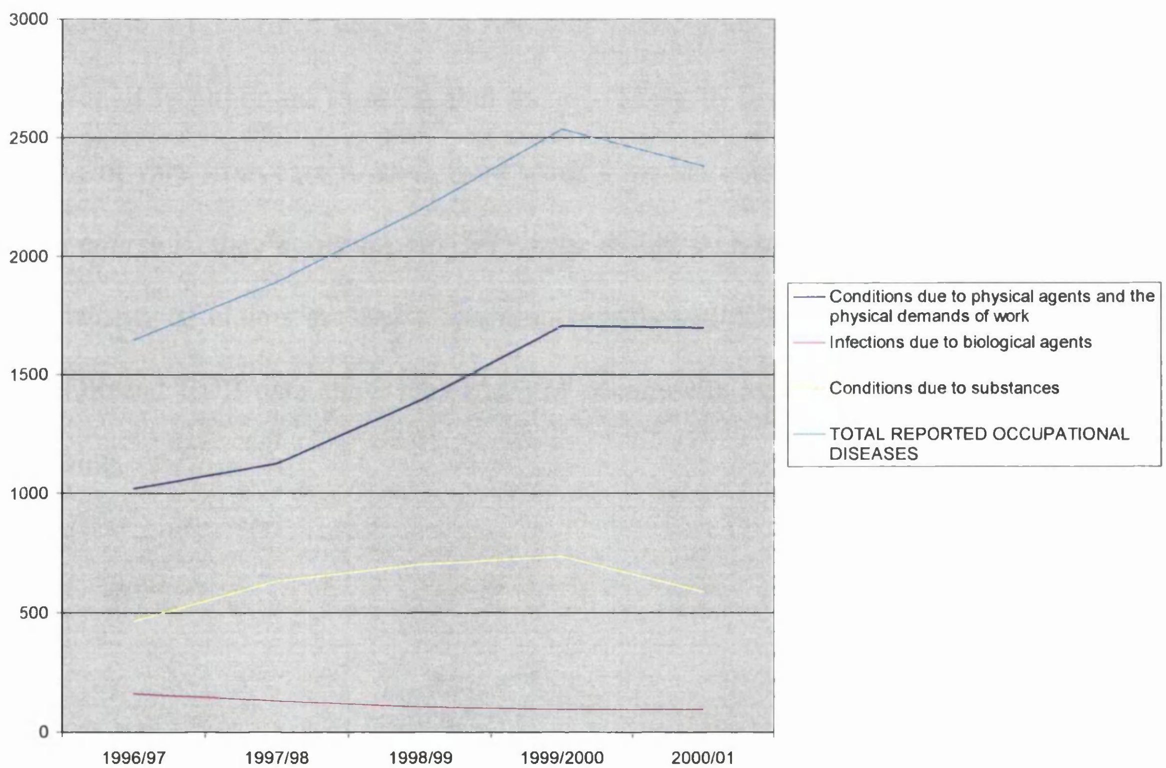


Figure 2.6: Incidences of Work-Related Ill-Health Reported Under RIDDOR 95 (Numbers)

Since 1996/97, the total number of occupational diseases reported under RIDDOR 95 has steadily increased. It fell for the first time in 2000/01 from 2534 to 2378.

2.8.3 IIDB Prescribed Disease Data

IIDB data by prescribed disease is available in many forms, from the number of assessments made in a particular year, which is a measure of incidence, to the number of IIDB awards being paid in a particular year, which is a measure of prevalence. Table 2.14 reports the number of first diagnosed prescribed diseases assessed from 1998 by type of disease. In order to have reached the assessment stage, the prescribed disease will have been accepted.

Table 2.14 shows there has been an overall reduction in the number of assessments for IIDB due to a prescribed disease, in line with observation from other data sources. However, it is important to stress that there is likely to be a delay, the duration of which will vary from case to case, from when a worker contracts a disease, to when, and of course if, they apply for IIDB. Figures should therefore be used a guide only. The majority of claims are due to pneumoconiosis and diffuse mesothelioma. Both RIDDOR and IIDB data show incidences of pneumoconiosis, and mesothelioma are increasing.

Table 2.14: Number of Prescribed Diseases Accepted and Assessed

	Total Assessments	Synovial Inflammation	Occupational Deafness	Vibration white finger	Carpal tunnel Syndrome	Pneumo coniosis	Diffuse mesothelioma	Unilateral/ bilateral pleural thickening	Bronchitis and emphysema	Others
1998	10 205	420	265	3 000	430	875	585	225	3 425	985
1999	8 400	355	310	3 285	500	865	620	245	1 445	765
2000	7 405	315	220	3 345	485	865	655	270	600	635
2001	7 250	315	260	2 985	620	970	750	290	450	600
2002	8 085	290	265	2 355	915	1 740	1 000	380	475	675
2003	7 525	240	335	1 495	940	1 790	1 175	400	405	745
2004	7 045	255	330	980	795	1 905	1 350	410	290	720
2005	6 380	220	250	815	640	1 590	1 535	415	184	730

Source: DWP (Online)

As more of a measure of prevalence, Table 2.15 reports the number of IIDB's in payment by prescribed disease for each particular year from 1998-2003. The number of payments due to a prescribed disease has remained fairly constant.

Table 2.15: Industrial injury assessments in payment by prescribed disease

	All Prescribed Diseases	Synovial Inflammation	Occupational Deafness	Vibration white finger	Carpal tunnel syndrome	Pneumo coniosis	Diffuse mesothelioma	Unilateral/ bilateral diffuse pleural thickening	Bronchitis and emphysema	Others
1998	57 500	2 300	14 700	5 200	600	11 400	700	1 400	12 000	9 400
1999	61 400	2 500	14 500	6 200	800	11 200	900	1 700	13 600	10 000
2000	61 500	2 500	14 300	6 800	900	11 000	1 000	2 000	13 200	9 800
2001	61 300	2 500	13 700	7 400	1 100	11 100	1 000	2 200	12 500	9 800
2002	60 600	2 500	13 200	8 100	1 400	11 000	800	2 400	11 500	9 700
2003	59 900	2 600	12 600	8 300	1 700	11 500	700	2 400	10 700	9 500

Source: DWP (Online)

2.8.4 THOR

Voluntary reports made to THOR are often regarded as minimal estimates as reports rely on occupational physicians within workplaces. However, the HSE cites figures from THOR, as they are a guide to the number of new incidences of particular work-related diseases over time.

Table 2.16 reports incidences of work-related diseases. Similar to reports from SWI surveys, there has been an increase in the incidence of stress, depression and anxiety from 5 523 in 1999/00 to 6 373 in 2003/04. There has been a reduction in incidences of musculoskeletal disorders, hearing loss, and dermatitis.

Table 2.16: Work-Related Ill-Health Incidence Reports to THOR

	Musculoskeletal disorders	Stress, depression or anxiety	Asthma & other short-latency respiratory disease	Dermatitis & other skin disease	Infections	Mesothelioma/ other long-latency respiratory disease	Vibration related disorders	Hearing Loss
1999/00	8 635	5 523	1 626	4 861	817	2 791	763	756
2000/01	7 816	6 327	1 236	4 322	926	2 556	923	648
2001/02	7 870	6 879	1 052	3 659	838	2 374	879	395
2002/03	8 043	6 675	1 082	3 746	2 331	2 112	1 181	222
2003/04	5 687	6 373	1 058	3 308	1 106	2 358	423	352

Source: HSE (2004b), Table 19

2.9 UK Illness Data Summary and International Comparison

It is difficult to compare ill-health statistics between sources due to many factors. The diseases that are reportable for each source vary, and there is a definite distinction between sources as to whether they measure incidence (RIDDOR and THOR) or prevalence (SWI and IIDB in payment). However, some broad conclusions can be made by comparing figures over time for specific occupational illnesses. For instance, SWI and THOR report an increase in stress, depression and anxiety due to work. RIDDOR and IIDB and THOR all show an increase in new reports of pneumoconiosis, and mesothelioma, although due to the potential for a long latency period, contraction of many such illnesses is likely to have occurred many years ago.

Given the difficulty in comparing occupational ill-health data in the UK, we are unable to compare data internationally as we were able to do for accidents. However, the EU strategy, *Adapting to Change in Work and Society: a New Community Strategy on Health and Safety at Work 2002-06*, emphasises the importance of improving ill-health data collection to enable comparability in the future. The strategy recommends member states should ensure all cases of occupational disease are reported. The European Statistics on Occupational Diseases (EODS) programme should soon publish comparable data on occupational illness within the EU.

2.10 Accuracy of Accident and Illness Reports

Under-reporting of both occupational accidents and illnesses is an issue that is of particular concern to the government and the HSC. Although legally employers have to meet the requirements of RIDDOR and report incidences of work-related accidents and ill-health as outlined in the regulation, there are still concerns that there is significant under-reporting. From the results of a health and safety module included in the British Social Attitudes Survey 2001, it was estimated that employers had been made aware of 80 per cent of accidents, and only 46 per cent of work-related illnesses (HSE, 2002, p.27). They noted this was an area for concern, with the potential for "adverse effects both on monitoring and on the potential for action by employers to reduce the occurrence of work-related illnesses at their workplace" (p.31). Daniels and Marlow (2005) were commissioned to conduct a review of the literature on under-reporting, and found that "whilst reporting of workplace fatalities is thought to be accurate, HSE remain concerned regarding the reporting of non-fatal workplace injuries" (p.2). They emphasise that this problem is not just observed in the UK, but is a "worldwide phenomenon" (p.iv).

In an effort to confirm whether under-reporting exists, and to what extent, the HSE compares reports of non-fatal injuries made under RIDDOR with estimates obtained from the LFS. As expected, Table 2.17 shows that the LFS estimated rate of reportable injury is greater than the RIDDOR reported rate, suggesting there is a certain amount of under-reporting of non-fatal injuries under RIDDOR. For example, in 2004/05, the averaged LFS rate is estimated to be 1 200 per 100 000, but only 590 per 100 000 injuries were actually reported under RIDDOR. Therefore, 49 per cent of non-fatal injuries were actually reported. Furthermore, there has been no significant improvement in reporting since 1999/2000.

Table 2.17: Rate of reported Non-Fatal Injuries

	1999/00	2001/02	2002/03	2003/04	2004/05
RIDDOR reported injury rate to employees	667	624	618	635	590
LFS reportable injury rate to workers	1 490	1 500	1 430	1 330	1 200
Percentage of injuries reported	45	42	43	48	49

* = rate per 100 000 employees/workers
Source: HSC, 2006, p.11

The RHS strategy outlines plans to address the issue of under-reporting of non-fatal accidents, part of which involved commissioning the review by Daniels and Marlow (2005). Their review considers the characteristics of firms and individuals that are found to be most likely to under-report, and also offers best-practice examples of when accurate reporting of accidents and illnesses is most likely.

Comparison between the LFS rates and RIDDOR reports show "actual report rates differ significantly by sector" (Daniels and Marlow, 2005, p.7) with accuracy particularly low in hotels and restaurants and finance and business sectors. In addition, under-reporting is prevalent in the healthcare sector. In a UK study of surgery theatre nurses and midwives, Cutter and Jordan (2004) found 32 per cent of their sample admitted failing to report an injury (p.441). Research also indicates there is significant under-reporting in the agriculture sector, where some of the highest occupational injury and mortality rates are observed. Daniels and Marlow (2005) summarise that in the literature "estimates of up to a 77 per cent under-reporting rate are cited" (p.8). They cite the main reasons for under-reporting in particular industries to be related to the perception of reporting as being time-consuming, and to the belief that nothing can be done about reducing the injuries they suffered at work.

Under-reporting is also thought to be common in small firms. Daniels and Marlow, in summarising the literature, find this to be due to "lack of awareness of legal reporting requirements among smaller enterprises" and "completing the relevant paper work posing a greater relative burden for smaller rather than larger firms" (p.iv). McKnight et al. (2001) emphasise that, whilst small firms will have a smaller number of injuries due to the smaller workforce, rates of injuries are usually found to be higher in small firms, as discussed in chapter 3A.6.

Management commitment and adequate reporting mechanisms are considered to be significant determinants of accurate accident reporting. Specifically, the 'safety culture' of a firm (which is discussed in more detail in chapter 3A.9) will greatly influence whether accidents are reported, as it will affect "the attitudes and beliefs in terms of health and safety performance" (Gadd and Collins, 2002, p.17) of the firm and ultimately its employees. Daniels and Marlow remark that "active and visible management commitment" (p.5) to a reporting scheme is needed. They further emphasise that "conscientious organisations with a strong managerial commitment to safety make it clear to all employees and supervisors that under-reporting of accidents is unacceptable" (p.5). The HSE attach great importance to the role of safety representatives in providing a signal of a firm's commitment to safety, and also in communicating the reporting procedure to workers who are unaware of it. Although management commitment to safety is clearly a key aspect in minimising under-reporting of accidents, some safety policies designed to reduce accidents may not always be beneficial. Specific examples of workplace safety policies will be discussed in chapter 3A.9, but policies designed to reward workers for a low accident rate may result in under-reporting, as "workers may try to hide minor injuries or be encouraged to continue to work despite being injured so as to avoid jeopardising their chances of receiving the incentive" (Daniels and Marlow, 2005, p.13). Collinson (1999) considered a case study of offshore oil rig workers, who received a collective bonus for a good safety record. Whereas managers were confident most accidents were reported, interviews revealed 50 per cent of workers had concealed an accident at some point in order to safe-guard their bonus. To ensure accurate reporting therefore, a firm must ensure management is committed to safety and reporting procedures, but recognise and address any potential incentives to manipulate the true firm's accident record arising from workplace safety policies.

The RHS strategy outlines a plan to review the reporting regulations to consider if changes can be made to reduce under-reporting. However, the review by Daniels and Marlow (2005) highlights that rather than being a problem with the reporting procedure, under-reporting is likely to occur because of a variety of other firm-specific reasons. The strategy suggests the possibility of devising an information and communications strategy to emphasise the importance of accurate accident reporting to employers. Conway and Svensson (1998) in an examination of potential under-reporting of accidents in the US, concluded that disincentives to report "often reflect psychological factors and attitudes among people in the organisation" (p.38) making the problem difficult to address.

Workplace accident under-reporting will have an impact upon the empirical work that follows. Chapters that concentrate upon workplace fatalities (for example chapter 5) will be less affected as such reports are considered accurate. Those that use non-fatal injury data however, will need to consider the impact of under-reporting. In particular, the finding that under-reporting is more common in specific sectors and in small firms will need to be considered in any interpretation of results. This is especially true for chapter 4 which relies on manager-reported injury data.

2.11 The Future of Policy and Data Collection

This chapter has summarised work safety legislation and enforcement, data sources and statistics in the UK and compared them to policies and equivalent rates in the EU and the US. In terms of the future for health and safety at work, the EU strategy *Adapting to Change in Work and Society: a New Community Strategy on Health and Safety at Work 2002-06* highlights many challenges. Specifically, policy must take account of changes in "work organisation, working time arrangements, hierarchical relations, transport-related fatigue, and the degree of acceptance of ethnic and cultural diversity within the firm" (EC, 2002, p.8). Linked to this, the strategy emphasises the need to consider "new and emerging risks" (p.8) given that recent years have seen an increase in stress, depression, anxiety and violence at work. A key element of the 2002-06 strategy was to encourage member states to devise their own, national strategy for targeting occupational health and safety. The EU recently published a new strategy, *Improving Quality and Productivity at Work: Community Strategy 2007-12,* which aims to continue with the work of the 2002-06 strategy by further supporting member states with their national strategies and focussed national action programmes.

Central to ensuring health and safety at work policy develops to take account of changing risks and conditions within the workplace, is the availability of accurate data. At the EU level, the strategy observes that data "remains incomplete, obscure or uncertain for many relevant topics" (EC, 2003, p.89). To improve this, many steps are being taken. The EODS for example, as previously discussed, is harmonising occupational illness data between member states. By making use of improved data collection, the EU also hopes to be able to provide data on the causes of a particular occupational injury or illness. By harmonising and increasing the accuracy and level of detail in data collection therefore, emerging risks due to changes in the composition of the workplace should be anticipated, assisting preventative policy.

CHAPTER 3

OCCUPATIONAL HEALTH AND SAFETY AND THE COMPENSATING WAGE DIFFERENTIALS LITERATURE

This chapter first reviews the literature that has investigated the influences upon occupational injury and illness (part A). A second section (part B) then considers the compensating wage differentials theory literature, whereby workers receive a wage premium for their exposure to adverse health and safety risk.

PART A

Accident and Illness Rates Literature

A large literature examines the relationship between aggregate workplace injury and illness and a variety of factors. Time series analysis looks at variations in injury rates over periods of changing economic conditions, government policy and industrial structure. Cross section analysis is also used to examine the relationship between injury rates and characteristics at the individual and firm level. Any significant influences upon injury rates are important to consider, in terms of determining any potential pattern in reports of injury rates and therefore guiding future workplace health and safety policy. However, Davies and Jones (2005) highlight that "there are likely to be a number of factors within the economic environment which are beyond the control of the HSE, that will influence the incidence of workplace injuries" (p.2), such as the unemployment rate and the change in occupational structure. This needs to be considered when attempting to make policy recommendations, and also when evaluating policy effectiveness.

3A.1 Gender

EC (2004) reports that men are three times more likely to have an accident at work than women (p.31). Although this is partly due to men working in more high-risk sectors and working longer hours, even after adjusting for such differences, "men are about twice as likely as women to suffer accidents at work" (p.34). Women may be performing less risky tasks within sectors. Differences in incidence rates however, are observed in financial, real estate and business sectors, where we would not expect the tasks of men and women to be significantly different. McKnight et al. (2001) for example, using LFS data, find that even after adjusting for the fact that men are more likely to work in manual occupations, men are more likely to experience workplace injury than women. The differences in male and female injury rates are likely to be partly due to differences in attitudes and willingness to accept workplace risks. A large literature examines this possibility (including investigations by Dohmen et al. 2005, and Ekeland et al. 2004), and this is discussed in detail in chapter 6.1.

When investigating geographical variations in injury rates, Davies and Elias (2000) find, surprisingly, that regional increases in female participation are related to increases in overall employee injury rates. Therefore, although women are least likely to have an accident at work, regions with increasing female participation are likely to have a higher injury rate. In a time series analysis, Davies and Elias (2000) find that although the rate of workplace injuries is following a long-run downward trend, the "overall trend is a net effect masking quite different trends for men and women" (p.63). Whilst the male injury rate is following a downward trend "female injury rates are estimated to follow an upward quadratic trend, although the rate of increase diminishes over time" (p.63). Overall therefore, female injury rates are lower than male injury rates but following an upward, yet diminishing trend.

3A.2 Age

Theoretically, we may expect older workers to be more likely to have an accident, as age "lessens the person's ability to cope with job demands" (Laflamme and Menckel, 1995, p.145). However, Laflamme and Menckel (1995) highlight the importance of experience in enabling "efficient utilisation of resources" (p.146), reducing the likelihood of an accident for older workers. Their literature survey reports the most common finding to be that as workforce age increases, accident frequency falls. Davies and Elias (2000) also find that age has a negative effect upon regional injury rates. Similarly, McKnight et al. (2001) find 16-24 year olds are 20 per cent more likely to have an accident than older workers (p.17). EC (2004) also report "for non-fatal accidents at work the incidence rate is at least 50 per cent higher among 18-24 years than in any other age category" (p.35). It should be noted however, that the age-effect is likely to be activity-specific. Laflamme and Menckel (1995) emphasise there will be a point where increases in age begin to cause accident frequency to rise, especially for physically demanding occupations.

Fenn and Ashby (2004), using WERS 98, show age has a different effect upon workplace illnesses than accidents; while workplaces with a younger workforce have a higher risk of reported accidents, their illness regression results indicate "establishments with a high proportion of young workers have lower illness rates" (p.473). Robinson and Smallman (2006) find a similar result when workplaces are divided into manufacturing and service sector establishments (p.100).

3A.3 Industry and Occupation

The industry and occupation of an employee are very significant in terms of defining an employee's risk of having a work-related accident. This is emphasised in Davies and Elias (2000), who in their model to explain geographical variations in injury rates in the UK, find that "the industrial and occupational composition of employment accounts for a majority of regional variation in the risk of a workplace injury" (p.4). Specifically, they find higher injury rates are associated with employment within the manufacturing and construction industries. In terms of occupation, Fenn and Ashby (2004) find that personal and protective service employees and the unskilled have "more than four times the injury risk faced by clerical workers" (p.473). Interestingly however, "the effects of occupational group on the risk of illness are not statistically significant" (p.473).

Given the importance of a worker's industry and occupation on the determination of their risk of having a work-related accident, it is important to consider the effect of changes in the concentration of employment within certain sectors. Davies and Elias (2000) highlight the fact that "since 1971 there has been a clear shift in employment away from primary industries, utilities and manufacturing, towards the service sectors" (p.14). For instance, between 1971 and 1997, they calculate employment in manufacturing fell from 31.2 per cent to 16.5 per cent of the workforce. Employment within business and miscellaneous services during the same period, however, increased from 11.5 per cent to 22.2 per cent (p.14). They emphasise that such "shifts in employment from traditional manual employment will have a significant impact upon the incidence of industrial injuries" (p.17).

Similarly, in the US, Loomis et al. (2004) highlight the shift from manufacturing employment to service sector employment (p.616), and discuss two potential impacts of this deindustrialisation on injury rates. First, the movement of workers from manufacturing employment where accident rates are relatively high, to jobs with lower risk, is likely to reduce the risk of injury for the average worker. Second however, on the negative side, there could be potential problems with struggling manufacturing firms having to "forego maintenance and replacement of obsolete equipment, and eliminate health and safety programmes" (p.616) which would have an adverse effect on injury rates. Their investigation however, "did not find evidence of a strongly negative or strongly beneficial effect of deindustrialisation on the rate of fatal occupational injuries in the US 1980-96" (p.617). They found that it did contribute to what they phrase "the long-term decline of fatal occupational injury rates", but explained only 10 to 15 per cent of the change over 17 years (p.617).

In an interview with the HSC chairman, Altman (2000) reports that in the UK the movement from traditionally high-risk manufacturing industries "has been a significant factor behind the long-term decline in overall accident rates" (p.10). Although this shift in employment has contributed to a fall in work-related accidents, he cautions that this change will present new risks, such as an increase in occupational illness. For instance, we are likely to see a reduction in physical injuries and an increase in stress related illnesses. As such therefore, the change in employment structure has meant "the nature of risk has become far more diverse" (Fenn and Ashby, 2004, p.461). This may explain Fenn and Ashby's and Robinson and

Smallman's recent findings that a worker's occupation is insignificant in determining their risk of an occupational illness: it may be that incidences of occupational illness are more evenly distributed amongst occupations compared to accidents. Overall therefore, the changing structure of the economy has meant that "it no longer seems justifiable to focus exclusively on the manufacturing sector in relation to health and safety at work" (Fenn and Ashby, 2004, p.461) and that "many of the future challenges lie in the area of occupational health" (Altman, 2000, p.9).

3A.4 Atypical Employment

Davies and Elias (2000) define atypical employment as "any type of work that is not full-time and permanent" (p.12). Altman (2000) notes that the insecurity associated with a "short-term contract culture" (p.10) can lead to an increase in stress-related illnesses. In addition to the potential for the increase in temporary employment causing an increase in anxiety-related illnesses, there are also concerns that it is associated with a reduction in health and safety standards generally in the workplace. For instance, it is hypothesised that firms with temporary contract workers may be associated with a reduction in the level of planning and organisation in the workplace, resulting in inadequate attention being paid to health and safety regulations. Although, as Burchell (1989) comments, health and safety legislation gives equal rights to all employees, in practice, workers with atypical contracts may be less likely to receive such rights, such as adequate health and safety training. Some forms of atypical employment may also be associated with a payment-by-results system. Davies and Elias (2000) emphasise that such a payment system could "contribute to the production of industrial accidents through the use of financial incentives to increase work intensification" (p.13).

Considering the empirical results of the effect atypical employment has upon occupational health, in an estimation examining variations in regional injury rates in the UK, Davies and Elias (2000) find the use of temporary workers increases injury rates (p.67). More recently, Robinson and Smallman (2006) find evidence that fixed-term workers are also associated with greater incidences of workplace illness (p.99). Similarly, Guadalupe (2003) in an estimation of injury rates in Spain found a temporary-contract effect, which "results in an increase of 5 points in the accident probability" (p.355). However, the results of Amuedo-Dorantes (2002) also using Spanish data, provide no evidence that temporary employment is associated with a higher likelihood of work injuries and illnesses "once working conditions and other factors are controlled for" (p.262). Hernanz and Tohana (2004) also reach similar conclusions with their study of the effect temporary workers has upon occupational health in Spain and Italy. While they observe that temporary employment tends to be correlated on average with higher accidents, they find the correlation "is not so significant when personal and job characteristics are controlled for" (p.5). They conclude that the balance of evidence in the literature tends to suggest that "contract type does not appear to be the main determinant of the risk of accidents" (p.16).

The effect that working unusual hours or shifts has upon occupational injury rates should also be considered. A study commissioned by the EC (2004) highlights the increased risk from working unusual hours. They attribute this to shift work "affecting the concentration of the workers, affecting the work environment (e.g. illumination) and by affecting the working arrangements (e.g. lower number of personnel, less supervision)" (p.39). Many papers in the psychology literature also highlight that working extended shifts, particularly night shifts, increases the likelihood of injury because of the pattern of work interfering with a person's circadian rhythm.

Harrington (2001) highlights that "mammals have a natural rhythmicity to many bodily functions" which is timed according to a day-night cycle with body temperature at its peak in the late afternoon (p.69). As people function best when they follow their body's natural circadian rhythm, any change in this pattern due to atypical work patterns will interrupt a person's natural pattern of alertness, increasing the likeliness of an accident. EC (2004) reports evidence that workers who usually or sometimes work in shifts, have 50 to 70 per cent higher incidences of accidents at work than those who do not (p.39).

Robinson and Smallman (2006) investigate whether there is an impact upon accidents and illnesses in workplaces that have a flexitime policy. They comment upon the trend for many workplaces to offer workers flexible hours, where employees can organise their working week to fit their own needs, with this now seen as a critical element to ensure competitiveness across Europe due to an increasingly diverse workforce (p.90). From a sociological point of view, Smith (1997) notes that such flexibility empowers workers enabling them to work in a fulfilling work environment, which we would expect to lead to a reduction in workplace stress and anxiety illnesses. However, summarising the findings of many papers, Sparks et al. (2001) highlight potential detrimental effects due to an often condensed working week, which diminishes workers' ability to identify hazards (p.497). Robinson and Smallman find flexitime is associated with a greater risk of reported injuries and illnesses in both the manufacturing and service sectors (p.99) which they attribute to increased work intensity.

Robinson and Smallman also examine the impact that working from home has upon workplaces' accident and illness records. Felstead (1996), using LFS data, highlights how the number of home workers tripled between 1981 and 1994, with the majority of home workers female and in the clerical and secretarial services industry. Quinlan (1999) argues that home working "presents major regulatory difficulties" as "many home workers operate in cramped conditions in a setting not designed for work, under tight home production schedules and at low rates of pay" (p.446). Robinson and Smallman (2006) however, find that home workers are associated with fewer workplace injuries. Conversely, employing home workers has the effect of increasing workplace illnesses (p.99) which could partly be attributed to working in continuous isolation.

It is also important to consider work intensity, and specifically whether there is a relationship between occupational health and safety and overtime working. Logically, we would expect an increase in hours to result in an increase in injury rates, if only because workers are exposed to the risk for an increased amount of time. However, there is evidence to suggest that overtime and extended work hours increase the hazard rate itself, not just the number of injuries, with workers suffering from fatigue. For instance, Sparks et al. (2001) report that working persistent 10 to 12 hour shifts resulted in increased fatigue with reduced reaction time and reasoning ability (p.491). Dembe et al. (2005), using panel data spanning from 1987-2000, consider the effect that extended hours per week (60 or more hours regularly), extended hours per day (12 or more hours regularly) overtime (the interpretation of which is left to the respondent), and extended commute time (2 or more hours per day regularly) have upon workplace injury rates. Their results indicate extended hours and overtime are positively associated with an increased risk of injury at work, which "lends support to the idea that there may be a causal process linking long work schedules with occupational injury" (p.594). Extended commute time however, had no significant impact upon occupational injuries. Overtime had the greatest effect "with overtime workers having a 6 per cent higher injury hazard rate compare to workers in jobs without overtime" (p.594). Furthermore, results persist after age, gender, occupation, industry and region are controlled for, showing jobs with longer working hours are not riskier simply because of the occupations and industries they are concentrated in or because of any dominant employee demographic characteristics. Commenting upon the findings of Dembe et al., Loomis (2005) highlights the fact that in the US, overtime has been increasing; "American workers – and many others around the world- have been working longer hours as global competition has intensified" (p.585). However, contrary to the findings of Dembe et al., which would suggest this would result in an increase in injury rates, "the overall rates of occupational injury and illness have been declining over time" (p.585). Loomis therefore emphasises that there are many other important factors impacting upon work-related injury, and while working hours have an effect, "they clearly do not tell the whole story" (p.585).

In terms of policy, Dembe et al. suggest that there should be more protective measures for employees working overtime. In particular, the study "supports the initiatives of the EU and other governments to regulate the length of working schedules" (p.595) and propose the US should consider the impact of introducing a similar schedule. The EU Working Time Directive, issued in 1993, limited working hours to 48 per week; however, the UK introduced a schedule to enable workers to opt out of the directive. Summarising the often detrimental impact that changing working practices in terms of flexible hours and overtime is likely to have upon occupational health and safety, Robinson and Smallman (2006) conclude that although it may aid productivity and competitiveness "perceived flexibility and choice is not without its costs" (p.90).

3A.5 Trade Unions and Health and Safety Committees

Freeman and Medoff (1984) describe how trade unions are viewed in two different ways, describing these as the 'two faces' of unionism. Unions can be seen as monopolies in the labour market that raise members' wages at the expense of non-members. Described as the 'monopoly face', this perspective views unions as having a harmful effect upon the functioning of the economy. Conversely, the 'collective voice/institutional response face' protects members "against arbitrary management decisions" and provides them with a "voice at the work place and in the political arena" (p.4). It is through the 'collective voice/institutional response face' that trade unions could theoretically improve health and safety in the workplace. In providing a collective voice, unions enable direct communication between employers and workers. Freeman and Medoff stress collective rather than individual bargaining is necessary within the workplace. For instance, for an individual worker, expressing concern about working conditions may be risky, but collective voice "is protected both by the support of all workers and by the country's labour law" (p.9). In addition, workplace safety is a public good by nature, with all workers benefiting from any improvements. Economic theory has shown "competitive markets will not provide enough of such goods; some form of collective decision making is needed" (p.9). Overall therefore, we may expect the presence of trade unions to reduce occupational injury rates.

There are however, arguments to suggest unionised workplaces will have a higher accident rate. Unions may provide members with health and safety information which will raise worker's awareness of their rights, and if an injury is sustained, encourage them to report it. Borooah et al. (1997) suggest that union members are more likely to report an accident at work. Fenn and Ashby (2004) comment that in unionised workplaces, accident reporting systems are more likely to be clearly established, which may in turn "give the false appearance of higher accident rates" (p.464) with unions trying to recover compensation for risk for their members. Furthermore, higher accident rates may be expected in the presence of trade unions because of the endogeneity of union membership; Wooden and Robertson (1997) raise this issue, suggesting workers in dangerous industries choose to belong to a unionised firm because of the potential safety benefits. Nichols (1997) supports this view, finding evidence that industries with higher union density also have higher injury rates.

Theoretically therefore, the effect that unions have upon health and safety in the workplace is ambiguous. Empirically, Currington (1986) and Wooden and Robertson (1997) find no statistically significant relationship between trade union membership and industrial injuries. Fenn and Ashby (2004) using WERS 98, also find no statistically significant relationship between union density and injury risk, but in terms of illness risk, find that workplaces with higher union membership are associated with a higher risk of reporting an illness. They acknowledge this is likely to reflect many factors including "the existence of better reporting practices or more generous sick pay arrangements in unionised workplaces" (p.475). Furthermore, tests for endogeneity do not enable them to reject the null hypothesis of exogeneity, suggesting employees who are at a greater risk of experiencing an injury are likely to choose to work for a unionised firm. A positive and significant relationship between union membership and industrial injuries is found by Lanoie (1992) and Worrall and Butler (1983). Using US data, Worrall and Butler (1983) find union members are "23 per cent more likely to have a health condition caused by either a job accident or bad working conditions" (p.344). They attribute this relationship to be due to the greater likelihood that union members report health and safety breaches.

In addition to considering the role of trade unions in occupational safety, studies have also investigated the role of safety representatives and health and safety committees. Chapter 2.2.1 discusses the regulations that were developed in the UK to enable safety representatives to be appointed in unionised, and more recently, also in non-unionised firms. Safety representatives have the role of investigating possible dangers at work, causes of accidents, general health and safety welfare issues, and consulting with employers. The HSC emphasise that they "attach great importance to the role played by safety representatives in securing good standards of health and safety" (HSC, 2000, p.29). This should include reviewing risk assessments and safety reports, monitoring all arrangements for health and safety in the workplace, and considering the adequacy of health and safety communication.

In terms of health and safety committees, an investigation by Reilly et al. (1995) highlights that in the UK, "these committees may adopt an even more important role given the potential for a continued decline in union workplace strength" (Reilly et al., 1995, p.276). They examine the effect that committees have upon workplace injuries using a sample of manufacturing establishments from the Workplace Industrial Relations Survey 1990 (WIRS 90). Results "confirm a relatively positive role for union safety representatives" (p.283) with firms with a health and safety committee having on average 5.7 fewer injuries per 1000 employees compared with firms with no such committee. Overall, they find "joint consultative health and safety committees (either with or without union-nominated safety representatives) perform a significant social role in reducing workplace injuries" (p.284) and suggest mandatory committees "may be one way of achieving a socially efficient level of safety" (p.284).

Cully et al. (1999) find evidence from WERS 98 that health and safety committees are important for occupational health and safety in the UK, with their presence prevalent in 39 per cent of workplaces. They found that even in non-union workplaces, representative structures for dealing with health and safety issues had been established, which can be attributed to the emergence of the HSCER 1996. Focussing specifically upon non-unionised workplaces, a study by Shearn (2005) comments that sites with a health and safety officer showed a much greater commitment to minimising workplace accidents. Compared to the non-unionised workplaces with no such officer, these sites dedicated more time and resources to improving safety (p.19).

Fenn and Ashby (2004) comment that the focus of research in this area is now upon union involvement in health and safety committees, and the impact this has upon injury rates, believing "the involvement of unions in health and safety issues in this way could provide a more direct indicator of their influence" (p.464). They do however, caution that examining the impact that health and safety committees have upon injury rates could suffer from the same endogeneity problem as a trade union variable, as health and safety committees "are more likely to emerge in establishments where workplace risk is higher" (p.464). They do find a significantly positive relationship between injury risk and the presence of health and safety committees, although they do not find conclusive evidence that the health and safety committee variable is endogenous. It should be emphasised however, that such endogeneity tests rely on the accuracy of available instruments.

Overall, the effect of the presence of unions and health and safety committees upon injury rates remains ambiguous. The relationship must be interpreted with caution, as reporting mechanisms are likely to be more established in unionised firms and firms where health and safety committees exist. Estimates may be affected by endogeneity, with unions and committees present in those firms where risk is greater.

3A.6 Firm Size

Theoretically, as outlined by Nichols et al. (1995), we may expect larger establishments to be associated with higher injury rates. We may expect worker morale to be lower in large, bureaucratic establishments, and if injuries are more likely when morale is low, this may increase the likelihood of injury. Also, injuries may be more likely in large firms because of the lack of worker autonomy. Finally, also stemming from the association of large firms with bureaucracy, poor communications could also lead to a higher injury rate. Larger firms however, may be expected to have lower accident rates for a number of reasons. Fenn and Ashby (2004) highlight that "larger establishments are more likely to be targeted by health and safety inspectors" (p.473). The incentive effect should therefore result in lower injury rates for larger firms. Larger firms are also more likely to have the capital to invest in health and safety training programmes, and to replace obsolete, potentially unsafe, equipment.

In the US, Currington (1986) and Lanoie (1992) find increased firm size is associated with smaller injury rates. In the UK, Reilly et al. (1995) and Nichols et al. (1995) using WIRS 90, find the same result. Reilly et al. (1995) find that a 1 per cent rise in an establishment's employment lowers injuries by around 0.9 per 1 000 employees (p.280). Fenn and Ashby (2004) find "a doubling of the number of employees in an establishment is associated with a 33 per cent reduction in the risk of reported injury" (p.475). In Europe as whole, EC (2004) reports that "the incidence rate of accidents at work is higher in small and medium sized units" (p.37) compared to firms that employ over 250 workers. Overall therefore, Fenn and Ashby (2004) conclude that "it seems that larger establishments are safer establishments" (p.477).

There are many potential explanations for larger firms being relatively safer. Reilly et al. (1995) suggest "larger establishments can exploit economies of scale in the provision of safety" (p.280). Frick and Walter (1998) also list numerous potential reasons for small firms to have a poorer safety record, including poor knowledge of legal requirements and safe working practices, and limited management resources to devote to health and safety (p.367).

The RHS Strategy recognises the tendency for smaller firms to have higher accident rates, and also, as discussed in chapter 2.10, a poorer reporting accuracy compared to larger firms. The HSC consultation process identified that "many small firms have difficulty understanding their legal duties and are unclear about the action they should take" (HSC, 2000, p.31). Furthermore, many small firms were deterred from seeking advice for fear of enforcement action being taken out against them. To address this, a Small Business Service was established in 2000 "to promote a one-stop shop for information and advice, free from any threat of enforcement action" (HSC, 2000, p.31) with regard to many issues facing small firms, including workplace health and safety. At the European level, the recent strategy *Improving Quality and Productivity at Work: Community Strategy 2007-2012 on Health and Safety at Work*, also stresses the need for member states to help small and medium-sized firms improve their health and safety record.

3A.7 Economic and Seasonal Effects

Many papers have examined the relationship between workplace injuries and macroeconomic conditions, with the unemployment rate often used as a proxy for economic conditions. In the UK, Davies and Elias (2000) use data provided by the HSE on the number of work-related accidents as reported under RIDDOR. Their estimation results indicate a negative relationship exists between employee injury rates and the claimant unemployment rate (p.60). However, it is important to consider the possible explanations for the relationship before concluding that policy should be directed towards improving workplace safety during periods of economic expansion.

Kossoris (1938) also found evidence of a negative relationship between the unemployment rate and workplace injuries using 1929-35 US panel data. He provided three possible explanations for his results. First, in periods of economic downturn redundancies are likely, with employees most recently hired more likely to be made redundant. During recession therefore, a firm's workforce is likely to be more experienced than the workforce during a boom. A more experienced workforce will be less prone to accidents, resulting in injury rates falling during a recession. Second, Kossoris (1938) highlights that work intensity is likely to fall during an economic downturn. During a boom, when demand for services and products are generally high, work intensity increases to meet this demand. Therefore, accidents are more likely when work intensity is greater, during a period of economic expansion. Finally, the vintage capital hypothesis is used to potentially explain the observed variation in injury rates with economic conditions. During periods of economic expansion, older and less efficient machinery may need to be used to meet demand. This increases the likelihood of an accident.

Alternatively, Nichols (1986) considers how the bargaining strength between employers and workers varies with the business cycle. When unemployment is high, employers have a bargaining advantage as the probability of a worker finding alternative employment is reduced. Workers then have little choice but to accept working conditions, increasing the likelihood of injury. Trade unions however, may prevent this from occurring through acting as a collective force.

Boone and Van Ours (2006) highlight two potential explanations for the relationship between the economic cycle and injury rates. The first is referred to as the 'working-conditions explanation'; like those explanations offered by Kossoris (1938), it directly refers to changes in a firm's accident rate in the workplace as a result of changes in economic conditions. Conversely, the alternative 'reporting explanation' attributes variations in the workplace injury rate with economic conditions directly to variations in reporting. If this explanation is correct, changes in working-conditions due to the economic cycle are not responsible for any observed relationship with injury rates.

The 'working-conditions explanation' considers variations in worker effort throughout the economic cycle. If more (inexperienced) workers are hired during a boom and a greater degree of effort is required from them, it is hypothesised that these workers will become less careful, leading to more work-related accidents. Consequently "if effort is procyclical (employers require higher effort levels in booms) so are workplace accidents" (Boone and Van Ours, 2006, p.1071). Empirically, this argument would suggest that during a boom there are more accidents at work. Alternatively, the 'reporting explanation' relates the variation in workplace accidents directly to the variation in absence rates. Brown and Sessions (1996) note that firms are more likely to fire workers who are frequently absent, and use this as a "worker discipline device" (p.40). Leigh (1985) finds evidence that this is more likely to occur when economic conditions are poor. Workers are aware of their vulnerability during an economic downturn and so will be less likely to report an accident. Consequently, research has shown there to be an inverse relationship between the unemployment rate and absence rates. Johanssen and Palme (1996), using Swedish panel data, find that "an increase of 1 per cent in the unemployment level would decrease the number of days absent by 0.45 per cent" (p.211). Workers are less likely to be absent during an economic downturn because of the increased likelihood of being fired. Using UK data, Davies and Jones (2005) also find evidence that economic growth is associated with more injuries, and specifically find "moving from a recession to a boom has been estimated to contribute to approximately an 11-12 per cent increase in the rate of major injuries among employees" (p.101). This effect varies by sector, with the greatest impact in the construction industry where an economic boom is associated with a 12-14 per cent increase in major injuries. They further find evidence that there is a significant correlation between injury rates and new hires and increased worker effort, supporting the 'working conditions' hypothesis.

Boone and Van Ours (2006) argue that in terms of workplace accidents, when unemployment is high "workers are reluctant to report accidents when they fear that employers will hold this against them" (p.1071). This explanation is directly related to variations in the reporting of accidents during changing macroeconomic conditions. To support this explanation, there must be a significantly negative relationship between the level and the change in unemployment and the number of accidents. Empirical results show that "workplace accidents are inversely related to both the level of unemployment and the change in unemployment" (p.1086). Furthermore, fatal accidents have no significant relationship with economic conditions. This leads Boone and Van Ours (2006) to conclude that the fluctuations in accident rates with the economic cycle are due to the reporting behaviour of workers. If unemployment is high or increasing, workers are less likely to report an accident. Therefore, they find "no evidence that working conditions deteriorate in cyclical upturns" (p.1086). The variations in the reporting behaviour of workers with the economic cycle must therefore be considered in the analysis of any data in a specific time period.

Davies and Elias (2000) also find evidence of seasonal variations in injury rates in their time series analysis. Results show injury rates are greatest during October for both males and females. They further observe that these seasonal effects are larger for males. Specifically, they calculate that "male employees are 18 per cent more likely to experience a workplace injury during October relative to April" (p.62). Overall, with the exception of December when fewer hours are worked, injury rates are found to be greatest during the winter months.

3A.8 Government Policy

Chapter 2 has discussed the RHS Strategy that sets specific targets to reduce workplace accidents and illnesses by 2010. The effect that such policy has upon injury rates however, is difficult to isolate. Davies and Jones (2005) highlight that "the establishment of such targets reflects a desire to demonstrate that the regulatory regime can have a positive impact on 'bottom line' measures of health and safety" (p.1), but in practice, there are many economic factors that impact upon the number of work accidents, which are beyond the control of health and safety at work policy. As discussed, workplace injury rates are influenced by the business cycle, personal characteristics, employment characteristics, and most importantly occupational composition within the labour market. The problem of assessing whether government policy has had an impact upon workplace safety "is being able to identify the separate and additional contribution of HSE against a background of varying economic conditions and a continually evolving labour market" (Davies and Jones, 2005, p.104). Whilst progress reports highlight some progress towards achieving the RHS strategy targets, economic conditions need to be considered alongside safety statistics when monitoring progress.

The effect government policy has had upon injury rates in the US and Canada, has been examined by a number of authors. Viscusi (1986) investigated the impact the OSHA in the US has had upon national injury rates. The OSHA was established in 1971, with the general philosophy of setting workplace health and safety standards. Viscusi (1986) estimates the OSHA's impact using a sample of injury rates from manufacturing industries between 1973-1983. Results are mixed, with evidence of a significant OSHA impact "only for the incidence of lost workday injuries and illnesses" (p.567), although there is no evidence of a significant impact on overall injury rates. Their evidence does however, show that "OSHA prevents from 1-2 injuries involving at least one lost day of work per 1000 employees annually" (p.578). Although acknowledging the impact is not large, they emphasise that evidence of some beneficial effect should be noted. Lanoie (1992) conducts a similar study into the effectiveness of the Canadian Board of Occupational Safety and Health from 1983-1987. Results, like those of Viscusi, are mixed; no significant effect upon the injury rate was found. However, the industry inspection rate was found to have a significant negative effect upon injury rates.

In terms of predicting the effect of potential health and safety policies in the US, Kniesner and Leeth (1988) use techniques to simulate hedonic labour market equilibrium in a bid to identify the labour market effects of various policy measures. They consider the effect of introducing an injury tax, where firms with a high accident record pay higher fines. Their model indicates "a clear negative effect on work-related injuries, which becomes more substantial as the tax rate grows" (p.780). In contrast, when considering the effect of an insurance scheme where firms pay benefits which compensate injured workers, they find little effect upon injury rates. These results are re-enforced by Wei et al. (2005) who, using Kniesner and Leeths' simulation model, consider the effect of various policies in Hong Kong. They too find an increase in workers' compensation benefits has little effect upon workplace injury rates. They attribute this to the fact that although it provides an incentive for firms to increase workplace safety it encourages workers to take more risky jobs. Alternatively, they find increasing fines for violating safety regulation, and a progressive injury tax would have a significant effect upon reducing injury rates (p.351).

3A.9 Safety Culture and Safety Policies at the Workplace Level

At the workplace level, firms can adopt various safety policies designed to reduce the accident rate. Adopting an overall 'safety culture' is seen as being the most effective workplace policy, involving adopting a commitment to safety within "the prevailing norms, values, attitudes, beliefs and practice" (Daniels and Marlow, 2005, p.11). In a review of the effect a positive safety culture has upon accident rates, Gadd and Collins (2002) remark that management's commitment to safety is crucial.

In addition, there are various safety incentive policies that workplaces can adopt. Daniels and Marlow (2005) comment that supporters of such policies "herald their merits as a means of encouraging worker safety and promoting safe behaviour" (p.12). Those who oppose them however, "stop little short of accusations of bribery and of buying safe behaviour" (p.12). Safety policies that reward workers for low accident rates can simply discourage accurate accident reporting, hence "the underlying cause of workplace hazards remains unaddressed" (p.12). Collinson (1999) provides evidence that such a policy in the US had this exact effect. Policies linking productivity to bonus schemes, including piece work rates, could also compromise safety. For instance, in a case study of foundry workers Dickety et al. (2002) found workers on piece rates were reluctant to wear safety gloves as they slowed their work pace. Sawacha et al. (1999) considered another safety policy that gave hazard pay to construction workers who were exposed to a greater level of risk than others. They found evidence that hazard pay encouraged workers to take risks, going against the promotion of safety in the workplace. Given that the compensating wage differentials theory, to be discussed in the following section, predicts that the market itself compensates workers exposed to hazards, such a policy would mean workers were in fact over-compensated.

3A.10 Interpreting and Forecasting Trends in Workplace Injuries

Although, as shown in chapter 2, there has been a general downward trend in workplace injuries between 1986 and 2006, given the preceding discussion this needs to be analysed in the context of changing economic conditions during this period. Primarily, a shift away from manufacturing employment will have contributed substantially to the fall in accidents, as highlighted in chapter 2.5. In addition, a period of economic expansion will have increased injury rates, for reasons previously outlined.

McKnight et al. (2001) consider the future movement of injury rates, using a forecast of employment by occupation, industry and gender, by the Institute of Employment Research (IER). This forecast includes changes in the composition of employment, with employment increasing in Distribution, Transport and Business (p.26). The forecast of workplace injuries takes no account of future changes in injury rates, but considers what would happen to injury rates if factors known to influence them change in the predicted way. They predicted that between 1996-2006, without policy intervention, reported injuries would rise for two reasons. First, an increase in white collar employment should more than offset the decline in employment in manufacturing, and "while injury rates are higher in the latter sectors, the scale of the expansion in employment in white collar occupations is such that this more than outweighs the decline in elementary occupations" (p.27). Second, the growth of employment in personal service occupations should contribute to a rise in reportable injuries. Overall, Mcknight et al. conclude that "if there is no decline in injury rates by occupation and industry sector over the 10 year period 1996-2006, we would expect workplace injuries to rise by more than 5 per cent" (p.30). Chapter 2 highlighted reported injuries over this period fell, suggesting occupational health and safety policy, most notably in the form of the RHS strategy, may have had a positive impact.

PART B

Compensating Wage Differentials Theory

The theory of compensating wage differentials is now considered in terms of if a wage premium is received to compensate workers exposed to health and safety risks.

3B.1 Model Outline

The theory of compensating wage differentials originates in Adam Smith's *The Wealth of Nations,* where he explains that:

> "the whole of the advantages and disadvantages of the different employments of labour and stock must,....be either perfectly equal or continually tending toward equality. If,......there was an employment evidently either more or less advantageous than the rest, so many people would crowd into it in the one case, and so many would desert it in the other, that its advantages would soon return to the level of other employments" (Smith, 1776, p.111) .

Jobs with disagreeable characteristics must therefore, pay wage premiums to attract workers. Thus, we can view the wage rate as embodying a series of implicit prices at which each of these characteristics is bought and sold. Although the theory of equalising differences dates back to 1776, the modern labour market still comprises of jobs with numerous characteristics as outlined by Smith: the theory, therefore, is still of interest today. Empirical studies are continually testing the theory, highlighting its importance. In enabling us to have a better understanding of the structure and determination of wage rates, Rosen (1986) emphasises its significance, believing it to make "legitimate claim to be the fundamental (long-run) market equilibrium construct in labour economics" (p.641).

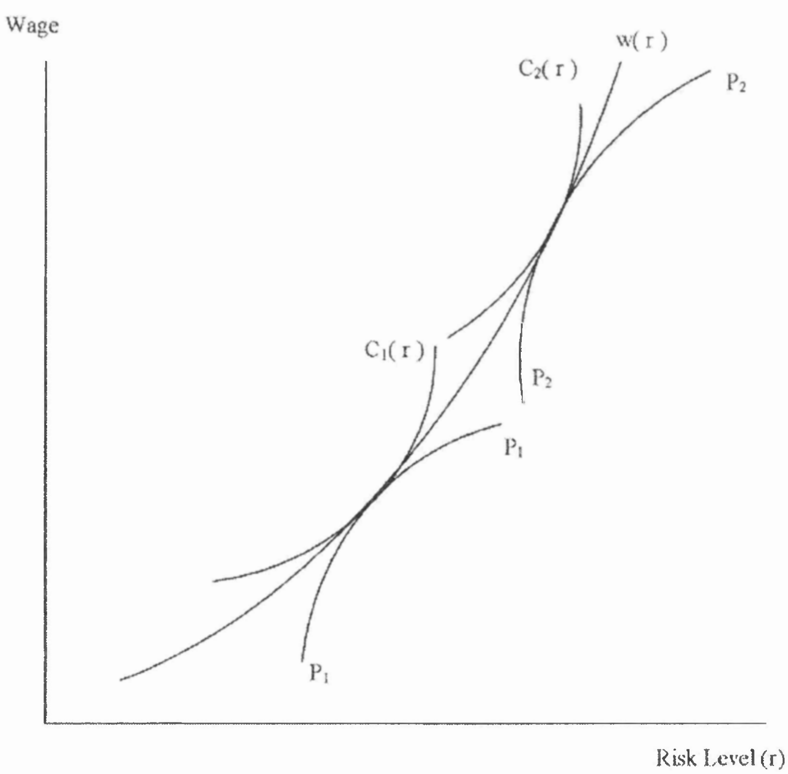
A disagreeable characteristic that is frequently applied to the theory in the literature concerns the risk of a worker experiencing a fatal or non-fatal workplace accident. This is because, as discussed in the previous section and as Thaler and Rosen (1976) summarize, "different work situations exhibit vastly different work-related probabilities of death and injury" (p.266). The compensating wage differential would be the price employers are required to pay workers in order for them to accept employment with an increased risk of fatality or injury. Recently, studies have attempted to consider the theory in terms of whether a premium is paid to compensate for the risk of an occupational long-term illness as they "are far more common than deaths at work" (Sandy and Elliott, 2005, p.745) although, for reasons discussed in chapter 2 and later, data problems have restricted the number of empirical studies in the literature.

Just as jobs will differ in their degree of hazardous conditions, firms and workers are heterogeneous. Firms will differ in their ability to provide safety; workers will vary in their willingness to accept a relatively hazardous job.

To provide a safe working environment, firms will face costs incurred from the installation and maintenance of various safety devices. To maintain a given level of profit however, firms will only invest in such devices if it translates into lower wage costs. Consequently, "greater safety (at constant profits) will be provided only at ever-increasing wage reductions" (Smith, 1979, p.340). It should be noted that the Health and Safety at Work Act 1974 places a duty upon employers to ensure the safety of workers and members of the public, as discussed in chapter 2.2.1. The Act gives employers significant freedom to decide how to control risk in the workplace; although in particularly hazardous industries, specific regulations place more obligations upon employers. Rationally, we would expect firms to assess the level of workplace safety and compare the cost of improving conditions to the cost of failing to comply with the health and safety legislation.

Figure 1 plots isoprofit curves for Firm 1 (P_1) and Firm 2 (P_2) showing combinations of the wage rate paid to workers, and the level of risk in the working environment that yield a given profit level. Isoprofit curves show that a relatively high level of risk will result in a greater wage bill, because of the high wage premium required to induce workers to accept a job with such a firm. As firms differ in their ability to provide a safe working environment, each firm will have a different set of isoprofit curves. For instance, in Figure 1, Firm 2 finds it more costly than Firm 1 to provide a safe working environment.

Workers will vary in their preferences for job safety and consequently have different attitudes towards accepting risk. A worker's preference for safety will be captured in his or her utility function. Desirable job characteristics and the wage will enter positively into this function, the magnitude of which depends upon the preferences of each individual worker. Thus, we can draw a set of indifference curves for each worker, illustrating "the trade-off each worker is willing to make between wages and risk level" (Smith, 1979, p.340). For an increasing level of risk in the workplace, workers require a higher wage to compensate them for the hazardous conditions. Figure 3B.1 illustrates that Worker 1 (C_1) places a greater value on safety than Worker 2 (C_2). Worker 2 is willing to accept a high level of risk for a relatively lower wage than Worker 1 would require for the same level of risk.



Source: Simon et al. 1999

Figure 3B.1: The Market Offer Curve

In equilibrium, firms maximise expected profits and workers maximise expected utility. As Rosen describes it, "the labour market must solve a type of marriage problem" (p.642) in matching jobs with particular levels of risk to individuals with corresponding preferences for risky work. This occurs when a worker's indifference curve and a particular firm's isoprofit curve are tangential. Here, employee and employer preferences are consistent. The market offer curve W(r) maps out points of equilibrium in the labour market, where isoprofit and indifference curves are tangential. Along W(r), the number of workers applying for jobs at each level of risk equals the number of jobs at each risk level. As shown, the most risk averse workers (Worker 1) who place the highest value on safety, are matched with firms that find it relatively easy to provide a safe working environment (Firm 1). Worker 2, who is relatively less risk averse, is matched with a comparably riskier job (Firm 2). In order to attract Worker 2 however, Firm 2 must pay a wage premium to accept the high level of risk associated with the job. This wage premium is less than the wage premium Worker 1 would have required in order to accept the same level of risk. As workers and firms make decisions based on a rational consideration of the risks and remuneration involved, W(r) illustrates points of optimal allocation of risk and earnings in the labour market. The process of allocating workers with particular preferences for risk to appropriate jobs "leads to socially optimal outcomes, where the social welfare criterion is the maximisation of the surplus received by employers and workers" (Viscusi, 1980, p.175). This neoclassical outcome requires there to be perfect labour market mobility, perfect information and perfect rationality.

3B.2 Policy Implications

There are several implications for public policy that result from the theory of compensating wage differentials. Siebert and Wei (1994) describe how the compensating wage differential "acts as a natural fine for unsafe working conditions" (p.172). If as the theory implies, workers are compensated through the market for being employed in a dangerous job then the "arguments for government intervention involving occupational safety and health are less compelling" (Leigh, 1989, p.823). However, as Purse (2004) observes, "this is an extreme position and is not one that is universally shared by all" (p.600). This is largely due to the acceptance that many of the neoclassical assumptions are unlikely to hold perfectly, as discussed later. Evidence of a positive compensating wage differential, however, certainly indicates the force of competition within the labour market.

The extra wage, or wage premium, that is received for being exposed to extra risk at work, can be viewed as the compensating variation for accepting extra risk. Thus, once a risk coefficient has been estimated, this can be used to evaluate the benefits of reducing risk. This concept has been termed the Value of a Statistical Life (VSL) or Injury (VSI). These calculations have been used in the application of numerous public policy areas which "involve a balancing of additional risk reduction and incremental costs" (Viscusi and Aldy, 2003, p.5). VSL estimates obtained from hedonic wage equation studies have had a substantial impact on US public policy, and have been used in "evaluating environmental issues, public safety in travel, medical intervention and in many other areas" (Ashenfelter, 2006, p.10) . Following a review of the literature, Viscusi and Aldy (2003) observe that "the Environmental Protection Agency (EPA) guidelines recommend a VSL of $6.2 million (2000 US $), reflecting the arithmetic mean of 26 studies" (p.54). Use of VSL from labour market studies in the UK however, has been less frequent than in the US. This is likely to be because "there have been far fewer such analyses for the UK, and the resulting empirical estimates have been much more unstable" (Viscusi and Aldy, 2003, p.56).

Empirical estimations that have included a non-fatal injury variable in their equations have also calculated VSI estimates, which have also been wide ranging. However, Viscusi and Aldy observe that the VSI in the US usually ranges from $20 000 to $70 000. Cousineau et al.'s (1992) estimate for Quebec of $33 600 in 1986 US dollars also falls within this range. Martinello and Meng's (1992) VSI estimates are however, "substantially lower than those reported in most other studies" (p.341), ranging from $9 568 and $12 789 per injury in 1986 US dollars. It has been emphasised however, that VSI estimates are likely to vary substantially across studies, "reflecting both the differences in the risk measures used, as well as whether mortality risk is included in the results" (Viscusi and Aldy, 2003, p.35).

The use of VSL estimates to aid policy decisions has received criticism. Purse (2004) comments that "value of life studies are highly controversial and have attracted criticism from both within and without the economics profession" (p.601). For instance, Smith (1979) observes that VSL estimates are attacked as "underestimating the losses attached to death" (p.348). However, Arabsheibani and Marin (2000) stress that the term VSL is misleading and should not be taken literally. Estimates are meant to provide a rough guide as to the benefit of reducing risk in a project, and are not meant to place a statistical value on life, as the name suggests. Ashenfelter (2006) comments that "when we expend wealth to avoid potentially fatal risks, and accept wealth to take such risks, we are implicitly defining a trade-off between wealth and the probability of death" (p.10), even though we are not as such, attaching a value to life.

The accuracy of VSL estimates depends upon the accuracy of empirical studies. Following concerns over the accuracy of VSL calculated from hedonic wage equation estimations, Dockins et al. (2004) commissioned an investigation into how robust such estimates are. In a review of numerous studies, they highlight findings from Black et al. (2003), who found the risk estimates were highly sensitive to the job risk measure used and the specification of the equation. This sensitivity resulted in "severe doubts about the usefulness of existing estimates to guide public policy" (p.3). Such findings were "of obvious concern to EPA given the Agency's reliance to date on the hedonic wage-risk literature in determining its central default VSL for use in policy analyses" (Dockins et al., 2004, p.8). Criticisms are supported by the fact that VSL estimates are so wide-ranging. Viscusi and Aldy (2003) in a review of VSL estimates found that in the US, VSL estimates typically range from $5.5 million to $12 million (p.28). They emphasise that VSL should not be considered as a single correct number, as a particular VSL will reflect the preferences of workers in a given sample. VSL estimates should provide government with an estimate to assist them when formulating policies of risk-reduction. They do however, stress that refining VSL estimates remains an important priority with the aim of assisting in "more informed government interventions to address market failures related to environmental, health, and safety mortality risks" (p.63).

3B.3 Criticisms

The theory of compensating wage differentials rests upon a number of key assumptions; it assumes workers behave rationally, have sufficient labour market mobility, and have perfect information. Studies that have raised objections to the theory have centred on criticising the applicability of these assumptions. This is because, as Leigh (1989) observes, "the logic cannot be faulted" and so "an attack on the neoclassical theory must be an attack on the assumptions" (p.825). Dorman and Hagstrom (1998) discuss the importance of the assumptions to the theory, as "if one of them is sufficiently at variance with the real world, actual compensation may be less than utility-offsetting, nonexistent, or even negative" (p.116). Purse (2004) attacks the assumptions that the theory is centred on, believing "they are not representative characterisations of how the labour market actually operates" (p.613). The relevance of each assumption will now be considered.

The assumption of labour mobility, also referred to as the 'exit option', requires all workers to have the ability to change jobs, if they wish to do so, when faced with hazardous working conditions. If workers are unable to move between jobs, employers would not need to pay a wage premium, as employees would have no employment alternative. Purse (2004) however, emphasises that "in the real world, workers are not at complete liberty to change jobs when they feel inclined to do so" (p.609). This is particularly true for low skilled workers; John Stuart Mill (1852) emphasised this point, suggesting "desirable workers, those whom everyone is anxious to have, can still exercise a choice. The undesirable must take what they can get" (p.385). However, Viscusi (1979) argued that relaxing the assumption of labour mobility may not compromise the compensating wages theory. In an investigation into labour turnover, he found job risk to be an important determinant of quit rates, with his multi-period model predicting that "workers should be more likely to quit jobs that pose health and safety risks" (p.54). He concluded that complete labour mobility is not essential for the theory to hold, as workers will quit jobs that pose an unacceptable level of risk.

The importance of full employment to labour mobility has been highlighted by many. In times of high unemployment, the degree of labour mobility will be substantially reduced, as "workers understandably are most unlikely to quit a job unless they have reasonable prospects of finding new employment elsewhere" (Purse, 2004. p.609). However, as Rees (1975) comments, Smith "could not have known involuntary unemployment of the kind that is present in modern industrial countries" (p.339). As such, in times of high unemployment, we would expect the degree of labour mobility to be substantially reduced, with the consequence that workers' who have been unemployed for long periods "will accept disagreeable work at low wages rather than have no work at all, and this makes compensating differentials unnecessary" (p.339). A major criticism of Viscusi (1979) is that his data are based on a period when unemployment was very low. Robinson (1991) carried out a similar estimation, examining the quit rate of manufacturing workers during an economic downturn. His results revealed the quit rate to be significantly lower for workers in hazardous jobs as compared to workers employed in safer jobs. Workers, therefore, may not always have complete labour market mobility to quit a hazardous job.

Labour market mobility will also be constrained if employers have a certain degree of market power. In the case of monopsony, where there is a single employer, the monopsonist is able to exercise its market power and pay below the competitive wage. For instance, coal mining towns are commonly used as an example of a monopsony, and we would expect coal miners to have a relatively high probability of being injured on the job. However, as Leigh (1989) comments, a monopsonist will be able to "thwart competitive forces that would normally require compensating wages for mine work" (p.826). Although we may think a monopsony model to be an unrealistic view of the labour market, Manning (2003) recently argued that a monopsony is "the best simple model to describe the decision problem facing an individual employer" (p.3), particularly concerning the determination of wages and employment. However, arguments for a monopsonistic labour market have been deemed unrealistic, "unless one focuses on workers with very specific skill types in very defined geographical areas" (Kuhn, 2004, p.376). Furthermore, labour markets dominated by a single employer seem even more unlikely "as barriers to goods and factor flows across regions and countries continue to fall." (Kuhn, 2004, p.376).

Worker mobility may also be constrained if the labour market is segmented. Doeringer and Piore (1971) argue that dangerous jobs will be within the 'secondary labour market', which is also characterised by poor wages and promotion prospects. The implication for labour market mobility is that "if dangerous jobs are predominantly in the secondary labour market, then possibilities of alternative employment are severely circumscribed for persons in dangerous jobs" (Leigh, 1989, p.827). Overall, in terms of the importance of the assumption of labour market mobility for the theory of compensating wage differentials, Leigh (1989) summarises that "if for whatever reasons employers offering dangerous jobs have a partially captive labour force, then those employers need not pay a premium" (p.827).

In order for workers to require a wage premium for dangerous work, they must have information about the risk levels of various jobs. Purse (2004) remarks however, that "the lack of risk information available to workers has been a major and long-standing issue of concern" (p.610). A study by Shilling and Brackbill (1987) found that in 1979, only 5 per cent of US workers were fully informed about the hazards associated with their occupations. There are a number of potential explanations for this apparent lack of information. We may expect poor awareness of hazards to be particularly prevalent today as changes in technology and work organisation have resulted in "dramatic increases in, often poorly understood, musculoskeletal and psychological injuries" (Purse, 2004, p.611). Workplace illnesses are often difficult to observe because of their cumulative nature which may mean it is unobservable until several years have passed since the initial contraction. Thus, Leigh (1989) suggests this lack of knowledge on workplace dangers may "undermine the ability of the market to generate compensating wages for health and disease hazards" (p.829).

We must also consider how workers would acquire information concerning hazards. In the UK, employers are legally required to display basic health and safety information under the Health and Safety Information for Employees Regulations 1989. In addition, the Chemicals (Hazard Information and Packaging for Supply) Regulations 2002, requires all dangerous chemicals to be appropriately classified and labelled, and for safety sheets to be provided. However, this does not specifically provide information to employees about how hazardous their job is, although occupational fatality and injury statistics are publicly available from the HSE. Purse (2004) suggests that specific information concerning workplace hazards are unlikely to be gained from an employer, mainly because they themselves are poorly informed, largely due to rapidly changing technology and therefore production processes. Furthermore, employers who are aware that their workplace is particularly hazardous, have an incentive to keep such information from workers and potential workers: "it is unlikely that employers with poor records would want to have this information made public" (Purse, 2004, p.612). Overall, Purse (2004) concludes "a lack of information means that workers seriously underestimate the risk of injury and death and to the extent that this occurs, they receive lower risk premium or none at all" (p.612).

O' Connor and Viscusi (1984) argue that workers learn about workplace hazards through on the job experience. Their evidence suggests that "workers are engaged in an ongoing experimentation process in which they learn about the risks posed by their job and quit once the position becomes sufficiently unattractive" (p.943). As such, Leigh (1991) emphasises that "lack of information may be especially serious for new entrants to dangerous jobs" (p.391). Mitchell (1988) finds that inexperience is indeed a strong predictor of work-related injuries, as "employees under age 25 are more prone to on the job risk than their more senior counterparts" (p.12). However, Purse (2004) emphasises that this does not enable us to conclude that experienced workers have perfect information. In order to make informed decisions as the level of risk they find acceptable, workers also need data and information concerning the health and safety record of alternative employers. A constant stream of information would therefore be required in order for the assumption of perfect information to hold; "the issue of how they are supposed to obtain this information has not been addressed by the neoclassical literature on compensating wage differentials" (Purse, 2004, p.612).

The compensating wages theory also assumes that workers behave rationally. Given the assumption that workers have perfect knowledge about the hazards of various occupations and the corresponding wage rates, the theory then assumes they use this information to make rational decisions. For instance, if an employee observes that their job is very hazardous in comparison to others, and pays little or no wage premium, we would expect them to quit, given the assumption of labour mobility, and move to a job with either safer conditions or a higher wage premium. Workers "select among jobs based on a rational consideration of wages, working conditions and hazards" (Leigh, 1989, p.825). However, the assumption of rationality has been criticised, largely because of evidence from the psychology literature; Purse emphasises that "the significance of these psychological findings on risk perception cannot be ignored" (p.613).

Kahneman and Tversky (1979) found that people underestimate the actual probability of low probability events occurring. This finding is especially relevant to the literature on compensating wage differentials for hazardous work, as the rate of fatal injury to workers was just 0.6 per 100 000 employees in 2005/06 (HSC, 2006, p.9). If workers underestimate the probability of it occurring however, they may accept jobs that have a higher likelihood of occupational fatality than they realise. In such a case, workers will not make a rational decision. Cognitive dissonance can also be applied to consider the behaviour of workers employed in dangerous jobs. Outlined by Akerlof and Dickens (1982), cognitive dissonance allows workers to ignore probabilities of work-related fatality, as workers will not want to believe they are exposing themselves to danger. As workers prefer not to acknowledge the true risk posed by their job, Akerlof and Dickens found workers "sometimes failed to have the appropriate marginal rate of substitution between safety and wages" (p.317). As a result, even if workers have the ability to change jobs and have perfect information, the failure of workers to behave rationally may result in wage premiums for hazardous work being unnecessary. Workers that choose to ignore the true threat of their job to their health will not require the optimal wage premium.

3B.4 Trade Unions

The fact that Adam Smith's theory was developed in the context of a perfectly competitive market, where "there is no productive role for unions" (Viscusi, 1980, p.175), means that the theory of compensating wage differentials does not take into account their influence in the labour market. Rees (1975) emphasises, the growth of trade unions has meant "the influence of market forces on wage structure is less direct and perhaps less sure than it was" (p.349) compared to in the 18th century. As "it seems plausible to suggest that neoclassical labour market theory is least likely to apply when wages are heavily influenced by collective bargaining" (Arabsheibani and Marin, 2000, p.247), the effect that trade unions have upon the wage premium for hazardous work has been widely considered in the recent literature.

Unions were created as a response to industrialisation "as a form of protection against possible or real exploitation by employers" to ensure "acceptable wages and conditions" (Bosworth et al., 1996, p.346). Trade union membership in the UK peaked in the late 1970s when over 50 per cent of the labour force was a union member. Closed shop agreements, where employees had to belong to a workplace's recognised union, were widespread in the 1980s, with 20 per cent of manual establishments and 9 per cent of non-manual workplaces having a closed-shop agreement (Booth, 1995, p.35). With closed shops now illegal, trade union membership has fallen, with 28.4 per cent of employees union members in 2006 (Grainger and Crowther, 2007, p.12). However, many workers remain covered by trade unions in practice, with 47.1 per cent of UK workers employed in a firm with a trade union presence, and as a result 33.5 per cent of all UK employees report that their pay and conditions are affected by a collective agreement (p.36). Forth and

Millward (2002) estimate that when collective bargaining covers between 70-99 per cent of employees, a wage premium of around 8 per cent of hourly pay is received. (p.557).

The impact trade unions may have upon injury rates has been discussed, but consider the impact that we would expect trade unions to have upon the wage premium received for dangerous work. Theoretically, as Olson (1981) emphasises, "there are several reasons to believe that union members may receive higher accident differentials" (p.170). We have discussed the context within which Adam Smith developed his theory, when the assumptions of labour mobility, perfect information and rational behaviour hold. Criticisms related to the assumption of labour mobility have been discussed, as workers are often not able to quit their job and so have no 'exit' option if confronted with work they believe to be too hazardous. In such a case, trade unions provide members with a 'voice' option in providing a collective route through which they can complain about, amongst other aspects, hazardous conditions. As oppose to complaining individually, "unions have a comparative advantage in this role because they are permanent institutions" (Fenn and Ashby, 2004, p.463). In this case therefore, trade unions may assist in the neoclassical outcome occurring, by ensuring workers, if constrained in their labour mobility, have a collective voice. For instance, Viscusi (1980) highlights that in a monopsonistic context, unions can act as "a source of countervailing power" (p.190) to ensure a balance is achieved between workplace safety and wage compensation.

Trade unions can also assist in the collection of information. If workers do not have perfect information about the danger to which they are exposed in their work, unions can assist by ensuring their members are informed. Unions are more effective than individual workers in this collection as they "provide economies of scale in the acquisition of and processing of data" and also "provide a solution to the externality problem" (Fenn and Ashby, 2004, p.463) as workers individually have little incentive to acquire information that will be used freely by fellow workers[8]. Viscusi (1979) highlights that this is because unions are a permanent institution, and so are in a better position to gather and communicate information than are individual workers who change jobs. Through this method, Gegax et al. (1991) hypothesise that "unions may heighten awareness of safety hazards" (p.593) which one would expect to result, through collective bargaining, in either a positive union wage premium for risk or a reduction in risk, or most likely, a combination of the two.

We would expect union members to benefit from the bargaining power of their union, which can be used to negotiate higher risk premiums; non members, and especially those not employed in a workplace with no union presence, may be considered to be at a relative disadvantage when it comes to negotiation with employers. The finding that unionism raises the premium may indicate labour market failure, as in the absence of trade union intervention, employers have an incentive to understate the hazards that threaten their employees. Any evidence that unions have a positive effect upon the wage premium for risk therefore, suggests that "one might question the adequacy of the non union market" (Olson, 1981, p.185). Alternatively however, a higher union premium may be because unions have forced employers off the competitive equilibrium offer curve by demanding higher premiums.

[8] Health and Safety Committees also take on a similar role to trade unions, only specifically related to workplace health and safety. Consequently, it is important also to consider the impact that such committees have upon the wage premium.

Unions could theoretically also lower the wage premium received for exposure to risk. As Sandy and Elliott (1996) highlight, preferences for the trade-off between wages and risk exposure are likely to be decided through union voting. As the median voter theorem reveals, such a mechanism is likely to "fail to reflect the preferences of the minority of union members who face the highest risks" (p.293) and therefore the process may fail to gain adequate wage compensation for the members that have the greatest exposure to hazards. As Marin and Psacharopoulos (1982) conclude, union mechanisms may mean that "the wage settlement could only consider some average degree of riskiness" (p.834). Furthermore, in specifically considering the labour market in the UK, unions campaign directly for improvements in work safety rather than for increasing the wage to compensate for hazardous working conditions. Therefore, "risk would seem less relevant and play less of a role in earnings determination by collective bargaining" (Marin and Psacharopoulos, 1982, p.834).

The effect that trade unions have upon the wage premium is an empirical issue, as "in theory, unions may either raise or lower the fatal risk premium" (Sandy and Elliott, 1996, p.293).

3B.5 Measurement

3B.5.1 Hedonic Wage Methodology

Numerous empirical labour market studies have attempted to test the theory of compensating wage differentials using US data, although there are few using UK data. Empirical studies have focused upon estimating a wage equation that includes, in addition to a range of personal and job characteristics that influence the determination of an individual's wage, a variable that measures risk of fatality at work, and in some studies, risk of work-related injury or disease. The equation takes the following form:

$$\text{Ln } Y_i = \beta_0 + \beta_1 X_i + \beta_2 D_i + \beta_3 U_i D_i + \beta_4 D_i^2 + \varepsilon_i \qquad [1]$$

Where Y_i denotes the earnings of the ith individual, X is a vector of other determinants of earnings, D_i is a measure of fatal or non-fatal risk in individual i's job, the interaction term U_iD_i denotes the union impact on the risk premium, and ε_i is a random error term which has an expected value of zero and zero covariance. A positive and significant β_2 coefficient indicates a wage premium is received for exposure to accident risk.

Equation 1 is estimated by Ordinary Least Squares (OLS), which entails the assumption that all explanatory variables, including risk and union status, are exogenously determined. We are also interested in whether the wage-risk trade-off takes a linear or concave form. If the relationship is concave, it implies that an increase in the level of risk results in a less than proportional increase in the wage differential. Alternatively, if the relationship is convex, an increase in the level of risk results in a greater increase in wages. To test this, an additional variable, D_i^2 is often included in equation 1, with a negative β_4 coefficient indicating the relationship to be concave. Most have found the relationship to be concave, including Olson (1981), Dorsey and Walzer (1983), and Martinello and Meng (1992).

3B.5.2 Measuring Risk

Tests of the theory before the 1970s were largely unsuccessful due to the fact that large data sets on individual workers were not available (Viscusi, 1993, p.1916). Although more data are now available, empirical work has been constrained by measurement error, with numerous factors citied that could potentially cause results to be biased. The extent of this is summarised by Viscusi and Aldy (2003) who observe that "every compensating differential study employs a less than perfect measure of any particular worker's job-related fatality risk" (p.14).

The construction of the risk variable is of central importance to estimations, as it will "significantly influence the magnitude of the risk premium estimated" (Viscusi and Aldy, 2003, p.10). Many studies have included a risk of death variable only as "a less ambiguous measure of risk" which is "much less susceptible to measurement error associated with reporting effects" (Purse, 2004, p.602). The fatality variable itself however, can take many forms. The most common approach is to create a variable based on published numbers of workplace deaths by occupation or industry. A risk of death rate is then derived using numbers of workers and or hours worked in a particular industry or occupation. The risk measure will be the average for an industry or occupation, and can be though of as an accident probability. The risk rate is matched to a data set that includes information on personal and worker characteristics, by using industry or occupation codes.

There are potential measurement problems with this method. The decision of whether to match risk measures by industry or occupation is vitally important. A disadvantage of matching by industry is that hazard rates will be the average for the entire industry. As a result, "the industry risk measure assigns the same job risk to a secretary in the coal mining industry as to the coal miner" (Black and Kneisner, 2003, p.208) which clearly overstates the risk to the secretary and understates the risk to the miner. Although matching by occupation also has potential problems, with occupations within certain industries arguably more dangerous than in others, this is usually now the preferred method[9]. Matching occupation risk by industry is a further method, which would capture the degree of risk to which a worker is exposed more accurately than risk by solely occupation or industry. However, the ability to assign risk by this method is constrained by data availability, with a large sample size required.

Smith (1979) highlights that matching average characteristics to individuals will create an "error-in-variables problem that tends to bias the tests against finding compensating wage differentials" (p.34). There are likely to be differences in the industry or occupation risk and the true risk facing an individual worker. To minimise the extent of this problem, studies usually restrict their sample to male blue-collar workers, "for whom the risk data are more relevant" (Viscusi, 1993, p.1928).

A further problem arises with regard to matching hazard rates. As this method relies on using industry or occupation codes, there is the potential for coding errors to introduce measurement error. In surveys, respondents provide interviewers with details about their workplace and their duties, from which industry and occupation codes are assigned. Mellow and Sider (1983) found that miscoding can seriously affect the results of compensating wage differential studies. By adjusting for

[9] Chapter 2.5 discusses the findings of Davies and Jones (2005) who find occupation is the greatest determinant of a person's risk of having an accident.

disagreement between employee and employer-reported industry in the 1977 Current Population Survey (CPS), they found coding errors could "lead to a downward bias of almost 50 per cent in estimates of the wage-risk trade-off" (p.377). Coding errors can also occur because of mistakes by the coders themselves. Keech and Orchard (1996) examined the accuracy of the assignment of industry and occupation codes in the New Earnings Survey (NES) by comparing codes assigned by coders and an expert panel. They found a 10 per cent disagreement rate for 3 digit Standard Industrial Classification (SIC) and Standard Occupational Classification (SOC) codes which was attributed to imprecise descriptions. However, they concluded that "coding errors have no greater effect on the accuracy of the NES results than do sampling errors" (p.33). Using a similar method, Martin et al. (1995) found a 23 per cent disagreement rate in occupation codes in the Family Resources Survey. Overall, Black and Kneisner (2003) comment it appears to be that "a worker's industry is measured more accurately than a worker's occupation" (p.208). Therefore, although we have concluded that matching by occupation codes is the most appropriate way to capture risk in testing the theory of compensating wage differentials, the assignment of occupation codes is found to be more prone to errors. Furthermore, Sandy et al. (2001) comment that fine occupation and industry codes "contain some irreducible error because a worker's duties can span more than one conventional occupation and a firm's product or services can span more than one industry" (p.38). The potential for measurement error involved with the use of industry and occupation codes to assign risk to individuals should therefore be considered when deciding upon the appropriateness of a risk measure, and when analysing any results.

Lalive (2003) discusses further potential problems with using aggregate industry or occupation measures to capture accident risk. Specifically, he comments that this method will give an inaccurate reflection "if there is substantial within industry or occupation heterogeneity in workplace risks" (p.172). He compares an aggregate industry injury and illness measure with a firm-specific injury and illness measure, using Austrian matched employer-employee panel data. His investigation reveals that "compensating wage differentials are very sensitive to the risk measure used" (p.188) with the aggregate industry measures resulting in estimates that are upward biased. Lalive attributes this to substantial within industry variation in risk. Arguably however, there is less variation in risk within occupations, which is the reason the majority of studies in this area calculate their risk measures by occupation. In a recent study using UK data, Wei (2007) constructs establishment-specific illness and injury rates using WERS 98. Aggregating risk by industry and occupation is found to cause an upward bias, similar to that found by Lalive (2003). Studies that use establishment-specific measures however, are unable to control for varying degrees of severity of an injury, and in particular, are unable to include a variable denoting the number of fatalities. Failing to control for this is likely to give biased results, and means comparison with studies that do include a risk of death variable is difficult.

Although much estimation is restricted to risk of death, several studies have attempted to estimate whether a wage premium is received for risk of non-fatal injury. Efforts to estimate a wage premium for non-fatal risk have however, proved problematic. Many issues need to be considered when constructing a non-fatal risk variable, largely because of "the high correlation (collinearity) between injury and mortality risks" (Viscusi and Aldy, 2003, p.15). However, as found by Cousineau et al. (1992), omitting injury risk may cause "a positive bias in the estimation of the value of a life" (p.169). As a consequence, "ideally, one would like to distinguish the compensation for fatality risks from that for non-fatal risks" (Viscusi, 1993, p.1931).

In terms of constructing a non-fatal risk variable, there are many different measures that can be used, such as the overall injury rate, the rate of injuries resulting in lost workdays, and the rate of lost workdays. When considering and comparing the estimation results of studies that include non-fatal risk variables, it is vital the method of measurement adopted is considered as "studies using different measures of nonfatal job risks will generate different risk premiums" (Viscusi and Aldy, 2003, p.35). The non-fatal risk variable can be constructed using a similar method to that discussed for constructing a mortality variable. By using published statistics to construct a variable for particular industries and occupations, rates can be matched to individual workers through codes. In order to distinguish between the severities of different injury risk however, detailed information would need to be made available and degrees of assessment made by the estimator as to which injuries are most severe. Alternatively, estimators can use the number of days an employee was absent from work due to an accident, to proxy the degree of severity of an injury. This method is however, subject to measurement error, as the relationship between days absent and degree of severity of an injury is not exact and will vary between individual workers.

As an alternative to using published statistics, some studies have used self-reported risk variables whereby workers assess subjectively the degree of risk they feel they are exposed to at work. This method may be thought to be preferable, as it is indeed the worker's perception of risk that ultimately leads them to accept or reject a job offer. Viscusi (1993) makes this point believing that "the ideal risk measure would reflect subjective assessment" (p.1918). This could involve incorporating a simple dummy variable where it takes the value 1 if the worker believes their job to be hazardous. However, Smith (1979) notes the results of such studies are "rather ambiguous" (p.344) as would be expected given the over-simplification of such a measure. A subjective variable however, could be constructed using a larger scale, reflecting perception of the severity of exposure more fully. Viscusi (1993) notes that some caution must be made when using such data as individual assessments of risk are likely to be biased, with workers overestimating low probability events and underestimating high probability events. Few studies have adopted this method, partly due to limited data availability, but also because it means comparisons with other studies are difficult, and therefore it is difficult to draw many conclusions with respect to policy.

A further issue that has received little consideration in the literature is the risk of disease and illness posed by a particular job. The distinction between an accident and illness is discussed in chapter 2. Sandy and Elliott (2005) highlight reasons why we may expect illness risk to generate a higher wage premium than accident risk. They emphasise "the greater incidence and longer duration of long-term illnesses" has the potential to "generate higher economy-wide wage premiums" (p.745). Workers are also likely to be very aware of the risk of occupational illness, having observed symptoms of co-workers, and so may be more likely to require a wage premium. However, problems with data have limited the inclusion of workplace illness variables within compensating wage estimations, with the focus of such studies instead on accidents, which pose fewer measurement problems in terms of data. The fact that the origin of some illnesses are difficult to identify creates a major problem, as illnesses "can develop slowly and may be exacerbated by outside-of-work factors" (p.748). Initially, the illness may result in no lost work-days, but may eventually force early retirement. Early retirees need to be considered in measures of workplace illness, as the group of workers that may have been exposed to illness risk in a particular occupation for the greatest duration. For the same reason, the measure should also take account of regular retirees with an occupational illness. Lost work days are therefore, a poor measure of workplace illness in failing to capture both workers in the early stages of an illness, and retired workers at the later stage. Sandy and Elliott (2005) estimate that in the UK, "a measure of occupational illnesses based solely on lost –days of work would miss two-thirds of all reported illnesses" (p.750). They discuss the ideal measure identifies the fraction of a group of workers who entered an occupation in the same year who have either have become ill or died as a result of an occupation illness, including those no longer working. Sandy and Elliott's measure does not entirely fit their ideal because of a lack of information on fatalities due to a long-term illness. Wei (2007) tests an establishment-specific illness rate, derived from WERS 98, similar to his accident variable. This measure is again far from ideal, as it is based on reports of managers, who may be unaware of workers who have developed an illness since leaving the establishment. Alternatively, and yet to be tested in the UK, subjective measures could be used in a similar way as discussed to measure exposure to accident hazards. Workers could then identify the extent to which they believe they are at risk of contracting a work illness.

3B.5.3 Measuring Worker and Firm Characteristics

Studies of compensating wage differentials often use additional data sets to obtain the variables, other than risk, that are required to estimate a wage equation. Therefore, in addition to potential problems caused by constructing the risk variable, there are other potential measurement issues. The fact that proxy responses are often used in the type of household surveys that are commonly utilised in the literature should be considered. Although interviewers try to collect information from each respondent, this is not always possible if they are not at home. In this case, information relating to the individual is collected from another person in the household. These are called proxy respondents. As Sandy et al. (2001) highlight however, male manual workers, the subject of most compensating wage differential studies, are less likely to be at home during the day and so "the proportion of proxy respondents among this group is substantially higher than the overall proxy rate" (p.38). Proxy respondents are less likely to know about the workplace and may give incorrect information. The extent to which this affects the results of estimations is, however, debatable. Mellow and Sider (1983) concluded that "information from proxy respondents appears to be no less accurate than that from self-respondents" (p.342).

3B.5.4 Inter-Industry Differentials

It has been claimed that risk premium estimates simply reflect an industry wage premium rather than a premium for an individual worker's exposure to hazards, because the risk variables usually reflect an industry-average level of risk. Leigh (1995) comments that poor health and safety conditions will be correlated, and will hence capture, other unpleasant aspects of jobs in certain industries. Dorman and Hagstrom (1998) suggest that a review of the literature supports this hypothesis, as "estimates of wage compensation for risk are highly sensitive to model specification and choice of risk variable" (p.133). In comparing models with and without industry dummy variables, they find a positive and significant risk premium when no industry dummies are included and an insignificant premium when they are. They therefore conclude that there is "strong support for the expectation that including industry-level effects will reduce measured wage compensation for risk" (p.127) casting doubt on the existence of compensating wage differentials. However, this theory has been criticised by Viscusi and Aldy (2003). The fact that numerous studies have included industry dummy variables and still found significant risk premiums, including Viscusi (1978) and Marin and Psacharopoulos (1982), does not support the hypothesis.

3B.5.5 Trade Union Measurement

Many studies have focused upon estimating the effect that trade unions have upon the risk premium, due to the theoretical ambiguity discussed in chapter 3B.4. Here, we first consider the methods researchers have employed to capture the union-risk premium. A union-risk interaction term in the wage equation, U_iD_i in equation 1, is often used to capture the effect unions have upon the wage compensation workers receive for being employed in a hazardous job. A variable capturing union membership is also included as an explanatory variable in the specification to capture the pure union wage premium. Alternatively, separate equations can be estimated for union and non-union workers. Fairris (1992) believes this to be the most appropriate method because of "important institutional differences between the union and non-union sectors" (p.266).

The definition of the variable used to capture union status is also particularly important. The majority of studies have focused upon defining the trade union variable as individual union status. However, subsequent researchers have argued this may be inappropriate. Siebert and Wei (1994) highlight the public goods nature of working conditions, meaning that any collective bargaining in a firm that recognises trade unions "will affect the working conditions of most workers in the firm, whatever their union status" (p.64) in a spillover effect. The union variable Sandy and Elliott (1996) utilise distinguishes between non-members of trade unions and those "though not members of trade unions, are still covered by union terms and conditions" (p.291). This may be particularly relevant to the UK, as Blackaby et al. (1991) find that 65 per cent of male blue collar workers belong to a trade union, with a further 12 per cent covered by union conditions at their workplace. To gain a more accurate understanding of the effect that trade unions have upon the risk premium therefore, the union variable should be defined in the context of whether a worker is employed by a firm that is covered by union terms and conditions.

A further measurement issue concerning the influence of trade unions is the possible endogeneity of union status. Union status may be a decision variable with workers' choosing to belong to a union or to work for a firm in the covered sector. This is particularly relevant since the Employment Acts of 1982 and 1988 made closed shops illegal. As Heckman (1979) suggests, "one observes wages for union members who found their non-union alternative less desirable" (p.153). There is hence the possibility of a selectivity bias which may affect the subsequent remuneration that is received for risk by both union and non-union members. Sandy and Elliott (1996) emphasise that not taking into account such sorting will result in "biased estimates of the size of both the union wage and the risk premium" (p.294).

As a solution to the problem of union selection, the Heckman Selectivity Correction method can be used, if the selection processes for risk level and union status are independent. Selection variables for union and non-union workers are derived, involving estimating a reduced form probit equation where union membership or coverage is estimated. Selection variables include employee and employer attitude to unions. Location variables and partner attitude to union variables are also often included, although often found to be insignificant in explaining union status. Sandy and Elliott (1996) for instance, find employer and employee favourable attitudes to trade unions are significantly positively related to union status, as is firm size and labour force experience (p.301). Results from the union probit are used to calculate the Inverse Mills Ratio:

$$\lambda(t) = -f(t) / F(t) \qquad [2]$$

where f is the standard normal density function, F is the cumulated normal and $t = \gamma' y$ calculated from the probit with y the explanatory variables. Lambda is included as an additional explanatory variable in the wage equation. In terms of interpreting lambda, a significantly negative coefficient would suggest the error terms in the selection and wage equation (without selection control) were negatively correlated; hence unobserved factors that make union coverage more likely would tend to be associated with lower wages.

Most empirical estimates that have controlled for union selectivity bias find "controlling for the endogeneity of union status makes only a small difference" (Sandy and Elliott, 1996, p.302) and therefore is "relatively unimportant for estimating the compensating differential for risk of a fatal accident" (Arabsheibani and Marin, 2000, p.263). However, it should be noted that the Heckman correction method requires the assumption of independence between selectivity into risky occupations and into union status. "If the process is more complex, the Heckman correction may not pick up the effects of selection on union status" (Sandy and Elliott, 1996, p.301).

3B.5.6 Endogeneity

Most studies assume job risk is exogenous, with workers choosing to be employed in a particular job with a given level of risk, independent from any other variable that determines wages. Viscusi (1978) suggests job risk is endogenous with "the optimal job risk for a worker negatively related to his wealth" (p.416). If we assume safety to be a normal good, we would expect those with greater earnings potential to choose safer jobs. Viscusi (1978) finds evidence to support this in his estimations with "the injury rate for an employee's industry negatively related to worker assets" (p.416). This has implications for the estimation of compensating wage differentials. As Garen (1988) goes on to explain, it implies that there is a correlation in the disturbance terms for wage determination and the choice of job risk. This would mean that estimation by OLS is biased.

Similarly, there may be unobserved heterogeneity influencing the wage premium for job risk. Sandy and Elliott (1996) hypothesise that "some individuals may possess unobserved characteristics which make them more productive in dangerous situations" (p.293). This includes individual attitudes towards risk: those with low risk aversion will be employed in the more dangerous jobs. Unobserved attributes can include 'cool-headedness', which makes workers more productive in dangerous situations. Workers that have such attributes will select into risky jobs, as they will be able to earn more through such employment. Thus, empirical studies that fail to take account of such unobserved heterogeneity will be biased in not fully considering the effects upon the risk premium.

Hwang et al. (1992) consider the effect that excluding such unobserved productivity differences between workers has upon estimations of compensating wage differentials. They specify intelligence, perseverance, and the ability to work well with others as qualities that increase productivity, but are unobserved by the econometrician. They show that the failure to take account of such qualities will result in a downward bias of the estimated risk premium of approximately 50 per cent, and so "contemporary labour market studies may severely underestimate workers' marginal willingness to pay for job attributes" (p.837). As a result, they conclude that safety in the workplace "may be much more important to workers than previous studies have indicated" (p.855). Shogren and Stamland (2002) present a case where workers differ in whether they possess a risk-handling skill which is again, unobserved. They hypothesise that workers with high risk-handling skills will choose risky jobs. They show that failing to take account of this skill will result in the wage premium being overestimated. Bell et al. (2004) conclude that the direction of the bias will depend upon the importance of these characteristics: "if the variations in risk-handling skill are small relative to the general unobserved productivity the bias would be downward" (p.5) and vice-versa.

The issue is best illustrated algebraically. Following Garen (1988) consider the following hedonic wage equation:

$$\text{Ln } Y_i = \beta 0 + \beta_1 X_i + \beta_2 F_i + \beta_3 M_i + \varepsilon_i + \varphi_{1i} F_i + \varphi_{2i} M_i \qquad [3]$$

As in equation 1, Y_i refers to workers earnings and X_i to variables that determine earnings. The variable D_i in equation 1 is then divided into fatal (F_i) and non-fatal injury (M_i). As before, ε_i represents unobservables which influence earnings regardless of the risk of death and injury involved in a job. In contrast, errors φ_1 and φ_2 are disturbances whose effect on earnings does depend on the risk of death and injury. Individuals who have unobserved risk-handling skills which make them more productive in risky situations will have large values of φ_1 and φ_2 as "their marginal wage gain to employment in a risky job is greater" (Garen, 1988, p.10). As F and M are choice variables, correlated with ε, φ_1 and φ_2, equation 3 cannot be estimated by OLS, as this requires the expected value of the disturbance term conditional on the regressors to be zero. Furthermore, as the expectation of $\varepsilon + \varphi_1 F + \varphi_2 M$ is non-zero, simultaneous equation methods such as Two-Stage Least Squares (2SLS) and Three-Stage Least Squares (3SLS) cannot be used.

Garen (1988) proposes an Instrumental Variables method for obtaining unbiased estimates of the compensating wage differential, which has been extensively used in the literature. The first stage involves estimating the following risk equations (equation 4):

$$F = \pi_0 + \pi_1 X_1 + \pi_2 X_2 + \pi_3 Z + \eta$$

$$M = \delta_0 + \delta_1 X_1 + \delta_2 X_2 + \delta_3 Z + \mu \qquad [4]$$

where X_2 proxies risk aversion, Z is non-wage income, and η and μ are unobserved heterogeneity. η and μ may depend on the wage equation (equation 3) disturbances ε, φ_1 and φ_2, as workers with unobservable characteristics that make them more productive in risky jobs, will choose higher F and M.

In order to estimate equation 4, a measure of risk-aversion must be available; risk aversion however, cannot be directly measured and so a proxy must be used. Garen (1988) acknowledges that "finding proxies for the degree of risk aversion is a difficult task" (p.12). Measures of the stability of an individual's lifestyle are frequently used, assuming that such measures are inversely correlated with the degree of aversion to risk. Such stability measures include household income other than wages, marital status, house value, and number of dependents. Instrumental variables, as Sandy et al. (2001) emphasise, must be "uncorrelated with unobserved ability while being correlated with the level of risk" (p.46).

The second stage of the estimation involves estimating the following equation:

$$Y = R\beta + \gamma_1 \hat{\eta} + \gamma_2 \hat{\mu} + \gamma_3 \hat{\eta}.F + \gamma_4 \hat{\mu}.F + \gamma_5 \hat{\eta}.M + \gamma_6 \hat{\mu}.M + \phi \qquad [5]$$

Where $\hat{\eta} = F - X\hat{\pi}$ and $\hat{\mu} = M - X\hat{\Delta}$, where $\hat{\pi}$ and $\hat{\Delta}$ are the OLS estimates of π and μ from equation 4. Garen shows that estimating equation 5 will yield consistent estimates.

Studies have highlighted problems with employing Garen's method. Central to this is the importance of the choice of instruments used in risk estimations. It was noted that stability variables are often used to proxy risk aversion, including non-labour income, marital status and number of children, which theoretically should all be negatively related to risk aversion. However, many studies have found these instruments to be poorly related to risk, resulting in very low R^2 values. For instance, Sandy and Elliott (1996) find wife's income, house ownership and marital status to be insignificant in their estimation of an equation similar to equation 4, resulting in an R^2 of 17.7 per cent (p.296). Hausman tests further suggest problems with the choice of instrumental variables in many studies. Sandy et al. (2001) find "modest support for the endogeneity of job risk" (p.47). However, Siebert and Wei (1994) conclude that "the imprecision of our instrumental variables is such that the Hausman test never supports the hypothesis of endogeneity" (p.72). A test of overidentifying restrictions further confirms the inadequacy of instruments in many studies. A chi-square statistic from this test that is significant indicates that the instruments should be included in the earnings equation, and are therefore not suitable instruments. In conclusion, Sandy et al. (2001) summarise that "the R^2 of the risk equation, the Hausman test, and the test of overidentifying restrictions" suggest the instruments used throughout the literature "are usable although far from ideal instruments" (p.47).

Subsequent papers have highlighted that the use of weak instruments will lead to biased results in the final estimation of the wage premium. Bound et al. (1995) acknowledge that "it is common to find that the candidates are only weakly correlated with the endogenous variable" (p.443). They show however, that using weak instruments will result in estimates that are biased towards the original OLS estimation. Staiger and Stock (1997) went on to find that when testing the strength of an instrument, the F statistic must take the value of at least 10. Similarly, Stock, Wright, and Yogo (2002) found that an F statistic of 9 or above is needed for an appropriate instrument. Overall therefore, these studies have shown that "it may be even harder than many have thought to find legitimate instruments for potentially endogenous variables" (Bound et al., 1995, p.444). As a result, unobserved heterogeneity remains "the greatest challenge facing researchers in estimating compensating wage differentials for workplace risks" (Bell et al., 2004, p.1).

A recent paper, Lalive and Ruf (2006) seeks to estimate how important controlling for unobserved heterogeneity is to studies in compensating wage differentials. Using Austrian longitudinal data, they are able to control for unobserved heterogeneity, and compare their results to those obtained with cross-section data. They show the compensating wage differential is roughly equal to the one obtained in the standard cross-sectional wage regression, and so conclude that they "find no evidence for a bias of the compensating differential obtained from a standard cross-sectional hedonic wage function that can be attributed to unobserved worker productivity" (p.4). The potential implications of this paper are very important, as it "suggests that the bias of the compensating differential obtained from a standard cross-sectional hedonic wage function that is due to unobserved productivity of workers or unobserved ability to cope with risks is small"(p.19). Further research using similar, large-scale data sets is needed to examine this claim.

3B.5.7 Worker Heterogeneity

The theory of compensating wage differentials recognises that workers are heterogeneous in their preferences for risk. The model, therefore, takes into account that some workers are more risk averse than others, and will consequently require a greater wage premium for accepting a job with the same level of risk than a worker who is less risk averse. DeLeire and Levy (2004) find that preferences for risk cause workers to sort into occupations in the US. They further show these risk preferences vary by gender and family structure, with women and parents being the most averse to risk and consequently sorting into relatively safe occupations. Earlier studies within the compensating wage differential literature also recognise that "women, by and large, do not take risky jobs" (Leigh, 1987, p.256). Leigh and Gill (1991) suggest this can be partly attributed to "the historical division of labour in the household" which "has perhaps kept women from seeking high-risk employment because of child-rearing responsibilities and other family concerns" (p.729).

Problems of measurement error have restricted empirical estimations of wage premia for women, with risk variables often failing to capture the true risk women face at work. DeLeire and Levy (2004) emphasise "there are too few fatalities and too few women in the occupations with the most fatalities" (p.942) to calculate reliable measures. Several studies in the US however, have attempted to estimate a wage premium for females. Hersch (1998) uses a gender-specific risk variable, and finds "strong evidence of compensating wage differentials for the job risk faced by female workers" (p.606). The evidence is less clear however, in the results of Leeth and Ruser (2003) who attempt to estimate equations by gender. They find women do not receive a wage premium for being exposed to the risk of death, but do for being exposed to the risk of non-fatal injury. Other estimations by Barry (1985), Filer (1985) and Leigh (1987) find no evidence of compensating wage differentials for females. Leigh and Gill (1991) conclude that "analyses of samples of women have yielded little evidence of compensating differentials" (p.729).

Recent empirical tests have found that the traditional model of compensating wage differentials may not fully explain results with regard to worker heterogeneity. Viscusi and Hersch (2001) distinguish between smokers and non-smokers in their estimations, finding that smokers are less risk averse and more prone to accidents. The finding that preferences for risk vary by smoking status, suggests that smoking may be used as an instrument for proxying risk aversion to estimate equation 4. However, the evidence is not completely conclusive with regard to smokers being less risk averse. Dohmen et al. (2005) for instance find "smoking can only be considered a very imperfect substitute for more direct measures of risk attitude" (p.31) and so caution should be exercised when using smoking status as an instrument.

Viscusi and Hersch (2001) explain that for all workers to face the same offer curve, as in Figure 1, smokers would select a greater job-risk level than non-smokers and consequently receive greater total risk premia. However, their results show smokers choosing riskier jobs but receiving a total wage compensation that is less than non-smokers. They emphasise that "such a finding is inconsistent with smokers and non-smokers facing the same wage offer curve" (p.269). Their results can only be explained by smokers facing a wage offer curve that is flatter than that of non-smokers. This result is explained by smokers being more hazard-prone, with evidence found that smokers are more hazard-prone at work and in their personal actions. Viscusi and Hersch (2001) highlight that this result is dependent upon firms' having information concerning the smoking status of workers, "monitoring smoking-related differences must be feasible for firms to be able to link wages to smoking status" (p.270). It is likely, particularly when employment is offered, that smoking status is unknown to the employer, and so the employer would not know which market-offer curve is relevant. In this instance, the differences in market offer curve would be revealed through worker preferences. As the Viscusi and Hersch (2001) analysis finds smokers and non-smokers to have different preferences for risk, certain wages will be unacceptable to non-smokers for employment in an occupation with a given level of risk. The finding that risk attitudes vary by smoking status is "an important result" (Sandy and Elliott, 2005, p760) for the development of the compensating wage differential literature, as it "confirms the need to adjust for worker heterogeneity" (p.760).

A further study by Viscusi (2003) estimated separate wage equations by race using US data. Results show black employees face higher job risks than whites, but receive less total fatality compensation. He further emphasises that "although differences in preferences could be influential, such differences cannot reconcile the various empirical findings" (p.254) and so separate offer curves must exist. The result is only explained by black workers facing a flatter market offer curve. He attributes the results to differences in "safety-related productivity, discrimination, or other factors, but the role of these factors is not resolved" (p.243). Viscusi (2003) emphasises that the explanation is unlikely to be due to varying preferences for risk. Instead, "explanations such as those pertaining to structurally different labour market opportunities by race are more likely explanations" (p.251).

Arguments for separate market opportunity curves, as Viscusi (2003) concludes, "cast considerable doubt on the traditional model of compensating wage differentials for risk" (p.255) that have estimated a single curve for all workers. Studies that continue to examine how risk preferences vary according to worker heterogeneity should consider if the traditional model is capturing these differences.

3B.5.8 Panel Data

Given the problems associated with estimating wage-risk premiums due to unobserved heterogeneity, it has been suggested that measurement error could be reduced by using panel data. This was recognised in an early paper by Brown (1980), who noted the importance of being able to control for all variables that influence earnings, with cross-section data often "deficient in that they provide no information on many potentially important characteristics" (p.121) resulting in omitted variable bias. More recently, panel data has been seen as a potential way to control for unobserved heterogeneity that influences workers' preferences for risk, such as that described by Hwang et al. (1992) and Shogren and Stamland (2002). Bell et al. (2004) suggest that a fixed-effect panel estimate should control for unobserved ability that remains constant. Specifically, they use the New Earnings Panel data to capture changes in risk exposure through occupation switches. Although this controls for differences in worker characteristics and preferences towards risk, it does not control for the endogeneity of occupation switching. Some workers may be forced to change their occupation and so may switch from a low risk occupation to a high risk occupation, meaning any occupation-specific human capital will depreciate. As Bell et al. observe, the decision to switch occupation would be endogenous as "it would be related to an unobservable component of the error-term – the obsolescence of the worker's skill" (p 7). To correct for this, they use the annual rate of increase or decrease in employment in an occupation as an instrumental variable. The availability of suitable panel data sets for compensating wage differential studies however, is limited. The sample size must be significantly larger than usually required for cross-sectional data estimation. However, Bell et al. conclude that the use of panel data in empirical estimations is the most effective way to control for unobserved heterogeneity as "it seems clear that many attempts, beginning with Garen, to use instruments to control for unobserved heterogeneity in a cross-sectional framework do not fully control for unobserved heterogeneity" (p.27).

3B.6 Estimation Results

Many studies focus exclusively upon the risk of fatality at work, with estimators believing workers are more likely to be compensated for this. Martinello and Meng (1992) comment "most empirical studies find a strong positive relationship between industrial or occupational fatality rates and earnings" (p.334). Leigh (1989) observes, however, that "the attempts to find compensating wages for non-fatal injuries and illnesses have had mixed results" (p.832). Findings from estimations will now be considered.

3B.6.1 Fatal and Non-Fatal Injury

Table 3B.1 provides a summary of the main papers in the literature that consider whether a risk premium is received for exposure to accident risk.

Most of the early US studies relied on data provided by the Bureau of Labour Statistics (BLS) on work-related fatalities and injuries, which was constructed from a survey of industries. Most estimation using such data provided evidence of a wage premium. There have, however, been major criticisms of BLS data for two main reasons. First, BLS data only include firms employing more than 10 workers, which as Leigh (1989) comments excluded approximately two-thirds of work-fatalities in the US (p.832). Second, the fact that the data is based on a survey means the data will be subject to sampling error.

Table 3B.1: Key Accident Studies

STUDY	COUNTRY	ACCIDENT DATA	MATCHED ACORDING TO:	VSL (US MILLION $ 2000)	UNION EFFECT	NON-FATAL INJURY
Thaler and Rosen (1975)	US	Society of Actuaries1967	Occupation	$1.0	Positive	No
Viscusi (1978)	US	Survey of Working Conditions and BLS Survey 1969	Individual and Industry	$5.3	Positive	Yes-significant
Olson (1981)	US	BLS Survey 1973	Industry	$16.7	Positive	Yes-significant
Marin and Psacharopolous (1982)	UK	OPCS	Occupation	$4.2	Negative	No
Arnould and Nichols (1983)	US	Society of Actuaries 1967	Occupation	$0.5-$1.3	Not tested	No
Dorsey and Walzer (1983)	US	BLS Survey 1976	Industry	$11.8-$12.3	Negative	Yes-significant
Dillingham and Smith (1984)	US	BLS Survey 1976	Industry	$4.1-$12.3	Negative	No
Moore and Viscusi (1988)	US	BLS Survey 1972-82 and NIOSH 1980-85	Industry	$3.2-$9.4	Positive	No
Herzog and Schlottmann (1990)	US	BLS Survey 1969	Industry	$11.7	Negative	No
Gegax et al. (1991)	Canada	Worker assessed measure 1984	Individual	$2.1	Positive	
Martinello and Meng (1992)	Canada	Labour Canada 1986	Occupation	$2.2-$6.8	No difference	Yes-significant for severe injuries
Cousineau et al. (1992)	Canada	Quebec Compensation Board	Occupation	$4.6	Positive	Yes-significant
Siebert and Wei (1994)	UK	HSE 1986-88	Industry and Occupation	$9.4-$11.5	Positive	Yes-insignificant
Sandy and Elliott (1996)	UK	OPCS	Occupation	$5.2-$69.4	Negative	No
Arabsheibani and Marin (2000)	UK	OPCS	Occupation	$19.9	Negative	Yes-insignificant
Sandy et al. (2001)	UK	OPCS and HSE	Occupation and Industry	$5.7-$74.1	Negative	No

Source: Viscusi and Aldy (2003)

Due to the problems associated with BLS survey, the National Institute of Occupational Safety and Health (NIOSH) in the US initiated its own death statistic system. These data is based on a census of all occupational fatalities, and so there is no sampling error. Moore and Viscusi (1988) compare the use of BLS and NIOSH risk data in wage premium estimations and find "the performance of the NIOSH death-risk variable is consistently superior to that of the BLS risk measure" (p.485) with "value of life over double those obtained using the BLS risk estimates" (p.486). Hence they conclude that such an extensive change in death-rate statistics "undermines the validity of the value-of-life estimates generated using BLS risk data" (p.477); there are however, problems with the NIOSH data. Data are only available at the one digit industry level, restricting its accuracy. There are also, as discussed, general problems associated with assigning risk by industry data to individuals. Since 1994, the BLS has provided detailed data on fatal occupational injuries via the Census of Fatal Occupational Injuries (CFOI). Viscusi and Aldy (2003) observe these data draw "on multiple sources such as death certificates, worker's compensation records, and other federal and state agency reports" (p.11).

The data used by Thaler and Rosen (1975), from the 1967 Occupation Study of the Society of Actuaries, have also been subject to major criticism. The actuarial risk data reported data for 37 occupations, from which the annual risk averaged approximately 1 in 1000. Viscusi and Aldy (2003) stress that estimations using this data will suffer from a selection bias, as the data reflect workers in extremely high-risk occupations. Furthermore, in measuring the risk of death of people in particular occupations, they fail to separate the risk of death due to the occupation from non-work related reasons. Hence, as Viscusi and Aldy (2003) comment, they "do not distinguish fatalities caused by the job but rather reflect the overall fatality rates of people within a particular job category" (p.10). The misleading nature of the data is apparent upon close examination, as "one of the highest risk occupations based on these actuarial ratings is actors" (p.10). This error seriously undermines the results of studies using these data.

Other studies have however, constructed a risk variable by occupation successfully. Marin and Psacharopoulos (1982), in the first empirical estimation of the wage premium for fatal injury in the UK, constructs two risk of fatality variables, using the Office of Population Censuses and Surveys (OPCS) Occupational Mortality Decennial Supplement 1978, which is based on deaths in occupations between 1970-72. Genrisk is defined as the extra risk of dying, measured as the actual death rate minus the death rate that could have been expected given the age and social class structure in the occupational group. Conversely, Accrisk is the rate of deaths from an accident at work minus the rate expected given the occupational age structure. They acknowledge that Accrisk is "much more clearly a labour-market-specific variable, as compared with Genrisk which refers to deaths in general" (p.833). As this method of calculating the risk of death takes into account the average accidental workplace death rate in all occupations, the variable can have a positive or negative value. Results of Marin and Psacharopoulos (1982) show "the theory of compensating differentials does apply in the UK" (p.848). As predicted, estimations using the Accrisk variable give stronger results. As the fatality data includes information on 223 occupations, Leigh (1989) comments that "Marin and Psacharopoulos appear to have assembled the best data to date to test for compensating wages for risk of death" (p.835). Further

UK studies have used the OPCS data, and all find significant compensating differentials for risk of death.

It is also possible to create a risk variable that is constructed from occupation by industry data. Siebert and Wei (1994) use data from the HSE for the years 1986-88. They calculate a mixed industry-occupation risk variable with data on 150 occupation-industry cells. They observe that their accident data "should be quite accurate with regard to fatal injury rates, since the method of averaging over three years will help pick up rare events" (p.66). Their estimation results indicate "there are significant compensating wage differentials for both unionised and non-unionised male manual worker groups" (p.71).

In a follow-up study that compares the estimation results of Siebert and Wei (1994) and Sandy and Elliott (1996), Sandy et al. (2001) argue that the OPCS risk data are superior to the HSE industry-occupation cells. They highlight the fact that OPCS data "allow the risk measure to be standardised for the age composition of the workforce in each occupation" (p.42) as a significant advantage. They also suggest that "the greater number of possible risk categories (371 versus 50) allows the nature of risk to be more finely distinguished" (p.42). In terms of defining the risk variable therefore, Sandy et al. (2001) conclude that "using fine occupational codes is superior to an assignment using either a mix of aggregated occupations and industry codes or industry codes alone" (p.49).

A subjective risk measure, whereby workers rank on a scale the level of risk to which they believe their job exposes them may be preferable, as it is indeed the worker's perception of risk that ultimately leads them to accept or reject a job. Some caution must be exercised when using such data however, as individual assessment of risk is likely to be biased (Viscusi 1993). Despite this difficulty with measuring individual perceptions Gegax et al. (1991) believe that data reflecting some subjectivity are "arguably superior" (p.589).

Viscusi (1978) compares the effectiveness of two risk variables, one of which is self-reported, in supporting the theory of compensating wage differentials. Viscusi constructs a self-assessed dummy variable, denoted as Danger. This variable "is not an objective index but rather the subjective assessment of the risk, the magnitude that motivates individual behaviour" (p.412). For comparison, he creates a variable denoted Injrate, defined as the number of injuries per million hours worked in 1969 for the worker's industry, constructed using data from the BLS. Results reveal positive and statistically significant wage premiums for both variables, with a slightly larger premium estimated for the subjective variable Danger. This supports the suggestion that workers may overestimate the extent of the risk to which their job exposes them. The accuracy of subjective measures is however emphasised, as Viscusi shows "there is a strong positive relationship" (p.412) between the two variables.

Few other studies have included subjective measures of risk, partly due to limited data availability, but also because it means comparisons with other studies are inadequate, and therefore it is difficult to draw conclusions with respect to policy. As Smith (1979) comments, self-reported measures "suffer from a lack of comparability across individuals because of their subjectivity" (p.342).

Most studies have found a positive wage premium for being exposed to risk of fatality, but estimation results are less clear with respect to non-fatal injury. As discussed, there are numerous specifications of the non-fatal injury variable, which is likely to influence whether a premium is found.

Siebert and Wei (1994) include a non-fatal variable in their estimations using UK data from the HSE, where accident data is available for serious injuries, defined as absent from work for 3 or more days. They do however, comment that such data are not very satisfactory "since serious accidents are lumped together with non-serious" as well as exposing the data to "reporting and moral hazard problems associated with less serious injuries" (p.66). Probably due to such measurement error associated with their non-fatal accident variable, they find little evidence of its significance. The issue of distinguishing non-fatal injuries by degree of severity is also highlighted as being potentially important for estimating a non-fatal wage premium by Arabsheibani and Marin (2000). Their non-fatal injury variable uses data from the GHS 1987-89, which asks respondents if they have had an accident at work or during hours of work that resulted in a visit to a doctor or hospital. A non-fatal injury variable for occupations is thus constructed, defined as the "excess rate (per thousand per year) of non-fatal injuries during hours of work" (p.255). Their results show that including a non-fatal variable makes no difference to the significance of the fatal-risk coefficient. However, they find that when both a fatal and non-fatal variable is included, the non-fatal variable coefficient is sensitive to the sample used and the other variables included in the regression. Furthermore, the non-fatal accident variable "is always negative" (p.264). They conclude that the issue of non-fatal accident wage premiums "remains to be investigated with data which distinguish non-fatal accidents by their degree of severity" (p.264).

Cousineau et al. (1992) find that including a severity variable in their estimation in addition to a non-fatal accident variable, defined as the average number of days of absence per injury, results in a significant wage premium. They conclude that "severity considerations do also appear to play a significant role in the determination of compensating differentials" (p.169). Martinello and Meng (1992) are also able to classify injuries as severe or minor. Their results show significant premiums for severe injuries, but find that "workers do not receive more compensation for higher risk of minor injuries" (p.343). Overall, there are many issues to consider in the construction of non-fatal accident variables, with results highly dependent upon how the variable is constructed. Data availability will often constrain the measure that is used.

There has been considerable interest in the effect that trade unions have upon the wage premium received for dangerous work because, as discussed, theoretically there are arguments for unions to potentially lower or increase the premium. Also, as an institution of the modern labour market, there is great interest in the effect that unions have upon this neoclassical theory. As Table 3B.1 reports, the majority of empirical studies in the US suggest that union workers receive a larger premium for dangerous work. This result is not exclusive to the US however, with some studies from Canada and the UK also reaching this conclusion. Most studies use a risk-union interaction variable in their estimations, with the exception of Fairris (1992), Siebert and Wei (1994) and Wei (2007), who estimate separate equations for union and non-union workers, with Olson (1981) comparing the two methods. All four studies find union workers receive a higher wage premium. Theoretically therefore, these studies suggest that unions may bargain for safety and provide members with safety information. Siebert and Wei note that under UK law at the time, workers in firms that did not recognise a trade union were unable to demand a safety representative. This led them to question whether special provisions were needed to protect workers in non-union firms. They do, however, conclude that such measures are unnecessary, "since the higher levels of non-union accidents need not be due to worse communication or less knowledge in the non-union plant, but rather to worker and firm choices" (p.73). However, since Siebert and Wei published their results, the HSCER 1996 has meant firms that do not recognise unions can elect safety representatives. We may, therefore, expect there to be a smaller difference between union and non-union workplaces in terms of safety and compensation using data post 1996, as both have the potential to benefit from safety representatives and health and safety committees. However, the findings of Reilly et al. (1995) and Litwin (2000) suggest that worker representation is most effective in unionised firms.

Just as much empirical estimation has found unions increase the risk premium, many have found unions reduce it, particularly those using UK data. Marin and Psacharopoulos (1982) highlight the significance of this, suggesting unions in the UK campaign directly for improvements in safety rather than increasing the wage compensation for hazardous working conditions, hence "risk would seem less relevant and play less of a role in earnings determination by collective bargaining" (p.834). The conflicting results with respect to the effect that unions have upon the wage premium mean that "all results should be interpreted with a good deal of caution"

(Dillingham and Smith, 1984, p.145). Sandy et al. (2001) comment that the balance of studies seems to suggest a higher premium for union workers, but caution against concluding that unions do increase the wage premium solely based on this observation. Specifically, they highlight the fact that the majority of studies that find a higher union-risk premium use industry risk data whereas the majority of studies using occupation risk data find a higher premium for non-union workers. Hence, "the contradictory results appear to be related to measurement error and the assignment of risk" (Sandy et al., 2001, p.40). The effect trade unions have upon the wage premium overall therefore, is still subject to disagreement empirically as well as theoretically, requiring that interpretation of the union-risk premium must take into account the data used and specification of the risk and union variables in each individual estimation.

3B.6.2 Work-Related Illness

Table 3B.2 provides a summary of the main papers in the literature that consider whether a risk premium is received for exposure to illness risk.

Few studies have attempted to estimate a wage premium for exposure to illness risk, largely due to the problems of measurement (see chapter 3B.5.2). As Sandy and Elliott (2005) emphasise "measurement errors in data have plagued research in this area" (p.748). However, despite the difficulties involved in creating an adequate illness-risk measure, studies that have considered illness risk emphasise the importance of including it in estimates of compensating wage differentials. Meng (1991) notes that diseases may be particularly prominent in certain occupations which "could lead to greater awareness of the long term costs of chronic diseases and a requirement for greater compensation" (p.331).

Table 3B.2: Key Illness Studies

STUDY	COUNTRY	ILLNESS DATA	EVIDENCE OF ILLNESS PREMIUM?
Meng (1991)	Canada	Labour Canada Workers Compensation Board	Yes
Fishback and Kantor (1992)	US	Historical Labour Statistics Project 1884-1887, 1890, 1892, 1903, 1992	Some limited evidence
Lott and Manning (2000)	US	Carcinogenic Exposure Compensation	Yes
Sandy and Elliott (2005)	UK	SWI 1990	Yes
Wei (2007)	UK	WERS 98	Yes

Meng (1991) uses data that enables causes of work-place fatalities to be distinguished as due to short-term hazards, defined as resulting from an accident, and long-term hazards, due to a prolonged disease. In his wage equation estimations, "the risk premium for additional diseases exceeds the one for accidents" (p.335) suggesting that workers demand a greater wage premium for being exposed to risk of death from disease. Meng (1991) attributes this to workers having greater knowledge of the risk of death from disease. Sandy and Elliott (2005) point out however, that the measure of occupational illness used is limited, as it does not consider occupational illnesses that do not result in death (p.748).

Fishback and Kantor (1992) use data from US industries from 1884-1903, when "dusts, fumes, gases, vapours, acids, compressed atmospheres" (p.835) posed significant threats to the health of workers. They use an employer-reported measure of illness and injury risk that resulted in absence from work. However, they find limited evidence of a wage premium for exposure to illness risk, which "lends credence to social reformers' claims that the private market inadequately compensated workers" (p.835). However, Sandy and Elliott (2005) criticise using a variable of lost workdays to capture illness risk, as the long-term nature of many occupational illnesses may not result in lost work days until the later stages of the illness. Some workers may also be more willing than others to be absent from work. It also fails to take account of workers who have been forced to retire early or switch occupations because of a long-term illness. Therefore, "any method of identifying occupational illnesses which relies on lost days of work is unlikely to offer any real insight into overall compensating differentials for illnesses" (p.6).

Lott and Manning (2000) investigate whether workers receive a wage premium for exposure to cancer risk in US industries. Using the Hickey-Kearney carcinogen exposure indicator, they calculate exposure variables for each industry. A statistically significant wage premium is estimated. This study only considers one type of occupational illness however, and so the risk variable does not take into account the risk of other illnesses in industries. Results from these estimations however, do suggest wage premiums are received for exposure to risk of disease, suggesting the need for further investigation.

As the first paper using UK data to estimate whether workers receive a wage premium for exposure to the risk of occupational illness, Sandy and Elliott (2005) use data from the SWI 1990 survey which was included as a trailer questionnaire to the LFS in the second quarter of 1990. The survey, as described in chapter 2.7.1, utilises professional interviewers and the link with the illness and work is investigated to minimise measurement error. There are difficulties in relying on self-reported data as "answers might not be thoughtful and the respondents may not have reflected sufficiently on what they believed to be the causes of their illnesses" (p.749). Jones et al. (2006) in a discussion of the surveys main findings however, do note high rates are found for diseases that have a known link with work. Sandy and Elliott (2005) further emphasise "we judge that this is the most robust data yet to be made available for a study of this nature" (p.749). They calculate a measure of illness probability for occupations based on current workers and former workers who had an illness caused by their former occupation. Estimations, which also include variables for risk of death and major injury (using data from the HSE), "find significant compensating differentials for male manual workers but none for male non-manual workers" (p.762). Furthermore, their results suggest wage premiums for illness risk are more important than compensation for accident risk. As a result, they conclude that "reducing workplace illnesses is now a matter of high priority" (p.762). They specifically suggest increasing the available information on illness rates by occupation.

Subsequently, Wei (2007) performs an estimation to test for compensating wage differentials for illness risk using WERS 98. Establishment-specific measures of illness and injury risk, with rates defined as per injury/ illness per employee per year, are calculated. Wei suggests that this method is particularly appropriate when measuring illness risk, as "many job-related illnesses may be caused by the factors prevailing at the same establishment" such as "bad working environment, high noise level, and chemical pollutants" (p.92). Descriptive analysis reveals that the illness rates derived from WERS 98 data are lower than those calculated using SWI 99 data, which is to be expected for a number of reasons. The SWI definition of an illness is much wider compared to the WERS question. Also, as the WERS illness question relies on manager reports, "individuals are perhaps more likely to over-report work-related illness incidences than managers of firms" (p.88). Further, the WERS 98 sample included firms with 10 or more employees only, which is likely to lead to downward biased rates, as large firms are consistently found to be safer. Wei does note, however, that the ranking of industries in terms of the number of illnesses each has reported is fairly consistent between the two data sets. Wei finds evidence of compensation for illness risk for both men and women (p.92), although estimates are lower than those found by Sandy and Elliott (2005), to be expected given the many differences in measurement of illness risk between the two studies, with establishment-specific illness risk hypothesised to give smaller risk premium estimates by the author (p.86).

3B.6.3 Controlling for Endogeneity

Following Garen (1988), whose estimations provide evidence that risk may be endogeneously determined, studies have attempted to control for endogeneity using the method he proposes. Garen himself (1988) shows that "the endogeneity of job riskiness causes a substantial bias in the estimation of the wage premia" (p.15) with the risk coefficient "substantially larger than OLS indicates" (p.14). As previously discussed, there have been problems in finding appropriate instruments to proxy risk aversion, as required to perform Garen's estimation technique. However, studies that have utilised the method have found similar results. For example, Sandy and Elliott (1996) find an "increase in the fatal risk coefficients using Garen's method" (p.300). Arabsheibani and Marin (2000) also find using the method substantially increases the risk coefficient. The finding that OLS estimations are biased downward is consistent with Garen's argument, as it implies "workers with high unobserved earnings capacity, ε, are willing to 'pay' for occupations with more safety" (Sandy et al., 2001, p.47).

Problems arising from using Garen's technique however, have been highlighted. Siebert and Wei (1994) note that estimates are "sensitive to the choice of instruments" (p.72) with results of a Hausman test in their estimations failing to support the hypothesis of endogeneity. Arabsheibani and Marin (2000) similarly find that "the values were very sensitive to precise specifications" (p.265). In a further paper, Arabsheibani and Marin (2001) return to this issue, by testing various specifications of the risk equations. They express particular concern over the "very high collinearity between the risk measure and the residual in the first-stage regression" (p.1909), with their estimates very sensitive to model specification. They recommend that when using Garen's technique, "users should examine the sensitivity of their estimates to minor changes in the specification of the second-stage equations" (p.1910). Overall therefore, although as Sandy and Elliott (1996) find "controlling for the endogeneity of risk makes a substantial difference to the value of life calculations" (p.302), these results are sensitive to the instrumental variables that are used in estimations.

3B.7 Summary

Adam Smith's theory has received considerable criticism, largely related to the question of whether its neoclassical assumptions can still be applied in today's labour market. The fact that "the theoretical case for wage compensation for risk is plausible but hardly certain" (Dorman and Hagstrom, 1998, p.116) has led authors to question whether the wage will compensate for disagreeable job characteristics and resulted in many empirical studies. Despite the criticisms, the theory does influence labour market policy, and as Rees (1975) summarises "it would be hard to imagine a theory of relative wages that did not make some use of this concept" (p.349)

In terms of testing the theory, this review has emphasised the problems associated with constructing an accurate measure of the risk variable, and studies within the literature have varied greatly in the type of data utilised to construct such a variable. It is therefore, perhaps not surprising that "where evidence for compensating wages is found, estimates of the amount of compensating wages for risk of death vary considerably" (Leigh, 1991, p.382). This discussion has shown that the majority of studies do find evidence of wage premiums; however, estimations are highly sensitive to the data and model specifications. Emphasis within the compensating literature is hence on constructing the appropriate measure of risk. Most recently, emphasis within the literature has been upon attempting to address measurement problems of endogeneity. Worker heterogeneity has also influenced recent literature, with studies testing how workers' preferences for risk vary. Some have gone further to suggest the traditional model does not capture differences in preferences by race and smoking status. If different groups of workers, sorted by characteristics such as race and smoking status, have different preferences for risk translating into different wage premiums being required by each group at each level of risk, it suggests groups of workers face separate market offer curves. Results of these studies "cast considerable doubt on the traditional model of compensating wage differentials for risk" (Viscusi, 2003, p.255). There is hence the opportunity to test how preferences for risk vary for many groups of workers. However, as is true for attempts to address many measurement problems within the compensating wage literature, empirical work is constrained by "the absence of injury statistics at the necessary level of detail" (Leeth and Ruser, 2003, p.250).

CHAPTER 4

WORKPLACE INJURIES AND ILLNESSES: DETERMINANTS AND INFLUENCES

4.1 Introduction and Background

There has been considerable research as to what causes injuries and illnesses in the workplace in order to inform policy upon how to reduce their incidence further. This is following the government's targets to improve safety in the workplace, as outlined in chapter 2. Given continuous economic and labour market changes, such research that takes into account changing workplace conditions is essential

This chapter uses data from WERS 04, and in particular utilises the questions in the Management Survey upon establishment injuries and illnesses, to consider what influences workplace safety. Reilly et al. (1995) and Nichols et al. (1995) use WIRS 90 to consider the influences upon workplace injuries in manufacturing establishments. Subsequently, Fenn and Ashby (2004) recognised that changes to the UK economy in terms of a reduction in manufacturing employment meant "it no longer seems justifiable to focus exclusively on the manufacturing sector in relation to health and safety at work" (p.461). Their paper therefore, using WERS 98, considers influences upon injuries in all establishments. A further paper, Robinson and Smallman (2006) conducted a similar analysis to Fenn and Ashby, again using WERS 98. They distinguish between the manufacturing and service sectors in their analysis, arguing that factors that have an impact upon workplace injuries and illnesses may vary "given the different incidences of work and employment practices and reported injury and illness rates between sectors" (p.94).

WERS 98 introduced a workplace illness question, enabling this element of workplace risk to be considered. This is particularly relevant given the reduction in manufacturing employment has meant that in terms of workplace safety, "many of the challenges lie in the area of occupational health" (Altman, 2000, p.4). The impacts upon workplace illness may be very different to workplace injuries; given the expected increase in occupational illnesses, it is therefore important such impacts are understood. In addition, WERS 98 increased its sample to include organisations with 10 or more employees, whereas WIRS 90 only included workplaces with 25 or more employees.

The sample for WERS 04 was increased further from WERS 98 to include workplaces with 5 or more employees. Changes to WERS and to the nature of the injury and illness questions means it is difficult to consider over time how the influences upon workplace safety have changed or remained the same using this survey. Analysis using this new data set however, will add further to the understanding of the influences upon injuries and illnesses within the firm.

Chapter 3A discusses papers that have estimated the influences upon workplace injuries and illnesses. As it is important to ensure all factors that impact upon safety at work are controlled for in any regression analysis of workplace injuries and illnesses, this will be considered when deciding which variables to include and in the analysis of results.

4.2 Data and Descriptive Statistics

WERS 04 is based on a stratified random sample of establishments, with the Inter-Departmental Business Register (IDBR) used as the sampling frame. Workplaces with 5 or more employees were eligible for inclusion, with around 2 300 establishments taking part (Chaplin et al., 2005, p.1)[10]. The data used here are the result of face-to-face interviews with a workplace manager, where manager is defined as "the senior manager dealing with personnel, staff or employment relations at the establishment" (*ibid*).

The sample design of WERS means that large workplaces are over-sampled. Purdon and Pickering (2001) note that "whereas the population of establishments has a considerable skew towards small establishments, the sample distribution has little or no skew by size" (p.2). Therefore, the achieved WERS sample is unrepresentative of the population and weights are required to produce unbiased estimates. Sampling weights in WERS therefore, give added weight to smaller establishments. In a paper that concludes sampling weights should almost always be used when using WERS, Purdon and Pickering observe that "the use of sampling weights in survey analysis has been the subject of a number of academic papers in recent years" (p.1) with some researchers arguing that "associations between variables will be approximately unbiased, and the interpretation of models, whether or not weighted, will be broadly the same" (p.1). Fenn and Ashby use sampling weights throughout their analysis to correct for the variation in sampling errors (p.465). The fact that the model seeks to investigate the relationship between workplace size and workplace accidents and illnesses further justifies the use of weights so the model is representative of

[10] WERS 98 achieved a sample size of just under 2 200 establishments.

establishments within Great Britain. The sampling weight ESTWTNR is used in the analysis that follows; an unweighted model however, will also be estimated for comparison.

The injury question asks managers how many, if any, employees in the establishment have sustained any of the following injuries during working hours in the last 12 months: i) bone fracture, ii) amputation, iii) dislocated joint, iv) loss of sight (permanent or temporary), v) chemical or hot metal burn to the eye, vi) penetrating eye injury, vii) acute illness requiring medical treatment, viii) any other injury leading to unconsciousness or requiring resuscitation or admittance to hospital for more than 24 hours. Compared to the injury question in WERS 98, dislocated joint is added to the list of injuries. WERS 98 also includes physical injury resulting from a work-related physical assault, a category which is not included in the WERS 04 question.

The illness question asks managers if any employees have suffered from any of the following types of illnesses, disabilities, or other physical problems that were caused or made worse by work: i) bone, joint or muscle problems, including back problems and Repetitive Strain Injury (RSI), ii) breathing or lung problems (including asthma), iii) skin problems, iv) hearing problems, v) stress, depression or anxiety, vi) eye strain, vii) heart disease/attack, or other circulatory problems, viii) infectious disease (virus, bacteria). Although the wording of the WERS 98 question is the same as in WERS 04, some illnesses are added to WERS 04, namely hearing problems, eye strain, heart disease/attack, and infectious disease.

The potential for managers to under-report the number of injuries and illnesses needs to be considered. Chapter 2.10 highlights research that has concluded under-reporting is a common occurrence with regards to non-fatal accidents and illnesses. Managers may be unaware of all incidences, with employees not reporting every case. Managers may also choose not to report all cases, for fear of their firm gaining a reputation for a poor safety record. Arguably, neither would be possible in the case of the most severe cases and so the WERS question should at the very least reflect major occurrences. The likelihood of under-reporting is greater for workplace illnesses. Chapter 3B.5.2 highlighted how illnesses are more difficult to attribute to work; as many illnesses develop slowly managers may be unaware of all cases amongst workers, and so the WERS data may underestimate the number of work-related illnesses. The potential for under-reporting does need to be considered when interpreting the estimation results.

Table 4.1: Number of Injuries and Illnesses Reported in WERS 04 (weighted)

Number of Injuries/Illnesses	**Number of Workplaces Reporting Injuries**	**Number of Workplaces Reporting Illnesses**
0	2084.91	1713.6
1	121.2	295.4
2	22.9	119.5
3	8.5	40.7
4	2	19.7
5	2.9	50.3
6	1.9	8.9
7	0.1	7.1
8	0.04	3.6
9	0.4	0.7
10	1.1	9.5
11 to 20	2.6	11.2
21 to 50	2.2	6.9
51 to 100	0.2	0.8
more than 100	0.4	1.1

Table 4.1 and Figure 4.1 show the distribution of responses to the injury and illness questions. The responses are skewed with many zero observations: 92.8 per cent of workplaces reported no injuries, and 74.9 per cent of workplaces reported no illnesses. As Fenn and Ashby found using WERS 98, workplace illnesses appear to now be more common than workplace injuries. Coupled with the potential for workplace illnesses to be under-reported, this difference may be even greater than estimated.

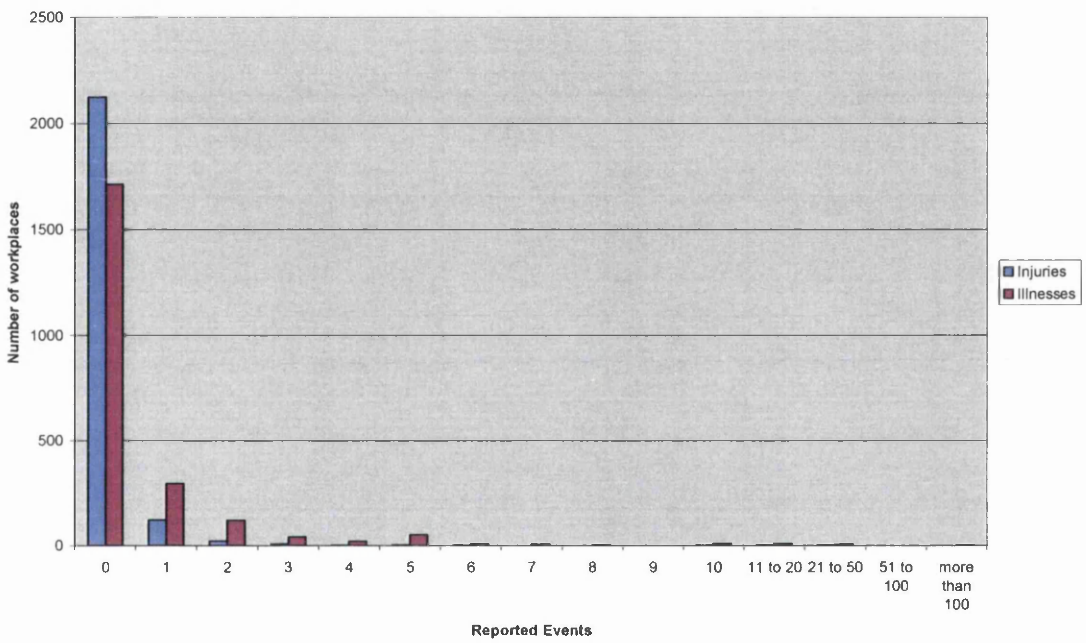


Figure 4.1: Distribution of Workplace Injuries and Illnesses (weighted)

Table 4.2 reports that there was an average of 0.189 injuries and 0.736 illnesses per British workplace in 2004, with t tests revealing the difference between the two is significant[11]. Weighted means are much smaller as the weights give greater importance to smaller workplaces, where there are fewer employees to sustain an injury or illness. Fenn and Ashby report weighted means of 1.040 injuries and 1.024

[11] A test for equal variance shows the variances to be unequal. The t test is therefore a two-sample t test that controls for unequal variance.

illnesses per workplace using WERS 98. T tests reveal means calculated using WERS 04 are significantly smaller to those calculated by Fenn and Ashby[12].

Table 4.2: Mean and Standard Deviation for Injury and Illness Variables (workplaces with 5 or more employees)

Variable	No. of Firms	Mean Number per Workplace (unweighted)	Mean Number per Workplace (weighted)
Injuries	2248	1.009 (7.647)	0.189 (2.755)
Illnesses	2094	7.258 (62.746)	0.736 (7.179)
T test with unequal variance: t		4.5258***	3.2696***

***=significant at the 1% level

Table 4.3 Mean and Standard Deviation for Injury and Illness Variables (workplaces with 10 or more employees)

Variable	No. of Obs	Mean Number per Workplace (unweighted)	Mean Number per Workplace (weighted)
Injuries	2015	1.122 (8.069)	0.308 (3.660)
Illnesses	1862	8.132 (66.490)	1.118 (9.560)
T test with unequal variance: t		4.5187***	3.4311***

***=significant at the 1% level

To compare results more directly to those obtained using WERS 98, means were also calculated for a sample that excluded workplaces with less than 10 employees (Table 4.3). Excluding workplaces with less than 10 employees has the expected effect of increasing the mean number of injuries and illnesses. Results continue to show that

[12] A test for equal variance shows the variances to be equal. Weighted injury rates are significantly different with a t statistic of 10.223, and weighted illness rates are significantly different with a t statistic of 13.732, both of which are significant at the 1 per cent level.

workplace illnesses are significantly more common than injuries. T tests reveal the differences between the weighted number of injuries in WERS 98 as reported by Fenn and Ashby, and WERS 04 as reported here, remains significantly smaller[13]. There is no significant difference however, between the number of illnesses, despite the definition widening in the WERS 04 survey. Even though WERS 04 reports more illnesses the increase is insignificant. Overall, these initial results suggest workplace injuries are becoming significantly less common which supports the trends reported in chapter 2, with no statistically significant change in workplace illnesses which continue to be significantly more common within establishments.

Explanatory variables were constructed after consideration of the literature. In order to compare results directly with Fenn and Ashby, initially the model will be estimated using the same explanatory variables used in their estimation. Appendix 4.1 lists the variable definitions. Table 4.4 reports descriptive statistics of these variables for the WERS 04 sample.

As WERS 04 includes smaller workplaces, the number of employees variable has a weighted mean of 31.9 employees, compared to 62.1 in Fenn and Ashby. Twelve industry dummy variables[14] and 9 occupation variables are derived[15], corresponding to the proportion of employees in a particular occupation within an establishment's workforce. Workplace union density is captured by a variable derived as the number of employees within an establishment that managers report as union members, divided by the total number of employees within an establishment. The unweighted mean

[13] Weighted injury rates are significantly different with a t statistic of 6.440 which is significant at the 1 per cent significance level.
[14] With manufacturing the control group.
[15] With proportion of clerical workers the control group.

indicates on average 26.2 per cent of workers within an establishment are union members, compared to the weighted mean 14.2 per cent. The sampling weight which places greater importance upon smaller workplaces, reduces the mean proportion of union members within workplaces, with smaller workplaces likely to have a smaller union presence.

Table 4.4: Descriptive Statistics

Variable	**No. of Obs**	**Min**	**Max**	**Unweighted Mean**	**Weighted Mean**
Employees	2295	5	10006	414.048 (950.017)	31.936 (124.422)
Ln (Employees)	2295	1.61	9.211	4.457 (1.766)	2.689 (0.960)
Part-time	2295	0	1	0.271 (0.275)	0.329 (0.304)
Turnover	2096	0	1	0.185 (0.179)	0.202 (0.214)
Age21	2203	0	1	0.089 (0.153)	0.119 (0.188)
Age50	2207	0	1	0.211 (0.159)	0.217 (0.189)
Manufacturing	2295	0	1	0.135 (0.342)	0.111 (0.315)
Electricity	2295	0	1	0.092 (0.139)	0.001 (0.037)
Construction	2295	0	1	0.049 (0.216)	0.049 (0.216)
Wholesale	2295	0	1	0.139 (0.347)	0.249 (0.432)
Hotel	2295	0	1	0.048 (0.215)	0.089 (0.285)
Transport	2295	0	1	0.063 (0.243)	0.048 (0.213)
Financial	2295	0	1	0.057 (0.231)	0.052 (0.222)
Real estate	2295	0	1	0.122 (0.324)	0.149 (0.356)
Public admin	2295	0	1	0.059 (0.237)	0.022 (0.146)
Education	2295	0	1	0.091 (0.287)	0.049 (0.217)
Health	2295	0	1	0.154 (0.361)	0.116 (0.319)

Community	2295	0	1	0.062 (0.242)	0.065 (0.25)
Managers	2279	0	1	0.108 (0.117)	0.149 (0.138)
Professional	2280	0	1	0.109 (0.191)	0.069 (0.159)
Technical	2282	0	1	0.113 (0.199)	0.068 (0.171)
Admin	2283	0	1	0.157 (0.212)	0.149 (0.218)
Skilled Trades	2279	0	1	0.070 (0.167)	0.082 (0.197)
Service	2283	0	1	0.082 (0.213)	0.076 (0.221)
Sales	2281	0	1	0.137 (0.272)	0.203 (0.326)
Machine Operatives	2281	0	1	0.087 (0.207)	0.078 (0.198)
Unskilled	2281	0	1	0.127 (0.247)	0.1249 (0.255)
Shifts	2295	0	1	0.479 (0.499)	0.2412 (0.428)
Overtime	2249	0	6	2.425 (1.79)	2.317 (2.092)
Union	1994	0	1	0.262 (0.329)	0.142 (0.282)
Committee	2287	0	1	0.370 (0.483)	0.110 (0.313)
Jointcomm	2295	0	1	0.062 (0.242)	0.030 (0172)
Specificcomm	2295	0	1	0.305 (0.461)	0.077 (0.266)
Pay (£'000)	1733	0	45241	17222.84 (7654.1)	14414.23 (7136.64)

Further variables are created to indicate the proportion of employees working shifts, and the proportion of part-time workers. In addition, variables are constructed to reflect whether there is a health and safety committee presence within the firm. The weighted mean shows 11 per cent of firms have a committee of some definition to deal with health and safety, with the majority of these established to deal solely with health and safety rather than a range of issues.

4.3 Negative Binomial Regression Model

We wish to estimate the influences upon the number of accidents and illnesses occurring within a workplace during a 12 month period. The nature of the dependent variable is hence count data in form. The dependent variable takes on many other characteristics, with many zero observations and small values (as illustrated by Figure 4.1) suggesting a least squares model is inappropriate.

Following Fenn and Ashby (p.469), we assume that for an employee in the ith workplace, data on the number of accidents or illnesses can be characterised by a Poisson process with a constant rate of occurrence μ_i. Therefore, where N_i refers to the number of employees within the ith workplace, if we assume μ_i to be equal and independent, the probability of an accident occurring within the ith workplace can be specified as $N_i \mu_i$. The number of accidents and illnesses (y_i) follows a Poisson distribution (equation 1):

$$F(y_i; N_i, \mu_i) = \frac{e^{N_i \mu_i} (N_i \mu_i)^{y_i}}{y_i!} \qquad [1]$$

The risk faced by workers in the ith establishment (μ_i) can further be denoted by equation 2:

$$\mu_i = \mu_i (x_i, \beta_i) = e^{x_i' \beta + \varepsilon_i} \qquad [2]$$

where x_i represents a vector of observed influences upon workplace safety, and β the vector of corresponding coefficients. The error term (ε_i) captures the impact of unobserved influences upon safety.

A weakness of the Poisson regression model is the assumption that the mean and variance are equal. Substituting equation 2 into equation 1 leads to over dispersion in that the variance will exceed the mean, violating the assumption of this model. However, if we assume a gamma distribution for ε_i, a Negative Binomial distribution for y_i is generated (equation 3):

$$F(y_i; N_i,\mu_i,\alpha_i) = \frac{\Gamma(\alpha^{-1}+y_i)}{\Gamma(\alpha^{-1})\Gamma(y_i+1)}\left(\frac{\alpha^{-1}}{\alpha^{-1}+N_i\mu_i}\right)^{\alpha^{-1}}\left(\frac{N_i\mu_i}{N_i\mu_i+\alpha^{-1}}\right)^{y_i} \quad [3]$$

Where α refers to the one parameter distribution for ε_i. Assuming data for n establishments, the log likelihood function for [3] is shown by equation 4:

lnL(α,β)=

$$\sum_{i=1}^{n}\left\{\sum_{j=0}^{y_{i-1}}\ln(j+\alpha^{-1})-\ln y_i! - (y_i+\alpha^{-1})\ln(1+\alpha N_i e^{x'_i\beta})+y_i\ln\alpha+y_i(x'_i\,\beta+\ln N_i)\right\} \quad [4]$$

Maximising [4] will give consistent estimates for β.

To test the effect that workplace size has upon injuries and illnesses, we cannot rely on the coefficient estimated for the Ln (Employees) variable as we would expect there to be a greater number of injuries and illnesses the greater the number of workers. To test whether workplace size has an independent effect upon workplace accidents and illnesses, Fenn and Ashby perform Wald tests. They reject the null in all cases with the coefficients estimated to be less than one, and so conclude workplaces with a greater number of employees have a smaller risk of reported workplace injuries and illnesses.

Negative Binomial Regression models are estimated with the WERS 04 sample that includes workplaces with 5 or more employees, and to enable comparison with Fenn and Ashby that use WERS 98, for a sample of workplaces with 10 or more employees. Results using the sampling weight are presented in Table 4.6[16].

In all regressions, *ln(employees)* is positive and significant, as expected given there are likely to be more reported injuries and illnesses in workplaces with more workers. Results of the Wald tests, to test whether workplace size has a significant independent effect, are shown in the final two rows in Table 4.6, with the null hypothesis that the coefficient is equal to 1. Regression results enable the null hypothesis of no significant size effect to be rejected in the illness regression, where the coefficient is estimated to be less than 1. In the injury regression however, there is no significant independent effect. In the sample that includes smaller workplaces therefore, workplace size does have a significant independent effect upon illness but not upon injury. In the sample of workplaces with 10 or more employees however (the WERS 98 sample), the null hypothesis is rejected in both regressions, although only at the 10 per cent significance level. Larger workplaces are therefore significantly safer in

[16] Standard errors are computed using the Huber-White Sandwich estimator and so are robust to sample structure and heteroscedasticity.
The overdispersion parameter is significant in all estimations, confirming the Negative Binomial Regression model is preferable to the Poisson model.

terms of risk of injury and illness in this sample. The log-linear specification enables the coefficients to be estimated as elasticity's. In the sample of firms with 10 or more employees, doubling the number of employees reduces the risk of reported injuries by 21 per cent, and the risk of reported illnesses by 13 per cent[17]. The impact of workplace size upon workplace health and safety is therefore considerable.

Evidence has frequently shown large firms to be safer in terms of a reduction in the probability of experiencing a workplace injury, including studies by Reilly et al. (1995), Nichols et al. (1995), Fenn and Ashby (2004) and Robinson and Smallman (2006). Explanations for these findings include the ability of large firms to exploit economies of scale in providing safe working conditions. Frick and Walters (1998) also list numerous potential reasons for small firms to have a poorer safety record, including poor knowledge of legal requirements and safe working practices, and limited management resources to devote to health and safety (p.367). It is also important to note that papers could be underestimating the number of accidents in small workplaces. Daniels and Marlow (2005) find under-reporting of accidents to be common in small firms, attributing "lack of awareness of legal reporting requirements" (p.4) and an increased relative burden of completing the necessary paperwork. This is particularly relevant given the nature of the WERS questions, with managers in small workplaces potentially not reporting all accidents and illnesses, and so the increased risk to workers employed in small businesses may be even greater than estimated.

[17] Fenn and Ashby calculate doubling the number of workers would reduce the risk of reported injuries and illnesses by 33 per cent and 25 per cent.

Table 4.6: Negative Binomial Regression Results

Workplaces with 5 or more Employees
Dependent Variable: Injuries/Illnesses

	INJURIES			ILLNESSES		
No. of Obs	*1357*			*1296*		
Wald Chi²	*285.99*			*299.15*		
Log pseudo-likelihood	*-18.5805*			*57.5095*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.7083***	1.3085	-6.66	-3.6031***	0.6694	-5.38
Ln(Employees)	0.9338***	0.1105	8.45	0.8021***	0.0776	10.33
Part-time	-0.7919	0.7196	-1.10	-0.3632	0.4216	-0.86
Turnover	-0.7089	0.6753	-1.05	0.2119	0.6275	0.34
Age21	0.3363	0.6626	0.51	-1.2319**	0.5998	-2.05
Age50	-0.6862	0.7402	-0.93	0.2335	0.4542	0.51
Shifts	0.4100	0.3005	1.36	0.2674	0.2078	1.29
Overtime	0.0749	0.0792	0.95	0.1044***	0.0399	2.62
Union	0.7975**	0.3362	2.37	0.6428**	0.2813	2.29
Committee	0.3044	0.2736	1.11	0.0229	0.1578	0.15
Pay	2.85e-05	2.32e-05	1.22	7.18e-05	1.77e-05	0.41
Electricity	-0.0854	0.5689	-0.15	-0.7618	0.5131	-1.48
Construction	-0.4702	0.5351	-0.88	-0.5867	0.3926	-1.49
Wholesale	0.3063	0.7013	0.44	0.0746	0.3244	0.23
Hotel	-0.2334	0.6753	-0.35	-0.5923	0.4945	-1.20
Transport	-1.7058***	0.4999	-3.41	0.1766	0.3621	0.49
Financial	-0.1387	0.9379	-0.15	0.3990	0.4873	0.82
Real estate	1.3135**	0.6074	2.16	0.0268	0.3636	0.07
Public admin	2.7396***	0.6593	4.15	0.9830**	0.4352	2.26
Education	1.2086*	0.7134	1.69	0.1733	0.4416	0.39
Health	2.0065***	0.6959	2.88	0.8476**	0.3805	2.23
Community	0.7776	0.5948	1.31	0.1588	0.3362	0.47
Skilled Trades	4.0782***	1.1211	3.65	0.5125	0.6175	0.83
Managers	1.5246	1.7943	0.85	-0.5527	0.9905	-0.56
Machine Operatives	4.6762***	1.1117	4.21	-0.2481	0.6515	-0.38
Professional	0.5508	1.2113	0.45	-0.4331	0.6434	-0.67
Service	0.7377	1.0271	0.72	-0.5624	0.4824	-1.17
Unskilled	3.5760***	0.9298	3.85	0.4501	0.5313	0.85
Sales	3.4359***	1.3411	2.56	0.4868	0.5480	0.89
Technical	-0.4900	0.9153	-0.54	-0.6702	0.5596	-1.20
TEST LNEMPS=1						
Chi²	0.36			6.50***		
Prob>Chi²	0.5493			0.0100		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees
Dependent Variable: Injuries/Illnesses

Variables	INJURIES			ILLNESSES		
No. of Obs	*1198*			*1138*		
Wald Chi²	*233.38*			*363.34*		
Log pseudo-likelihood	*-15.0768*			*-39.6404*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-7.6245***	1.3282	-5.74	-3.0580***	0.6823	-4.48
Ln(Employees)	0.7942***	0.1291	6.15	0.8663***	0.0757	11.45
Part-time	-1.1643	0.7426	-1.57	-0.1503	0.4256	-0.35
Turnover	-1.3284*	0.7083	-1.88	-0.0080	0.4062	-0.02
Age21	0.7149	0.7875	0.91	-0.8185*	0.5046	-1.62
Age50	-0.3846	0.8524	-0.45	-0.6285	0.5121	-1.29
Shifts	0.6016**	0.2976	2.02	0.3361**	0.1680	2.00
Overtime	0.0913	0.0718	1.27	0.0842**	0.0376	2.24
Union	0.6774*	0.3649	1.86	0.4603*	0.2519	1.83
Committee	0.4915*	0.2738	1.80	0.0911	0.1603	0.57
Pay	8.39e-05	2.41e-05	0.35	1.48e-05	2.0e-05	0.74
Electricity	0.0810	0.5762	0.14	-0.7328	0.5343	-1.37
Construction	-0.0732	0.4570	-0.16	-0.0392	0.4165	-0.09
Wholesale	0.4261	0.6037	0.71	-0.0979	0.3464	-0.28
Hotel	-0.1400	0.6893	-0.20	-1.1555***	0.4455	-2.59
Transport	-1.5135***	0.4844	-3.12	0.2927	0.3571	0.82
Financial	0.2390	0.8696	0.27	0.6525	0.5557	1.17
Real estate	1.3555***	0.5401	2.51	-0.3791	0.3603	-1.05
Public admin	2.7277***	0.6413	4.25	0.3904	0.4072	0.96
Education	1.1838*	0.6726	1.76	0.1132	0.4168	0.27
Health	1.9616***	0.6571	2.99	0.5589	0.3972	1.41
Community	0.4273	0.5526	0.77	0.3881	0.3700	1.05
Skilled Trades	3.6046***	1.1241	3.21	-0.6326	0.6386	-0.99
Managers	0.2229	2.1174	0.11	-2.4589***	1.0015	-2.46
Machine Operatives	3.8231***	1.0964	3.49	-1.3658**	0.6635	-2.06
Professional	0.6970	1.1655	0.60	-0.8720	0.6371	-1.37
Service	0.7254	1.0688	0.68	-0.9206*	0.5071	-1.82
Unskilled	3.4369***	0.8731	3.94	-0.1894	0.5241	-0.36
Sales	3.2610***	0.8788	3.71	0.0628	0.6357	0.10
Technical	-0.3949	0.9283	-0.43	-0.7852	0.5820	-1.35
TEST LNEMPS=1						
Chi²	2.54*			3.12*		
Prob>Chi²	0.100			0.0773		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

The most dangerous industries are found to be Health and Social Work, and Public Administration and Defence, with Transport, Storage and Communication being a relatively low risk industry. Fenn and Ashby find the same results. Although these results may not have been as expected, they are likely to reflect the accepted belief that classifying risk in terms of injuries by industry is not as accurate as classifying it by occupation (Sandy et al., 2001, p.49). A workplace in a particular industry will employ workers in many occupations, each with a varying degree of risk. In terms of occupation, results are more in line with expectations, with a higher proportion of manual employees associated with a greater number of injuries. Conversely however, occupation variables are insignificant in the illness regressions. This immediately highlights the differences between incidences of workplace injuries and illnesses.

As the average age of an establishment's workforce has been found to influence accident and illness rates, variables are included to indicate the proportion of employees under 21 and the proportion of employees over 50. In both samples, *age21* is significantly negative in the illness regressions, indicating workplaces with a younger workforce have fewer work-related illnesses. *Age50* is insignificant in all estimations.

Work practices including overtime and shift work have all been shown to influence health and safety in the workplace. EC (2004) shows shift work to be associated with a higher risk of injury, with this being attributed to shift work reducing worker concentration. In all regressions, the variable *shift* is positive but is only significant in the sample of 10 or more employees. This is likely to be because smaller establishments have fewer employees working shifts to enable a significant effect to be estimated.

In terms of overtime, logically we would expect an increase in hours to result in an increase in injury rates, and evidence from Dembe et al. (2005) suggests overtime increases the hazard rate itself, not just the number of injuries. The variable *overtime* is positive in all regressions and significantly so in the illness regressions in both samples. Overtime therefore, is at the very least associated with an increase in workplace illnesses. Note that this variable refers to overtime that is either paid or unpaid. It would be interesting to consider if there are separate effects upon workplace accidents and illnesses; for instance, paid overtime, which is most likely to be voluntary, may not have as great a positive impact upon a workplace's health and safety record as unpaid overtime, which may not be voluntary. Unfortunately, the nature of the questions in WERS does not allow this to be tested. The impact that overtime has upon a workplace's health and safety record will be considered in more detail in a later section.

The effect that trade unions have upon a workplace's accident rate has been subject to wide debate, as discussed in chapter 3A.5. We may expect trade unions to have the effect of reducing accidents with collective bargaining resulting in an improvement in workplace safety (Freeman and Medoff 1984). However, there are arguments to suggest unionised workplaces will have a higher accident rate. Such arguments are largely attributed to improvements in reporting, with unions increasing workers' knowledge of their rights and correct procedures for reporting accidents, and helping to ensure there is a clearly established accident reporting system within the workplace. Trade unions may be used as a channel to air grievances, but also as a means through which compensation can be recovered. Nichols et al. (1995) find evidence suggesting that industries with higher union density report higher injury rates in WIRS 90. Fenn and Ashby (2004) however, find no statistically significant relationship between union density and injury risk, but in terms of illness risk estimate a significantly positive relationship. Regression results here show a significantly positive impact of union density upon workplace injuries and illnesses in both samples, supporting these two previous studies. It should be emphasised that higher accident rates may be expected in the presence of trade unions because of the endogeneity of union membership. Workers in dangerous industries or occupations may choose to belong to unionised workplaces because of the potential safety benefits. The potential endogeneity of union membership will be tested in the next section.

In addition to considering the role of trade unions in occupational safety, studies have also investigated the role of safety representatives and health and safety committees. Under current legislation in the UK, firms are not obliged to appoint a safety representative and establish a health and safety committee. However, Reilly et al. (1995) comment that EU legislation may eventually require this; in France and Germany health and safety committees are mandatory for firms over a certain size. The UK government has already recognised their benefits, with the HSCER 1996 making it possible for a group of employees not covered by a trade union to establish a health and safety committee. Reilly et al. find evidence that health and safety committees reduce workplace injuries (p.283). Fenn and Ashby caution that examining the impact of health and safety committees suffers from the same endogeneity problems as a trade union variable, as they are "more likely to emerge in establishments where workplace risk is higher" (p.464). They estimate a significantly positive relationship between injury risk and health and safety committees, attributing this to such committees improving accident reporting mechanisms. Results here show the presence of a health and safety committee has a significantly positive effect upon the number of injuries in the sample of workplaces with 10 or more employees but is insignificant in all other estimations. There is therefore no evidence here to suggest such committees improve health and safety in the workplace, although they may assist in the reporting of accidents.

For comparison, an unweighted model is also tested, with results reported in Appendix 4.2. Returning to the earlier discussion of the debate over whether to use weighted data (p.133), it was recommended that weighted data be used and compared to an unweighted model. The main advantage of using unweighted data is the smaller standard errors that result "and so significant associations are more likely to be found" (Purdon and Pickering, 2001, p.16). However, Purdon and Pickering recommend that "if the coefficients do differ by a non-negligible amount then the weighted model should be used" (p.17).

Comparisons of weighted and unweighted models do suggest differences. For example, the union variable is not significant in the unweighted injury model, whereas it is positive and significant in the weighted model. Average pay variables are positive and significant in the unweighted injury models, but insignificant in the weighted models. The main difference however, relates to the firm size effect, with firm size much more likely to be significantly associated with lower injuries and illnesses in the unweighted model compared to the weighted model. Purdon and Pickering recommend that if differences arise "since the weights remove the selection biases in the survey data we would trust the conclusion from the weighted analysis rather than the unweighted" (p.16). Weighted data will therefore be used for the rest of this analysis, which also enables comparison with Fenn and Ashby.

4.3.1 Testing for Endogeneity

Union membership and the presence of a health and safety committee may be endogenous, in that workers in dangerous workplaces may choose to belong to a workplace where such institutions are present because of the potential safety benefits. In addition, exposure to workplace risk may be a choice variable. Individuals with higher incomes may be expected to choose jobs in a safe environment. A variable capturing a workplace's average annual *pay* is included in regressions, and as in Fenn and Ashby, is positive but insignificant in all estimations. The potential endogeneity of this variable is tested along with *union* and *committee.*

Table 4.7: Descriptive Statistics for Instrumental Variables (5 or more employees)

Variable	**No. of Obs**	**Min**	**Max**	**Unweighted Mean**	**Weighted Mean**
Female	2295	0	1	0.5076 (0.2950)	0.5437 (0.3205)
'Unions help performance' (4=strongly disagree)	813	0	4	2.0255 (1.0421)	2.2716 (0.9889)
'No employee consultation' (4=strongly disagree)	2295	0	4	2.7865 (0.9415)	2.6555 (0.9766)

Reduced form regressions are estimated with *pay*, *union* and *committee* as dependent variables. These regressions include all exogenous variables used in the injury and illness regressions, and instruments that are thought to be good predictors of the dependent variables. The same instruments used by Fenn and Ashby are used to enable comparison, namely the proportion of *female* employees in a workplace, and two variables indicating the extent at which *unions help to improve performance* and the extent to which managers agree that d*ecisions are made without consulting* *employees* (see Appendix 4.1 for formal definitions). The descriptive statistics for these three instrumental variables are reported in Table 4.7.

Reduced form regressions are estimated for the three potentially endogeneous variables and residuals saved. Full results for both samples are reported in Appendix 4.3, with key results reported in Table 4.8.

Table 4.8: Key Reduced Form Regression Results

Workplaces with 5 or more Employees

	UNION DENSITY		**H&S COMMITTEE**		**AVERAGE PAY**	
Obs	*1747*		*1984*		*1523*	
Log Likelihood	*-693.7580*		*-901.6808*			
Psuedo R²	*0.4261*		*0.3019*		*0.7159*	
	Coefficient	**z**	**Coefficient**	**z**	**Coefficient**	**t**
Constant	-2.6605*** (0.6221)	-4.28	-2.9755*** (0.5661)	-5.26	9.9089*** (0.0685)	144.6
Ln(Employees)	0.6077*** (0.0566)	10.7	0.6808*** (0.0477)	14.3	0.0477*** (0.0054)	8.77
Female	0.1470 0.4080	0.36	-0.1821 (0.3915)	-0.47	-0.2502*** (0.0431)	-5.80
Age21	-1.2707** (0.5876)	-2.16	-0.1973 (0.5601)	-0.35	-0.3427*** (0.0616)	-5.57
Age50	1.2651*** (0.4423)	2.86	0.2698 (0.4212)	0.64	-0.0766 (0.0487)	-1.57
Shifts	0.3873** (0.1666)	2.33	0.4337*** (0.1463)	2.97	-0.0307* (0.0183)	-1.68
Overtime	0.0328 (0.0397)	0.83	-0.0484 (0.0358)	-1.35	0.0153*** (0.0041)	3.73
'Unions help performance'	-0.5266*** (0.0706)	7.46	-1.7494*** (0.0604)	-2.90	-0.0053 (0.0071)	-0.74
'No employee consultation'	0.3198*** (0.0729)	4.39	0.1203* (0.0683)	1.76	0.0133* (0.0079)	1.67

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

	UNION DENSITY		H&S COMMITTEE		AVERAGE PAY	
Obs	*1533*		*1766*		*1361*	
Log Likelihood	*-603.1526*		*-846.4746*			
Psuedo R^2	*0.4245*		*0.2847*		*0.7341*	
	Coefficient	**z**	**Coefficient**	**z**	**Coefficient**	**t**
Constant	-3.3798*** (0.7010)	-4.82	-2.7947*** (0.5949)	-4.70	-9.9251*** (0.0705)	140.8
Ln(Employees)	0.6478*** (0.0649)	9.98	0.6833*** (0.0513)	13.3	0.0455*** (0.0056)	8.07
Female	0.3842 (0.4620)	0.83	-0.3014 (0.4119)	-0.73	-0.2741*** (0.0457)	-6.00
Age21	-1.4479** (0.6585)	-2.20	-0.2818 (0.5896)	-0.48	-0.4353*** (0.0662)	-6.58
Age50	1.3802*** (0.5115)	2.70	0.3977 (0.4451)	0.89	-0.0757 (0.0513)	-1.48
Shifts	0.3722** (0.1756)	2.12	0.4622*** (0.1501)	3.08	-0.0324* (0.0181)	-1.79
Overtime	0.0522 (0.0443)	1.18	-0.0720* (0.0375)	-1.92	0.0125*** (0.0043)	2.95
'Unions help performance'	-0.5257*** (0.0754)	-6.97	-0.1945*** (0.0623)	-3.12	-0.0052 (0.0072)	-0.73
'No employee consultation'	0.3756*** (0.0783)	4.80	0.1272* (0.0703)	1.81	0.0112 (0.0080)	1.40

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

The variable *unions help improve performance*, as the instrument used to predict union density, is significantly negative in the union density regressions, indicating union density is high in firms that believe unions help improve performance. For average pay, the instrument *female* is significantly negative, again as expected. The instruments used to predict the presence of a health and safety committee, d*ecisions made without consulting employees* is positive and significant, indicating health and safety committees are more likely to be present in firms who do not consult with employees. The instruments used in the reduced-form regressions therefore, all work in the expected way.

The residuals saved from these reduced-form regressions are used as additional variables in the injury and illness regressions to test for endogeneity. Full results are reported in Appendix 4.4 with key coefficients reported in Table 4.9.

Table 4.9: Key Negative Binomial Regression Results including Reduced-Form Residuals

Workplaces with 5 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No of Obs	*1326*			*1267*		
Log pseudo likelihood	*-18.3857*			*-56.2324*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std. error**	**z**
Constant	-8.8538***	1.6365	-5.41	-3.5346***	0.5091	0.79
Ln(Employees)	0.8965***	0.1389	6.46	0.7818***	0.0982	7.96
Overtime	0.0667	0.0803	0.83	0.1243***	0.0422	2.94
Union	1.1636***	0.3854	3.02	-0.1548	0.2964	-0.52
Committee	0.6103	0.7486	0.82	0.6492	0.4905	1.32
Pay	3.44e-05	5.9e-05	0.58	3.56e-06	4.05e-05	0.09
Runion	-0.1865*	0.0011	-1.78	0.2840***	0.0461	6.16
Rcomm	-0.1186	0.1046	-0.43	-0.2511	0.1806	-1.39
Rpay	-0.1435	1.0266	-0.14	0.1919	0.6102	0.31
TEST LNEMPS=1						
Chi²	0.56			4.93**		
Prob>Chi²	0.4563			0.0263		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

	INJURIES			**ILLNESSES**		
No of Obs	*1168*			*1110*		
Log pseudo likelihood	*-14.8705*			*-39.2409*		
	Coefficient	**Std. error**	**z**	**Coefficient**	**Std. error**	**z**
Constant	-8.5152***	1.5926	-5.35	-2.3095***	0.8791	-2.63
Ln(Employeess)	0.7318***	0.1874	3.91	0.8491***	0.1099	7.73
Overtime	0.0668	0.0723	0.92	0.1071***	0.0395	2.71
Union	0.8569**	0.4033	2.12	0.0183	0.3002	0.06
Committee	0.6132	1.0838	0.57	0.5175	0.6436	0.80
Pay	6.4e-05	4.91e-05	1.30	-2.25e-05	3.77e-05	-0.60
Runion	-0.1039	0.1076	-0.97	0.1926***	0.0736	2.62
Rcomm	-0.0559	0.4433	-0.13	-0.1730	0.2628	-0.66
Rpay	-1.0341	0.7517	-1.38	0.6192	0.5731	1.08
TEST LNEMPS=1						
Chi²	2.05			1.89		
Prob>Chi²	0.1522			0.1697		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Estimates for the residuals from the average pay regression (*rpay*) and health and safety committee regression (*rcomm*) are insignificant in the injury and illness regressions in both samples. These results are also found by Fenn and Ashby, and imply pay and presence of a health and safety committee does not determine workplace risk. For union density however, the union residual *runion* is significant in three of the four regressions, suggesting union density is endogenously determined by a workplace's risk of illness. Employees are therefore likely to join a unionised firm because they are concerned about being exposed to high illness risk, partly explaining the positive union density variable estimate in the illness regressions. Conversely, Fenn and Ashby found *runion* to be insignificant in all regressions.

4.4 New Workplace Variables

Chapter 3A discussed the potential of many other factors to influence the occurrence of workplace injuries and illnesses. Therefore, additional explanatory variables to those used in Fenn and Ashby are created, again using data from the management questionnaire, for use in the estimations. Appendix 4.1 provides formal definitions, with descriptive statistics reported in Table 4.10.

WERS allows us to derive a variable to capture the proportion of employees that regularly work more than 48 hours per week. The effect working over 48 hours has upon the health and safety record of a workplace is particularly important given the EU Working Time Directive which limits working hours to 48 per week. The UK has adopted a schedule to enable employees to opt out of this directive. *Fortyeighthrs* indicates the proportion of non-managerial employees that regularly work in excess of 48 hours, with a value of 6 indicating all employees regularly work over 48 hours. A weighted mean of 0.924 indicates approximately 15 per cent of non-managerial workers regularly work over 48 hours.

Table 4.10: Additional Explanatory Variables Descriptive Statistics

Variable	Obs	Min	Max	Unweighted Mean	Weighted Mean
Fixed	2228	0	1	0.062 (0.161)	0.052 (0.170)
Hstrain	2295	0	1	0.667 (0.472)	0.517 (0.499)
Resultspay	2294	0	1	0.221 (0.415)	0.255 (0.436)
Sickpay	2295	0	1	0.698 (0.459)	0.5277342 (0.499339)
Redundancy	2212	0	1000	6.354 (41.915)	0.903 (16.874)
Fortyeighthrs	2258	0	6	1.107 (1.454)	0.924 (1.625)
Apprais	2173	0	6	4.645 (2.278)	3.982 (2.724)
Discrete	2285	0	3	1.813 (0.870)	1.934 (0.863)
Control	2286	0	3	1.736 (0.882)	1.837 (0.894)
Team	2288	0	6	3.596 (1.963)	2.682 (2.335)
Flex	2295	0	1	0.431 (0.495)	0.346 (0.476)
Night	2295	0	1	0.288 (0.453)	0.110 (0.314)
Home	2295	0	1	0.396 (0.489)	0.247 (0.431)

These 13 new variables are added to the Negative binomial regressions. Full results are reported in Appendix 4.5, with key coefficients reported in Table 4.11.

The proportion working overtime in a workplace has already been found to have a positive effect upon injury and illness. *Fortyeighthrs* is positive in all estimations, but only significant in the injury regression for the sample of workplaces with 10 or more employees[18]. Therefore, although working over 48 hours regularly does have some

[18] This variable was also tested excluding *overtime* because of the potential for collinearity. The significance of the *fortyeighthrs* variable remained the same, suggesting separate effects from working extensive overtime (where extensive is defined as over 48 hours).

significant impact upon injuries in the workplace, results are not conclusive for all samples. This issue will be considered in more detail in a later section.

Table 4.11: Negative Binomial Regression Results with new Workplace-Level Variables

Workplaces with 5 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*1265*			*1209*		
Wald Chi²	*408.39*			*413.80*		
Log pseudo-likelihood	*-16.528*			*-52.818*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.9821***	1.2896	-6.96	-3.354***	0.7090	-4.73
Ln(Employees)	0.8565***	0.1306	6.56	0.8123***	0.0784	10.4
Overtime	0.0911	0.0945	0.96	0.1161***	0.0423	2.74
Union	0.8630***	0.3863	2.50	0.5882**	0.2977	1.98
Committee	0.2765	0.2573	1.07	0.0271	0.1619	0.87
Fixed	0.5563	0.5832	0.34	-0.1973	0.4391	-0.45
Hstrain	0.3962	0.2918	1.36	-0.3490**	0.1554	-2.25
Resultspay	-0.7654**	0.3260	-2.35	0.2126	0.2079	1.02
Sickpay	-0.0009	0.2963	0.10	0.4392***	0.1713	2.56
Redundancy	-0.0114*	0.0067	-1.71	0.0010	0.0056	0.17
Fortyeighthrs	0.0330	0.0918	0.72	0.0272	0.0502	0.54
Apprais	-0.1700***	0.0534	-3.19	0.0322	0.0331	0.97
Discrete	-0.1205	0.1630	0.46	-0.1837*	0.0984	-1.87
Control	0.0139	0.1870	0.07	0.0168	0.0910	0.18
Team	0.0421	0.0801	0.60	-0.0055	0.0391	-0.14
Flex	-0.1868	0.2403	-0.78	-0.1134	0.1711	-0.66
Night	0.6146*	0.3317	1.85	0.3102	0.1984	1.56
Home	-0.0864	0.4228	0.84	0.3248*	0.1739	1.87

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*1121*			*1066*		
Wald Chi²	*268.29*			*368.87*		
Log pseudo-likelihood	*-13.098*			*-37.0765*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-7.8746***	1.2596	-6.25	-3.0791***	0.6775	-4.54
Ln(Employees)	0.8150***	0.1313	6.21	0.8274***	0.0831	9.95
Overtime	0.0471	0.0881	0.54	0.0707*	0.0414	1.71
Union	0.8076**	0.4012	2.01	0.5374*	0.2886	1.86
Committee	0.4839**	0.2406	2.01	0.1267	0.1674	0.76
Fixed	1.1495**	0.5186	2.22	0.0986	0.4409	0.22
Hstrain	0.5560**	0.2741	2.03	-0.2519*	0.1644	-1.66
Resultspay	-0.3324	0.2858	-1.16	-0.0550	0.1845	-0.30
Sickpay	-0.2683	0.3096	-0.87	0.1998	0.1744	1.15
Redundancy	-0.0042	0.0079	-0.53	0.0027	0.0059	0.46
Fortyeighthrs	0.1397**	0.0762	1.83	0.0786	0.0508	1.55
Apprais	-0.1680***	0.0601	-2.80	0.0378	0.0348	1.09
Discrete	-0.1120	0.1499	-0.75	-0.0053	0.0946	-0.06
Control	0.0920	0.1635	0.56	-0.0378	0.0905	-0.42
Team	-0.0705	0.0611	-1.16	0.0178	0.0390	0.46
Flex	-0.3502	0.2689	-1.30	-0.1949	0.1788	-1.09
Night	0.7309**	0.2892	2.53	0.2148	0.1793	1.20
Home	-0.5383	0.3307	-1.63	0.5216***	0.1796	2.90

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Considering temporary employment contracts, the effect they have upon workplace accidents is inconclusive in the literature. The variable *fixed* indicates the proportion of workers who have fixed employment contracts, and is positive and significant in the injury regression for workplaces with 10 or more employees. A greater proportion of fixed contract employees is therefore associated with a greater number of injuries, and could be attributed to a lack of experience and awareness, and lack of motivation. *Fixed* is insignificant in the illness regressions, perhaps related to the long-term nature of workplace illnesses.

Workplace policies can impact upon their health and safety record, and so a variable indicating whether employees have had health and safety training in the last 12 months is included. This variable is negative and significant in the illness regressions in both samples, suggesting health and safety training has the effect of reducing illnesses, but not injuries. For the sample of workplaces with 5 or more employees, *hstrain* is positive and significant in the injury regression. Robinson and Smallman (2006) find health and safety training has the effect of increasing both reported injuries and illnesses. This is likely to be related to reporting, as health and safety training "prepares people to spot accident and illness potential, but also arms them with legal knowledge, which encourages them to report more incidents" (p.97). The fact that in this estimation training is found to have a significant impact upon reducing illnesses however, is an important result, as it highlights how workplaces' can improve employee health in the workplace.

We may also expect the amount of sick pay an employee receives to have a positive effect upon the number of illness reported, and so *sick pay* indicates if workers are paid over the statutory sick pay requirement. *Sick pay* is insignificant in the sample of 10 or more employees, but positive and significant in the illness regression in the sample of firms with 5 or more employees. This is likely to be due to reporting, with employees more likely to report an illness if they are going to receive above average sick pay.

Workplaces that operate a payment-by-results system may also have a higher injury rate as employees increase their work pace, sacrificing care and increasing the likelihood of an accident. Payment-by-results is insignificant in the sample of firms with 10 or more workers, but negative and significant in the injury regression in the sample of 5 or more workers. This is likely to be related to reporting, with workers less likely to report an injury to managers if there is a chance it will impact upon their pay.

The variable *apprais* captures whether non-managerial employees have regular appraisals. This variable is negative and significant in both injury regressions suggesting a workplace policy of regular appraisals is effective in promoting a low workplace injury rate. Regular appraisals may provide an opportunity for workers to voice any concerns regarding health and safety procedures, thus meaning that any problems are addressed before an accident occurs. Similarly, managers are presented with the opportunity to observe whether employees are working safely, giving a chance to correct any problems.

Redundancy denotes the number of employees that have been made redundant in a particular workplace in the last 12 months. The variable is negative and significant in the injury regression within the sample of firms with 5 or more workers. This is also likely to be due to reporting, with a high number of redundancies reducing the likelihood of accidents being reported to management, as employees fear this will increase their chance of also being made redundant during periods when colleagues have lost their jobs in this manner.

Employing workers to work night shifts significantly increases the number of injuries, probably due to a fatigue effect. Employing home workers is also associated with a greater number of workplace illnesses. There could be an element of endogeneity here, with workers with poor health choosing to work for a firm that allows work to be carried out at home. However, the question specifically relates to work-related illness, and so part of this may be reflecting stress and anxiety related illnesses associated with working alone. Given an increasing trend for working from home, with technological advances making this possible, this is an important result. Robinson and Smallman (2006) also estimate that home working is associated with a greater number of illnesses but fewer injuries in the service sector, concluding that working from home "offers a safer but potentially less healthy work environment" (p.99).

Variables depicting flexitime, the amount of control a workers has over pace, and working in formally designated teams has no significant impact upon injuries and illnesses. This is in contrast to the findings of Robinson and Smallman (2006) who find flexitime increases reported injuries in the service sector and illnesses in both the manufacturing and service sectors (p.98). *Discretion* is significantly negative in only one out of the four regressions, suggesting discretion over how tasks are carried out has some impact at reducing reported illnesses.

Endogeneity tests are carried out in the same way as before, with results reported in Appendix 4.6. *Union* is again found to be endogenous in both illness estimations. The presence of a health and safety committee is also now found to be endogenous in three out of the four regressions. *Pay* however, remains exogenous.

Given the relevance of considering the effect that working over 48 hours has upon a firm's health and safety record, in addition to testing the effect that non-managerial employees working over 48 hours has upon safety (*fortyeighthrs*), a separate variable is constructed denoting the proportion of managerial employees working over 48 hours in a workplace (*fortyeightmgs*). Descriptive statistics are reported in Table 4.12.

Table 4.12: Descriptive Statistics for Fortyeighthrs and Fortyeightmangs

Variable	**No. of Obs**	**Min**	**Max**	**Unweighted Mean**	**Weighted Mean**
Fortyeighthrs	2258	0	6	1.107 (1.454)	0.924 (1.625)
Fortyeighthrs (10 or more employees)	2025	0	6	1.151 (1.433)	1.069 (1.641)
Fortyeightmgs	2236	0	6	2.459 (2.271)	2.493 (2.584)
Fortyeightmgs (10 or more employees)	2005	0	6	2.460 (2.215)	2.572 (2.481)

Descriptive statistics confirm that managers are significantly more likely to work 48 hours plus regularly: 42 per cent of managerial employees are likely to regularly work over 48 hours, compared to only 15 per cent of non-managerial employees[19]. *Fortyeightmgs* is added to the Negative Binomial regressions in addition to *fortyeighthrs*, with key results reported in Table 4.13 and full results reported in Appendix 4.7.

Results indicate separate effects, with *fortyeightmgs* significantly positive in the illness regressions of both samples. *Fortyeighthrs* is insignificant in the illness regressions but positive and significant in the injury regression for the sample of firms with 10 or more workers[20]. Thus, managers' working over 48 hours regularly has a significant effect upon increasing workplace illnesses, whilst having a large proportion of non-managerial employees working over 48 hours regularly, increases

[19] T tests with equal variance reveal the differences to be statistically significant, with t statistics of 24.391 for workplaces with 5 or more employees, and 22.703 for workplaces with 10 or more employees. Both are significant at the 1 per cent significance level.
[20] Regressions were also estimated with both *fortyeighthrs* and *fortyeightmangs* but excluding *overtime* in case of collinearity. The significance of both variables in all models remained the same.

the likelihood of workplace injuries. Overall, regularly working over 48 hours does appear to have a detrimental effect upon health and safety in the firm, suggesting the UK schedule that enables workers to opt out of the EU Working Time Directive has a negative effect upon health and safety in the workplace. This is particularly apparent with regards to managers working over 48 hours and workplace illness. Given the increased importance of workplace illness compared to workplace injury in terms of prevalence in firms, the impact of working excessive hours upon workplace illness needs to be considered.

Table 4.13: Key Negative Binomial Regression Results with Forty Eight Hours Variables

Workplaces with 5 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*1251*			*1195*		
Wald Chi²	*410.67*			*425.50*		
Log pseudo-likelihood	*-16.0496*			*-51.8563*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-9.2887***	1.3324	-6.97	-3.6106***	0.7280	-4.96
Ln(Employees)	0.9671***	0.1265	7.65	0.8240***	0.0802	10.3
Hstrain	0.3522	0.2975	1.18	-0.3992**	0.1616	-2.47
Redundancy	-0.0121*	0.0066	-1.84	0.0005	0.0052	0.10
Apprais	-0.1590***	0.0561	-2.83	0.0508	0.0340	1.49
Night	0.5879*	0.3333	1.76	0.3377*	0.1991	1.70
Home	-0.0382	0.4040	-0.09	0.2786*	0.1691	1.65
Overtime	0.0781	0.1059	0.74	0.0946**	0.0440	2.15
Fortyeighthrs	0.0067	0.0913	0.07	-0.0206	0.0548	-0.38
Fortyeightmgs	0.1078*	0.0618	1.75	0.1192***	0.0341	3.50

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

	INJURIES			ILLNESSES		
No. of Obs	*1108*			*1053*		
Wald Chi²	*294.00*			*401.95*		
Log pseudo-likelihood	*-12.6855*			*-36.3187*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.1302***	1.3718	-5.93	-3.6105***	0.7064	-5.11
Ln(Employees)	0.9607***	0.1324	7.26	0.8764***	0.0857	10.2
Hstrain	0.5217*	0.2826	1.85	-0.3096*	0.1622	-1.91
Redundancy	-0.0047	0.0082	-0.57	0.0022	0.0057	0.39
Apprais	-0.1645**	0.0661	-2.49	0.0642*	0.0346	1.85
Night	0.6935**	0.2937	2.36	0.1732	0.1785	0.97
Home	-0.4339	0.3335	-1.30	0.5051***	0.1784	2.83
Overtime	0.0469	0.0983	0.48	0.0599	0.0419	1.43
Fortyeighthrs	0.1601**	0.0773	2.07	0.0311	0.0546	0.57
Fortyeightmgs	0.0119	0.0584	0.20	0.1061***	0.0346	3.07

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Union is positive but endogeneous in the injury and illness estimations. One reason suggested for the positive but endogenous union density effect is that unions work to provide compensation to workers for being exposed to hazardous working conditions. Workers may join a trade union if their job is risky in terms of health and safety to ensure gaining a risk premium for this exposure. A union-pay interaction variable would capture the union's effect upon any risk premium, with a positive and significant coefficient suggesting unions have a role in ensuring risk premiums are paid. The coefficient estimated for *union* would then purely capture the union's effort to influence safety through bargaining and reporting procedures.

Appendix 4.8 reports the main results from negative binomial regressions that include, in addition to the variables *pay* and *union*, an interaction variable *union-pay*. *Union-pay* is positive and significant at the 5 per cent level in the illness regression for the sample of workplaces with 5 or more employees, indicating unions do have a role in ensuring risk premiums are paid. *Union-pay* is positive but insignificant in all other regressions however, providing limited evidence for this hypothesis. The role of trade unions therefore, appears not to be primarily in ensuring a risk premium is paid. The positive and endogenous union density effect is most likely to be due to those exposed to high risk preferring to join a trade union because of the chance to air grievances, and the improved reporting mechanisms, rather than to recover risk premiums[21].

4.5 Tobit and Alternative Models

There are potential alternatives to the Negative Binomial Regression model which also take account of the workplace accident Poisson probability distribution. The Zero Inflated Negative Binomial Regression model incorporates the Poisson distribution, but unlike the Negative Binomial Regression model, it assumes different probability models for the zero and non-zero counts. As accident records over a 12 month period are likely to be explained in the same manner for workplaces that have had no accidents and those that have had accidents, we may expect the Negative Binomial Regression model to be the most appropriate. As a further alternative, the Tobit model censors the zero counts and so would emphasise the effect workplace characteristics have in workplaces that have had at least one accident. As a test of the appropriateness of the Negative Binomial Regression model, and of the assumption that zero and non-zero accident workplaces face the same probability model, the estimation is repeated using the Tobit model. If the relationships are similar in the Negative Binomial Regression and Tobit models, the assumption that there is little difference between workplaces with a zero and a positive accident record can be considered justified.

[21] Regressions were also estimated excluding *sickpay* and *resultspay* because of the potential for collinearity. The significance of *union-pay* remained the same.

To estimate the Tobit model, a dependent variable that divides the number of injuries or illnesses in a workplace by the number of workers is constructed (*injrisk* and *illrisk*). This enables the effect that workplace size has upon the number of accidents and illnesses to be tested directly. Table 4.14 reports descriptive statistics for the new dependent variables.

Table 4.14: Descriptive Statistics for Injrisk and Illrisk

Variable	**Obs**	**Mean rate per workplace (unweighted)**	**Mean rate per workplace (weighted)**
Injrisk	2248	0.0057 (0.0347)	0.0053 (0.0328)
Injrisk (10 or more employees)	2015	0.0059 (0.0348)	0.0059 (0.0337)
Illrisk	2094	0.0261 (0.0655)	0.0298 (0.0819)
Illrisk (10 or more employees)	1862	0.0249 (0.0588)	0.0236 (0.0585)

As before, results show workplace illnesses to be more common than injuries[22]. Tobit models are estimated with the same variables as the Negative Binomial Regression estimations, only with the new dependent variables *injrisk* and *illrisk*. Results are presented in Table 4.15.

[22] Differences are statistically significant at the 1 percent significance level, with t statistics (with unequal variance) of 12.6860 for workplaces with 5 or more employees, and 12.1241 for workplaces with 10 or more employees.

Table 4.15: Tobit Estimates

Workplaces with 5 or more Employees

Variables	**INJRISK**			**ILLRISK**		
No. of obs	*1251*			*1195*		
Log likelihood	*-212.7666*			*-338.6590*		
Pseudo R^2	*0.3692*			*0.2471*		
	Coefficient	**Std error**	**t**	**Coefficient**	**Std error**	**t**
Constant	-0.1813***	0.0503	-3.60	0.0011	0.0396	0.03
Ln(Employees)	-0.0236***	0.0054	-4.36	-0.0296***	0.0058	-5.13
Part-time	-0.0103	0.0249	-0.41	-0.0376*	0.0228	-1.65
Turnover	-0.0156	0.0239	-0.65	-0.0143	0.0246	-0.58
Age21	0.0523	0.0323	1.62	-0.0266	0.0336	-0.79
Age50	-0.0717**	0.0308	-2.33	0.0531**	0.0249	2.13
Shifts	-0.0025	0.0122	-0.21	-0.0003	0.0133	-0.03
Overtime	0.0044*	0.0025	1.76	0.0078***	0.0023	3.36
Union	0.0394**	0.0201	1.96	0.0621***	0.0183	3.39
Committee	0.0120	0.0128	0.94	-4.99e-05	0.0142	-0.00
Pay	1.60e-06*	9.37e-07	1.71	-1.03e-06	9.55e-07	-1.08
Fixed	0.0271	0.0259	1.05	-0.0165	0.0298	-0.55
Hstrain	0.0121	0.0096	1.26	-0.0302***	0.0095	-3.19
Resultspay	-0.0299***	0.0115	-2.61	0.0176	0.0110	1.61
Sickpay	0.0023	0.0096	0.24	0.0346***	0.0096	3.60
Redundancy	-0.0009	0.0007	-1.26	0.0005	0.0010	0.45
Fortyeighthrs	-0.0026	0.0032	-0.81	-0.0037	0.0031	-1.21
Fortyeightmangs	0.0041**	0.0020	2.03	0.0086***	0.0019	4.43
Apprais	-0.0051***	0.0019	-2.70	0.0033*	0.0019	1.70
Discrete	-0.0095*	0.0056	-1.70	-0.0180***	0.0062	-2.91
Control	-0.0001	0.0054	-0.03	0.0056	0.0058	0.97
Team	0.0035	0.0021	1.62	-0.0010	0.0021	-0.47
Flex	-0.0011	0.0100	-0.12	-0.0130	0.0098	-1.32
Night	0.0340**	0.0136	2.50	0.0419***	0.0156	2.70
Home	0.0119	0.0117	1.02	0.0232**	0.0112	2.07
Electricity	-0.0760	0.0973	-0.78	-0.2533	0.1825	-1.39
Construction	-0.0064	0.0253	-0.25	-0.0939***	0.0315	-2.98
Wholesale	0.0368**	0.0180	2.04	-0.0155	0.0195	-0.80
Hotel	0.0119	0.0269	0.44	-0.0347	0.0287	-1.21
Transport	-0.0883***	0.0336	-2.63	0.0309	0.0248	1.24
Financial	0.0058	0.0352	0.16	-0.0338	0.0287	-1.18
Real estate	0.0609***	0.0192	3.15	-0.0055	0.0199	-0.28
Public admin	0.0929***	0.0348	2.67	0.0705**	0.0315	2.24
Education	0.0630*	0.0325	1.94	-0.0124	0.0308	-0.40
Health	0.0669**	0.0281	2.38	0.0461**	0.0232	1.98
Community	0.0498**	0.0208	2.39	-0.0075	0.0227	-0.33
Skilled Trades	0.2650***	0.0439	4.18	0.0847**	0.0350	2.42
Managers	0.0966*	0.0564	1.71	0.0004	0.0439	0.01
Machine Operatives	0.2650***	0.0429	6.18	-0.0119	0.0354	-0.33
Professional	-0.0073	0.0539	-0.13	0.0201	0.0405	0.50
Service	0.0258	0.0459	0.56	-0.0106	0.0293	-0.36
Unskilled	0.1327***	0.0411	3.23	0.0524*	0.0315	1.66
Sales	0.1531***	0.0392	3.91	0.0554**	0.0280	1.98
Technical	0.0187	0.0457	0.41	-0.0325	0.0327	-0.99

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

Variables	INJRISK			ILLRISK		
No. of obs	*1108*			*1053*		
Log likelihood	*-100.5547*			*-102.2060*		
Pseudo R^2	*0.5131*			*0.4143*		
	Coefficient	**Std error**	**t**	**Coefficient**	**Std error**	**t**
Constant	-0.0493	0.0368	-1.34	0.0013	0.0396	0.03
Ln(Employees)	-0.0138***	0.0044	-3.16	-0.0149***	0.0051	-2.91
Part-time	-0.0310*	0.0186	-1.67	-0.0172	0.0190	-0.90
Turnover	-0.0344*	0.0207	-1.66	-0.0003	0.0219	-0.01
Age21	0.0455*	0.0245	1.85	-0.0141	0.0281	-0.50
Age50	-0.0242	0.0228	-1.06	-0.0247	0.0232	-1.06
Shifts	0.0110	0.0081	1.36	0.0099	0.0095	1.04
Overtime	0.0020	0.0020	1.00	0.0037*	0.0022	1.73
Union	0.0176	0.0140	1.26	0.0388***	0.0146	2.66
Committee	0.0201**	0.0088	2.29	0.0070	0.0101	0.69
Pay	-3.75e-07	7.50e-07	-0.50	-3.71e-07	7.80e-07	-0.48
Fixed	0.068**	0.0165	2.23	-0.0079	0.0215	-0.37
Hstrain	0.0125*	0.0073	1.71	-0.0214***	0.0076	-2.80
Resultspay	-0.0064	0.0082	-0.78	-0.0087	0.0092	-0.95
Sickpay	-0.0054	0.0074	-0.72	0.0091	0.0081	1.12
Redundancy	-0.0003	0.0005	-0.73	0.0001	0.0007	0.21
Fortyeighthrs	0.0056**	0.0024	2.34	0.0003	0.0027	0.12
Fortyeightmangs	-0.0011	0.0016	-0.71	0.0067***	0.0016	4.09
Apprais	-0.0052***	0.0014	-3.68	0.0034**	0.0016	2.06
Discrete	-0.0073*	0.0040	-1.82	0.0006	0.0048	0.13
Control	0.0029	0.0040	0.73	-0.0001	0.0044	-0.03
Team	-0.0019	0.0017	-1.13	0.0005	0.0018	0.29
Flex	-0.0088	0.0075	-1.17	-0.0155*	0.0080	-1.93
Night	0.0250***	0.0092	2.74	0.0092	0.0114	0.81
Home	-0.0106	0.0093	-1.14	0.0365***	0.0090	4.07
Electricity	-0.0268	0.0614	-0.44	-0.1612	0.1154	-1.40
Construction	-0.0014	0.0179	-0.08	-0.0298	0.0242	-1.23
Wholesale	0.0125	0.0133	0.94	-0.0030	0.0157	-0.19
Hotel	0.0049	0.0191	0.26	-0.0576**	0.0234	-2.46
Transport	-0.0591***	0.0221	-2.67	0.0303	0.0190	1.59
Financial	0.0162	0.0242	0.67	0.0198	0.0222	0.89
Real estate	0.0392***	0.0149	2.63	-0.0255	0.0164	-1.55
Public admin	0.0620**	0.0245	2.53	0.0154	0.0259	0.60
Education	0.0409*	0.0234	1.75	-0.0273	0.0238	-1.14
Health	0.0415*	0.0215	1.92	0.0146	0.0193	0.76
Community	-0.0012	0.0201	-0.06	0.0018	0.0197	0.09
Skilled Trades	0.0927***	0.0316	2.94	-0.0163	0.0321	-0.51
Managers	0.0484	0.0466	1.04	-0.1632***	0.0470	-3.47
Machine Operatives	0.1095***	00302	-0.23	-0.0521*	0.0302	-1.72
Professional	0.0077	0.0365	0.21	-0.0254	0.0306	-0.83
Service	-0.0068	0.0302	-0.23	-0.0319	0.0236	-1.35
Unskilled	0.0531*	0.0280	1.89	0.0201	0.0252	0.80
Sales	0.0843***	0.0282	2.99	0.0148	0.0240	0.63
Technical	0.0198	0.0306	0.65	-0.0381	0.0258	-1.47

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

As noted, the nature of the dependent variables enables the independent effect that workplace size has upon a workplace's injury and illness risk to be directly observed. Results indicate larger workplaces have significantly lower injury and illness rates. This is the same result found by Fenn and Ashby, who strongly reject the null hypothesis with the coefficients estimated to be less than one. For the equivalent negative binomial regression model (using all the variables above and the same sample) however, an independent effect between workplace size and injury is found but not between workplace size and illness. All other variable coefficients are similar to that estimated using the alternative model. This model, therefore, supports the findings of other papers that larger firms are safer.

To ensure direct comparison with results from the Negative Binomial Regression models, endogeneity tests are conducted using the same method as previously. Results are reported in Appendix 4.9. As before, the union residual is significant in the illness regressions, and the health and safety committee residual is significant in one out of the four regressions, suggesting some endogeneity.

For comparison purposes, Tobit models are also repeated including a *union-pay* interaction variable. Results are presented in Appendix 4.10 and are the same as in the negative binomial regression model, with *union-pay* significant in only one of the four regressions.

Overall, results from the Tobit model reinforce earlier findings concerning the relationship between a workplace accident record and workplace characteristics. This suggests the assumption that there is little difference between workplaces with a zero and a positive accident record, is justified. The Negative Binomial Regression model that takes account of these zero counts is therefore the preferred model.

4.6 Manufacturing and Service Sectors

Prior to Fenn and Ashby (2004), analysis of the influences on workplace injuries tended to focus on the manufacturing sector. With the decline in manufacturing establishments, and with the addition of the availability of data on workplace illness in WERS, Fenn and Ashby argued the service sector should also be included in estimations. Robinson and Smallman (2006) however, conducted separate estimations for the manufacturing and service sectors, arguing there are likely to be many differences between how the two sectors deal with workplace health and safety. Furthermore, their estimation results did point to differences.

Descriptive statistics (Table 4.16) reveal workplace illnesses are more common than injuries in both sectors. T tests (with unequal variance) reveal there to be no significant difference between the mean number of injuries and illnesses between the two sectors. The influences upon the health and safety record in each sector however, may differ. To investigate this, Negative Binomial Regressions are estimated for each sector.

Table 4.16: Descriptive Statistics by Sector

	INJURIES		**ILLNESSES**	
	Manufacturing	Service	Manufacturing	Service
Obs	*463*	*1785*	*437*	*1657*
Weighted Mean Standard Deviation	0.2907 (2.7305)	0.1688 (2.7603)	0.7536 (3.2343)	0.7329 (7.7152)

The model is estimated separately for the manufacturing sector and the service sector and compared to the full model using a likelihood ratio test[23]. A test statistic of 34.37 is estimated which is statistically significant at the 5 per cent level. There are therefore differences between the two sectors and it is appropriate to divide the model.

Dividing the sample of establishments into manufacturing and service sectors does have an impact upon estimates (Table 4.17). Having a greater proportion of workers aged 21 or more employed within a workplace is still associated with fewer workplace illnesses, but they are also associated with a greater number of injuries in the manufacturing sector. This suggests manufacturing firms should monitor younger workers in terms of their safety practices. *Overtime* is again associated with more illnesses, but now also more manufacturing sector injuries. Regularly working over 48 hours per week is only significant in the service sector regressions, where this is associated with more illnesses. Health and safety training is associated with fewer illnesses in both sectors, reinforcing earlier findings. Also supporting earlier conclusions, working from home is associated with more reported workplace illnesses in both sectors.

[23] Manufacturing sector defined as: Manufacturing; Electricity gas and water; Construction. Service sector defined as: Wholesale and retail; Hotels and restaurants; Transport and communication; Financial services; Other business service; Public administration; Education; Health; Other community services.

Table 4.17: Negative Binomial Regression Estimates

MANUFACTURING SECTOR

Workplaces with 5 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*253*			*240*		
Wald Chi²	*223.11*			*233.33*		
Log pseudo-likelihood	*-3.2658*			*-7.2030*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-7.7005***	2.5321	-3.04	-2.4251	2.2394	-1.08
Ln(Employees)	0.6290***	0.2252	2.79	0.6727***	0.1190	5.65
Part-time	2.4635	2.2682	1.09	-1.0642	1.6843	-0.63
Turnover	-2.7269	1.8579	-1.47	2.0891**	0.9552	2.19
Age21	5.3295***	2.0115	2.65	-0.5364	2.0135	-0.27
Age50	-1.7692	1.4404	-1.23	0.6201	1.1817	0.52
Shifts	-0.9306	0.5705	-1.63	0.5319	0.4085	1.30
Overtime	0.3382***	0.1243	2.72	0.2344**	0.1023	2.29
Union	0.6045	0.8292	0.73	2.9996***	0.6414	4.68
Committee	0.5176	0.4626	1.12	0.2291	0.3514	0.65
Pay	0.0001***	4.95e-05	2.70	-5.1e-05*	2.87e-05	-1.78
Fixed	-3.1288	2.0552	-1.52	-3.7417**	1.5304	-2.44
Hstrain	-0.2516	0.406	-0.62	-0.5745*	0.3454	-1.66
Resultspay	0.5286	0.5096	1.04	0.2121	0.2748	0.77
Sickpay	0.9046**	0.4185	2.16	0.0345	0.3380	0.10
Redundancy	-0.0002	0.0095	-0.02	-0.0085	0.0053	-1.62
Fortyeighthrs	-0.1109	0.1401	-0.79	-0.0211	0.1188	-0.18
Fortyeightmangs	0.0625	0.0960	0.65	0.0992	0.0764	1.30
Apprais	-0.0840	0.0718	-1.17	0.0791	0.0509	1.55
Discrete	-0.0317	0.2040	-0.16	0.3977**	0.1850	2.15
Control	-0.1361	0.2196	-0.62	-0.2850**	0.1435	-1.99
Team	-0.0186	0.1020	-0.18	-0.1492*	0.0772	-1.93
Flex	0.0958	0.4321	0.22	0.6394**	0.2949	2.17
Night	2.1314***	0.4779	4.46	0.5858	0.3664	1.60
Home	1.3477***	0.4277	3.15	0.5309**	0.2622	2.02
Skilled Trades	0.6104	2.3058	0.26	-1.2106	1.8311	-0.66
Managers	-6.5454*	3.4671	-1.89	-6.3908**	2.5584	-2.50
Machine Operatives	2.6031	2.1596	1.21	-2.2648	1.9190	-1.18
Professional	-1.1787	2.9941	-0.39	0.1206	2.2407	0.05
Service	-9.8164	6.3178	-1.55	-10.1519	11.8567	-0.86
Unskilled	0.7316	2.4847	0.29	-0.8033	2.1392	-0.38
Sales	-11.0291***	3.4171	-3.23	-1.0243	2.4095	-0.43
Technical	-4.4191	3.2914	-1.34	-0.1730	1.9941	-0.09
TEST LNEMPS=1						
Chi²	2.71			7.56		
Prob>Chi²	0.0995			0.0060		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

SERVICE SECTOR

Workplaces with 5 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*998*			*955*		
Wald Chi²	*267.43*			*291.19*		
Log pseudo-likelihood	*-12.3409*			*-43.7257*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.5701***	1.3877	-6.18	-3.2775***	0.6558	-5.00
Ln(Employees)	1.2642***	0.1403	9.01	0.8504***	0.0868	9.80
Part-time	-0.8402	0.7451	-1.13	-0.3599	0.4219	-0.85
Turnover	-0.3785	0.7236	-0.52	-0.2200	0.6784	-0.32
Age21	-03993	0.8903	-0.45	-1.0833*	0.6073	-1.78
Age50	0.0305	0.8277	0.04	0.8395*	0.4977	1.69
Shifts	0.4295	0.3544	1.21	0.0343	0.1936	0.18
Overtime	0.0254	0.1155	0.22	0.0969**	0.0463	2.09
Union	1.1361**	0.5179	2.19	0.5544**	0.2808	1.97
Committee	0.5527*	0.3003	1.84	0.1562	0.1882	0.83
Pay	3.29e-05	2.75e-05	1.20	-1.34e-05	1.9e-05	-0.71
Fixed	0.5616	0.5906	0.95	-0.3541	0.4146	-0.85
Hstrain	0.5935*	0.3156	1.88	-0.4284**	0.1846	-2.32
Resultspay	-1.4790***	0.4406	-3.36	0.0573	0.2376	0.24
Sickpay	-0.3960	0.3261	-1.21	0.4739**	0.1913	2.48
Redundancy	-0.0251***	0.0095	-2.66	-0.0014	0.0087	-0.16
Fortyeighthrs	0.0012	0.1207	0.01	-0.0532	0.0603	-0.88
Fortyeightmangs	0.0868	0.0739	1.17	0.1122***	0.0373	3.01
Apprais	-0.1409**	0.0609	-2.31	0.0639*	0.0396	1.70
Discrete	-0.1612	0.2340	-0.69	-0.2396**	0.1140	-2.10
Control	0.1011	0.2273	0.44	-0.0084	0.1126	-0.07
Team	0.0795	0.0830	0.96	0.0329	0.0409	0.80
Flex	-0.2983	0.2800	-1.07	-0.2154	0.1936	-1.11
Night	0.3591	0.3662	0.98	0.4398*	0.2288	1.92
Home	-0.4012	0.3682	-1.09	0.3211*	0.1944	1.65
Skilled Trades	2.5846*	1.3415	1.93	0.2159	0.7414	0.29
Managers	3.7178*	1.9084	1.95	-0.6567	0.9811	-0.67
Machine Operatives	4.0265***	1.2667	3.18	-0.5810	0.6681	-0.87
Professional	-0.5923	1.1808	-0.50	-0.7790	0.6491	-1.20
Service	0.2008	1.1137	0.18	-0.1792	0.4867	-0.37
Unskilled	1.9146*	1.1030	1.74	-0.3865	0.5279	-0.73
Sales	3.1069***	1.1374	2.73	-0.0188	0.4680	-0.04
Technical	0.5327	1.0198	0.52	-0.5784	0.5379	-1.08
TEST LNEMPS=1						
Chi²	3.55			2.97		
Prob>Chi²	0.1597			0.0847		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Firm size is found to have a significant impact in the manufacturing sector. Doubling the number of workers is associated with a 37 per cent reduction in the risk of reported injuries, and a 33 per cent reduction in the risk of reported illnesses. This is much larger than the combined sector results of 21 per cent and 13 per cent. Confirming firm size is a greater determinant of workplace health and safety in manufacturing establishments, the number of employees has no significantly independent effect upon injuries in the service sector. Doubling the number of workers however, is associated with a 15 per cent reduction in service sector illness risk. This is important in terms of policy direction, with small manufacturing firms potentially benefiting the most from assistance with their health and safety policies.

There are many more significant impacts upon workplace injuries and illnesses in the manufacturing sector compared to the service sector. For instance, working in teams, which was previously insignificant, is associated with fewer workplace illnesses in manufacturing firms. Having more control over the pace at which tasks are carried out is also significantly negative in the manufacturing illness estimation. *Flexitime* however, is associated with more manufacturing illnesses, as is having more discretion over how tasks are carried out.

4.7 Worker Survey

So far, workplace level variables have been used to consider the influences upon the number of accidents and illnesses experienced within a workplace. WERS also randomly selects up to 25 employees from each workplace to complete a survey. The WERS data set enables workers' responses to this questionnaire to be matched by workplace to other data resulting from the management questionnaire; we are therefore, able to consider both manager and employee views in one data set. As worker opinions and attitudes to their workplace could potentially have a significant effect upon an establishments' health and safety record, variables from the worker survey are constructed and merged into the management questionnaire data set.

Worker survey responses are collated for each workplace and the following variables created based on average responses to questions for each workplace, and then matched into the management data set according to workplace code. Descriptive statistics are reported in Table 4.18.

Table 4.18: Worker Survey Variables Descriptive Statistics

Variable	No. of Obs	Min	Max	Unweighted Mean	Weighted Mean
Avforty	1733	0	4	1.0175 (0.7333)	0.9201 (0.8078)
Avskill	1733	1	4	2.6852 (0.3538)	2.6655 (0.4581)
Avsecurity	1733	0	4	2.5201 (0.5625)	2.6272 (0.6033)
Avrelations	1733	0	4	2.6135 (0.6046)	2.9085 (0.6875)

Avforty indicates how frequently employees have worked more than 48 hours in a week, with a value of 0 indicating they have never worked more than 48 hours per week and 4 indicating they do every week. This variable is included instead of the 48 hour variables derived from management responses and we would expect it to give the same results found using the management survey data. *Avskill* refers to workers skills in relation to the skills required to do his or her job. A value of 4 indicates workers feel their skills are much higher than needed (overskilled) and a value of 1 indicates they are much lower than required (underskilled). *Avsecurity* indicates workers' satisfaction with job security, a value of 4 indicating they are very satisfied with this aspect of their employment. Finally, *avrelations* refers to manager-employee relations, and is equal to 4 if workers believe relations are very good.

Table 4.19: Key Negative Binomial Regression Results with Worker Survey Variables

Workplaces with 5 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*1268*			*1212*		
Wald Chi²	*448.44*			*454.86*		
Log pseudo-likelihood	*-16.0381*			*-52.4740*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-11.4704***	2.0724	-5.53	-2.6222***	0.8729	-3.00
Ln(Employees)	1.0270***	0.1278	8.04	0.7765***	0.0810	9.59
Overtime	0.0433	0.0830	0.52	0.1052***	0.0395	2.67
Union	0.8082**	0.4004	2.02	0.5581*	0.3044	1.83
Night	0.5996*	0.3361	1.78	0.3028	0.1953	1.55
Home	0.0353	0.4436	0.08	0.4043**	0.1767	2.29
Apprais	-0.1424***	0.0554	-2.57	0.0437	0.0324	1.35
Avskill	0.6682*	0.3604	1.85	0.0446	0.1782	0.25
Avrelations	-0.0464	0.2478	-0.19	-0.3227**	0.1305	-2.47
Avsecurity	-0.0913	0.2933	-0.31	0.0072	0.1348	0.05
Avforty	0.2510	0.2103	1.19	0.2815**	0.1243	2.26

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*1124*			*1069*		
Wald Chi²	*285.82*			*376.44*		
Log pseudo-likelihood	*-12.605*			*-37.0148*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-11.9317***	1.5859	-7.52	-2.1377**	0.8689	-2.46
Ln(Employees)	1.1372***	0.1323	8.60	0.8041***	0.0828	9.72
Overtime	0.0097	0.0666	0.14	0.0882**	0.0387	2.28
Union	0.5193	0.4223	1.23	0.3753	0.2756	1.36
Night	0.8425***	0.2596	3.25	0.2332	0.1730	1.35
Home	-0.4956	0.3392	-1.46	0.5562***	0.1769	3.14
Apprais	-0.1262**	0.0548	-2.30	0.0439	0.0335	1.31
Avskill	1.1368***	0.2872	3.96	-0.0315	0.1957	-0.16
Avrelations	0.1897	0.2202	0.86	-0.2500*	0.1311	-1.91
Avsecurity	-1.1368***	0.2872	-3.96	-0.1331	0.1414	-0.94
Avforty	0.3573**	0.1442	2.48	0.2317*	0.1237	1.87

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

The four worker survey variables are included in the negative binomial regression models for workplace injuries and illnesses. Full results are reported in Appendix 4.11 and key results reported in Table 4.19.

The worker survey variables are more significant in the sample of workplace with 10 or more employees, reflecting the fact that more worker surveys will have been completed in larger workplaces and so are probably the most reliable results. *Avskill* is positively significant in the injury regression, suggesting workplaces with overskilled workers are likely to have greater injuries. The opposite may have been expected, but may reflect carelessness resulting from boredom performing tasks workers feel they are too skilled to be doing. *Avrelations* is significantly negative in the illness regression suggesting good management-employee relations reduce workplace illnesses (or conversely poor relations increases workplace illnesses). This result is as expected, as illnesses include stress, depression and anxiety. *Avsecurity* is significantly negative in the injury regression, suggesting a workforce that is satisfied with their jobs security reduces workplace injuries. If workers are anxious about their job security, this could increase the level of carelessness hence increasing accidents. Finally *Avforty* is positive and significant, suggesting regularly working over 48 hours is associated with more injuries and illnesses. As this result was also found using 48 hours variables constructed from management responses, this confirms that regularly working over 48 hours per week, as reported by both management and workers, increases the likelihood of workplace accidents and illnesses.

These results show worker attitudes do play a role in determining a workplaces safety record, but regressions with just workplace-level variables yield more significant results and so are preferred.

4.8 Conclusions

This analysis using WERS 04 largely supports the findings of studies using earlier WERS data. Larger workplaces are still found to be safer, with this conclusion holding with this sample that includes smaller workplaces. This is an important finding in terms of policy implications, as it suggests more support in terms of health and safety should be directed towards smaller workplaces. Furthermore, when the sample is divided by manufacturing and service sector, the number of employees is found to have the greatest impact upon workplace safety in the manufacturing sector. This suggests small manufacturing workplaces may benefit the most from assistance with workplace health and safety policies. Union density has a significantly positive effect upon injuries and illnesses, which is also found in the previous UK literature. This union effect is found to be endogenous in some of the estimations, suggesting workers are likely to join a unionised workplace because of the potential safety benefits. In terms of the effect of health and safety committees, a significantly positive effect is found in the injury estimations, which does not support the suggestion that they help to improve workplace safety.

This analysis included additional variables compared to many other papers in the literature, which has enabled the effect that changes in the organisation of labour have upon a workplace's safety record to be considered. In terms of policy, findings here could assist in informing what appears to be having a successful impact in improving occupational health and safety. For instance, health and safety training is found to significantly reduce reported illnesses. This result remains when workplaces are split by sector. Regular employee appraisals are also found to significantly reduce reported injuries. Specifically in the manufacturing sector, working in formally designated teams, and allowing workers to have more control over the pace at which tasks are carried out, are significantly associated with fewer workplace illnesses. In the service sector, giving workers discretion as to how tasks are carried out is associated with fewer reported workplace illnesses.

Many of the findings however, point to the detrimental impact that workplace policies can have upon safety. Whilst flexitime is found to have no significant impact in the combined estimations, it is associated with a greater number of reported illnesses in the manufacturing sector, possibly due to "the combination of a condensed working week, anti-social hours and sleep deprivation" (Robinson and Smallman, 2006, p.90). Working from home significantly increases reported work-related illnesses, which is likely to be due to stress and anxiety illnesses of working in isolation. Employing workers to work shifts increases both injuries and illnesses, and the use of fixed-term employees increases reported injuries.

The effect that working overtime, and specifically working over 48 hours per week regularly, has upon workplace injuries and illnesses is particularly interesting. In the combined sector estimations, results indicate that non-managerial employees regularly working a 48 hour week have more workplace injuries, likely as a consequence of fatigue. Conversely, managerial employees working over 48 hours have more workplace illnesses, possibly as a consequence of stress and anxiety. Evidence that regularly working over 48 hours has these two separate adverse effects upon both managerial and non-managerial employees, suggest the UK schedule enabling workers to opt out of the EU Working Time Directive may be counter productive. This is especially true given the high costs to UK society associated with incidences of workplace injuries and illnesses, as discussed in chapter 2.1. When the sectors are divided into manufacturing and services, this effect only holds in the service sector, implying the consequences of overtime policy should focus specifically upon this sector.

The potential for under-reporting also needs to be considered. Chapter 2.10 outlines the research that has found non-fatal accidents are often under-reported, and this is particularly relevant to the WERS 04 question that is directed at managers. The literature specifically highlights under-reporting to be common within small firms; if small firms' under-reporting is inherent within the WERS data, this only reinforces the finding here that workers' employed in small firms are more likely to have a workplace accident or illness. The fact that the government and HSE are aware of under-reporting and continue to commission research to investigate it also draws managers' attention towards it, potentially reducing its occurrence.

In conclusion, there are many differences between the causes and influences upon the number of injuries compared to the number of illnesses within a workplace, with injury and illness estimations giving different results with respect to the significance of variables. In line with the literature, workplace illnesses are found to be more common within establishments compared to workplace injuries, and so it is particularly important that we understand what impacts upon a workplace's illness record if we wish to reduce their occurrence.

CHAPTER 5

COMPENSATING WAGE DIFFERENTIALS FOR EXPOSURE TO ACCIDENT RISK

5.1 Introduction and Background

Rosen (1986) states that the theory of compensating wage differentials can make "legitimate claim to be the fundamental (long-run) market equilibrium construct in labour economics" (p.641). It is therefore, not surprising that many papers have investigated the theory, especially with regard to whether workers receive a wage premium for being exposed to high accident risk. Such findings have a direct policy application; estimates of a risk premium can be used to calculate the VSL or VSI which can be used to evaluate many public policies as discussed in chapter 3B.2.

Marin and Psacharopoulos (1982), in the first paper using British data from the OPCS Occupational Mortality Decennial Supplement 1970 to 1972, find evidence of a wage premium for exposure to fatal risk. Sandy and Elliott (1996) and Arabsheibani and Marin (2000) using similar data over the period 1979 to 1983, and Siebert and Wei (1994) using HSE data for 1986 to 1988, all find evidence of a fatal risk premium. There are no papers that attempt to estimate the fatal accident risk premium using more recent British data.

Although most studies find evidence in support of a fatal premium, the existence of a wage premium for exposure to risk of non-fatal injury is less certain. Viscusi (1993) emphasises that "ideally one would like to distinguish the compensation for fatality risks from that for non-fatal risks" (p.1931), as failing to do so could result in an upward bias of the fatal risk premium. Arabsheibani and Marin (2000) and Siebert and Wei (1994) include a non-fatal injury variable in their estimations, but fail to find evidence of its significance. Overall, no British study has found evidence of a non-fatal risk premium.

There are numerous issues raised in the compensating wage literature that require further investigation. First, the effect that trade unions have upon the risk premium is unclear. Theoretically trade unions could increase the risk premium, through advantages in information collection and collective bargaining, or reduce it, if unions are more concerned with reducing risk rather than increasing compensation for exposure to it. US studies tend to find that unions increase the premium, while British studies tend to find they reduce it, Siebert and Wei being the exception. Reilly et al. (1995) observe that "the 1980's witnessed legislative and macroeconomic changes that ultimately altered the face of industrial relations in the UK and led to a significant weakening of organised labour" (p.275). Under the Health and Safety at Work Act (1974) regulations were introduced to enable unions to appoint safety representatives and health and safety committees. Unions hence kept some of their power with regard to health and safety, although Reilly et al. emphasise that a certain "diminution of influence is inevitable" (p.275). With the HSCER 1996 enabling safety representatives to be appointed where there is no trade union presence within the firm, workplaces with health and safety committees are likely to increase.

Reilly et al. (1995) found evidence that health and safety committees significantly reduced workplace injuries in Britain. This paper has been extremely influential, with their findings widely cited in support of the beneficial effects that trade union and health and safety committees have upon workplace safety. In a replication of Reilly et al. (1995) however, Nichols et al. (2007) are unable to find evidence to support their conclusions. Although their results support the notion that health and safety should not be left to management alone, they find no evidence to support the more precise conclusions made by Reilly et al.[24]. Related to this, Fenn and Ashby (2004) find the presence of health and safety committees is associated with a higher number of injuries, a result which is mirrored using WERS 04 in chapter 4. Nichols et al. go on to conclude that "there is good cause to re-examine a whole number of issues and dynamics that may affect the determination of health and safety" (p.222). Litwin (2000) suggests that, given the decline in union strength and the emergence of health and safety institutions within the workplace, studies should "separate the effect of health and safety committees and joint consultative committees from the effects of the variables of workplace union strength" (p.5). Given the changes in general trade union power and with regard to health and safety since the 1980s, which is the main period from which all British papers have taken their data, the impact trade unions have upon the risk premium seems to require further investigation. In particular, the effect that the presence of health and safety committees may have upon the accident risk premium has not yet been investigated.

Problems of endogeneity and unobserved heterogeneity are of great concern to research in this area. Risk may be endogenously determined with wages; if safety is a normal good, we would expect those with greater earnings potential to choose safer

[24] This refers specifically to Reilly et al.'s finding that establishments with joint consultative committees established exclusively for health and safety and with all employee representatives chosen by unions, have on average 5.7 fewer injuries per 1000 employees compared with establishments where the management deals with health and safety with no consultation (p.283).

jobs. In addition, unobserved heterogeneity may influence the wage premium for job risk if some individuals possess unobserved qualities that affect their ability to work in risky jobs. There is a disagreement over the effect this will have upon risk estimates. While Hwang et al. (1992) find such measurement error leads to a downward bias in the risk premium, Shogren and Stamland's (2002) analysis suggests the risk premium will be overestimated. Although Garen (1988) formulates a model to control for such bias, his method involves finding instrumental variables that proxy risk aversion, and this has proved problematic. Bound et al. (1995) suggest the use of weak instruments will lead to biased estimates close to the original OLS estimates. Consequently, Bell et al. (2004) describe controlling for unobserved heterogeneity as "the greatest challenge facing researchers in estimating compensating wage differentials for workplace risks" (p.1).

This chapter uses recent data to estimate whether workers receive a compensating wage differential for exposure to fatal accident risk in Britain. As no risk premium has been found for exposure to non-fatal accident risk using British data, this chapter also investigates this further using data which distinguishes major injuries from less severe accidents. In addition, the impact of trade unions and health and safety committees on the risk premium is considered. The latter is particularly important given the changing nature of industrial relations.

5.2 Methodology

A standard wage equation is estimated (equation 1) where Y_i denotes the earnings of the ith individual, X is a vector of other determinants of earnings, D_i is a measure of fatal and/or non-fatal risk in individual i's occupation, the interaction term U_iD_i

denotes the trade union and/or health and safety committee impact on the risk premium, and ε_i is a random error term which has an expected value of zero and zero covariance.

$$\text{Ln } Y_i = \beta_0 + \beta_1 X_i + \beta_2 D_i + \beta_3 D_i^2 + \beta_4 U_i D_i + \varepsilon_i \qquad [1]$$

A positive and significant β_2 coefficient indicates a premium is received for exposure to risk. We are also interested in whether the wage-risk trade-off takes a linear, convex or concave form. To test this, D_i^2 is often included in equation 1. A significantly negative coefficient estimated for β_3 indicates the relationship is concave.

WERS 04 is used to provide data on worker and management characteristics, including the wage workers receive. As the wage question in WERS is structured in intervals, interval regression is used to estimate the model.

If positive and significant risk coefficients are estimated in the model, they can be used to calculate VSL and VSI estimates. Chapter 3B.2 discusses the potential inaccuracy of the VSL and VSI terms, and they should only be used as a guide for policy wishing to evaluate the benefits of reducing risk of death and injury by a small amount. Equation 2 depicts the VSL/I formula, assuming risk is measured per 1000 workers.

$$\text{VSL / I} = \text{(Average Annual Income) (Risk Parameter * 1000)} \qquad [2]$$

Viscusi and Aldy (2003) survey VSL and VSI estimates obtained through compensating wage differentials estimations, and report them in terms of US 2000 dollars. A summary of the resultant UK and some key international estimates are reported in Appendix 5.1. To enable estimates to be compared with the literature, VSL estimates here are reported in 2004 pounds and also in US dollars in 2000 prices[25].

Several potential measurement error problems have been highlighted in the literature. With regard to the effect that trade unions have upon the risk premium, workers may select into unions or firms covered by trade unions. Hence union status may be a decision variable and therefore non-random. The Heckman Selectivity Correction (1979) is employed in the earlier literature to control for sample selectivity. A probit equation for union status is estimated with explanatory variables including variables that determine earnings, excluding union and risk variables, and a vector of instruments that determine union status but which are uncorrelated with earnings. Instrumental variables in the literature refer to worker and employer attitudes towards unions; the matched survey format of WERS allows such variables to be created. Results are used to calculate the Inverse Mills Ratio, as denoted by equation 3:

$$\lambda(t) = -f(t) / F(t) \qquad [3]$$

where f is the standard normal density function, F is the cumulated normal and $t = \gamma' y$ calculated from the probit with y the explanatory variables. Lambda is included as an explanatory variable in the wage equation. As there is also the potential for the presence of a health and safety committee to be endogeneous within a firm, with

[25] Estimates are converted into 2000 US dollars using Officer and Williamson (2006)

employees in risky occupations choosing to join a firm where one is established, the same method is employed to control for selection into health and safety committees.

The previous literature has highlighted endogeneity of risk as being one of the greatest problems for research in this area. There are two problems: individuals with higher earnings potential are likely to choose safer jobs, and there is unobserved heterogeneity (for instance some individuals may possess a risk-handling skill) that affects productivity and therefore earnings in risky jobs. Consequently, there is a cross-equation correlation of disturbances in the wage and risk equations. Heckman's method cannot be used here because risk is a continuous variable. Garen (1988) proposes an instrumental variables method for obtaining unbiased estimates of the compensating wage differential and this has been extensively used in the subsequent literature. Considering only fatal risk, the first stage involves estimating a fatal risk equation [4]:

$$D = \pi_0 + \pi_1 X_1 + \pi_2 X_2 + \pi_3 Z + \eta \qquad [4]$$

where X_2 proxies risk aversion, Z is non-wage income, and η is unobserved heterogeneity. The disturbance term may depend on the wage equation [1] disturbances as workers with unobservable characteristics that make them more productive in risky jobs will choose higher D. To estimate equation 4, a measure of risk aversion must be available; as risk aversion cannot be directly measured, a proxy must be used. Measures of the stability of an individual's lifestyle are frequently used, assuming such measures are inversely correlated with the degree of aversion to risk. Such stability measures include household income other than wages, marital status, house value, and number of dependents. Instrumental variables, as Sandy et al. (2001) emphasise, must be "uncorrelated with unobserved ability while being correlated with the level of risk" (p.46).

The second stage, again considering only fatal risk, involves estimating equation 5, which uses the disturbances obtained through the risk estimation:

$$Y = R\beta + \gamma_1 \hat{\eta} + \gamma_2 \hat{\eta}.D + \phi \qquad [5]$$

where $\hat{\eta} = D - X\hat{\pi}$ and $\hat{\pi}$ the OLS estimate of π from equation 4. Garen shows estimating equation 5 will yield consistent estimates.

5.3 Data and Descriptive Statistics

Data from the HSE are used to provide numbers of workers who have suffered a fatal, major or over 3 day injury for the years 2002/03, 2003/04 and 2004/05. The risk data are therefore much more recent than those used by Siebert and Wei. The number of accidents over a three year period is utilised given that fatal accidents are rare events. Chapter 2.2.1 discusses RIDDOR 95 which requires employers to report to the HSE fatal accidents and certain non-fatal injuries that occurred at work. Risk is calculated across occupations following Sandy et al. (2001) who find this is superior to assigning risk by industry or by a mix of industry and occupation codes. The LFS is used to provide data on the number of workers employed in each occupation (weighted). The September-November quarters 2002, 2003 and 2004 are merged, with the 2002 and

2003 data restricted to rotation group 5 to prevent over counting. Risk is calculated for each occupation as a rate per 1000 workers, as shown by equation 6:

$$\text{Risk} = \left[\frac{\text{Work Accidents 2002/03 - 2004/05}}{\text{Workers Employed in Occupation}}\right] \times 1000 \qquad [6]$$

Separate variables are created for Fatal, Major Injury, and Over 3-Day Injury risk. Risk is calculated for 3 digit (81) occupations[26]. The values of the risk variables for each occupation are reported and discussed in the Accident Variable Appendices.

WERS 04 is used to provide data on employees. As a matched employer-employee survey, WERS provides detailed information on employee personal characteristics, the nature of their work and their attitudes towards their job, but also provides manager reported workplace data. Risk variables are assigned to workers in WERS via their 3 digit SOC 2000 code.

Estimations are usually carried out for male manual workers as an accident premium is most likely to be found for samples of workers who are exposed to the most risk, and so the sample is divided into manual and non-manual occupations[27]. This leaves 33 three digit manual occupations. Regressions are estimated for 4 samples: all workers, all manual workers, male manual and non-manual workers, and male manual workers. Estimations are usually restricted to men only because of problems

[26] 4 digit rates are not calculated because of problems with the large number of zero deaths that are likely the finer the occupation breakdown.

[27] The following occupations are classed as manual: 51 skilled agricultural trades, 52 skilled metal and electrical trades, 53 skilled construction and building trades, 54 textiles, printing and other skilled trades, 61 caring personal service occupations, 62 leisure and other personal service occupations, 81 process, plant and machine operatives, 82 transport and mobile machine drivers and operatives, 91 elementary trades, plant and storage related occupations, 92 elementary service occupations.

measuring risk for women, who are less likely to be found in the more risky occupations. However, the risk data used are applicable to both men and women and so two samples that include women are tested. Those that work less than 30 hours per week are excluded as they may be exposed to less risk than that captured by the risk variable for their particular occupation and so again a premium is less likely to be estimated for these workers[28]. Table 5.1 presents means and standard deviations for the three risk variables in each sample.

Table 5.1: Risk Variable Descriptive Statistics (per 1000 workers)

	ALL WORKERS	MANUAL WORKERS	MALE WORKERS	MALE MANUAL WORKERS
Sample Size	*17079*	*5580*	*9313*	*3956*
Fatal	0.0132 (0.0270)	0.0328 (0.0382)	0.0210 (0.0326)	0.0412 (0.0399)
Major Injury	2.2907 (3.0650)	5.0212 (3.8317)	3.0685 (3.5177)	5.6499 (3.8043)
Over 3-day Injury	10.3204 (16.9963)	24.5541 (22.5883)	13.7651 (19.5778)	26.6986 (23.1427)

Male manual workers face an average fatal risk of 0.041 per 1000 workers. Overall, male manual workers are found to be exposed to a greater mean risk of injury than all manual workers, with this difference statistically significant[29].

In line with the literature, manual workers are much more likely to suffer an accident than samples that also include non-manual workers. Siebert and Wei (1994) calculate a mean fatal risk of 0.038 per 1000 male manual workers, and Sandy and Elliott (1996) calculate a mean fatal risk of 0.044 per 1000 male manual workers. Derived fatal accident rates do not differ considerably from the earlier literature, with a t test

[28] Estimations are also conducted separately for samples with workers that work 16 hours per week or more, with no major difference in the estimated coefficients.
[29] T statistics, taking account of unequal variance, of 10.301 for fatal, 7.927 for major injury, and 4.503 for over 3-day injury, indicate means are significantly different at the 1 per cent significance level.

revealing the difference between the male manual rates calculated for the sample here is not significantly different from that calculated by Sandy and Elliott with a t statistic of 0.749 calculated. However, the difference between fatal and that calculated by Siebert and Wei is statistically significant at the 1 per cent level with a t statistic of 3.109. This difference is likely to be because Siebert and Wei calculate risk for industry by occupation cells, whereas for reasons discussed, risk here and by Sandy and Elliott is assigned by occupation.

In terms of the non-fatal risk variables, Siebert and Wei derive a variable that encompasses major and over 3-day injuries with a mean value of 14.246 per 1000 workers for their male manual sample. For the equivalent sample, means of 5.65 per 1000 workers for major injury and 26.70 per 1000 workers for over 3-day injury are calculated. Hence, major injury risk is found to be much lower than their variable which also encompassed less serious injuries, emphasising the difference between the two.

The 3 digit fatal risk rates include 33 out of the total 81 occupations that have been assigned a zero value, although only six of these are manual occupations. Sandy et al. (2001) suggest assigning the average value of this variable for a particular sample to each occupation[30]. They believe it unlikely these occupations have no accident risk, and suggest the zero rate occurs because of measurement error, with no accidents occurring over the time period taken. If the accident risk of an occupation is very small, there may only be a fatal accident, for instance, every six years. If data are collected over a three year period where no deaths have occurred, a zero death risk

[30] Sandy and Elliott (1996) do this but Siebert and Wei (1994) do not.

would be assigned to that occupation. A three year period however, is fairly extensive, and considered to result in a fairly accurate picture of the degree of riskiness of occupations. Sandy et al. acknowledge that assigning average risk to such occupations makes little difference, as this value is very close to zero. However, for comparison purposes this is considered with the resulting descriptive statistics presented in Appendix 5.2. Assigning average fatal risk to zero fatal risk occupations has the effect of increasing the male manual workers' mean fatal risk rate from 0.041 per 1000 workers to 0.042 per 1000 workers; t tests (with equal variance) reveal rates are not significantly different with a t statistic of 1.122 calculated. Although estimations will be carried out without assigning average risk to zero risk occupations, this will be considered for comparison purposes.

The dependent variable is based on WERS, which asks employees to consider their average weekly pay before tax and other deductions. Each worker has a choice of 14 possible pay brackets, so interval regression must be used. Two wage variables are created; the first *wpayl* reflects the lower value of each pay bracket, with the second *wpayh* reflecting the higher value of the interval. Natural logs are taken (*lnwpayl* and *lnwpayh*) and both are used as dependent variables in the interval regression. To calculate VSL and VSI we need to know the average annual income for each sample. The same question used to formulate the dependent variables is used, only the mid point of the mean wage bracket is taken as the average income, and multiplied by 52 to give a yearly figure. The resulting variables are *wkincome* and *anincome*.

Table 5.2: Descriptive Statistics (Mean and Standard Deviation)

	ALL WORKERS	**MANUAL WORKERS**	**MALE WORKERS**	**MALE MANUAL WORKERS**
Sample Size	*17079*	*5580*	*9313*	*3956*
Wkincome	414.1386 (198.626)	314.4742 (136.1954)	457.4307 (205.9142)	347.3085 (134.2789)
Anincome	21535.210 (10328.55)	16352.66 (7082.163)	23786.40 (10707.54)	18060.04 (6982.503)
Wpayl	377.9078 (187.0436)	285.4982 (122.8716)	418.8498 (197.0543)	315.4544 (120.3039)
Wpayh	425.0142 (190.3483)	340.8521 (145.0228)	461.0082 (192.5238)	376.0072 (143.3464)
Educ1	0.6696 (0.4704)	0.5070 (0.5000)	0.6342 (0.4817)	0.5038 (0.5000)
Educ2	0.3240 (0.4680)	0.1199 (0.3249)	0.3046 (0.4627)	0.1145 (0.3185)
Educ3	0.2979 (0.4574)	0.0914 (0.2882)	0.3033 (0.4597)	0.0897 (0.2858)
Educ4	0.1507 (0.3577)	0.3254 (0.4686)	0.1794 (0.3837)	0.3296 (0.4701)
Tenure1	0.1524 (0.3594)	0.1407 (0.3477)	0.1403 (0.3474)	0.1322 (0.3388)
Tenure2	0.1235 (0.3291)	0.1095 (0.3123)	0.1125 (0.3160)	0.0996 (0.2995)
Tenure3	0.2659 (0.4418)	0.2344 (0.4237)	0.2578 (0.4375)	0.2265 (0.4186)
Tenure4	0.1864 (0.3894)	0.2022 (0.4016)	0.1899 (0.3923)	0.2030 (0.4023)
Tenure5	0.2701 (0.4440)	0.3115 (0.4631)	0.2979 (0.4573)	0.3375 (0.4729)
Overtime	4.1278 (6.4295)	4.4294 (7.0093)	4.7324 (6.8710)	4.9074 (7.2196)
Flexitime	0.3758 (0.4843)	0.2566 (0.4368)	0.3463 (0.4758)	0.2343 (0.4236)
Supervise	0.3921 (0.4882)	0.2482 (0.4320)	0.4097 (0.4918)	0.2492 (0.4326)
Permanent	0.9448 (0.2283)	0.9448 (0.2284)	0.9492 (0.2196)	0.9542 (0.2090)
Age	4.5254 (1.3145)	4.6405 (1.4130)	4.6219 (1.2992)	4.7037 (1.3837)
Nemps	433.2691 (897.3429)	360.8466 (730.4300)	409.9597 (781.3342)	365.4467 (683.7581)
Meritpay	0.2884 (0.4530)	0.2283 (0.4198)	0.3041 (0.4600)	0.2417 (0.4281)
Public	0.3000 (0.4583)	0.2129 (0.4089)	0.2297 (0.4206)	0.1663 (0.3724)

Unioncov	0.5245 (0.4994)	0.5256 (0.4994)	0.5384 (0.4986)	0.5609 (0.4963)
Runion	0.5574 (0.4967)	0.5575 (0.4967)	0.5525 (0.4973)	0.5758 (0.4943)
HS1	0.0590 (0.2357)	0.0441 (0.2053)	0.0628 (0.2426)	0.0513 (0.2207)
HS2	0.0187 (0.1354)	0.0667 (0.2495)	0.0178 (0.1323)	0.0718 (0.2582)
HS3	0.2994 (0.4580)	0.3520 (0.4776)	0.3227 (0.4675)	0.3744 (0.4840)
HS4	0 (0)	0 (0)	0 (0)	0 (0)
HS5	0 (0)	0 (0)	0 (0)	0 (0)
HS6	0.0683 (0.2522)	0.0636 (0.2441)	0.0699 (0.2550)	0.0705 (0.2561)
HS7	0.2572 (0.4371)	0.2443 (0.4297)	0.2573 (0.4372)	0.2475 (0.4316)
HS8	0.2974 (0.4571)	0.2735 (0.4458)	0.2695 (0.4437)	0.2358 (0.4246)
Commspecific	0.3771 (0.4847)	0.4186 (0.4934)	0.4033 (0.4906)	0.4462 (0.4972)
Commgen	0.0683 (0.2522)	0.0636 (0.2441)	0.0699 (0.2550)	0.0705 (0.2561)
Emprep	0.2572 (0.4371)	0.2443 (0.4299)	0.2573 (0.4372)	0.2475 (0.4732)
Nohsconsult	0.2974 (0.4571)	0.2735 (0.4458)	0.2695 (0.4437)	0.2358 (0.4246)

WERS is used to construct explanatory variables similar to those used in the earlier literature. Appendix 5.3 defines the variables, which are taken from both the employee and management surveys. Table 5.2 reports descriptive statistics. A comparison of descriptive statistics reveals many differences between the four samples. In terms of pay, all male workers earn much more than male manual workers (average weekly income of £457 compared to £347). Results also confirm that women earn less than men, with all workers earning less than all male workers (£414 compared to £457).

Analysis of the education dummy variables reveals that manual workers are more likely to have no academic qualifications. A further difference concerns the size of the workplaces. The variable *nemps*, which denotes the number of employees in each workplace, is larger for the samples of both manual and non manual workers. Manual workplaces on average therefore, have fewer employees.

The health and safety committee variables *hs1-hs8* follow those derived by Reilly et al. (1995). However, some of the variables have very small means in the sample, with no manual firms having the structures described by *hs4* and *hs5*. One of the criticisms made by Nichols et al. (2007) of the Reilly et al. study is that there are too many variables covering the organisation of the arrangement of health and safety committees. They highlight that *hs4* and *hs5* have very small means with each variable only applicable to 3 per cent (or 13 establishments) of Reilly et al.'s sample (p.9). Therefore, four variables are constructed by merging some of the Reilly et al. variables. *Commspecific* denotes a workplace that has a committee exclusively for health and safety (*hs1, hs2* and *hs3*), whilst *commgen* denotes a workplace that has a committee that deals with a range of issues in addition to health and safety (*hs4, hs5* and *hs6*). *Emprep* denotes a workplace that has no such committee but has an employee representative for health and safety (*hs7*). Finally, *nohsconsult* reflects those that have no form of health and safety consultation mechanism (*hs8*). Whilst 41.9 per cent of manual workplaces have a committee that deals specifically with health and safety issues, 27.4 per cent of manual workplaces do not consult with employees regarding health and safety matters.

Two trade union variables are constructed. *Unioncov* is derived from the employee survey and indicates whether the workplace has a union presence, regardless of whether the individual is a union member. Table 5.2 reports that for the sample of all workers, 52.5 per cent of workplaces do have a trade union presence compared to 56.1 per cent in the male manual sample. A further trade union variable, *runion*, is a dummy drawn from the management survey, according to whether managers have reported recognising a union. Descriptive statistics reveal differences between the two variables, with *runion* having a greater mean in all four samples. Therefore, some workers do not realise their workplace is covered by union terms and conditions, although t tests reveal the mean difference between the two variables is statistically insignificant with a t statistic of 1.338 calculated. We would expect *runion* to be the most accurate in reflecting union presence, and so this is used in the estimation. However, as *unioncov* reflects employee beliefs about union presence, this may provide some indication of the extent of influence and strength of unions in workplaces, and so estimations will also be conducted using this variable.

5.4 Interval Regression Results

Interval regressions are first estimated with just the fatal risk variable, as many studies in the literature do not include a non-fatal injury variable. Table 3 presents the results. Standard errors, reported here and throughout this chapter, are robust, calculated using the Huber-White formula.

Considering first the X variable coefficients, variables have the expected impact upon wages. Education dummies are positive and significant in all samples, with estimates having a greater magnitude the higher the qualification, indicating more educated workers receive higher wages compared to those with no academic qualifications. The estimates for *age* and age^2 indicate an inverted u relationship between age and wages.

Tenure dummies are positive and significant, indicating employers that have worked for a firm for a significant period receive higher wages compared to those that have been employed there for one year or less. Working overtime, being a supervisor, and being a permanent employee are all associated with a greater wage. Working for a large firm is significantly associated with greater pay, with *nemps²* negative and significant indicating a concave relationship. Working in the public sector is associated with lower wages. *Runion* is positive and significant, suggesting unions have a positive impact upon wages overall.

Table 5.3: Interval Regression Estimates (Fatal risk variable only)

Dependent variables: Lnwpayl Lnwpayh

	ALL WORKERS	**MANUAL WORKERS**	**MALE WORKERS**	**MALE MANUAL WORKERS**
Obs	*16791*	*5474*	*9191*	*3897*
Wald Chi²	*12400.44*	*3092.41*	*6337.68*	*1263.89*
Log pseudo likelihood	*-34497.88*	*-10988.213*	*-18507.512*	*-7784.2315*
Constant	4.7592*** (0.0322)	4.8388*** (0.0443)	4.5785*** (0.0512)	4.7005*** (0.0584)
Educ1	0.1195*** (0.0073)	0.1270*** (0.0105)	0.1298*** (0.0097)	0.1224*** (0.0122)
Educ2	0.1289*** (0.0075)	0.0466*** (0.0160)	0.1200*** (0.0106)	0.0400** (0.0188)
Educ3	0.3030*** (0.0077)	0.2123*** (0.0188)	0.2756*** (0.0105)	0.2090*** (0.0215)
Tenure2	0.0210* (0.0118)	-0.0002 (0.0190)	0.0294* (0.0171)	-0.0210 (0.0225)
Tenure3	0.0559*** (0.0101)	0.0484*** (0.0157)	0.0877*** (0.0142)	0.0531*** (0.0183)
Tenure4	0.0407*** (0.0111)	0.0484*** (0.0165)	0.0576*** (0.0152)	0.0608*** (0.0191)
Tenure5	0.1007*** (0.0109)	0.1430*** (0.0164)	0.1182*** (0.0150)	0.1422*** (0.0189)
Overtime	0.0092*** (0.0006)	0.0066*** (0.0008)	0.0094*** (0.0008)	0.0076*** (0.0010)
Flexitime	0.0316*** (0.0064)	-0.0002 (0.0109)	0.0352*** (0.0089)	-0.0018 (0.0129)
Supervise	0.2516***	0.1336***	0.2689***	0.1255***

	(0.0067)	(0.0119)	(0.0092)	(0.0138)
Runion	0.0269*** (0.0084)	0.0904*** (0.0144)	0.0632*** (0.0119)	0.0600*** (0.0177)
Commspecific	0.0202*** (0.0065)	0.0408*** (0.0103)	0.0250*** (0.0088)	0.0477*** (0.0119)
Permanent	0.0517*** (0.0151)	0.0668*** (0.0230)	0.0468** (0.0218)	0.0696** (0.0285)
Age	0.3046*** (0.0136)	0.2234*** (0.0171)	0.3672*** (0.0219)	0.2815*** (0.0223)
Age^2	-0.0269*** (0.0015)	-0.0212*** (0.0019)	-0.0313*** (0.0023)	-0.0259*** (0.0024)
Nemps	5.84e-05*** (7.37e-06)	4.6e-05*** (1.33e-05)	7.32e-05*** (1.08e-05)	5.45e-05*** (1.57e-05)
$Nemps^2$	-7.36e-09*** (1.21e-09)	-5.77e-09** (2.50e-09)	-9.87e-09*** (2.02e-09)	-7.17e-09** (3.22e-09)
Meritpay	0.1070*** (0.0070)	0.0545*** (0.0114)	0.1006*** (0.0094)	0.0481*** (0.0129)
Public	0.0051 (0.0076)	-0.0737*** (0.0123)	-0.0364*** (0.0104)	-0.1136*** (0.0145)
Female	-0.2417*** (0.0067)	-0.3285*** (0.0115)		
Fatal	-1.7573*** (0.1575)	0.6456*** (0.1828)	-1.8077*** (0.1731)	0.5074** (0.2028)
Fatal*Runion	0.9367*** (0.2102)	-0.3789** (0.3643)	1.1300*** (0.2380)	-0.1345 (0.2893)
Lnsigma	*-0.9678**** *(0.0077)*	*-1.1052**** *(0.0135)*	*-0.9647**** *(0.0112)*	*-1.1363**** *(0.0163)*
Sigma	*0.3799* *(0.0029)*	*0.3311* *(0.0045)*	*0.3811* *(0.0043)*	*0.3210* *(0.0052)*
VSL(2004 £)		£10,557,277		£9,163,644
VSL (2000 US$)		$15,194,431		$13,188,691

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Manual workers and male manual workers receive a wage premium for being exposed to risk of death in the workplace, with a positive coefficient estimated for *fatal* which is significant at the 1 per cent and 5 per cent level. The all manual workers sample produces the greatest wage premium, with a VSL of £10.6 million compared to £9.2 million for the male manual sample. The premium is likely to be larger in the all manual sample because of the inclusion of women, who are exposed to less risk and are more averse to risk, and hence require a larger wage premium[31]. The union-risk interaction variable *fatal*runion* is negative in the two samples where fatal is positive and significant, but only significantly so in the all manual sample. This suggests trade unions have the effect of reducing the risk of death premium, as found in most of the UK literature, in the all manual sample only. Trade unions appear to have no significant impact upon the risk premium in the male manual sample which is the sample that most UK studies have focused upon. The estimation is repeated for the two samples where fatal is positive and significant including $fatal^2$. Results are reported in Appendix 5.4. $Fatal^2$ is significantly negative in both samples indicating the relationship between wages and fatal risk is concave. Thus, an increase in risk results in an increase in the wage that is less than proportional to any previous increase in risk. This is consistent with findings in the earlier literature[32].

The estimation is repeated including in addition to the risk of death variable, the *major injury* variable. Table 5.4 reports.

A premium for exposure to risk of death still remains when *major injury* is included in the manual workers and male manual workers sample. *Major injury* however, is insignificant in both samples, suggesting no premium is received for exposure to non-fatal injury risk. This finding is similar to that found in other compensating wage differential studies using UK data

[31] Chapter 6 specifically investigates the impact that gender has upon risk aversion.
[32] As reported in the literature, the inclusion of $fatal^2$ increases the *fatal* coefficient by an unrealistic magnitude. The preferred model therefore is to exclude $fatal^2$.

Table 5.4: Interval Regression Results (Fatal and Major Injury)

Dependent Variables: Lnwpayl Lnwpayh

	ALL WORKERS	MANUAL WORKERS	MALE WORKERS	MALE MANUAL WORKERS
Obs	*16791*	*5474*	*9191*	*3897*
Wald Chi²	*12953.58*	*3119.68*	*6618.25*	*1301.19*
Log pseudo likelihood	*-34313.408*	*-1098.661*	*-18420.298*	*-7770.9375*
Constant	4.8212*** (0.0321)	4.8544*** (0.0443)	4.6292*** (0.0511)	4.7244*** (0.0583)
Educ1	0.1084*** (0.0072)	0.1251*** (0.0104)	0.1218*** (0.0095)	0.1197*** (0.0121)
Educ2	0.1206*** (0.0074)	0.0460*** (0.0160)	0.1108*** (0.0105)	0.0398** (0.0187)
Educ3	0.2877*** (0.0076)	0.2084*** (0.0187)	0.2592*** (0.0104)	0.2041*** (0.0214)
Tenure2	0.0206* (0.0117)	1.31e-05 (0.0189)	0.0286* (0.0169)	-0.0197 (0.0225)
Tenure3	0.0530*** (0.0100)	0.0470*** (0.0157)	0.0829*** (0.0141)	0.0506*** (0.0183)
Tenure4	0.0426*** (0.0109)	0.0682*** (0.0164)	0.0584*** (0.0151)	0.0599*** (0.0190)
Tenure5	0.1035*** (0.0108)	0.1434*** (0.0163)	0.1193*** (0.0148)	0.1409*** (0.0189)
Overtime	0.0095*** (0.0006)	0.0066*** (0.0008)	0.0095*** (0.0008)	0.0076*** (0.0010)
Flexitime	0.0209*** (0.0063)	-0.0018 (0.0109)	0.0242*** (0.0088)	-0.0047 (0.0128)
Supervise	0.2397*** (0.0067)	0.1321*** (0.0119)	0.2548*** (0.0092)	0.1227*** (0.0138)
Runion	0.0194** (0.0083)	0.0921*** (0.0144)	0.0536*** (0.0118)	0.0622*** (0.0179)
Commspecific	0.0299*** (0.0064)	0.0447*** (0.0103)	0.0343*** (0.0087)	0.0523*** (0.0119)
Permanent	0.0517*** (0.0149)	0.0683*** (0.0229)	0.0480** (0.0215)	0.0708** (0.0283)
Age	0.3051*** (0.0136)	0.2263*** (0.0172)	0.3699*** (0.0221)	0.2857*** (0.0225)
Age²	-0.0273*** (0.0015)	-0.0216*** (0.0019)	-0.0319*** (0.0024)	-0.0264*** (0.0024)
Nemps	5.59e-05*** (7.28e-06)	4.74e-05*** (1.34e-05)	7.15e-05*** (1.08e-05)	5.62e-05*** (1.62e-05)
Nemps²	-7.38e-09*** (1.20e-09)	-6.26e-09** (2.56e-09)	-1.02e-08*** (2.08e-09)	-7.96e-09** (3.50e-09)
Meritpay	0.1038*** (0.0069)	0.0547*** (0.0114)	0.0972*** (0.0093)	0.0481*** (0.0128)
Public	0.0035 (0.0076)	-0.0783*** (0.0124)	-0.0384*** (0.0104)	-0.1186*** (0.0145)

Female	-0.2511*** (0.0066)	-0.3298*** (0.0115)		
Fatal	0.3400* (0.2024)	1.0374*** (0.2160)	-0.3003 (0.2093)	0.9343*** (0.2309)
Major Injury	-0.0281*** (0.0016)	-0.0066*** (0.0016)	-0.0221*** (0.0018)	-0.0085*** (0.0018)
Fatal*Runion	0.9999*** (0.2321)	-0.3848** (0.1520)	1.1570*** (0.2530)	-0.1191 (0.3006)
Lnsigma	*-0.9794*** (0.0078)*	*-1.1071*** (0.0136)*	*-0.9750*** (0.0113)*	*-1.1398*** (0.0165)*
Sigma	*0.3755 (0.0029)*	*0.3305 (0.0045)*	*0.3772 (0.0043)*	*0.3199 (0.0053)*
VSL (2004 £)	£7,321,971	£16,964,249		£16,873,495
VSL (2000 US$)	$10,538,057	$24,415,587		$24,284,970

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

HSE data allows injuries to be divided by severity, and so a further non-fatal injury can be constructed in addition to *major injury*, defined as an injury that resulted in absence from work for three days or more[33]. *Over 3-day injury* is now included in the estimations, in addition to *fatal* and *major injury.* Estimates are reported in Appendix 5.5 and show as expected, a premium is not received for exposure to these minor non-fatal injuries.

Following Sandy et al. (2001), estimations are repeated assigning average risk to occupations that have a zero death rate. This analysis is restricted to manual workers and male manual workers, as the two samples that have shown significant wage premiums for risk. Taken from Table 5.1, occupations that have a zero value for *fatal* are assigned the mean value of 0.0328 for the manual sample and 0.0412 for the male manual sample. Interval regression estimates are reported in Appendix 5.6. *Fatal* remains positive and significant in both samples. The magnitude of *fatal* is slightly

[33] This variable does not include major injuries which are encompassed by *major injury.* It therefore reflects only the less severe injuries, unlike the non-fatal injury variable used by Siebert and Wei which captures both major injuries and injuries that resulted in 3 or more days of absence.

smaller when average values are assigned, which is reflected in smaller VSL estimates.

As we would expect estimates to be influenced by the degree that risk is classified, risk variables are also derived for each 2 digit occupation code. The risk coefficients and resultant VSL estimates are smaller with this broader classification of fatal risk. The very risky occupations, and hence the occupations that are most likely to result in a significant wage premium, are highlighted the finer the classification of risk. *Fatal* however, remains positive and significant, indicating the strength of the result. As it reflects occupational risk more accurately, 3 digit risk classification is to be preferred and hence the 2 digit results are not reported. However, the fact that wage premiums are still estimated with accident risk defined more broadly, gives strength to conclusions as to the existence of compensating wage differentials for risk.

5.5 Trade Unions

The role that trade unions have upon the risk premium is examined further here. The variable *unioncov*, taken from the employee questionnaire, is included in the estimation in replace of *runion.* Appendix 5.7 illustrates that *fatal*unioncov* is again only significantly negative in the all manual sample, and is insignificant in the male manual sample.

An alternative way to consider the effect that trade unions have upon the premium for injury risk is to split the sample of workers according to their union coverage status. Although the usual method in the literature is to use a risk*union interaction variable, Siebert and Wei use this sample splitting method, and Fairris (1992) argues that estimating separate equations by union status is the most appropriate method because of "important institutional differences between the union and non-union sectors" (p.266). Hence, the two samples are divided according to the variable *runion*; workers who are employed by a firm where managers have indicated they do recognise a union are assigned to the covered sector, those that do not are assigned to the uncovered sector. Descriptive statistics for pay and risk variables are reported in Appendix 5.8.

Workers covered by union terms and conditions receive higher pay in both samples. This is consistent with the positive coefficients estimated for *runion* in the wage regressions. As expected, covered workplaces are more likely to have a specific health and safety committee established. T tests (adjusting for unequal variance) reveal these differences to significantly different, with a t statistic of 23.460 for the male manual sample and 24.892 for the all manual sample calculated, which are both significant at the 1 per cent level. Workers in the covered sector are shown to face a lower risk of death. Again, t tests (adjusting for unequal variance) reveal this difference to be significant at the 1 per cent level in the all manual and male manual samples with t statistics of 3.869 and 5.281 calculated. This is consistent with the argument that unions are concerned with increasing safety in the workplace rather than increasing the compensation for risk; although chapter 4 did not find unions reduced workplace risk, this finding was likely to be due to endogeneity with reporting more likely in unionised firms. Siebert and Wei also find lower fatal injury rates for unionised workers, but go on to suggest they also receive a greater risk premium. However, these are two separate issues; any finding that unions are successful in reducing workplace risk does not mean it will translate into a greater compensating wage differential. Estimations using a fatal*union interaction variable have in fact suggested the opposite. Interval regressions are estimated separately for the covered and uncovered sectors and compared to the full model using a likelihood ratio test. Test statistics of 69.65 for the all manual sample and 51.08 for the male manual sample are estimated which are both statistically significant at the 1 per cent level. There are therefore differences between the covered and uncovered sectors and it is appropriate to divide the model Table 5.5 reports interval regression estimates.

Table 5.5: Interval Regression Results

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL		**MALE MANUAL**	
	Covered	**Uncovered**	**Covered**	**Uncovered**
Obs	*3058*	*2416*	*2251*	*1646*
Wald Chi²	*1518.49*	*1342.14*	*698.28*	*523.08*
Log pseudo likelihood	*-6065.5404*	*-4890.8649*	*-4395.5211*	*-3363.5314*
Constant	4.9403*** (0.0626)	4.8263*** (0.0612)	4.8590*** (0.0758)	4.6304*** (0.0829)
Educ1	0.1199*** (0.0134)	0.1366*** (0.0165)	0.1129*** (0.0152)	0.1342*** (0.0199)
Educ2	0.0606*** (0.0194)	0.0303 (0.0271)	0.0556** (0.0219)	0.0214 (0.0335)
Educ3	0.2119*** (0.0229)	0.2172*** (0.0311)	0.1976*** (0.0262)	0.2268*** (0.0362)
Tenure2	0.0477 (0.0291)	-0.0364 (0.0247)	-0.0114 (0.0338)	-0.0300 (0.0302)
Tenure3	0.0444* (0.0227)	0.0565*** (0.0217)	0.0282 (0.0252)	0.0752*** (0.0261)
Tenure4	0.0877*** (0.0231)	0.0521** (0.0236)	0.0577** (0.0258)	0.0596** (0.0285)
Tenure5	0.1677*** (0.0222)	0.1084*** (0.0256)	0.1429*** (0.0242)	0.1287*** (0.0312)
Overtime	0.0046*** (0.0010)	0.0092*** (0.0013)	0.0053*** (0.0011)	0.0108*** (0.0016)
Flexitime	0.0134 (0.0140)	-0.0174 (0.0171)	-0.0058 (0.0161)	0.0064 (0.0207)
Supervise	0.1266*** (0.0162)	0.1414*** (0.0176)	0.1286*** (0.0179)	0.1233*** (0.0217)
Commspecific	0.0345*** (0.0131)	0.0432** (0.0174)	0.0409*** (0.0145)	0.0622*** (0.0214)
Permanent	0.0382 (0.0307)	0.0933*** (0.0339)	0.0165 (0.0337)	0.1110** (0.0434)
Age	0.2271*** (0.0239)	0.2216*** (0.0235)	0.2754*** (0.0303)	0.2827*** (0.0315)
Age²	-0.0216***	-0.0210***	-0.0256***	-0.0257***

	(0.0026)	(0.0027)	(0.0032)	(0.0034)
Nemps	3.75e-05*** (1.38e-05)	0.0001 (8.58e-05)	5.11e-05*** (1.63e-05)	-2.70e-06 (8.7e-05)
Nemps²	-4.46e-09* (2.50e-09)	-1.19e-08 (7.55e-08)	-6.72e-09** (3.32e-09)	6.27e-08 (7.11e-08)
Meritpay	0.0604*** (0.0139)	0.0370* (0.0192)	0.0533*** (0.0159)	0.0391* (0.0218)
Public	-0.0869*** (0.0134)	-0.0149 (0.0384)	-0.1165*** (0.0154)	-0.0948 (0.0590)
Female	-0.3017*** (0.0154)	-0.3589*** (0.0170)		
Fatal	0.3564* (0.1931)	0.5054*** (0.1906)	0.3489* (0.2057)	0.4910** (0.2054)
Lnsigma	*-1.1485**** *(0.0202)*	*-1.0639**** *(0.0181)*	*-1.1878**** *(0.0247)*	*-1.0800**** *(0.0212)*
Sigma	*0.3171* *(0.0064)*	*0.3451* *(0.0062)*	*0.3046* *(0.0075)*	*0.3397* *(0.0072)*
VSL (2004 £)	£5,828,088	£8,264,634	£6,301,148	£8,867,480
VSL (2000 US$)	$8,388,004	$11,894,773	$9,068,850	$12,762,411

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Splitting the sample by union status suggests trade unions have a negative effect upon the fatal risk premium. The fatal coefficient is positive and significant in all samples, but is larger for uncovered workers. This reinforces earlier conclusions that trade unions reduce the fatal risk premium. As a lower average fatal risk is calculated for unionised workers, see Appendix 5.8, this further implies that unions may be more concerned with reducing risk rather than increasing the risk premium.

5.6 Health and Safety Arrangements

Trade unions appear to be associated with a lower risk premium. We now estimate the effect that the presence of safety representatives and committees may have upon the risk premium, regardless of whether there is a trade union presence. First, we consider the correlation between workplace presence of a trade union and a health and safety committee. Correlation coefficients are reported in Table 5.6. A positive correlation confirms expectations that committees are more likely in unionised firms with the correlation stronger for specific health and safety committees. The coefficients however are small and insignificant, and so the union and committee effects can be considered separately.

Table 5.6: Correlation Coefficients

	ALL MANUAL		MALE MANUAL	
	Commspecific	Commgeneral	Commspecific	Commgeneral
Runion	0.3113	0.1243	0.3433	0.1425
Unioncov	0.3202	0.0873	0.3473	0.0965

Despite recent interest in the effect health and safety committees have upon injury rates, their impact on the compensating wage differential has not been investigated. The impact of specific health and safety committees is first considered compared to having no such committee, as we would expect an effect to be more likely in such workplaces. The interaction variable *fatal*commspecific* is included as an explanatory variable in the wage estimations. See Table 5.7.

Table 5.7: Interval Regression (Fatal, Commspecific)

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	MALE MANUAL
Obs	*5474*	*3897*
Wald Chi²	*3108.04*	*1264.37*
Log pseudo likelihood	*-10986.093*	*-7783.4355*
Constant	4.8427*** (0.0444)	4.7042*** (0.0586)
Educ1	0.1267*** (0.0105)	0.1224*** (0.0122)
Educ2	0.0461*** (0.0160)	0.0397** (0.0189)
Educ3	0.2128*** (0.0188)	0.2090*** (0.0216)
Tenure2	0.0003 (0.0189)	-0.0210 (0.0225)
Tenure3	0.0488*** (0.0158)	0.0531*** (0.0183)

Tenure4	0.0687*** (0.0165)	0.0607*** (0.0191)
Tenure5	0.1433*** (0.0164)	0.1425*** (0.0190)
Overtime	0.0066*** (0.0008)	0.0076*** (0.0010)
Flexitime	5.64e-05 (0.0109)	-0.0019 (0.0129)
Supervise	0.1344*** (0.0119)	0.1259*** (0.0138)
Runion	0.0940*** (0.0145)	0.0634*** (0.0180)
Commspecific	0.0227* (0.0138)	0.0327* (0.0173)
Permanent	0.0663*** (0.0231)	0.0690** (0.0286)
Age	0.2231*** (0.0171)	0.2812*** (0.0223)
Age^2	-0.0212*** (0.0019)	-0.0259*** (0.0024)
Nemps	4.74e-05*** (1.33e-05)	5.55e-05*** (1.57e-06)
$Nemps^2$	-5.88e-09** (2.48e-09)	-7.25e-09** (3.20e-09)
Meritpay	0.0551*** (0.0114)	0.0485*** (0.0129)
Public	-0.0740*** (0.0123)	-0.1139*** (0.0144)
Female	-0.3288*** (0.0115)	
Fatal	0.5492*** (00.1921)	0.4445** (0.2124)
Fatal*Runion	-0.5244* (0.2725)	-0.2298 (0.3098)
Fatal*Commspecific	0.5582** (0.2725)	0.3876* (0.2021)
Lnsigma	*-1.1056**** *(0.0134)*	*-1.1365**** *(0.0163)*
Sigma	*0.3310* *(0.0045)*	*0.3210* *(0.0052)*
VSL (2004 £)	£8,980,881	£8,027,688
VSL (2000 US$)	$12,925,622	$11,553,751

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

It appears that unions reduce the fatal wage premium in the all manual sample but have no impact in the male manual sample, as found earlier. However, health and safety committees appear to increase the fatal premium, with the variable *fatal*commspecific* significantly positive in both samples. The pure wage effect should also be noted with specific health and safety committees reinforcing the positive union wage impact. There is no theoretical justification for health and safety committees increasing wages directly. However, it may be that they are having an indirect effect upon wages, and consequently the wage premium for risk, by reinforcing the bargaining environment within firms.

Interval regressions are also estimated including in addition to the *fatal*commspecific* interaction variable, a *fatal*commgeneral* variable to capture the effect that committees that deal with a range of issues rather than specially health and safety have upon the risk premium. See Appendix 5.9. Whilst *fatal*commspecific* remains significantly positive in the all manual worker sample, *fatal*commgeneral* is insignificant. In terms of risk compensation therefore, it is only committees that deal specifically with health and safety that have an independent impact. A significantly positive coefficient estimated for *commgeneral* however, indicates a positive impact upon wages, again supporting the positive union wage effect[34].

To consider this further, the samples are divided according to whether a specific health and safety committee is present in a workplace. Appendix 5.10 presents descriptive statistics of the wage and risk variables. Workers that are employed by a firm that does have a health and safety committee have lower mean fatal injury risk, with this difference statistically significant in the male manual sample[35]. Through descriptive statistical analysis only, health and safety committees do therefore appear

[34] Regressions are also estimated with a *fatal*emprep* variable. No significant result is found, indicating workplaces with safety representative have no independent effect upon the premium.

[35] A t statistic of 5.328 that adjusts for unequal variance is calculated which is significant at the 1 per cent level.

to be associated with fewer workplace accidents. This in part can be attributed to the fact that such committees are more likely in firms that are covered by union terms and conditions (although as shown by Table 5.6 the correlation coefficient is small and insignificant) as it has also been shown accidents are less likely in such firms. The finding that trade unions and health and safety committees have the same negative effect upon accident rates, but have a different effect upon the risk premium however, is particularly interesting. It could be that such committees have a positive impact upon the compensation bargaining environment as health and safety committees have no direct power to influence the wage rate. If committees work to highlight and disseminate information concerning the injury risk of certain occupations, they could strengthen the case for higher compensation.

Likelihood ratio tests are calculated, comparing the full model to a model that divides the sample according to health and safety committee presence. Test statistics of 41.68 for the all manual sample and 32.95 for the male manual sample are significant at the 1 per cent and 5 per cent level. It is therefore appropriate to divide the model. Table 5.8 presents interval regression estimates.

Earlier conclusions are supported; higher fatal risk premiums are estimated for workers in the samples that are employed in firms where there is a specific health and safety committee compared to those where no such committee is present. For instance, in the male manual sample, a fatal premium of 0.3801 is estimated for workers with no health and safety committee, compared to 0.5232 for workers where there is one.

Table 5.8: Interval Regression Results (split by Commspecific)

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL		MALE MANUAL	
	Commspecific Presence	**No Commspecific**	**Commspecific Presence**	**No Commspecific**
Obs	*2299*	*3175*	*1745*	*2152*
Wald chi²	*1349.84*	*1595.11*	*600.76*	*638.77*
Log pseudo likelihood	*-4532.1895*	*-6433.9152*	*-3403.9261*	*-4363.2703*
Constant	4.9269*** (0.0615)	4.8277*** (0.0589)	4.8129*** (0.0704)	4.6770*** (0.0814)
Educ1	0.1390*** (0.0155)	0.1154*** (0.0141)	0.1350*** (0.0174)	0.1116*** (0.0170)
Educ2	0.0384 (0.0254)	0.0552*** (0.0206)	0.0341 (0.0292)	0.0468* (0.0245)
Educ3	0.2438*** (0.0273)	0.1892*** (0.0257)	0.2428*** (0.0304)	0.1807*** (0.0300)
Tenure2	-0.0219 (0.0322)	0.0086 (0.0233)	-0.0462 (0.0371)	-0.0066 (0.0281)
Tenure3	0.0192 (0.0265)	0.0628*** (0.0196)	0.0151 (0.0290)	0.0743*** (0.0235)
Tenure4	0.0505* (0.0265)	0.0753*** (0.0211)	0.0331 (0.0294)	0.0729*** (0.0250)
Tenure5	0.1248*** (0.0260)	0.1496*** (0.0213)	0.1226*** (0.0287)	0.1527*** (0.0254)
Overtime	0.0077*** (0.0015)	0.0059*** (0.0010)	0.0073*** (0.0015)	0.0079*** (0.0012)
Flexitime	0.0237 (0.0167)	-0.0133 (0.0144)	0.0061 (0.0195)	-0.0040 (0.0172)
Supervise	0.1222*** (0.0178)	0.1426*** (0.0161)	0.1146*** (0.0199)	0.1319*** (0.0191)
Permanent	0.1102*** (0.0370)	0.0465 (0.0295)	0.1532*** (0.0406)	0.0266 (0.0388)
Age	0.1913*** (0.0244)	0.2368*** (0.0221)	0.2406*** (0.0283)	0.2995*** (0.0301)
Age²	-0.0179*** (0.0027)	-0.0227*** (0.0024)	-0.0225*** (0.0031)	-0.0273*** (0.0032)
Nemps	4.33e-05*** (1.67e-05)	6.44e-05*** (2.04e-05)	4.27e-05** (1.94e-05)	8.56e-05*** (2.65e-05)
Nemps²	-6.52e-09** (2.96e-09)	-6.18e-09* (3.47e-09)	-5.69e-09 (3.82e-09)	-9.88e-09** (5.02e-09)
Meritpay	0.0719*** (0.0157)	0.0467*** (0.0166)	0.0521*** (0.0176)	0.0445** (0.0190)
Public	-0.1030*** (0.0183)	-0.0544*** (0.0175)	-0.1135*** (0.0209)	-0.1206*** (0.0211)
Runion	0.0631*** (0.0235)	0.0957*** (0.0190)	0.0300 (0.0294)	0.0761*** (0.0232)
Female	-0.3306***	-0.3261***		

	(0.0183)	(0.0147)		
Fatal	0.6816*** (0.2077)	0.5179 (0.3703)	0.5232** (0.2261)	0.3801 (0.4244)
Fatal*Runion	-0.7605** (0.3323)	0.2248 (0.4346)	-0.4417 (0.30)	0.3651 (0.5023)
Lnsigma	*-1.1495**** *(0.0199)*	*-1.0804**** *(0.0181)*	*-1.1817**** *(0.0218)*	*-1.1076**** *(0.0230)*
Sigma	*0.3168* *(0.0063)*	*0.3395* *(0.0061)*	*0.3068* *(0.0067)*	*0.3303* *(0.0076)*
VSL (2004£)	£11,145,973		£9,449,013	
VSL (2000$)	$16,041,705		$13,599,376	

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Given the changing nature of industrial relations in Britain, the role of ensuring risk compensation in the form of a wage premium is received for exposure to danger of having a fatal accident, may be better investigated by examining the role of health and safety committees in addition to the union effect. As the impact must be indirect, health and safety committees may influence the bargaining environment, and so examining only the trade union impact potentially omits an important mechanism.

5.7 Heckman Selectivity Correction

The Heckman selection correction is employed to correct for potential endogeneity of union presence within a firm. Instruments typically reflect management and worker attitude towards trade unions, which are available in WERS. Descriptive statistics are reported in Appendix 5.11. Managers are most likely to report they are in favour of trade unions. There is clear disagreement however, between manager and worker reports of manager attitude. Only 17 per cent of workers report managers have a favourable attitude towards unions (variable *wrkmgrf*), compared to 35 per cent of managers reporting they have a favourable attitude (variable *mgrf*). Table 5.9 reports correlation coefficients. Variables are positively correlated but insignificantly so; both managers and worker reports can therefore be included in the probit.

Table 5. 9: Correlation Coefficients

	ALL MANUAL	MALE MANUAL
Wrkmgrf - Mgrf	0.23732	0.2899
Wrkmgrnf - Mgrnf	0.1426	0.1427

To ensure the selected variables are appropriate instruments, they are first included in the wage estimation. If they are significant, and hence correlated with wages, they are not appropriate instruments. Results are reported in Appendix 5.12. The instruments *mgrf*, *mgrnf* and *wrkmgrf* and *wrkagree* are significant, indicating favourable manager attitudes towards unions are associated with higher wages. However, workers reporting management have a negative attitude towards unions (*wrkmgrnf*) and workers having an unfavourable attitude towards unions (*wrkdis*) are not significant (except in the male manual sample where *wrkdis* is only significant at the 10 per cent level). The union probit is therefore estimated with two instruments, *wrkmgrnf* and *wrkdis*. See Table 5.10.

Both instruments are significant. *Wrkmgrnf* is negative indicating workers reporting managers have an unfavourable attitude towards unions is associated with a management that is less likely to report recognising a union. *Wrkdis* is significantly positive indicating workers that report they are not in favour of trade unions are likely to work for a firm where managers recognise a union. This is likely because employees that have some experience of dealing with a trade union are most likely to have an opinion upon their effectiveness, whether positive or negative.

Table 5.10: Union Probit Results

Dependent Variable: Runion

	ALL MANUAL	**MALE MANUAL**
Obs	*5563*	*3953*
LR chi²	*2604.06*	*1817.43*
Log likelihood	*-2516.7022*	*-1785.432*
Pseudo R^2	*0.3410*	*0.3373*
Constant	-1.7817*** (0.1626)	-1.9855*** (0.2018)
Educ1	0.1520*** (0.0464)	0.1962*** (0.0551)
Educ2	0.0857 (0.0673)	0.0862 (0.0817)
Educ3	0.0335 (0.0739)	-0.0426 (0.0883)
Tenure2	0.0637 (0.0797)	0.0127 (0.0962)
Tenure3	0.1373** (0.0683)	0.0646 (0.0812)
Tenure4	0.2704*** (0.0717)	0.1757** (0.0847)
Tenure5	0.5920*** (0.0712)	0.5927*** (0.0834)
Overtime	0.0059** (0.0030)	0.0048 (0.0034)
Flexitime	0.0367 (0.0472)	0.0102 (0.0575)
Supervise	-0.2205*** (0.0478)	-0.1859*** (0.0568)
Permanent	0.0768 (0.0916)	0.2066* (0.1172)
Age	0.2952*** (0.0655)	0.3102*** (0.0796)
Age^2	-0.0247*** (0.0075)	-0.0245*** (0.0089)
Nemps	0.0013*** (9.17e-05)	0.0012*** (0.0001)
$Nemps^2$	-1.42e-07*** (1.59e-08)	-1.32e-07*** (1.85e-08)
Meritpay	0.0983** (0.0497)	0.1672*** (0.0579)
Public	1.7102*** (0.0675)	1.8299*** (0.1021)
Commspecific	0.6844*** (0.0445)	0.7478*** (0.0527)
Female	-0.3292*** (0.0473)	
Wrkmgrnf	-0.6849***	-0.6942***

	(0.0542)	(0.0612)
Wrkdis	0.7766*** (0.0729)	0.8588*** (0.0848)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Lambda is calculated, according to equation 3, and included in the wage estimation (Table 5.11).

Table 5.11: Interval Regression Results with Union Selection term (Lambda)

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	MALE MANUAL
Obs	*5251*	*3897*
Wald chi²	*3018.67*	*1269.21*
Log pseudo- likelihood	*-10530.211*	*-7784.1298*
Constant	4.9119*** (0.0575)	4.7206*** (0.0713)
Educ1	0.1232*** (0.0107)	0.1214*** (0.0123)
Educ2	0.0420*** (0.0162)	0.0395** (0.0189)
Educ3	0.2117*** (0.0189)	0.2090*** (0.0215)
Tenure2	-0.0019 (0.0194)	-0.0210 (0.0225)
Tenure3	0.0443*** (0.0161)	0.0529*** (0.0183)
Tenure4	0.0648*** (0.0170)	0.0601** (0.0192)
Tenure5	0.1319*** (0.0174)	0.1397*** (0.0194)
Overtime	0.0065*** (0.0009)	0.0076*** (0.0010)
Flexitime	-0.0003 (0.0111)	-0.0020 (0.0129)
Supervise	0.1381*** (0.0122)	0.1265*** (0.0139)
Permanent	0.0684*** (0.0238)	0.0684** (0.0286)
Age	0.2192*** (0.0179)	0.2796*** (0.0226)
Age²	-0.0210*** (0.0020)	-0.0257*** (0.0024)
Nemps	3.52e-05** (1.43e-05)	5.16e-05*** (1.67e-05)

Nemps²	-4.40e-09* (2.57e-09)	-6.78e-09** (3.28e-09)
Meritpay	0.0518*** (0.0116)	0.0474*** (0.0129)
Public	-0.0985*** (0.0171)	-0.1197*** (0.0197)
Runion	0.0838*** (0.0155)	0.0577*** (0.0186)
Commspecific	0.0245* (0.0128)	0.0436*** (0.0147)
Female	-0.3263*** (0.0117)	
Fatal	0.6399*** (0.1868)	0.5059** (0.2026)
Fatal*Runion	-0.3560* (0.1396)	-0.1323 (0.2892)
Lambda	-0.0405** (0.0190)	-0.0010 (0.0215)
Lnsigma	*-1.1069**** *(0.0139)*	*-1.1363**** *(0.0163)*
Sigma	*0.3306* *(0.0046)*	*0.3210* *(0.0052)*
VSL (2004 £)	£10,464,067	£9,136,574
VSL (2000 $)	$15,060,280	$13,149,702

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Lambda is significant in the all manual sample suggesting a problem of union selection. *Fatal* however, remains significantly positive and *fatal*runion* significantly negative when *lambda* is included. *Lambda* is insignificant in the male manual sample, which may be related to the lack of appropriate instruments, as frequently found in the literature. Conclusions as to the union effect therefore, remain unchanged.

As with trade unions, the presence of a health and safety committee in a firm may be endogenous, with workers employed in risky occupations selecting into firms with such a committee[36]. Instrumental variables that predict whether a respondent works

[36] Specific health and safety committees only are considered here as they appear to have the greatest independent effect upon the risk premium.

for a firm that has a specific health and safety committee are constructed. Instruments proxy management attitude towards health and safety consultation and communication. Descriptive statistics are reported in Appendix 5.13 and illustrate that around 16 per cent of firms have had a health and safety grievance raised in the last year. Over 50 per cent of workplaces regularly discuss health and safety issues and have formal procedures in place to deal with grievances.

The instrumental variables are included in the wage estimations to check that they are uncorrelated with pay and therefore suitable instruments. See Appendix 5.14. All three instruments are insignificant in the male manual sample, indicating they are uncorrelated with wages. The instruments *hsdisproc* and *hsgriev* are however, positive and significant although only at the 10 per cent level, in the all manual sample. Instruments, although not ideal, are fairly satisfactory. Results from the health and safety committee probit estimation are reported in Table 5.12.

Table 5.12: Health and Safety Committee Probit Results

Dependent Variable: Commspecific

	ALL MANUAL	**MALE MANUAL**
Obs	*5563*	*3953*
LR chi²	*1336.74*	*1007.38*
Log likelihood	*-3113.9914*	*-2213.6439*
Pseudo R^2	*0.1767*	*0.1854*
Constant	-1.1703*** (0.1469)	-1.0878*** (0.1837)
Educ1	0.0105 (0.0417)	0.0579 (0.0496)
Educ2	-0.1873*** (0.0616)	-0.2382*** (0.0742)
Educ3	0.0776 (0.0676)	0.0685 (0.0805)
Tenure2	0.1008 (0.0758)	0.0113 (0.0928)
Tenure3	0.1913*** (0.0642)	0.1285* (0.0769)

Tenure4	0.1774*** (0.0673)	0.1127 (0.0799)
Tenure5	0.2575*** (0.0660)	0.2226*** (0.0773)
Overtime	-0.0028 (0.0027)	-0.0012 (0.0030)
Flexitime	-0.0640 (0.0427)	-0.0782 (0.0522)
Supervise	0.0179 (0.0437)	-0.0162 (0.0521)
Permanent	-0.1001 (0.0844)	-0.0703 (0.1088)
Age	0.1187** (0.0588)	0.0725 (0.0725)
Age^2	-0.0135** (0.0067)	-0.0090 (0.0081)
Nemps	0.0012*** (6.27e-05)	0.0013*** (7.79e-05)
$Nemps^2$	-1.74e-07*** (1.18e-08)	-1.97e-07*** (1.58e-08)
Meritpay	-0.0881* (0.0455)	-0.1171** (0.0531)
Public	-0.7177*** (0.0506)	-0.7415*** (0.0631)
Runion	0.7067*** (0.0437)	0.7721*** (0.0516)
Female	-0.0601 (0.0425)	
Hsmeet	0.0733* (0.0383)	0.1116** (0.0454)
Hsdisproc	0.2062*** (0.0388)	0.2127*** (0.0473)
Hsgriev	-0.0444 (0.0500)	-0.2154*** (0.0593)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

The instrumental variables work well in the probit. *Hsmeet* indicates firms that have regular meetings between senior management and employees regarding health and safety are more likely to have a health and safety committee. Similarly, *hsdisproc* is positive and significant, indicating firms that have a formal procedure in place for dealing with health and safety issues are also more likely to have a health and safety committee. *Hsdisproc* is positive and significant indicating workplaces that have formal procedures for dealing with health and safety disputes are also more likely to have a health and safety committee. *Hslambda* is calculated, according to equation 3, and included in the wage estimations (Table 5.13).

Table 5.13: Interval Regression Results with Health and Safety Committee Selection term (Hslambda)

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	**MALE MANUAL**
Obs	*5474*	*3897*
Wald chi²	*3106.55*	*1264.51*
Log likelihood	*-10985.612*	*-7783.3734*
Constant	4.9175*** (0.0870)	4.7300*** (0.0943)
Educ1	0.1267*** (0.0105)	0.1217*** (0.0124)
Educ2	0.0527*** (0.0173)	0.0426** (0.0203)
Educ3	0.2104*** (0.0189)	0.2082*** (0.0216)
Tenure2	-0.0029 (0.0192)	-0.0210 (0.0225)
Tenure3	0.0426** (0.0168)	0.0518*** (0.0188)
Tenure4	0.0630*** (0.0172)	0.0596*** (0.0194)
Tenure5	0.1353*** (0.0178)	0.1402*** (0.0199)
Overtime	0.0067*** (0.0008)	0.0076*** (0.0010)
Flexitime	0.0021 (0.0112)	-0.0009 (0.0132)
Supervise	0.1339*** (0.0120)	0.1261*** (0.0138)
Permanent	0.0689*** (0.0231)	0.0695** (0.0287)
Age	0.2189*** (0.0175)	0.2803*** (0.0226)
Age²	-0.0207*** (0.0019)	-0.0257*** (0.0024)
Nemps	1.55e-05 (3.32e-05)	4.36e-05 (3.57e-05)
Nemps²	-9.56e-10 (5.32e-09)	-5.14e-09 (6.49e-09)

Meritpay	0.0575*** (0.0116)	0.0497*** (0.0132)
Public	-0.0531** (0.0233)	-0.1069*** (0.0241)
Runion	0.0695** (0.0286)	0.0540* (0.0321)
Commspecific	0.0212 (0.0139)	0.0320* (0.0176)
Female	-0.3268*** (0.0116)	
Fatal	0.5523*** (0.1921)	0.4444** (0.2125)
Fatal*Runion	-0.5374** (0.2725)	-0.2345 (0.3103)
Fatal*Commspecific	0.5634** (0.2784)	0.3799 (0.3174)
Hslambda	-0.0485 (0.0476)	-0.0171 (0.0484)
Lnsigma	*-1.1057**** *(0.0134)*	*-1.1365**** *(0.0163)*
Sigma	*0.3310* *(0.0044)*	*0.3209* *(0.0052)*
VSL (2004 £)	£9,031,574	£8,025,881
VSL (2000 $)	$12,998,582	$11,551,151

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

The Heckman selectivity correction term *hslambda* is insignificant in both samples suggesting there is not a problem here with workers with risky jobs selecting into firms with a health and safety committee.

5.8 Risk Endogeneity

Garen's method is employed to control for the potential endogeneity of risk, as highlighted in the methodology (section 5.2). A regression with risk as the dependent variable is estimated, with explanatory variables including variables for non-labour income, and proxies for a workers' degree of risk aversion. Garen acknowledges "finding proxies for the degree of risk aversion is a difficult task" (p.12). Measures of the stability of an individual's lifestyle are frequently used, assuming they are inversely correlated with the degree of aversion to risk. These include household income other than wages, marital status, house value and number of dependents. Some variables that are often used in the risk estimation are not in WERS, including whether the respondent is a house owner, partners' schooling, and whether their partner works. Essentially therefore, there is a lack of variables to give an indication of non-labour income. The WERS management survey does include however, questions for the largest occupational group on access to an employer pension scheme, company car or car allowance, and private health insurance. These non-monetary variables may provide some approximation to workers' non-wage wealth. Industry dummies are also included in the risk estimations, following the literature[37].

Table 5.14: Risk Regression Results

Dependent Variable: Fatal

	ALL MANUAL	**MALE MANUAL**
Number of obs	*5563*	*3809*
F	*51.79*	*22.78*
R^2	*0.2575*	*0.1786*
Adj R^2	*0.2526*	*0.1707*
Constant	0.0332*** (0.0039)	0.0338*** (0.0053)
Educ1	-0.0027*** (0.0010)	-0.0036*** (0.0014)
Educ2	-0.0057*** (0.0015)	-0.0082*** (0.0020)
Educ3	-0.0027 (0.0017)	-0.0026 (0.0022)
Tenure2	0.0015 (0.0018)	0.0010 (0.0025)
Tenure3	0.0008 (0.0015)	0.0015 (0.0021)
Tenure4	0.0016 (0.0016)	0.0016 (0.0022)
Tenure5	0.0022 (0.0016)	0.0018 (0.0021)
Overtime	1.22e-05	1.14e-05

[37] Although there may be some argument for including industry dummies in the wage regressions, they are often excluded, as the risk coefficients can be sensitive to their inclusion.

	(6.54e-05)	(8.33e-05)
Flexitime	-0.0009 (0.0010)	-0.0019 (0.0014)
Supervise	0.0035*** (0.0011)	0.0029** (0.0014)
Permanent	0.0011 (0.0020)	0.0023 (0.0029)
Age	0.0029** (0.0015)	0.0034* (0.0020)
Age^2	-0.0003* (0.0002)	-0.0004 (0.0002)
Nemps	-1.66e-06 (1.41e-06)	-2.83e-06 (1.89e-06)
$Nemps^2$	9.74e-11 (2.73e-10)	1.82e-10 (3.83e-10)
Meritpay	0.0024** (0.0011)	0.0027* (0.0015)
Public	-0.0054*** (0.0015)	-0.0061*** (0.0021)
Runion	-0.0008 (0.0012)	6.84e-05 (0.0016)
Commspecific	0.0012 (0.0011)	0.0011 (0.0014)
Female	-0.0184*** (0.0012)	
Married	-0.0002 (0.0010)	-0.0004 (0.0015)
Children	0.0023 (0.0378)	0.0027 (0.0411)
Disability	0.0009 (0.0013)	0.0009 (0.0017)
Pension	-0.0039*** (0.0012)	-0.0055*** (0.0017)
Car	0.0062*** (0.0015)	0.0081*** (0.0020)
Healthins	-0.0040*** (0.0014)	-0.0037** (0.0018)
Ind1	0.0009 (0.0019)	-0.0016 (0.0024)
Ind2	0.0036 (0.0037)	0.0031 (0.0044)
Ind3	0.0424*** (0.0024)	0.0427*** (0.0028)
Ind5	-0.0112*** (0.0029)	-0.0125*** (0.0043)
Ind6	-0.0049** (0.0022)	-0.0061** (0.0027)
Ind7	0.0009 (0.0076)	-4.92e-06 (0.0104)

Ind8	-0.0024 (0.0024)	-0.0034 (0.0030)
Ind9	0.0103*** (0.0040)	0.0112** (0.0052)
Ind10	-0.0087*** (0.0029)	-0.0044 (0.0045)
Ind11	-0.0131*** (0.0023)	-0.0147*** (0.0035)
Ind12	0.0153*** (0.0025)	0.0235*** (0.0033)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 5.15 lists the instrumental variables and descriptive statistics. The mean values indicate 66.8 per cent of the all manual workers sample and 69 per cent of the male manual workers sample are married or cohabiting, with 37.4 per cent and 42 per cent having dependent children. Approximately 14 percent of the manual workers sample consider themselves to have long-term health problems or a disability, with roughly the same percentage entitled to private health insurance. Over 77 per cent are entitled to an employee pension scheme, and around 12 per cent have a company car or car allowance. Instrumental variables are included in fatal risk regressions (Table 5.14).

The R^2 of the fatal injury regressions are around 25 and 17 per cent which although small, are similar to those reported in the literature[38]. In terms of the instruments, *married* is negative but insignificant as commonly reported. The variables *children* and *disability* are also insignificant. *Pension* and *health insurance* are both significantly negative and may provide some proxy for risk aversion.

[38] For example Sandy and Elliott report R^2 of 17 per cent for their fatal estimation.

5.8.1 Hausman Test

To see if risk endogeneity is a problem, Hausman tests are conducted. Wage regressions are estimated including the residuals from the risk estimations. If the residual is significant, the null of exogeneity is rejected. See Table 5.15.

Table 5.15: Hausman Tests

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	**MALE MANUAL**
Obs	*5474*	*3754*
Wald chi²	*3280.91*	*1333.09*
Log likelihood	*-10933.072*	*-7445.318*
Constant	4.7015*** (0.0462)	4.5624*** (0.0612)
Educ1	0.1372*** (0.0104)	0.1337*** (0.0121)
Educ2	0.0701*** (0.0161)	0.0744*** (0.0195)
Educ3	0.2253*** (0.0188)	0.2190*** (0.0217)
Tenure2	-0.0029 (0.0188)	-0.0167 (0.0223)
Tenure3	0.0452*** (0.0155)	0.0487*** (0.0183)
Tenure4	0.0604*** (0.0162)	0.0553*** (0.0191)
Tenure5	0.1334*** (0.0161)	0.1363*** (0.0190)
Overtime	0.0067*** (0.0008)	0.0076*** (0.0010)
Flexitime	0.0039 (0.0108)	0.0050 (0.0128)
Supervise	0.1167*** (0.0120)	0.1103*** (0.0140)
Permanent	0.0698*** (0.0228)	0.0776*** (0.0289)
Age	0.2176*** (0.0172)	0.2779*** (0.0230)
Age²	-0.0205*** (0.0019)	-0.0254*** (0.0024)
Nemps	5.29e-05*** (1.31e-05)	6.71e-05*** (1.6e-05)
Nemps²	-5.59e-09** (2.44e-09)	-7.88e-09** (3.36e-09)

Meritpay	0.0488*** (0.0113)	0.0396*** (0.0131)
Public	-0.0542*** (0.0124)	-0.1028*** (0.0147)
Runion	0.0998*** (0.0144)	0.0748*** (0.0181)
Commspecific	0.0162 (0.0137)	0.0298* (0.0174)
Female	-0.2335*** (0.0147)	
Fatal	3.7743*** (0.3509)	-0.2224 (0.3057)
Fatal*Runion	-0.4613* (0.2618)	-0.2224 (0.3057)
Fatal*Commspecific	1.0162*** (0.2791)	0.8371*** (0.3258)
Resid	-3.9312*** (0.3822)	-3.6312*** (0.3910)
Lnsigma	*-1.1158**** *(0.0135)*	*-1.1511* *(0.0612)*
Sigma	*0.3277* *(0.0044)*	*0.3163* *(0.0052)*

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Risk endogeneity is a problem, with the residual variable *resid* significant in both estimations.

5.8.2 Controlling for Endogeneity

Following Garen, residuals from the risk estimations are included in the wage regressions. Residuals are multiplied by the risk variable with this also included as an explanatory variable. Results are reported in Table 5.16.

Table 5.16: Interval Regression Results Controlling for Endogeneity

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	MALE MANUAL
Obs	*5474*	*3754*
Wald chi²	*3300.18*	*1357.32*
Log likelihood	*-10922.264*	*-7434.2351*
Constant	4.7012*** (0.0463)	4.5606*** (0.0613)
Educ1	0.1367*** (0.0104)	0.1330*** (0.0121)
Educ2	0.0712*** (0.0161)	0.0744*** (0.0194)
Educ3	0.2254*** (0.0188)	0.2195*** (0.0216)
Tenure2	-0.0034 (0.0187)	-0.0178 (0.0222)
Tenure3	0.0447*** (0.0154)	0.0484*** (0.0182)
Tenure4	0.0604*** (0.0162)	0.0554*** (0.0190)
Tenure5	0.1332*** (0.0161)	0.1358*** (0.0189)
Overtime	0.0067*** (0.0008)	0.0075*** (0.0010)
Flexitime	0.0049 (0.0108)	0.0068 (0.0128)
Supervise	0.1215*** (0.0120)	0.1166*** (0.0141)
Permanent	0.0688*** (0.0229)	0.0770*** (0.0290)
Age	0.2164*** (0.0172)	0.2761*** (0.0230)
Age²	-0.0204*** (0.0019)	-0.0253*** (0.0024)
Nemps	5.13e-05*** (1.31e-05)	6.48e-05*** (1.58e-05)
Nemps²	-5.37e-09** (2.43e-09)	-7.47e-09** (3.26e-09)
Meritpay	0.0486*** (0.0113)	0.0390*** (0.0131)
Public	-0.0439*** (0.0126)	-0.0863*** (0.0150)
Runion	0.0950*** (0.0142)	0.0702*** (0.0178)
Commspecific	0.0215 (0.0135)	0.0384** (0.0171)
Female	-0.2326*** (0.0147)	

Fatal	2.8489*** (0.3621)	2.2658*** (0.3762)
Fatal*Runion	-0.4164* (0.2523)	-0.0952 (0.2933)
Fatal*Commspecific	0.8009*** (0.2692)	0.5638* (0.3170)
Resid	-3.2124*** (0.4152)	-2.8076*** (0.4421)
Fatal*Resid	-9.2013*** (2.0702)	-10.2950*** (2.4620)
Lnsigma	*-1.1178**** *(0.0135)*	*-1.1541**** *(0.0162)*
Sigma	*0.3270* *(0.0044)*	*0.3153* *(0.0051)*
VSL (2004£)	£46,587,093	£40,920,438
VSL (2000 US$)	$67,049,902	$58,894,238

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

When we control for endogeneity, *fatal* remains positive and significant, with the magnitude of the coefficients much larger. This is reflected in the considerably higher VSL estimates. This is consistent with the literature; OLS estimates that do not control for endogeneity appear to be biased downwards. Sandy and Elliott (1996) observe this is consistent with the argument that safety is a normal good, as "workers with high unobserved earnings capacity are willing to pay for occupations with more safety" (p.300). The fact the *fatal*resid* is significantly negative is also consistent with the literature, implying "workers with unusually high risk have low values of unobserved earnings ability in the presence of risk" (p.300). Other key conclusions remain once risk endogeneity is controlled for, with health and safety committees having a positive effect and unions having a negative impact upon the risk premium.

5.8.3 Instrument Tests

The instruments selected to proxy risk aversion are included in the wage estimation to ensure they are appropriate (Table 5.17).

Table 5.17: Instrument Test

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	**MALE MANUAL**
Obs	5474	3754
Wald chi²	4134.53	1936.64
Log likelihood	-10715.402	-7260.1018
Constant	4.7939*** (0.0470)	4.6941*** (0.0619)
Educ1	0.1120*** (0.0100)	0.1028*** (0.0116)
Educ2	0.0526*** (0.0152)	0.0549*** (0.0179)
Educ3	0.1974*** (0.0179)	0.1794*** (0.0202)
Tenure2	0.0063 (0.0180)	-0.0077 (0.0209)
Tenure3	0.0406*** (0.0149)	0.0402** (0.0173)
Tenure4	0.0584*** (0.0155)	0.0482*** (0.0181)
Tenure5	0.1253*** (0.0156)	0.1216*** (0.0183)
Overtime	0.0060*** (0.0008)	0.0067*** (0.0010)
Flexitime	0.0045 (0.0105)	0.0015 (0.0122)
Supervise	0.1413*** (0.0115)	0.1273*** (0.0133)
Permanent	0.0634*** (0.0223)	0.0780*** (0.0275)
Age	0.1878*** (0.0179)	0.2311*** (0.0239)
Age²	-0.0181*** (0.0020)	-0.0215*** (0.0025)
Nemps	3.35e-05*** (1.24e-05)	4.58e-05*** (1.41e-05)
Nemps²	-1.18e-09 (2.21e-09)	-2.86e-09 (2.64e-09)
Meritpay	0.0415*** (0.0109)	0.0339*** (0.0126)

Public	-0.0394*** (0.0141)	-0.0699*** (0.0168)
Runion	0.0435*** (0.0149)	0.0170 (0.0187)
Commspecific	0.0110 (0.0134)	0.0266 (0.0169)
Female	-0.2546*** (0.0124)	
Fatal	-0.2249 (0.1926)	-0.4010* (0.2195)
Fatal*Runion	-0.2517 (0.2565)	0.0126 (0.2949)
Fatal*Commspecific	0.8875*** (0.2708)	0.7668** (0.3094)
Married	0.0679*** (0.0101)	0.0804*** (0.0123)
Children	0.0202** (0.0098)	0.0348*** (0.0114)
Disability	-0.0129 (0.0122)	-0.0158 (0.0141)
Pension	0.0368*** (0.0126)	0.0287* (0.0148)
Car	0.0754*** (0.0145)	0.0716*** (0.0171)
Healthins	0.0650*** (0.0135)	0.0874*** (0.0150)
Ind1	0.1127*** (0.0194)	0.0967*** (0.0209)
Ind2	0.3516*** (0.0359)	0.3235*** (0.0381)
Ind3	0.2543*** (0.0251)	0.2461*** (0.0261)
Ind5	-0.1336*** (0.0283)	-0.1804*** (0.0368)
Ind6	0.1634*** (0.0221)	0.1281*** (0.0241)
Ind7	0.1849*** (0.0699)	0.1389 (0.1051)
Ind8	0.1563*** (0.0258)	0.1439*** (0.0272)
Ind9	0.1333*** (0.0393)	0.1339*** (0.0446)
Ind10	-0.0366 (0.0295)	-0.0248 (0.0406)
Ind11	-0.0296 (0.0236)	-0.0766** (0.0335)
Ind12	0.0271 (0.0285)	0.0305 (0.0321)
Lnsigma	*-1.1568****	*-1.2021****

	(0.0140)	*(0.0169)*
Sigma	*0.3145* *(0.0044)*	*0.3006* *(0.0051)*

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Most of the instruments are significant in the wage estimations in both samples (with the exception of *disability* and some of the industry dummies, and *disability* is never significant in the risk estimation) indicating they are not appropriate instruments. The problems encountered in the literature when attempting to control for risk endogeneity are so large, that Bound et al. (1995) have suggested using weak instruments results in coefficients that are biased towards the original OLS estimates. To test if the instruments are weak, F tests are conducted. See Table 5.18.

Table 5.18: F Tests

	ALL MANUAL	**MALE MANUAL**
Married *Prob>F*	0.11 (0.7446)	0.06 (0.8088)
Children *Prob>F*	5.49** (0.0191)	5.91** (0.0151)
Disability *Prob>F*	0.03 (0.8552)	0.04 (0.8433)
Pension *Prob>F*	21.33*** (0.0000)	22.01*** (0.0000)
Car *Prob>F*	37.18*** (0.0000)	35.30*** (0.0000)
Healthins *Prob>F*	13.79*** (0.0002)	11.07*** (0.0009)

***=significant at the 1% level; **=significant at the 5% level

Staiger and Stock (1997) recommend that when testing the strength of an instrument, the F statistic must take the value of at least 10. Similarly, Stock, Wright, and Yogo (2002) found that an F statistic of 9 or above is needed for an appropriate instrument. Table 18 reports *married*, *children* and *disability* are weak instruments in this case. *Pension*, *car* and *healthins* however, appear to be strongly correlated with a workers' occupational risk. However, each of these three instruments were all significant in the wage estimations.

Controlling for risk endogeneity may not be as essential to studies of compensating wage differentials as some imply. Lalive and Ruf (2006) use Austrian longitudinal data to estimate compensating wage differential for risk of injury. Their data therefore controls for unobserved heterogeneity. They estimate a risk premium that is roughly equal to the one obtained in a standard cross-sectional wage regression and hence "find no evidence for a bias of the compensating differential obtained from a standard cross-sectional hedonic wage function that can be attributed to unobserved worker productivity" (p.4). Their results therefore "suggest that the bias of the compensating differential obtained from a standard cross-sectional hedonic wage function that is due to unobserved productivity of workers or unobserved ability to cope with risks is small"(p.19). This paper had access to very detailed data upon work accidents and individual employment over time and so replication using other international data may be difficult. It does however, suggest that risk premium estimates obtained from cross sectional data with risk exogenous, may not be misleading. Furthermore, although endogeneity may impact upon the magnitude of the risk premium, the effect that institutions such as trade unions and health and safety committees have upon the premium are unlikely to be altered by such potential bias.

5.9 Value of Statistical Life and Injury

VSL estimates are reported throughout, and provide a useful means of comparing estimates between studies. A summary of some estimates from the literature are reported in Appendix 5.1, and vary widely. This is due to the many variations between studies, including differences in method and in the variables included, and also because, as Viscusi and Aldy (2003) highlight, a calculated VSL "reflects the preferences of workers in a given sample" (p.18). Bell et al. comment that "the variation in published estimates is so wide that there is no sense that they converge on a range that could guide public policy" (p.9). The Accident Variable Appendices highlight differences in the risk variables depending upon the method and occupation data used. Therefore, interval regression estimations are repeated using alternative risk rates, and the corresponding VSL estimates compared. Table 5.19 summarises.

Table 5.19: VSL Estimates

SAMPLE	OCCUPATION DATA	ENDOGENEITY CONTROL?	VSL (2004 £)	VSL (2000 US$)
All manual	LFS 2002-2004	No	£10,557,277	$15,194,431
Male manual	LFS 2002-2004	No	£9,163,644	$13,188,691
All manual	LFS 2004	No	£12,643,446	$18,196,925
Male manual	LFS 2004	No	£12,350,972	$17,775,985
All manual	ASHE 2004	No	£12,656,959	$18,216,373
Male Manual	ASHE 2004	No	£12,064,107	$17,363,118
All manual	LFS 2002-2004	Yes	£46,587,093	$67,049,902
Male manual	LFS 2002-2004	Yes	£40,920,937	$58,894,238

Consistent with the literature, VSL estimates obtained throughout this chapter are extremely wide ranging, from $13 million to $67 million, depending upon whether endogeneity is controlled for. When endogeneity is not controlled for, VSL estimates for the male manual sample range from $13 million to $17 million. Estimates using occupation data from ASHE rather than LFS raise the estimate slightly, as the Accident Variable Appendices discusses, the use of ASHE data results in slightly higher accident rates. Sandy and Elliott (1996) VSL estimates range from $5.2 million to $69.4 million, and Sandy et al. (2001) estimates range from $5.7 million to $74.1

million[39]. Estimates calculated here fit within such ranges. Estimates are greater than most estimated using US data; Viscusi and Aldy (2003) comment upon this common finding which is particularly puzzling given "the mortality risk is lower than in many US studies" (p.29). They suggest larger UK estimates "may reflect correlation between the risk measure and other unobservables that yield substantial returns to the worker" (p.29).

5.10 Conclusion

This chapter has highlighted that manual workers do appear to receive a wage premium for being exposed to risk of death in British workplaces. Given that the only other UK cross sectional studies use data from the 1980s, this is an important finding. VSL estimates are calculated which enables the size of risk premiums to be compared with other studies. For the sample of male manual workers, a VSL of approximately $13 million (in 2000 US$) is estimated, which is larger than those typically estimated in the US. As with most studies using cross-sectional data, estimates suffer from potential risk endogeneity. Although attempts to control for this bias are adopted, here and in other papers, the problem of finding appropriate instruments to proxy risk aversion limits the effectiveness of Garen's method. Recent papers however, have suggested the bias may not be as great as first thought.

Trade unions are found to have a negative effect upon the risk premium although this effect is not always significant, unlike that reported in most studies using UK data. In most specifications however, they have no impact upon the risk premium in the male manual sample. The negative union impact is found in most UK literature, and is

[39] As converted by Viscusi and Aldy (2003).

often explained by the suggestion that unions are more concerned with increasing safety in the workplace rather than bargaining for compensation for accidents. This explanation is supported by the finding that firms that recognise a trade union have a smaller average risk rate. Results here however, suggest the trade union impact may not be very significant in influencing the risk premium.

The role of other health and safety institutions was considered, given that their role may be increasing in importance in the workplace with the decline in the presence of trade unions. Having a committee that deals specifically with health and safety had a positive impact upon the risk premium in the manual workers sample, with the union effect, when significant, remaining negative. As health and safety committees have no role in directly influencing wages, results could be reflecting an indirect effect. For instance, if we assume health and safety committees have a positive impact upon the workplace bargaining environment, they could influence wages and consequently the risk premium. This suggests that health and safety committees have a significant role in influencing risk compensation and that they operate differently and independently from trade unions in terms of health and safety. It should be noted that having a general committee that deals with a range of issues or a safety representative with no committee had no impact upon the risk premium. This suggests health and safety committees have a positive impact upon the environment in which bargaining takes place. In conclusion, these findings support Litwin's (2000) suggestion that the health and safety committee effect should be separated from the union effect.

CHAPTER 6

OCCUPATIONAL CHOICE AND SORTING BY ACCIDENT RISK

6.1 Introduction

The compensating wage differentials theory assumes that workers choose amongst occupations according to many attributes, one of which is the risk of death and/or injury. Workers will have differing degrees of risk aversion, and so it is also interesting to consider how individual preferences influence this initial occupation choice. DeLeire and Levy (2004) show using US data that preferences for accident risk vary by gender and family structure, with this translating into occupation sorting. They further show that differences in risk across occupations contribute to occupational gender segregation. The proposition that gender and family structure influences preferences for risky work is investigated here using UK data.

Central to the theory of compensating wage differentials, discussed in chapters 3 and 5, is the recognition that firms and workers are heterogeneous. In relation to safety in the workplace, firms differ in their ability to provide safety. Workers also vary in their willingness to accept a hazardous job, with preference for safety captured by their utility function, with the wage and desirable job characteristics entering positively. Risk of death will enter the utility function negatively, the magnitude of which depends upon the preferences of each worker. Each worker therefore has a set of indifference curves reflecting the trade-off each worker is willing to make between wages and risk. A market offer curve maps out points of equilibrium in the labour market (see Figure 3B.1). The most risk averse workers, those who place the highest value on safety, are matched with firms that find it relatively easy to provide a safe working environment.

The preferences that workers have for risk, and more precisely how they vary, is considered in this chapter. Dohmen et al. (2005) emphasise the importance of understanding individual attitudes towards risk as it is "intimately linked to the goal of predicting economic behaviour" (p.1). The recognition that workers preferences do vary is an essential component of the compensating wage differentials theory, with workers sorting into occupations according to these preferences. Here, the proposition that men and women have different preferences for risk, which translates into occupation sorting, is investigated. Furthermore, following DeLeire and Levy (2004), the idea that these preferences vary by family structure within gender is examined.

Numerous tests outside labour economics have illustrated that women are more risk averse. For instance, Dee and Evans (2001) show men to be riskier drivers. Using US life insurance data, Halek and Eisenhauer (2001) estimate Pratt-Arrow coefficients for relative risk aversions. Results show women to be more risk averse concluding that "purely demographic variables such as age, gender and race affects an individual's degree of risk aversion" (p.22). Furthermore, they find a significant relationship between marriage and risk aversion, but conclude that the direction of the relationship remains uncertain. Brown and Taylor (2005) also show that men are more likely than women to invest in risky assets such as shares and unit trusts. Within the labour economics literature, Ekeland et al. (2004) use psychometric data from a cohort of Finns to show that men are less risk averse than women, with this making them significantly more likely to become self employed than women. Reed and Dahlquist (1994) find for their sample of US workers that women are more likely to be employed in safer jobs than men. Dohmen et al. (2005) consider how risk preferences vary using a survey of German individuals, and find considerable heterogeneity in risk attitudes across individuals. Specifically, they conclude "willingness to take risks is negatively related to age and being female and positively related to height and parental education" (p.34). Within the UK, using the British Social Attitudes Survey (2001) the HSE (2002) reports substantial differences between men and women regarding their attitudes towards health and safety in the workplace, with men significantly less likely to say that not enough attention was paid to protecting workers from risk of injury. Men were also significantly less likely to wear protective clothing at work when required to do so. DeLeire and Levy (2004) summarise that "it seems fairly well established that men are less risk averse than women on a number of different dimensions" (p.928).

Having established that preferences for risk do appear to vary by gender, and possibly by family structure, consider if this could translate into occupational sorting according to risk. The persistence of occupational gender segregation has been well documented. Miller et al. (2004) find "many occupational sectors and jobs in the UK remain strongly gender segregated" (p.1). Specifically, Thewlis et al. (2004) find evidence that in the UK and other European countries, men are concentrated within agriculture, manufacturing, financial services, IT and technology occupations. Women are dominant in service sector occupations, including health, social work and education. As Thewlis et al. comment, occupations which have a large concentration of women are "predominantly stereotyped as female" (p.91). Of particular interest however, concerns what is causing this occupational gender segregation.

Numerous theories exist that fall in to two categories: those that imply segregation is due to labour demand factors, and those that suggest it is due to labour supply. In terms of labour demand, men and women could have different skills which cause employers to demand a specific gender of worker, or employers could simply discriminate and choose one gender over another for a variety of reasons. England (1982, 1985) argues that it is labour demand factors which drive occupational gender segregation, attributing social and cultural factors as influencing employers' demand for labour towards a specific sex. In contrast, occupations could be gender segregated because of labour supply factors; men and women could have different preferences for specific occupations, and hence segregation is the result of individual choice. For example, Polacheck (1981) proposes that women anticipate having time out of the labour market to have children, and so choose an occupation for which the penalties for time-out are minimal. Men and women could also have different preferences for a variety of occupational attributes, such as working conditions, and the degree of manual labour involved. One occupational trait that men and women also have different preferences for and could cause selection into specific occupations by gender concerns the risk of fatality due to an accident at work. DeLeire and Levy (2004) focus upon this. DeLeire and Levy recognise that whilst there is evidence that preferences for risk vary by gender, "there is a general disagreement about whether these preferences are expressed in their choices of occupation" (p.929). It would be of interest to see if these differences in preferences for this specific occupational attribute contribute, and to what extent, to occupational gender segregation.

DeLeire and Levy (2004) test their hypothesis that workers select into a particular occupation dependent upon the risk of fatality and injury associated with it, using US data. As preferences for risk cannot be measured directly, they use gender and family structure as proxies for preferences, hypothesising that following the literature discussed, preferences for risk will vary according to gender and family structure. The distinction by family structure is made because, as they consider, the fact that women choose safer jobs than men may not be due to just differences in preferences, but it could also be due to discrimination. They decompose their sample according to family structure within gender, as family structure will not correlate so obviously with discrimination. There is still the possibility of this however, if employers adopt paternalistic attitudes and prefer not to employ parents in the most dangerous occupations. They hypothesise that single parents should be most risk averse, with the presence of children resulting in greater preferences for safety for all family groups. They find evidence to support this proposition. Their results confirm that single parents are the most averse to risk and, regardless of family structure, that men are less risk averse than women. Consequently "single parents choose jobs with lower risk of death than their married or childless counterparts" (p.940). Overall, they conclude that workers sort into occupations based on their aversion to risk with results offering "strong empirical support for the hypothesis that workers sort into jobs on the basis of their preferences" (p.946).

The findings of DeLeire and Levy have many important implications. Their results suggest that preferences for risk will vary by gender and family structure, with this resulting in occupational sorting. For example, single mothers, the most averse to risk, will require a higher wage at all levels of risk than other groups. It therefore highlights the importance of worker heterogeneity when considering the wage premium required for risk. It would therefore be of interest to see if the conclusions reached are relevant to the UK.

6.2 Methodology

In order to test empirically the effect that accident risk has upon occupational choice between groups of workers in the UK, the same method as used by DeLeire and Levy (2004) is employed. Following Greene (2003), it is assumed that individuals choose an occupation consistent with a random utility model. Individual i's choice of occupation (j from J occupations) results in utility U_{ij} as illustrated by equation 1.

$$U_{ij} = \chi' Z_{ij} + \varepsilon_{ij} \qquad [1]$$

The exogenous variable Z_{ij} can be divided into variables that depend only on the individual (W_i) such as education, and those that vary across the occupation choices (X_j) such as risk of death. Hence:

$$Z_{ij} = f(W_i, X_j) \qquad [2]$$

If the individual chooses occupation j, we assume that the resulting utility U_{ij} is the maximum among the J utilities. The probability that choice j is made can therefore be illustrated by equation 3:

$$\Pr(U_{ij} > U_{ik}) \text{ for all other } k \neq j \qquad [3]$$

If the disturbances are independent and identically distributed with an extreme value distribution, McFadden (1973) shows that the observed occupation choice of individual i (Y_i) can be denoted by the conditional logit model, as shown by equation 4:

$$\Pr(Y_i = j) = \frac{e^{\beta Z_{ij}'}}{\sum_{j=1}^{J} e^{\beta Z_{ij}'}} \qquad [4]$$

Substituting in W_i and X_j for Z_{ij} we derive the following:

$$\Pr(Y_i = j) = \frac{e^{\beta' X_j} e^{\alpha_i' W_i}}{\sum_{j=1}^{J} e^{\beta' X_j} e^{\alpha_i' W_i}} \qquad [5]$$

Terms that do not vary across alternatives (W_i) and are specific to the individual fall out of the probability and we are unable to estimate the effect of individual characteristics upon occupational choice (α), which are invariant to the choice. However, we can estimate β and therefore the effect that occupational characteristics have upon occupational choice, as in McFadden's (1973) fixed effects model.

The conditional logit model makes the assumption that the error terms independently and identically follow an extreme value distribution. The assumption that the error terms are independent across irrelevant alternatives needs to be considered. This assumes, in this case, that the choice between two occupations is independent from the choice of other alternatives (occupations). If we were to add a further occupation into the choice that was irrelevant in terms of the choice between two specific occupations, the relative probability between these two occupations would not change. Hausman and McFadden (1984) formulate a specification test to enable the validity of the Independence of Irrelevant Alternatives (IIA) assumption to be tested. They argue that if omitting a choice does not significantly change parameter estimates, then the assumption holds, and choices are independent from irrelevant alternatives. Two models must be estimated: the first, denoted by subscript l, the model with a full-set of choices, and the second, denoted by subscript d, the model with restricted choice omitting a possible occupational choice from the model. The resultant parameter estimates (β) and covariance matrices (Ω) are recorded and the test statistic, which follows a chi-square distribution, calculated as in equation 6:

$$\chi^2 = (\beta_d - \beta_l)'(\Omega_d - \Omega_l)^{-1}(\beta_d - \beta_l) \qquad [6]$$

If the null hypothesis cannot be rejected, alternative choices are irrelevant and the IIA assumption is valid. If it can be rejected, alternative choices are relevant and the assumption of IIA does not hold.

6.3 Data and Sample

Three data sets are used in the estimation: LFS employment data, HSE data on fatal and major injuries, and Skills Survey data on occupational characteristics.

6.3.1 Sample

DeLeire and Levy restrict their analysis to full-time workers on the grounds that part-time workers will allocate some time to household production, for which risk data are unavailable. The estimation here is conducted for full-time and part-time workers for several reasons. The risk measures created refer to occupations from which all workers, regardless of the number of hours they choose to work in an occupation, should be aware. The risk measures do include part-time workers, and so are applicable to them. Although full-time workers are exposed to a greater risk because of the increased number of hours supplied, part-time workers in certain occupations are still more exposed to risk than in other occupations. Once an occupation has been chosen, an individual could change the number of hours supplied throughout their working life. Hence, current part-time workers in an occupation could have once been full-time workers in the same occupation. We are particularly interested in the occupation choice of part-time workers, as we would expect family group to be an important determinant of whether an individual works part-time or full-time. To exclude them from the estimation would result in a disproportionate elimination of parents from the analysis. To enable comparison however, conditional logit models are also estimated for a sample of full-time workers.

DeLeire and Levy also restrict their estimation to workers aged 25 to 34, arguing that current risk measures are not an accurate measure for older workers, who have accumulated occupation-specific knowledge. However, current risk rates do reflect these older workers, and so control for the fact that older, more experienced workers may be less accident prone. It would therefore bias the sample to leave them out of the estimation. Risk rates reflect workers of all ages, and so it would be inaccurate to restrict the sample to a specific age group, especially given that proneness to accidents may vary with age. Also, as we are considering occupational choice and how this may vary by family structure, we may expect to see variation in choice as family circumstances change. Older workers may have initially based their occupation decision on their current family circumstances. As these circumstances changed, it is likely that they may have revised this decision within some possible margin. The estimation is therefore conducted for workers of all ages. Again for comparison purposes, the estimation is also performed for 25-34 year olds only and compared to the sample of workers of all ages[40].

6.3.2 Accident and Employment Data

Data on occupational risk of fatal and non-fatal injury are provided by the HSE, who compile the data from reports made to them under RIDDOR 1995, as discussed at length in chapter 2.

As the Accident Variable Appendices discusses, there are many important issues to consider when trying to accurately capture the risk of fatality and injury a worker faces. Risk rates are typically calculated by industry or occupation, and then matched into another data set using industry or occupation codes. DeLeire and Levy measure risk by occupation, and Sandy et al. (2001) find this to be the most accurate method. The way occupations are classified also needs to be considered. Risk is more finely distinguished the greater the number of occupations, but "if the categories are too fine compared to the number of workers in the economy and the accidental death rate, most of the occupations will have zero recorded deaths" (Sandy et al., 2001, p.55). In addition, fatalities at work are rare, and so in order to capture accurately the true risk of a particular occupation, it is important to use data that spans over a longer period than may be the case when constructing other variables. Therefore, numbers of fatalities and major injuries from RIDDOR reports for 2002/03, 2003/04, and 2004/05 measured according to occupation SOC 2000 are compiled.

[40] Self-employed workers are excluded from the estimation. RIDDOR does not require injuries to the self-employed that occurred at their own premises to be reported, and so their inclusion would bias the results.

LFS September-November quarter data for the years 2002, 2003 and 2004 are merged to provide data on the number of workers employed in each occupation. With a large sample size that includes detailed information on occupation, marital status, and number of children, this enables workers to be divided according to family group.

Table 6.1: Men and Women in Employment (2004) and Average number of Fatal and Major Injuries at Work (2002/03, 2003/04, 2004/05)

	Numbers
EMPLOYMENT	
Men	12338061
Women	11937856
Fraction Men	0.508
FATAL INJURIES	
Men	207.3
Women	8.3
Fraction Men	0.962
MAJOR INJURIES	
Men	22006.7
Women	7912.3
Fraction Men	0.736

Source: LFS (2004); LFS (2002-2004); HSE (2002/03, 2003/04, 2004/05)

Table 6.1 compares the number of workers in employment in 2004 to the average number of fatalities and major injuries between 2002/03-2004/05. Men are shown to have made up 50.8 per cent of full time and part time employment. However, 96.2 per cent of fatal injuries and 73.6 per cent of major injuries at work were to men, which is disproportionate to the percentage of male employees. This confirms that men are more likely to have an accident at work than women.

The LFS is used to convert the occupational fatality and injury numbers into rates. Given the measurement issues regarding risk previously discussed, risk rates are calculated according to 2 digit SOC 2000, giving a total of 25 occupations to minimise the number of zero accident rates[41]. Non-gender-specific rates are calculated[42], but male-specific measures are later considered. A fatal rate per 100 full-time and part-time workers and a major injury rate per 100 full-time and part-time workers are calculated for each occupation[43]. In addition, the fraction of female workers employed in each occupation (full-time and part-time) is also calculated[44]. The appropriate fatal and major injury rates are then assigned to each worker in the LFS sample according to their 2 digit occupation. Table 6.2 reports the rates for each occupation in order of the highest fatal accident rate. This reveals that 4 of the 25 occupations have a zero fatal rate, compared to DeLeire and Levy's analysis where 2 of their 44 occupations have a zero death rate. Sandy et al. suggest assigning the average risk in a sample to occupations with a zero death rate. However, they find that this does not make a substantial difference to estimates as average risk is usually very close to zero. We therefore proceed assigning zero risk to these occupations, as in DeLeire and Levy.

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[41] Estimations are also conducted using 3 digit SOC for comparison, discussed in the occupational gender segregation section.

[42] It is not possible to split accurately the number of accidents by gender and family composition. As DeLeire and Levy comment "there are too few fatalities and too few women in the occupations with the most fatalities to calculate reliable gender-specific risks of death" (p.942). The same applies to family structure. We are therefore overstating the risk women face and understating the risk men face.

[43] Death rate per 100 workers=(total fatal injuries/total workers)*100
Major injury rate per 100 workers=(total major injuries/total workers)*100

[44] Fraction female=female workers/total workers

Table 6.2: Occupational Fatal and Major Injury Rates per 100 Workers and Fraction of Female Workers

SOC 2000	**Fatal Rate per 100 Workers**	**Major Injury Rate per 100 Workers**	**Fraction Female**
51 Skilled Agricultural Trades	0.01886	0.30009	0.07952
91 Elementary Trades, Plant & Storage Related Occupations	0.00716	0.74740	0.14773
81 Process Plant & Machine Operatives	0.00636	0.92697	0.21928
53 Skilled Construction & Building Trades	0.00631	0.50353	0.00715
82 Transport & Mobile Machine Drivers & Operatives	0.00568	0.60828	0.03602
52 Skilled Metal &Electrical Trades	0.00333	0.38961	0.01313
33 Protective Service Occupations	0.00265	0.70791	0.17359
12 Managers & Proprietors in Agriculture & Services	0.00208	0.16311	0.37585
21 Service & Technology Professionals	0.00156	0.17985	0.13367
92 Elementary Admin & Service Occupations	0.00120	0.29944	0.48224
31 Science & Technology Associate Professionals	0.00088	0.17179	0.20944
62 Leisure & other Personal Service Occupations	0.00073	0.18632	0.61903
11 Corporate Managers	0.00052	0.06802	0.29954
54 Textiles, Printing & Other Skilled Trades	0.00051	0.20847	0.30554
34 Culture, Media & Sports Occupations	0.00027	0.70791	0.39251
61 Caring Personal Service Occupations	0.00023	0.22486	0.89811
71 Sales Occupations	0.00020	0.19486	0.64019
24 Business & Public Service Professionals	0.00018	0.04831	0.34594
42 Secretarial & related Occupations	0.00008	0.05014	0.97174
41 Administrative Occupations	0.00005	0.06233	0.71360
35 Business & Public Service Associate Professionals	0.00005	0.03538	0.42006
72 Customer Service Occupations	0	0.13093	0.66393
32 Health & Social Welfare Associate Professionals	0	0.11504	0.80230
23 Teaching & Research Professionals	0	0.11211	0.61981
22 Health Professionals	0	0.04648	0.39934

The two occupations with the greatest fatal rate are Skilled Agricultural Trades (8 per cent of workers are female), and Elementary Trades, Plant and Storage Related Occupations (15 per cent of workers are female). The occupations with the least risk are Health Professionals (40 per cent female) and Teaching and Research Professionals (62 per cent female). The UK death rate is lower than that calculated by DeLeire and Levy for the US. Their greatest death rate is calculated as 0.0872 per 100 workers compared to 0.0189 per 100 workers here. However, rates here include part-time workers and so we would expect the risk to be slightly lower. Also, the overall fatality rate at work is slightly greater in the US compared to the UK, where there are several differences in the enforcement policies of health and safety legislation, as discussed in chapter 2.2.2.

The correlation between the fatal rate per 100 workers for each occupation, and the fraction of female workers employed in each occupation is reported in Table 6.3 and shown in Figure 6.1. The correlation is significantly negative, indicating that occupations with the highest death rates are associated with fewer female employees.

Table 6.3: Correlation between Log Fatal and Fraction Female

		Fraction of Female Workers	**Log Fatal**
Log Fatal	Pearson Correlation	-0.767**	1
Log Major Injury	Pearson Correlation	-0.522**	0.757**

** Correlation is significant at the 5% level

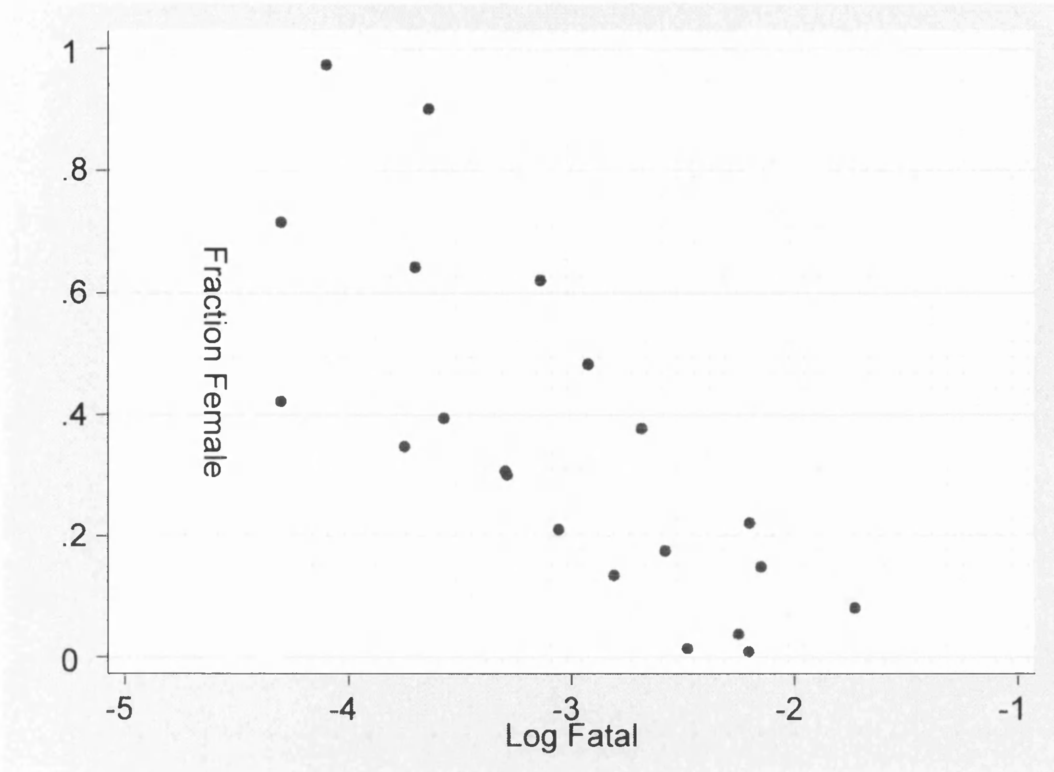

Figure 6.1: Correlation between Log Fatal and Fraction Female

Table 6.3 and Figure 6.2 show the correlation between the major injury rate and the fraction of female workers is also significantly negative. As expected, the correlation is slightly lower than the correlation between the fatal rate and the fraction of female workers which may be due to a stronger aversion to risk of fatality.

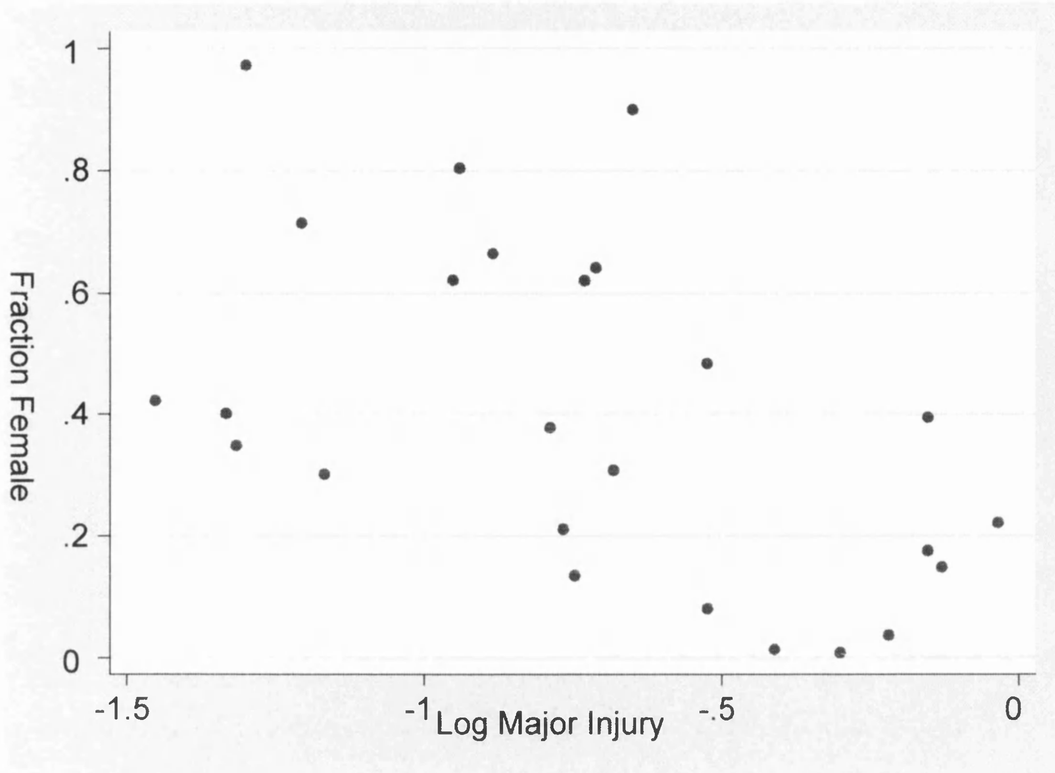

Figure 6.2: Correlation between Log Major Injury and Fraction Female

To check the accuracy of the occupational risk estimates, Table 6.3 shows there is a significant positive correlation between the fatal rate and major injury rate. This confirms that occupations with a high fatal rate are also likely to have a high major injury rate. The fact that the correlation is strong but not perfect means the effect of both an occupations fatal and major injury rate can be estimated separately.

6.3.3 Occupational Characteristics

In order to estimate the effects risk of death and injury have upon occupational choice, other characteristics associated with each occupation must be controlled for. This is particularly important when comparing what influences occupational choice between different groups of workers as specific groups may have particular preferences. For example, men may be more likely to work in physically demanding occupations, and women in occupations requiring more caring skills[45]. In addition, employers may have different demands such as requiring workers to have a certain amount of strength and stamina in physically demanding jobs. By including controls for occupational attributes, in addition to the risk of fatal and major injury rates, we are able to consider their effect upon occupational choice and how this varies between groups.

Occupational attribute variables are created using the Skills Survey 2001, which surveyed 4470 individuals aged 20-64 in Great Britain. The questions utilised here asked workers how important a particular skill or attribute was to their work. Table 6.4 lists the variables and definitions to be used in the estimation.

Table 6.4: Occupational Attributes Variables

Variable Name	**Occupational Attribute**
STRENGTH	Physical strength
STAMINA	Physical stamina
HANDS	Skill or accuracy in using hands or fingers
TOOLS	Knowledge of how to use or operate tools
WRITELG	Writing long documents
CALCA	Adding, subtracting, multiplying or dividing numbers
STATS	Calculations using advanced mathematical or statistical procedures
CARING	Counselling, advising or caring of customers or clients
SPECIAL	Specialist knowledge or understanding
ANALYSE	Analysing complex problems in depth
MYTIME	Organising own time
USEPC	Using a PC or other computerised equipment
SPEECH	Making speeches or presentations
PERSUADE	Using persuasion
LISTEN	Listening to customers or clients
MOTIVATE	Motivating staff
FUTURE	Making decisions that affect the future of the company
PERCENTC	Percentage of workers covered by union terms and conditions

Variables created from the Skills Survey 2001

Each variable takes a value from 0-4, with 4 defined as essential to the work, and 0 defined as not at all important. The mean of each attribute for each occupation is then calculated using 2 digit SOC 2000. The means are reported in Appendix 6.1. In

[45] Thewlis et al. (2004) discuss this.

addition, the percentage covered by union terms and conditions has been calculated for each occupation using the LFS.

All skills variable means are as would be expected. In terms of the physical variables for instance, low means for *strength*, *stamina*, *hands* and *tools* are calculated for Corporate Managers (11), Administrative Occupations (41), and Business and Public Service Associate Professionals (35), indicating these skills are relatively unimportant for these occupations. In contrast, they are very important for working in Skilled Agricultural Trades (51), Skilled Metal and Electrical Trades (52), and Skilled Construction and Building Trades (53).

Appendix 6.2 reports correlations between all skills variables, fatal and major injury rate variables, and the fraction female in each occupation. *Fatal* and *major injury* are positively and significantly associated with *strength*, *stamina*, *hands* and *tools*. As would be expected, occupations that require physical skills are associated with a higher fatal and major injury rate. In contrast, *usepc* and *persuade* are negatively associated with both fatal and major injury rates. Fraction female is significantly positively correlated with *caring* and *listen* skills, indicating that women are more likely to work in occupations that require these attributes. Also, it should be noted that there are no perfect correlations between variables, which allows the effect of each variable to be estimated separately.

Standardised scores (z statistics) are calculated for each of the occupational attributes variables to check the significance of their variation between the 25 occupations, as shown by equation 7:

$$Z=\frac{X-\overline{X}}{\sigma} \qquad [7]$$

Where X is the calculated value for each occupation (as listed in Appendix 6.1), $\overline{X}$ is the mean value, and σ the standard deviation. A Z statistic of 1.96 (plus or minus) indicates significant variation at the 5 per cent level. Appendix 6.3 lists the calculated Z statistics for each attribute for each occupation. Results show there to be no significant variation between occupations for variables *writelong*, *stats*, *special*, *usepc*, and *future*. Therefore, in addition to a model with all attribute variables included, the model is also estimated excluding these five variables to ensure it does not affect the pattern of results[46].

6.3.4 Family Variables

The finding that risk has a greater negative impact upon occupational choice for women could be due to direct discrimination by employers, which forces women to work in safer jobs regardless of their preferences. It could also take the form of indirect discrimination, for instance with schools portraying stereotypical womens' jobs, which are relatively less hazardous occupations. As it is less likely, although possible, that this type of discrimination occurs according to family structure, the model is estimated also by family structure. This enables us to determine whether workers sort into occupations according to preferences for risk, which are likely to vary according to whether a person is married and/or has children.

[46] It was decided it was appropriate to estimate the model including all attribute variables as each is significant in the estimations, as results will later show.

Separate samples of workers are created according to gender, marital status, and whether a worker has children[47], using data from the LFS. Table 6.5 describes the groups created, and the fraction of the whole sample to which each contributes. The groups with the greatest number in the sample are those married with children and married with no children. By contrast, separated, divorced or widowed men with children make up the smallest fraction of the sample. The mean fatal and major injury risk for each family composition group is reported.

Men face an average risk of 0.0027 per 100 workers, compared to an average of 0.0007 per 100 workers for women. As predicted, women work in safer occupations. There is no significant difference in risk rates between family groups however, in this purely descriptive analysis.

[47] Where a child is defined as a dependent under the age of 19.

Table 6.5: Descriptive Statistics by Family Composition

	All Men		**Single Men no Children**		**Single Men with Children**		**Married Men no Children**		**Married Men with Children**		**SDW Men no Children**		**SDW Men with Children**	
Obs	*42326*		*9718*		*3800*		*11477*		*13222*		*3064*		*883*	
Fraction	*1.00*		*0.2296*		*0.0898*		*0.2712*		*0.3124*		*0.0724*		*0.0209*	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Fatal	0.0027	0.0034	0.0027	0.0035	0.0029	0.0034	0.0028	0.0035	0.0025	0.0033	0.0030	0.0034	0.0030	0.0033
Major Injury	0.3021	0.2620	0.3011	0.2599	0.3535	0.2519	0.2975	0.2605	0.2847	0.2628	0.3278	0.2688	0.3436	0.2765

	All Women		**Single Women no Children**		**Single Women with Children**		**Married Women no Children**		**Married Women with Children**		**SDW Women no Children**		**SDW Women with Children**	
Obs	*38456*		*7344*		*4385*		*10270*		*10537*		*3406*		*2374*	
Fraction	*1.00*		*0.1910*		*0.1140*		*0.2671*		*0.2740*		*0.0886*		*0.0617*	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Fatal	0.0007	0.0016	0.0006	0.0015	0.0007	0.0014	0.0007	0.0018	0.0006	0.0015	0.0007	0.0016	0.0007	0.0015
Major Injury	0.1673	0.1611	0.1559	0.1635	0.2021	0.1488	0.1656	0.1684	0.1574	0.1486	0.1736	0.1771	0.1804	0.1618

SDW=Separated, Divorced or Widowed
Cohabiting unmarried couples are classified as single

6.4 Conditional Logit Estimation Results

The conditional logit model is utilised as outlined in chapter 6.2. As we are interested in how the effect of occupation-specific variables upon occupation choice varies between specific groups of workers, the model is estimated separately by gender and family structure (the groups listed in Table 6.5). The complete results from the conditional logit estimation for full-time and part-time workers of all ages are presented in Appendix 6.4. Table 6.6 presents the estimated coefficients for *fatal* and *major injury* from the fourteen estimations.

First, consider the occupational attributes variables. Overall, as expected, *strength* has a greater positive effect upon occupational choice for men than for women. Women are more likely to choose an occupation that requires *hands* skills, with the coefficient significantly negative for men (-1.526) and significantly positive for women (2.778). A further significant difference in the estimated coefficients between the male and female samples concerns the variable *listen*, with the effect upon occupational choice significantly negative for men (-2.311), but significantly positive for women (2.928). F tests reveal occupational attributes are highly jointly significant in all estimations.

In terms of the risk variables, risk of death has a greater negative effect upon women's occupational choice compared to men's. For men, *fatal* has a coefficient of -165.4, whilst for women a coefficient of -216.3 is found, both of which are significant at the 1 per cent level.

Table 6 6: Conditional Logit Fatal and Major Injury Estimates by Family Group (Full-Time and Part-Time Workers of all Ages)

	MEN	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No. of obs	42326	9718	3800	11477	13222	3064	883
Log Likelihood	-125645.270	-29236.078	-10533.593	-33709.450	-37941.839	-9013.120	-2542.427
Fatal							
Coefficient	-165.416***	-87.731***	-201.841***	-151.900***	-186.466***	-163.888***	-199.728***
Standard error	(4.567)	(9.864)	(20.059)	(8.630)	(8.373)	(17.193)	(33.687)
Major Injury							
Coefficient	2.964***	1.152***	2.235***	2.783***	4.352***	3.485***	4.503***
Standard error	(0.083)	(0.173)	(0.371)	(0.156)	(0.144)	(0.305)	(0.571)

	WOMEN	**Single Women no children**	**Single Women with children**	**Married Women no children**	**Married Women with children**	**SDW Women no children**	**SDW Women with children**
No. of obs	38456	7344	4385	10270	10537	3406	2374
Log Likelihood	-105311.010	-20647.331	-10530.944	-27952.729	-28508.339	-9358.235	-6390.861
Fatal							
Coefficient	-216.274***	-242.929***	-235.515***	-164.324***	-207.882***	-247.424***	-279.922***
Standard error	(8.932)	(26.218)	(43.221)	(13.675)	(16.383)	(41.592)	(45.792)
Major Injury							
Coefficient	0.187***	0.990**	0.640	-0.161	-0.165	1.332**	1.039
Standard error	(0.158)	(0.400)	(0.646)	(0.289)	(0.309)	(0.605)	(0.730)

Data: LFS 2002-2004, Skills Survey 2001, HSE 2002/03-2004/05.
Other variables included in estimation: Strength, Stamina, Hands, Tools, Writelg, Calca, Stats, Caring, Special, Analyse, Mytime, Usepc, Speech, Persuade, Listen, Motivate, Future, and Percentc
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Considering the within-gender family composition estimations results, in the male samples, having children is always associated with a greater negative *fatal* coefficient. The least risk averse group are single men with no children, with a significant coefficient of -87.7 estimated. As predicted, single men with children are the male group most likely to work in the safest occupations, with a significant *fatal* coefficient of -201.8 estimated. For the female estimations, the presence of children increases aversion to risk at work for all groups except single women, where the coefficients are similar in magnitude. Results are in line with expectations.

To interpret the relative magnitudes of the between group coefficients, simulations similar to those carried out by DeLeire and Levy are conducted. First, as generally single parents are found to be the most averse to risky work, the reduction in risk each of the other family groups would face if their preferences were the same as that of a single parent is calculated. Predicted probabilities, P_j, are calculated for each group using the conditional logit estimates. Average predicted risk for each group is then calculated according to equation 8 where r_j refers to the actual risk associated with each occupation.

$$\text{Average predicted risk} = \sum_j r_j P_j \qquad [8]$$

For men, the coefficient on fatal risk is set equal to that estimated for single men with children, and a new set of predicted probabilities calculated for each occupation. The average predicted risk each group would face if they had the same preferences as single fathers can then be calculated. The process is repeated for women.

Single men without children would face a 37 per cent lower risk of death if preferences towards risk were the same as those of single men with children. Married men with children would work in occupations that were 6 per cent safer, and married men with no children in occupations that were 19 per cent safer. Risk would be 14 per cent lower for SDW men with no children, and 1 per cent lower for those with children. Married women with no children would face a 22 per cent lower risk of death at work if their preferences were the same as single mothers. For married women with children, risk would be 9 per cent lower.

As a further way of assessing whether the differences in risk coefficients between family groups is significant, a further model was tested for a pooled sample of male and female workers. Family group dummy variables were derived and multiplied by the fatal risk rate to create a set of interaction variables. Each family interaction variable was then included in the conditional logit model, excluding the single men with no children variable. In addition, a *female*fatal* variable was derived and included. Table 6.7 presents results. A significant coefficient of -233.33 was estimated for *female*fatal* indicating women have a significant greater aversion to risk at work compared to men. Other results follow the same pattern estimated in the original model, with single and married women with children the most averse to risk compared to single men with no children, with both interaction coefficients significantly negative.

Table 6.7: Conditional Logit Estimates: Pooled Sample

	POOLED SAMPLE
No Obs	*90530*
Log likelihood	*-272021.92*
Pseudo R^2	*0.0632*
Strength	2.976*** (0.050)
Stamina	-3.729*** (0.077)
Handskill	-0.189*** (0.034)
Tools	-0.109*** (0.041)
Writelong	-0.607*** (0.047)
Calca	-0.231*** (0.035)
Stats	0.545*** (0.043)
Caring	0.070*** (0.019)
Special	-0.029 (0.058)
Analyse	-0.814*** (0.034)
Mytime	1.272*** (0.055)
Usepc	-0.185*** (0.022)
Speech	0.488*** (0.056)
Persuade	-0.547*** (0.062)
Listen	-0.055 (0.048)
Motivate	0.098** (0.049)
Future	0.977*** (0.050)
Percentc	0.008*** (0.001)
Fatal	-138.666*** (4.152)
Major Injury	2.105*** (0.063)
Female*Fatal WOMEN	-233.334*** (50..551)
Singmch*Fatal	-7.604

SINGLE MEN WITH CHILDREN	(4.883)
Marm*Fatal MARRIED MEN	3.352 (3.561)
Marmch*Fatal MARRIED MEN WITH CHILDREN	-3.461 (3.533)
Sdwm*Fatal SDW MEN	15.829*** (5.109)
Sdwmch*Fatal SDW MEN WITH CHILDREN	26.179*** (8.337)
Singf*Fatal SINGLE WOMEN	-75.940 (51.184)
Singfch*Fatal SINGLE WOMEN WITH CHILDREN	-115.291** (51.644)
Marf*Fatal MARRIED WOMEN	-47.308 (50.897)
Marfch*Fatal MARRIED WOMEN WITH CHILDREN	-107.560** (51.057)
Sdwf*Fatal SDW WOMEN	-62.042 (51.728)
Sdwfch*Fatal SDW WOMEN WITH CHILDREN	-54.620 (52.354)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

Major injury estimates are positive in all of the male sample regressions. For women, a negative but insignificant coefficient is found for married women. DeLeire and Levy also find a positive coefficient for their non-fatal injury variable in all of their regressions. As reported earlier, the *fatal* and *major injury* variables are collinear with a significant correlation coefficient if 0.757, possibly explaining the positive sign when both variables are included in the model. Therefore, the estimation is repeated for each family group, first with just *fatal,* and then with just *major injury.* The estimated coefficients are reported in Appendix 6.5.

The effect of excluding the major injury variable has little impact upon the estimated *fatal* coefficients. For men, groups with children are still the most averse to risk with greater negative coefficients estimated for *fatal* compared to childless groups. This is especially true for men with no partner. Single men with no children are found to be the least averse to risk. For women, those married with children remain the most averse to risk.

Now consider the effect of excluding *fatal* from the model. *Major injury* remains either insignificant or positive for male groups except for single men with children where the coefficient is negative but insignificant. For women however, *major injury* is significantly negative for all estimations. Furthermore, the magnitude of the coefficient follows the predicted pattern, with groups with children having a greater negative *major injury* estimate. The role of the major injury variable therefore, appears to be relatively more important for female occupational choice compared to male occupational choice.

To enable direct comparison with DeLeire and Levy, the estimations are repeated for a sample of full-time workers aged 25-34. The estimated coefficients for *fatal* and *major injury* are reported in Appendix 6.6. Again, women are more risk averse than men, with the *fatal* coefficient estimated as -158.041 for women and -83.229 for men. For the male family groups, having children increases the aversion to risk, as before. For women however, *fatal* is insignificant for single women with children. This is likely to reflect the small sample size of only 490 for this group, as there are few single mothers in this age bracket working full-time. For married women, the coefficients are significantly negative for those with and without children and similar in magnitude.

Following the results of the standardised score in which the variation of the occupational attributes variables between occupations was considered, the conditional logit model is re-estimated excluding the five variables with no significant variation (*writelong*, *stats*, *special*, *usepc* and *future*). The death and major injury estimates are reported in Appendix 6.7. Excluding these five explanatory variables has no effect upon the pattern of results between groups for the death variable. The only difference in the results concerns the major injury variable. Whereas in the previous estimation with all variables included the major injury variable was never significantly negative, when the five variables are excluded, major injury is significantly negative for all of the female estimations. Furthermore, the major injury coefficient follows the pattern expected, being greater for all groups with children. It may therefore be that the five excluded variables were correlated with major injury and hence affected the coefficient when included.

Overall, results indicate women are more averse to risk than men in terms of their occupational choice. This could be due to women preferring safer work, or due to labour demand factors. Within gender, risk has different effects upon occupational choice according to family structure in the predicted way. This may partly be attributed to paternalistic attitudes in the part of the employer, although this would imply that employers distinguish between applicants on the basis of the presence of children in the family. Legislation in the UK does not allow interviewers to ask potential employees questions related to their marital or family status. This result therefore, suggests that preferences for risk do affect occupational choice in the UK.

6.4.1 Independence of Irrelevant Alternatives

As discussed in chapter 6.2, the conditional logit model assumes the error terms are independent across irrelevant alternatives. In this case, this requires the choice between two occupations to be independent from the choice between other occupations. If the IIA assumption does not hold, this could lead to inconsistent estimates. Hausman and McFadden (1984) formulate a method to enable the IIA assumption to be tested. Two models must be estimated: the first, denoted by subscript f, the model with a full-set of choices, and the second, denoted by subscript r, the model with restricted choice (omitting an occupation choice from the model). The resultant parameter estimates (β) and covariance matrices (Ω) are recorded and the test statistic (equation 5), which follows a chi-square distribution, calculated.

The calculated test statistic is compared to the relevant value from the χ^2 distribution. If the test statistic is significantly greater, given by the probability value (p value), then the estimates are significantly different and the null hypothesis, and therefore the IIA assumption, is rejected. If the null hypothesis cannot be rejected, alternative choices are irrelevant and the IIA assumption is valid.

DeLeire and Levy conduct Hausman and McFadden tests for the validity of the IIA assumption, although they do not report the full results. They do however, note that "we reject that the coefficients are the same, which is equivalent in this case to rejecting the IIA property of the conditional logit model" (p.942). The choice of one occupation over another is therefore influenced by the existence of other occupations. The IIA assumption may therefore be quite difficult to satisfy in a model of occupation choice. DeLeire and Levy do not discuss the implications of this result for the estimates of their model. This could be because they are solely interested in comparing the estimates (especially the risk estimates) between models rather than the effect of each estimate upon occupational choice. They may have therefore concluded that the failure of the model to satisfy the IIA assumption does not affect the main conclusion of their paper: that preference for risk vary by gender and family structure with this translating into differences in occupation choice.

Table 6.8: IIA Test Results

Omitted Occupation	**MEN**		**WOMEN**	
SOC 2000 (2 digit)	Test Statistic	P value	Test Statistic	P value
11	1708.88	0.0000	2.86	0.9993
12	1837.43	0.0000	208.34	0.0000
21	2022.86	0.0000	337.94	0.0000
22	1.14	1.0000	182.60	0.0000
23	1211.88	0.0000	34.34	0.0114
24	72.13	0.0000	30.33	0.0477
31	490.04	0.0000	82.46	0.0000
32	582.82	0.0000	356.99	0.0000
33	665.34	0.0000	926.99	0.0000
34	555.87	0.0000	637.70	0.0000
35	1167.14	0.0000	329.66	0.0000
41	1041.09	0.0000	367.52	0.0000
42	1473.91	0.0000	105.14	0.0000
51	26.31	0.0033	879.03	0.0000
52	663.76	0.0000	73.09	0.0000
53	32.81	0.0253	245.28	0.0000
54	1606.76	0.0000	106.08	0.0000
61	20.56	0.3023	250.78	0.0000
62	148.93	0.0000	4.39	0.9995
71	85.38	0.0000	126.83	0.0000
72	76.51	0.0000	293.90	0.0000
81	49.54	0.0002	865.50	0.0000
82	1136.13	0.0000	191.15	0.0000
91	444.96	0.0000	627.42	0.0000
92	147.62	0.0000	11.95	0.5315

To test whether the IIA assumption holds in the model here, Hausman and McFadden tests are conducted. Separate tests are conducted for men and women. In total, 25 tests are conducted separately for men and women, omitting each occupation in turn. The results are presented in Table 6.8.

Most of the tests resulted in large test statistics, which are significantly greater than the critical χ^2 value. In these cases (where the p value is equal to 0.0000) the null hypothesis that differences in estimates are not significant is rejected, and the IIA assumption does not hold. The IIA assumption does hold however, for men when occupations 22 and 61 are omitted, and for women when occupations 11, 62 and 92 are omitted.

As an alternative to the conditional logit model, a nested logit model can be used if the IIA test fails. To confirm the reliability of the estimates given that the model fails the IIA assumption therefore, a nested logit is estimated. The 25 occupations are grouped into manual and non-manual occupations[48] and the model estimated by family group[49]. Appendix 6.8 reports the estimated coefficients for *fatal* for each family group. The pattern of results is the same as in the conditional logit model. Women are more averse to *fatal* in occupational choice. Children and marriage also increase aversion to risk. This confirms that failure to satisfy the IIA assumption in the conditional logit model does not affect the pattern of results. The conclusions reached remain unaffected.

6.5 Further Tests

The conditional logit estimates suggest that workers have different preferences for risky work according to gender and family structure, and this in turn leads to a degree of occupation sorting. However, to be sure that the estimation results are confirming

[48] In SOC 2000 codes, manual occupations are 51,52, 53, 54, 61, 62, 81, 82, 91, 92 and non-manual occupations are 11, 12, 21, 22, 23, 24, 31, 32, 33, 34, 35, 41, 42, 71, 72.

[49] The nested logit model is estimated with fewer variables than the conditional logit model because of problems with collinearity. *Strength* was dropped and a variable *strong* created for manual and also non-manual occupations (the variables therefore has only 2 values). It was not possible to estimate the model with more manual and non-manual specific variables. *Major injury* was also dropped from the model.

this hypothesis, it is necessary to consider a number of other possibilities that may be causing or biasing the results.

As a persons' occupation itself may influence whether they get married and/or have children, family structure may be endogeneous. For instance, as DeLeire and Levy speculate, "individuals who choose dangerous occupations may have difficulty attracting a spouse" (p.941). The extent at which workers sort into occupations based on preferences determined by their family composition may hence be over-estimated. Other results therefore, rely on the assumption that family structure is exogenous.

6.5.1 Gender-Specific Variables

A further issue relates to the occupational risk variables. DeLeire and Levy consider the possibility that within a given occupation, men are less careful than women. Therefore, "for a given occupation the risk of death facing women would be lower than the risk of death facing men if it were possible to measure these separately" (p.942). Indeed, as shown in Table 6.1, in the UK men were the victims of 96.2 per cent of fatal accidents between 2002-04. By using the average risk in an occupation therefore, we are overstating the risk women face and understating the risk men face. However, as DeLeire and Levy emphasise, "there are too few fatalities and too few women in the occupations with the most fatalities to calculate reliable gender-specific risks of death" (p.942). For instance, taking the previously calculated average death risk variables, the two riskiest occupations are Skilled Agricultural Trades and Skilled Construction and Building Trades, where only 8 per cent and 15 per cent of employees are female[50]. In order to calculate a female-specific rate, the number of female fatalities between 2002-05 would be divided by the number of female workers.

[50] See Table 6.2

But with so few female employees within these two occupations, the likelihood of there being any fatalities during this time period, as a relatively rare event, would be very small. Female risk measures would fail to reflect the true risk of fatality in occupations where there are few female employees. If, as results here suggest, women prefer to work in safer occupations, there is a degree of endogeneity; women are not employed in risky occupations because they are more averse to dangerous conditions, and so death rates for women will not reflect the true risk.

Male-specific measures are however, derived and reported in the Accident Variable Appendices. T tests show there are significant differences between the male-specific and collective means. The order of risky occupations however, remains the same.

6.5.2 Demographic Characteristics

It is important to ensure that the observed results between family groups are not due to the correlation between family structure and other demographics. For example, education could be correlated with family group, which in turn could determine aversion to risk and consequently occupation choice. Therefore, following DeLeire and Levy, we need to ensure that the pattern of results is due to family group and not due to differences in education, race and union status.

Three sets of dummy variables are created using the LFS data. First, education variables denote if an individual's highest qualification is a degree, A level, GCSE, or whether the individual has no qualifications. Second, race variable dummies denote if a respondent is white or non-white. Finally, union dummies denote whether a respondent is a member of a trade union or not. Appendix 6.9 reports the mean and standard deviation of each of these dummy variables for each family group. As their main observation of the differences between family groups, DeLeire and Levy find that single parents have lower levels of education than any other group. It is also shown here that single men and women with children are much less likely to have a degree, compared to other groups, with it most likely that their highest qualification is a GCSE.

Three sets of models are estimated, separately for each of the family groups, including all variables as before except for the death rate variable. *Fatal* is interacted with the four education dummies in the first model, and these four interaction variables are added to the model. The same method is applied to a model for race and a model for union status. The estimated interaction coefficients from the 3 models are shown in Appendix 6.10.

Consider the model with the education interaction variables. As expected, individuals with more education place a greater negative weight on risk of death when making their occupation choice. For all family groups, having a degree results in the greatest risk aversion, whilst having no qualifications results in the least aversion to risk. However, the pattern of aversion remains the same as before between family groups. For example, taking the variable *fatal*degree*, a greater negative coefficient is observed for women (-630.069) compared to men (-525.004). Within family groups, having children still results in a greater negative coefficient for all education interaction variables. Those that are married are the most averse, whereas the original estimation found that single parents were the most averse to risk. It appears that this result was being driven by differences in education between the groups[51]. The overall pattern of risk aversion however, remains unchanged.

For race, the *fatal*white* variable again shows women to be the most averse to risk. For men and women, having children increases the aversion, with single parents, and separated, divorced or widowed men with children remaining the most averse. For women, as before, separated, divorced or widowed women with no children and married women with children are the most averse. The same pattern of results is shown for the union status model.

Overall, estimating the model with race and union interaction variables makes no difference to the pattern of results. The inclusion of education interaction variables however, shows the single parents result is driven by differences in education, with married parents shown to be the most averse to risk. Overall however, in terms of occupation choice in the UK, family structure and gender are driving the aversion to risk in the occupation decision, rather than the differences in other demographics between the groups.

6.5.3 Occupations Requiring Absences from Home

DeLeire and Levy consider the possibility that risky occupations may also require absences from home, resulting in certain groups of workers avoiding them for this reason, not just because they are averse to the high fatality rate. That is, fatal risk could be correlated with absences from home. They re-estimate the model dropping occupations they believe are most likely to involve frequent absences from home:

[51] DeLeire and Levy also find this (p.940)

motor vehicle operators, other transportation, farm workers and forestry and fishing. They find no change in the pattern of results when these occupations are omitted.

To repeat this analysis, consider the occupations that are most likely to require absences from home. Transport and Mobile Machine Drivers and Operatives (82) are likely to require lots of travel (likely to be outside normal office hours). Skilled Agricultural Trades (51) is probably the nearest occupation to what DeLeire and Levy define as farm workers. There may be other occupations however that require frequent absences from home, which would deter, for example, single parents from being employed in such an occupation.

To find out precisely which occupations involve the most working away from home, data from the Skills Survey 2001 is used. The survey asks respondents where their job requires them to mainly work, to which they can answer at home, same grounds as home, at a fixed workplace, at a variety of places or working on the move. Table 6.9 shows for each occupation, the percentage of responses for each option.

Table 6.9: Main Place of Work by Occupation (Full-Time and Part-Time Workers of all Ages) 2001

SOC 2000	At Home	Same grounds as home	Fixed workplace	Variety of Places	Working on the Move
11	5.00	1.60	73.40	18.40	1.60
12	4.00	5.60	73.60	12.80	4.00
21	3.64	1.21	73.33	21.82	0.00
22	0.00	0.00	81.40	18.60	0.00
23	2.41	4.02	80.32	12.85	0.40
24	12.93	0.86	56.03	30.17	0.00
31	5.21	2.08	79.17	13.54	0.00
32	1.05	0.53	71.05	26.84	0.53
33	0.00	0.00	64.00	30.00	6.00
34	16.67	1.11	57.78	23.33	1.11
35	4.06	0.00	67.16	21.77	7.01
41	2.81	0.43	92.21	4.11	0.43
42	4.65	0.58	93.60	1.16	0.00
51	0.00	10.34	37.93	48.28	3.45
52	0.00	0.78	72.55	24.71	1.96
53	0.00	1.37	20.55	77.40	0.68
54	3.03	2.02	83.84	11.11	0.00
61	5.80	1.79	70.09	19.64	2.68
62	3.36	0.96	73.42	20.39	1.87
71	0.80	0.40	89.96	5.62	3.21
72	0.00	0.00	95.24	4.76	0.00
81	0.83	0.83	84.17	14.17	0.00
82	0.00	0.59	30.18	5.92	63.31
91	1.23	2.45	77.30	19.02	0.00
92	0.34	1.03	80.69	10.00	7.59

Data: Skills Survey 2001

The majority of occupations involve mainly working at a fixed workplace. As predicted, Transport and Mobile Machine Drivers and Operatives (82) involve lots of working on the move, with 63 per cent saying their work involves doing mainly this; no other occupation comes close to this in terms of working on the move. There are occupations however, that have a high percentage of respondents saying they work in a variety of places and on the move; for example, for Skilled Agricultural Trades (51) 48 per cent work in a variety of places. However, for this occupation, working in a variety of places is most likely to be defined as working in a variety of fields, within the local vicinity. Skilled Agricultural workers are unlikely to work great distances from home on a regular basis that requires overnight stays. This occupation is therefore unlikely to be avoided because of a dislike for work-related absences from home, and therefore unlikely to deter single parents for this reason alone. For Skilled Construction and Building Trades (53), 77 per cent work in a variety of places. Although this would not always involve working from home, construction workers could regularly be sent out on temporary contracts away from home that would involve spending a certain number of days away. This may deter certain family groups (especially parents) from choosing this occupation.

Following the results of the above analysis, the model is repeated omitting two occupations that involve the most work away from home, and hence the most likely to be avoided by certain family groups. These are Transport and Mobile Machine Drivers and Operatives (82), and Skilled Construction and Building Trades (53). These occupations also have some of the highest death rates (4^{th} and 5^{th}). There could therefore be a correlation between fatality rates and frequent absences from home.

The *fatal* and *major injury* parameter estimates from the conditional logit model omitting the two occupations are reported in Appendix 6.11. We are interested in whether the pattern of results observed before, in terms of the magnitude of the risk coefficients, changes when the two occupations are omitted. Overall, women remain more averse to risky work than men. For both men and women, having children continues to increase aversion to risky work for all groups.

Overall, there are no major differences between this and the previous estimation, indicating that the omission of an absence from home variable is not driving the observed occupation choice pattern between family groups.

6.5.4 Number of Children

In order to consider if the number of children a worker has influences their aversion to occupation risk, the model is re-estimated splitting the family groups further. For each marital status group, a further group for workers with two of more children is created.

Table 6.10: Conditional Logit Estimates: Families with Two or More Children

	Single Men	**Married Men**	**SDW Men**
No. of obs	*1664*	*8439*	*452*
Log Likelihood	*-4461.846*	*-24043.214*	*-1307.148*
Fatal			
Coefficient	-260.406***	-187.396***	-186.492***
Standard error	(31.674)	(10.662)	(47.407)
Major Injury			
Coefficient	2.948***	4.648***	3.907***
Standard error	(0.599)	(0.182)	(0.781)

	Single Women	**Married Women**	**SDW Women**
No. of obs	*1924*	*6448*	*1211*
Log Likelihood	*-4319.771*	*-17251.990*	*-3235.752*
Fatal			
Coefficient	-279.018***	-220.488***	-287.704***
Standard error	(66.239)	(21.063)	(56.343)
Major Injury			
Coefficient	-0.437	-0.510	0.944
Standard error	(1.062)	(0.409)	(0.979)

Data: LFS 2002-2004, Skills Survey 2001, HSE 2002/03-2004/05.
Other variables included in estimation: Strength, Stamina, Hands, Tools, Writelg, Calc, Stat, Caring, Special, Analyse, Mytime, Usepc, Speech, Persuade, Listen, Motiv, Future and Percentc
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Table 6.10 illustrates that the presence of more than one child increases aversion to fatal risk for all groups, compared to the estimation results reported in Table 6.6. This suggests that the greater the number of dependents, the least likely a worker is likely to be employed in an occupation with a high risk of death.

6.6 Occupational Gender Segregation

Having established that gender does appear to influence the effect that risk has upon occupational choice, it would be interesting to calculate the contribution of this to occupational gender segregation. Regardless of whether the observed differences in occupation risk are due to preferences or discrimination, it is still possible to determine how much less occupational gender segregation there would be if all jobs had equal risk rates.

The Duncan and Duncan (1955) Index of Dissimilarity is calculated as shown by equation 9:

$$D=\frac{1}{2}\sum_{j=1}^{J}| f_j - m_j | \qquad [9]$$

where m_j and f_j refer to the predicted number of men and women in occupation j.

Conditional logit models are estimated separately for men and women, and the predicted probabilities used to calculate the Duncan index. To consider whether occupational gender segregation would be less if all occupations had equal risk, risk is counterfactually set equal to the same level in all occupations and a new set of predicted probabilities calculated. In addition to the sample used here, indices are also calculated for full-time workers aged 25-34 years to enable comparison with DeLeire and Levy's US estimates.

Table 6.11: Index of Segregation

	All Workers	Full Time Aged 25-34
Index with Actual Risk	50.4%	44.7%
Index with Equal Risk	48.7%	40.4%
Percentage fall in index	3.3%	9.6%

To achieve an identical distribution of men and women across occupations, 50.4 per cent of women would have to change jobs. However, if risk were equal across occupations, 48.7 per cent of women would have to change occupations. Thus, occupational gender segregation would fall by 3.3 per cent if risk were equal across all occupations. For the full time aged 25-34 sample, occupational gender segregation would fall by 9.6 per cent if risk were equal across occupations. This is still smaller than the effect calculated for the US by DeLeire and Levy, who calculate a large fall in the index from 42.5 per cent to 24.2 per cent. However, there are generally higher risk rates for occupations in the US than in the UK. For instance, the most risky occupation found by DeLeire and Levy (Forestry and Fishing Occupations) has a death rate per 100 workers of 0.0872, whereas for the equivalent sample, the occupation with the highest death rate in the UK (Skilled Agricultural Trades) has a death rate of 0.0223 per 100 workers. We therefore expect risk to contribute less to occupational gender segregation in the UK.

The fineness of the occupation classification will affect the calculated risk rates. Consequently, this breakdown will affect the calculated index of segregation. DeLeire and Levy do not discuss how their breakdown of occupations affects results. For instance, their model is estimated for 44 occupations. If there were fewer occupations, we may expect occupations to be less gender segregated. On the other hand, if they were to increase the number of occupations, gender segregation would rise. Dolton and Kidd (1994) highlight this as being important when considering gender segregation, as "the more detailed the occupation breakdown, the greater the contribution of gender differences in occupation distribution to the overall gender wage differential" (p.461). Therefore, the model is estimated and indices of segregation calculated for 3 digit (81 occupations) occupations according to SOC 2000.

Table 6.12: Index of Segregation with 3 Digit Occupational Classification (81 Occupations)

	All Workers	**Full Time Aged 25-34**
Index with Actual Risk	46.2%	42.7%
Index with Equal Risk	37.6%	37.9%
Percentage fall in index	18.6%	11.2%

The results using the 3 digit breakdown show that occupational gender segregation falls by 18.6 per cent for all workers and by 11.2 per cent for full time workers when risk is equal between 3 digit occupations. As predicted, the contribution of injury risk to gender segregation is more pronounced the finer the classification. This highlights the importance of considering the breakdown of occupations when calculating this index.

6.7 Conclusion

This chapter has highlighted how worker preferences for hazardous work translate into occupation sorting. Using gender and family composition to proxy risk aversion, tests have supported the hypothesis that women prefer safer work. The analysis further shows that within gender, occupation sorting occurs by family structure, with evidence that single parents select into occupations with low accident risk. Workers therefore, do appear to have different preferences for risky work, highlighting the importance of worker heterogeneity. Furthermore, differences in accident risk between occupations contribute to occupational gender segregation, with the degree of segregation falling slightly if there were no differences in accident rates between occupations. The analysis also highlights the importance of measuring risk, with the aggregation of occupations affecting results.

CHAPTER 7

RISK PREFERENCES AND SMOKING BEHAVIOUR

7.1 Introduction

The compensating wage differentials theory centres around the observation that jobs differ in their degree of risk, and workers differ in their willingness to accept such risks with some requiring higher wage premiums than others. Risk aversion therefore varies between individuals, and chapter 6 examines whether we can use gender and family composition to predict how averse a person will be to accident risk. Hersch and Viscusi (1990) however, comment upon the lack of such research, as "the literature has not addressed the differences in wage-risk tradeoffs in great detail" (p.203). Bonin et al. (2006) summarize that in fact "very little is known empirically about how individual attitudes towards risk affect sorting into occupations" (p.2) because in practice risk preferences are difficult to measure. There are likely to be many other personal characteristics in addition to gender and family composition that may help us to recognise which workers will select into relatively more risky occupations.

Evans and Montgomery (1994) consider a person's health, observing that the decision to lead a healthy lifestyle "is not randomly distributed in the population" (p.1). If health habits are revealing a person's value of the future, they could potentially be used to proxy risk aversion. For instance, if a person smokes cigarettes even though they are aware of the health risks, they could be revealing a lower level of risk aversion compared to a non-smoker. This chapter seeks to investigate if there is a relationship between smoking and occupation-specific accident risk.

7.2 Background

The number of smokers in Great Britain has followed a downward trend since the 1970s. Using data from the GHS 2005, the ONS reports that 45 per cent of adults smoked in 1979 which fell to 35 per cent by 1982. It has since declined gradually to 28 per cent in 1998/99 to 25 per cent in 2004/05 (ONS, 2006, p.10). During this period of decline, many medical studies have highlighted the health consequences of smoking. ONS (2006) summarises the key findings. Highlighting the detrimental effect smoking has upon health, 6 per cent (or 560,000) of all hospital admissions of adults aged 35 or over in England in 2004/05 were estimated to be attributable to smoking. Illnesses included cancer, respiratory disease, circulatory disease and digestive system disorders. Lung cancer is the disease most associated with smoking, with 85 per cent of all lung cancer hospital admissions estimated to be due to smoking[52] (ONS, 2006, p.100). In terms of smoking-related deaths, the same report states that in England and Wales in 2004, 18 per cent of deaths amongst adults aged 35 or over were caused by smoking (p.101).

ONS (2006) also reports relative risks of a smoker aged 35 or over dying from various diseases compared to a person who has never smoked[53]. Key relative risk statistics are reported in Table 7.1, with a value greater than one indicating an increased risk of death. As illustrated, smokers face a much greater risk of death from a number of

[52] Including passive smoking.
[53] These figures are derived from Health Education Authority (1998).

diseases because of their smoking compared to someone who has never smoked. The figures for ex-smokers also illustrate how quitting smoking can have a positive impact, with risk of death significantly lower compared to current smokers[54].

Table 7.1: Relative Risks for Fatal Diseases for Current and Ex Smokers by Gender

	Male Smoker		**Female Smokers**	
Disease caused by Smoking	Current Smokers	Ex Smokers	Current Smokers	Ex Smokers
Lung Cancer	26.6	8.2	13.6	4.1
Oesophagus Cancer	5.3	4.0	9.3	3.1
Chronic Obstructive lung disease	14.1	8.4	14.0	8.6
Stomach Ulcer	4.5	1.6	6.4	1.4
Aortic Aneurysm	5.3	2.6	8.2	1.6

Source: ONS (2006) Table B.3 p.133

We need to consider whether people are aware of these large health risks. Government campaigns over recent years have sought to ensure the public are well informed about the dangers of smoking. The Department of Health published white papers in 1998[55] and 2004[56] which set out targets and strategies for reducing the number of smokers. One such strategy was to end tobacco advertisements, and to encourage and help smokers to quit. The campaign has since culminated with a ban on smoking in public places, which since 1st July 2007 has been in place in all parts of the UK. ONS (2005) reports that the public are in favour of the ban, with 91 per cent in favour of it in restaurants, 86 per cent in favour of it in work, and 65 per cent in favour of it in public houses. Given the public support for the ban it seems reasonable to conclude that the vast majority are aware of the health risks of cigarette smoke, both first and second hand.

[54] Although these figures refer to all ex-smokers and do not consider how risk changes with the number of years a person has not smoked, or how heavy a smoker a person was.
[55] *Smoking Kills – A White Paper on Tobacco*
[56] *Choosing Health: Making Healthier Choices Easier*

Compensating wage differential research involves estimating a standard wage equation as depicted by equation 1 in chapter 5. As discussed in chapter 3B.1, long-run points of equilibrium trace out a wage-risk market offer curve; firms locate along it according to their ability to provide job safety, and workers locate according to their preferences. The β estimate obtained through regression analysis is the point of tangency between a firm's wage offer curve and a worker's indifference curve. Individuals select a point on the market offer curve, choosing a particular combination of risk and its equivalent wage premium, based on their attitude towards risk. Workers who are more willing to accept risk will select employment with a relatively large hazard rate and receive a wage premium for this exposure.

Long-run equilibrium in the labour market depends upon both labour supply, in terms of worker preferences for risk and risk compensation, but also upon firms' labour demand for a particular type of worker. Considering first labour supply, Hersch and Viscusi (1990) comment, "there have been only a few attempts to distinguish differences in willingness to bear job risk" (p.203). Levine et al. (1997) comment that "since the pleasures associated with smoking occur today, while the adverse health consequences are largely concentrated in the future, the decision to smoke may reflect a high rate of time preference" (p.494). Smokers could also smoke cigarettes because they value their health less, and so smoking behaviour is simply reflecting a person's preference towards risk. Alternatively, smokers could undervalue the losses they will suffer. Given recent government campaigns designed to increase awareness of the health consequences of smoking, it seems reasonable to conclude smokers have some knowledge of the effects upon their health.

Firms' labour demand could also potentially vary according to workers smoking behaviour, for many reasons. Levine et al. (1997) notes how "mild public intolerance of smoking has developed into fairly widespread hostility" (p.493) which they hypothesise could result in discrimination against smokers that reduces both their wages and employment prospects. They discuss numerous reasons through which smoking could affect worker productivity. The detrimental effect upon a person's health may mean smoking interferes with the ability to carry out manual tasks. Through a similar argument, smokers are likely to have higher absence rates, with Bertera (1991) estimating that smokers miss an average of one additional work day per year due to illness compared to non-smokers. Levine et al. (1997) also cite negative effects on staff morale as a potential reason for smokers to impact upon an entire workforce's productivity. Although Levine et al. (1997) find smokers earn 4-8 per cent less than non-smokers controlling for differences between the groups, they find no evidence that smokers have lower productivity. Viscusi and Hersch (2001) find that smokers are more hazard prone on the job and in their personal actions, and are hence "less efficient in the production of safety" (p.279) with this affecting labour demand for smokers. The argument that smokers have different market opportunities than non-smokers rests upon the assumption that firms are aware of workers' smoking behaviour. As Viscusi and Hersch (2001) emphasise, "firms must either observe smoking status directly or observe other characteristics correlated with smoking status" (p.270). They acknowledge that if this is not observed, labour supply factors alone will determine how smokers, as a proxy for risk preferences, sort into occupations with varying hazard rates.

Hersch and Viscusi (1990) examine the labour supply side of the market, in terms of how smoking behaviour as a proxy for risk aversion influences the risk premium smokers require. The theory predicts that smokers, as relatively less risk averse, should sort into riskier jobs and receive a greater total risk premium than non-smokers for doing so. Smokers however, should require a smaller premium per unit of risk than non-smokers. This proposition is tested using US data. They modify the hedonic wage equation to include a *Risk*Smoke*r variable, as denoted by equation 1:

$$LnY_i = \beta_0 + \beta_1 X_i + \beta_2 R_i + \beta_3 R_i * \text{Smoker} + \varepsilon_i \qquad [1]$$

As predicted, Hersch and Viscusi (1990) estimate a negative β_3 coefficient, indicating that smokers receive a smaller risk premium per unit of increased risk compared to non-smokers.

As an alternative way of investigating the relationship between smoking and risk premiums, Viscusi and Hersch (2001) develop a model that enables them to consider both demand and supply sides of the market. Whereas Hersch and Viscusi (1990) showed that smokers are more willing to work in risky jobs and require a smaller risk premium per unit of risk, Viscusi and Hersch (2001) consider the possibility that smokers also face different market opportunities to non-smokers. If smokers do indeed face different market opportunities, smokers may face a separate offer curve and the econometric model given by equation 1 would not be appropriate. Instead, separate wage regressions would need to be estimated for smokers and non-smokers. Their results indicate that smokers work in occupations with greater hazard rates. Also as predicted, the magnitude of the risk premium is greater in the non-smoker estimation than the smoker estimation, suggesting non-smokers are more risk averse and hence require a larger premium as compensation per unit of risk. However, as smokers are exposed to greater job risk, the theory predicts that total risk payments should be greater for smokers, as they select a point further along the market offer curve. Results show the opposite however, with smokers receiving considerably less total risk compensation than non-smokers. As they comment "such a finding is inconsistent with smokers and non-smokers facing the same wage offer curve" (p.269). Relating back to the arguments for smokers potentially having lower productivity, they suggest that smokers face a lower wage offer curve than non-smokers, with smokers less efficient in the production of safety. As a consequence of such labour demand factors, firms will offer lower wage compensation for smokers. Such a phenomenon however, assumes they observe smoking status.

To summarise, smoking is shown in these two US papers to be a significant predictor of a worker's preferences for risky work with smokers selecting riskier jobs and requiring lower premiums per unit of risk. The relationship between smoking and risk is however, shown to also be influenced by labour demand factors, with firms who observe smoking status offering smaller risk compensation for smokers, possibly because they believe them to be less productive and more hazard prone. Viscusi and Hersch (2001) summarize that "an economically interesting aspect of this heterogeneity is that the pattern of influences suggests that both the supply and demand components of the hedonic market equilibrium vary with smoking status" (p.279). The relationship between cigarette smoking, work-related risk and risk premiums will be investigated using UK data.

As highlighted in chapters 3 and 5, research in the compensating wage differential literature has been plagued by problems of unobserved heterogeneity. Garen (1988) proposes an instrumental variables method for obtaining unbiased estimates of the compensating wage differential. The first stage involves estimating the fatal risk equation [2]:

$$f = \pi_0 + \pi_1 X_1 + \pi_2 X_2 + \pi_3 Z + \eta \qquad [2]$$

where X_2 proxies risk aversion, Z is non-wage income, and η is unobserved heterogeneity. The disturbance term may depend on the wage equation (equation 1) disturbances as workers with unobservable characteristics that make them more productive in risky jobs, will choose higher f. The second stage of the estimation involves estimating equation 3, which uses the disturbances obtained through the risk estimation:

$$Y = R\beta + \gamma_1 \hat{\eta} + \gamma_2 \hat{\eta}.f + \phi \qquad [3]$$

where $\hat{\eta} = f - X\hat{\pi}$ and $\hat{\pi}$ the OLS estimate of π from equation 2. The challenge facing researchers is to find a suitable measure of risk aversion to enable estimation of equation 2. A suitable instrument must be correlated with risk but uncorrelated with the observed determinants of earnings. Instruments are frequently found to be unsatisfactory, and were largely insignificant in risk regressions in chapter 5.

The problem of finding suitable instruments in two-stage estimation is not a problem restricted to compensating wage differentials research. In the returns to education literature for instance, OLS estimates are considered biased because individuals with greater ability will acquire more schooling and thus have greater earnings. To correct for such bias, an instrument that is correlated with schooling but not with ability needs to be found. Evans and Montgomery (1994) using US data test whether a person smoked at 18 is a suitable instrument to use in their estimation of the returns to education. They argue smoking is probably the most suitable health habit to use as an instrument, as "many health habits, such as heavy drinking, may directly effect a worker's current productivity and hence his wage" (p.8). However, subsequent research has shown smokers receive lower wages (Levine et al. 1997) and may also have lower productivity (Viscusi and Hersch 2001). Whether a person smoked at 18 rather than whether they currently smoke however, is unlikely to have an impact upon their current wages or productivity. Using a similar argument to Evans and Montgomery, smoking behaviour, current or past, could be used as an instrument to proxy risk aversion in the compensating wage differential research. If smoking is correlated with risk and uncorrelated with ability, it may be a valid instrument.

This chapter will investigate if there is a relationship between smoking and the injury risk of a person's chosen occupation. If there is a relationship, the appropriateness of using smoking behaviour as an instrument to proxy risk aversion will be considered. Finally, in an analysis similar to Hersch and Viscusi (1990) and Viscusi and Hersch (2001), the premiums that smokers and non-smokers receive for exposure to risk of injury at work will be compared.

7.3 Data and Sample

The BHPS is a nationally representative survey with a stratified clustered sample. In the first wave (1991), approximately 5 000 households were included in the sample, resulting in around 10 000 individual interviews. Individuals are re-interviewed annually, with any new household members also added to the sample. Wave 14 (2004) is the most recent data available, and so this is used as the base data set to provide information on individuals and their current occupation. In each wave the survey asks respondents if they smoke, and so in addition to current smoking behaviour, the BHPS allows variables to be derived relating to if they have classed themselves to be a smoker at any time between 1991 and 2004. In addition, wave 9 asks respondents the age at which they began to smoke. This information can be used to construct variables relating to whether a respondent smoked at age 16 and/or 18, as in Evans and Montgomery (1994).

The sample constructed for this analysis consists of full time workers with respondents from Northern Ireland, the self-employed[57], and those who work less than 30 hours per week excluded[58]. Tests are usually restricted to samples of men as historically men have had higher smoking rates, with the male smoking rate declining in the 1960s and the female rate increasing in the 1960s and then declining in the late 1970s (Evans and Montgomery, 1994, p.29). Farrell and Fuchs (1982) argue that the male rate declined because of an increase in health risk knowledge, but "female smoking trends were confounded by other broader social trends" (p.226). Supporting this view, in using smoking behaviour as an instrument for ability in education estimations, Evans and Montgomery find the negative correlation between smoking and education to be much weaker among women than among men. In total, three samples are constructed; one for men and women, and also for men and women separately.

The average occupational injury rates are constructed using data from the HSE, as described and reported in the Accident Risk Appendices. Three variables denoting an

[57] Due to the fact that the occupation-specific death and injury variables do not relate to Northern Ireland or the self-employed.
[58] As part-time workers will be exposed to a smaller injury risk than the occupation-specific variable captures.

occupations Fatal, Major Injury, and Over 3-day Injury risk are matched into the BHPS data set using respondents' current occupation coded at the 3 digit SOC 2000. In addition, the BHPS asks whether a respondent has had any kind of accident that resulted in a visit to a doctor or hospital in the last 12 months. Such accidents will include, amongst others, work accidents. This variable should capture a degree of individual-specific accident risk in addition to the average occupation risk captured by the HSE derived variables.

7.4 Descriptive Statistics

If smoking is to be used as a proxy for risk aversion, in that we expect smokers to engage in riskier behaviour than non-smokers, then we may expect smokers and non-smokers to differ in many ways. A descriptive analysis is conducted to consider if there are significant differences between smokers and non-smokers in terms of personal and work characteristics.

A series of variables are constructed from the BHPS, with the full list reported in Appendix 7.1. Several smoking dummy variables are derived. *Smoker* indicates if the respondent currently smokes. As the amount of cigarettes a person smokes may be important, *lightsmoke* indicates those that smoke between 1 and 15 cigarettes per day and *modsmoke* denotes those that smoke 16 or more per day. As previous smoking behaviour may be related to current occupational choice, *evsmoke* denotes whether the respondent has reported themselves as being a smoker in any of the BHPS waves. Whether a person smoked at age 16 or 18 may be the most appropriate measure to use; given the addictive nature of smoking some smokers may want to give up but are unable to. Supporting this, ONS (2006) reports that 72 per cent of smokers said they wanted to give up in 2005 with 80 per cent of smokers reporting attempting to give up at some point in the past (p.59). By using a variable denoting whether they smoked at a specific age, we are capturing risk aversion at a particular point in a respondent's life. *Smoke16* and *smoke18* identify those individuals who smoked at age 16 and 18 respectively. Table 7.2 reports descriptive statistics for a whole sample and a male and female sample.

Approximately 26 per cent of all full-time workers in the sample currently smoke, with a greater percentage of men smoking compared to women. This is in line with the ONS estimate that 25 per cent of adults currently smoke. The majority of these smokers are light smokers with just 9 per cent of the whole sample reporting smoking 16 cigarettes or more per day. The percentage of the sample that has ever smoked is much higher than the percentage of current smokers however, with 37 per cent reporting they were smokers at some point between 1991 and 2004.

Table 7.2: Smoking Variables: Mean and Standard Deviation

	WHOLE SAMPLE	MALE SAMPLE	FEMALE SAMPLE
Smoker	0.2622 (0.4399)	0.2767 (0.4475)	0.2410 (0.4278)
Lightsmoke	0.1549 (0.3619)	0.1563 (0.3632)	0.1530 (0.3601)
Modsmoke	0.0912 (0.2880)	0.1124 (0.3159)	0.0623 (0.2417)
Evsmoke	0.3715 (0.4833)	0.3895 (0.4877)	0.3470 (0.4761)
Smoke16	0.2313 (0.4217)	0.1737 (0.3789)	0.2300 (0.4210)
Smoke18	0.2616 (0.4396)	0.2252 (0.4178)	0.1564 (0.3633)

Means and standard deviations for all derived variables for the whole sample of men and women are reported in Table 7.3. The sample is also split by current smoking behaviour (using the dummy variable *smoker)* to enable means to be compared. T tests are reported to enable us to consider if any differences between smokers and non-smokers are statistically significant[59].

Table 7.3: Descriptive Statistics (Mean, Standard Deviation and T Test)

VARIABLES	WHOLE SAMPLE	SMOKERS	NON-SMOKERS	T TEST
Obs	*4844*	*1270*	*3574*	
Fatal	0.0169 (0.0343)	0.0235 (0.0405)	0.0150 (0.0320)	6.7664***
Major Injury	2.4311 (3.0133)	3.1392 (3.3709)	2.2094 (2.8420)	8.7830***
Over 3-day Injury	10.0356 (15.3638)	13.0789 (16.9708)	9.0341 (14.5852)	7.5594***
Accident	0.1076 (0.3099)	0.1307 (0.3372)	0.0993 (0.2991)	2.9337***
Noaccident	0.1161 (0.3606)	0.1488 (0.4153)	0.1088 (0.3448)	3.0763***
Age	38.5965 (12.0886)	36.5394 (12.0860)	39.2918 (12.0107)	7.0033***
Racew	0.8941 (0.3077)	0.8740 (0.3320)	0.9032 (0.2957)	2.7684***
Raceb	0.0070 (0.0836)	0.0087 (0.0927)	0.0062 (0.0782)	0.8586
Raceo	0.0173 (0.1303)	0.0110 (0.1045)	0.0199 (0.1396)	2.3743**
Educ0	0.1553 (0.3622)	0.1984 (0.3990)	0.1086 (0.3111)	7.2733***
Educ1	0.2029 (0.4022)	0.1053 (0.3070)	0.2451 (0.4302)	12.4546***
Educ2	0.3134 (0.4639)	0.2943 (0.4559)	0.3319 (0.4710)	2.4641**
Educ3	0.3270 (0.4692)	0.3995 (0.4900)	0.3136 (0.4640)	5.4405***
Married	0.5118 (0.4999)	0.3819 (0.4860)	0.5560 (0.4969)	10.7867***
Cohabmarr	0.7030 (0.4570)	0.6449 (0.4787)	0.7224 (0.4479)	5.0388***
SDW	0.0816 (0.2737)	0.0984 (0.2980)	0.0758 (0.2648)	2.3883**
Nevermarr	0.2154 (0.4111)	0.2567 (0.4370)	0.2017 (0.4014)	3.9341***
Disabled	0.0213	0.0228	0.0210	0.3727

59 Equal variance tests are also conducted. T tests therefore adjust for unequal variance when appropriate.

	(0.1444)	(0.1494)	(0.1434)	
Childlive	0.5288 (0.8773)	0.5157 (0.8944)	0.5411 (0.8782)	0.8811
Health	3.0121 (0.8090)	2.8684 (0.8250)	3.0588 (0.8013)	7.2170***
Workhealth	0.0818 (0.2740)	0.0898 (0.2860)	0.0789 (0.2697)	1.1840
Permanent	0.9686 (0.1744)	0.9606 (0.1946)	0.9715 (0.1665)	1.7782*
Supervise	0.4115 (0.4922)	0.3668 (0.4821)	0.4300 (0.4951)	3.9343***
Public	0.2796 (0.4488)	0.1960 (0.3972)	0.3031 (0.4597)	7.9094***
Noemps	2.7289 (1.7006)	2.5900 (1.6529)	2.7757 (1.7168)	3.3432***
Nohrs	38.4717 (6.3315)	39.1524 (7.2919)	38.2456 (5.9680)	3.9830***
Paidover	2.0824 (4.8214)	3.1094 (6.1230)	1.7949 (4.2941)	7.0587***
Overtime	4.1951 (6.2183)	4.5921 (6.7547)	4.2101 (6.0774)	1.7761
Wkgrosspay	438.2054 (432.0232)	373.4915 (221.0807)	461.0372 (482.9920)	8.5946***
Bonus	0.3141 (0.4642)	0.2955 (0.4564)	0.3207 (0.4668)	1.6621*
Perfpay	0.1582 (0.3649)	0.1264 (0.3324)	0.1695 (0.3752)	3.8337***
Presunion	0.5284 (0.4992)	0.4636 (0.4989)	0.5512 (0.4974)	5.3868***
Unionmemb	0.6289 (0.4832)	0.5839 (0.4933)	0.6423 (0.4795)	3.7000***
Flexitime	0.1493 (0.3564)	0.1142 (0.3181)	0.1673 (0.3733)	4.8475
Scotland	0.2116 (0.4085)	0.2354 (0.4244)	0.2026 (0.4020)	2.3983**
Wales	0.1776 (0.3822)	0.1764 (0.3813)	0.1752 (0.3802)	0.0965
Northeast	0.0436 (0.2042)	0.0362 (0.1869)	0.0464 (0.2105)	1.6147
Northwest	0.0778 (0.2678)	0.0787 (0.2694)	0.0769 (0.2665)	0.2062
Yorkshire	0.0641 (0.2449)	0.0669 (0.2500)	0.0644 (0.2454)	0.3103
Eastmids	0.0591 (0.2358)	0.0583 (0.2343)	0.0613 (0.2399)	0.3851
Westmids	0.0549 (0.2277)	0.0472 (0.2122)	0.0562 (0.2304)	1.2689
Easteng	0.0277 (0.1642)	0.0339 (0.1809)	0.0255 (0.1575)	1.4688

Southwest	0.0591 (0.2358)	0.0543 (0.2268)	0.0624 (0.2419)	1.0740
London	0.0595 (0.2365)	0.0575 (0.2328)	0.0588 (0.2352)	0.1705
Southeast	0.1310 (0.3374)	0.1323 (0.3389)	0.1312 (0.3377)	0.0996
Ownhouse	0.4957 (0.4033)	0.7000 (0.4584)	0.8548 (0.3524)	10.9404***
Newemp	0.2590 (0.4381)	0.3189 (0.4662)	0.2473 (0.4315)	4.7922***
Female	0.4227 (0.4940)	0.4334 (0.4957)	0.4394 (0.4964)	0.3701

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

There are many significant differences between the two samples. Smokers are significantly younger, have fewer academic qualifications, have poorer health, and are less likely to be married or cohabiting or to own a house. Smokers are significantly more likely to work in occupations with higher average fatal and non-fatal injury rates. They are also more likely individually to have an accident of some type compared to non-smokers (indicated by the variable *accident*). Although smokers have significantly poorer health, they are not more likely to report that health problems mean performing work activities is difficult. There is therefore no evidence from this descriptive analysis that because of their poorer health, smokers have lower productivity. This variable does however, rely on self-reporting, and employers may disagree with some of the smoker's responses. Non-smokers earn significantly more which is to be expected given that smokers are found to have fewer qualifications. However, smokers on average work more hours, both usual and overtime. A similar analysis is carried out separately for samples of male and female samples, with results reported in Appendix 7.2.

The correlation between smoking and accident variables is considered, with correlation coefficients reported in Table 7.4. All correlation coefficients are positive, indicating current smokers are more likely to be employed in an occupation with a high fatal, major and over 3-day injury rate, and also more likely to have an individual-specific accident. However, the coefficients are statistically insignificant.

Table 7.4: Correlation Coefficients

	Smoker
Fatal	0.1070
Major Injury	01356
Over 3-day Injury	0.1159
Accident	0.0419

Most compensating wage differential studies are conducted for samples of manual workers only; as they face the greatest injury risk at work, a significant risk premium is most likely to be found for this group of workers, as found in chapter 5. Therefore, the descriptive analysis is repeated for a sample that excludes non-manual workers[60]. Table 7.5 reports the means and standard deviations of the smoking variables.

Compared to the sample of all workers, a much greater percentage of manual workers currently smoke (37 per cent compared to 26 per cent). Similarly, a greater percentage of manual workers have reported smoking at least once in the panel. In fact, all smoking variables have greater means in the manual workers sample.

[60] The following occupations are classed as manual: 51 skilled agricultural trades, 52 skilled metal and electrical trades, 53 skilled construction and building trades, 54 textiles, printing and other skilled trades, 61 caring personal service occupations, 62 leisure and other personal service occupations, 81 process, plant and machine operatives, 82 transport and mobile machine drivers and operatives, 91 elementary trades, plant and storage related occupations, 92 elementary service occupations.

Table 7.5: Smoking Variable Means and Standard Deviations

	MANUAL SAMPLE
Obs	*1839*
Smoker	0.3665 (0.4820)
Lightsmoke	0.2015 (0.4012)
Modhsmoke	0.1509 (0.3580)
Evsmoke	0.4717 (0.4993)
Smoke16	0.2825 (0.4503)
Smoke18	0.3236 (0.4680)

Dividing the manual sample into smokers and non-smokers, the differences between the accident risk variables are considered[61]. Results are reported in Table 7.6.

Table 7.6: Descriptive Statistics Manual Workers (Mean and Standard Deviation)

VARIABLES	**WHOLE SAMPLE**	**SMOKERS**	**NON-SMOKERS**	**T TEST**
Obs	*1818*	*660*	*1123*	
Fatal	0.0388 (0.0477)	0.0409 (0.0019)	0.0384 (0.0014)	29.4321***
Major Injury	4.8314 (3.5926)	5.0247 (0.1396)	4.7516 (0.1061)	43.4249***
Over 3-day Injury	21.0302 (19.5703)	21.5593 (0.7423)	20.7081 (0.5868)	25.1940***
Accident	0.1311 (0.3375)	0.1558 (0.3629)	0.1167 (0.3212)	2.3487**
Noaccident	0.1429 (0.3971)	0.1766 (0.4528)	0.1279 (0.3660)	2.3487**
Wkgrosspay	343.0775 (171.9595)	331.3345 (170.8087)	349.8355 (172.3392)	2.1960**

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
T tests adjust for unequal variance when appropriate.

[61] Differences between the other variables are very similar as to the previous sample and so results are not reported.

The significant difference between the occupation-specific accident variables for smokers and non-smokers remains when workers are divided into manual and non-manual occupations. The individual-specific variable *accident* is also significant, indicating that smokers are more likely to have a personal accident, whether at home or at work.

7.5 Smoking as an Instrument

Efforts to control for risk endogeneity have been plagued by problems of finding suitable instruments to use in the risk estimation (equation 2). As outlined, a suitable instrument must be correlated with risk but uncorrelated with the observed determinants of earnings. Smoking behaviour could be used as an instrument to proxy risk aversion in the compensating wage differential research.

A risk regression is estimated using, in addition to the variables described in the descriptive section, a dummy variable denoting smoking behaviour. Several smoking dummy variables are tested reflecting current smoking behaviour, the amount of cigarettes smoked, whether the respondent has classed themselves as a smoker in any of the BHPS waves, and whether they smoked at age 16 and 18. Three sets of regressions are estimated by OLS using *fatal*, *major injury* and *over 3-day injury* as dependent variables. Following the literature, a set of industry dummy variables are included in the estimation as explanatory variables. Descriptive statistics for these industry dummies are reported in Appendix 7.3. Estimated coefficients for the smoking variables are reported in Table 7.7 with full results presented in Appendix 7.4.

Table 7.7: Risk Regression Smoking Estimates (Male and Female Workers Sample)

	FATAL	**MAJOR INJURY**	**OVER 3-DAY INJURY**
No. Obs	*4478*	*4478*	*4478*
R^2	*0.2668*	*0.2543*	*0.2191*
Adj R^2	*0.2617*	*0.2491*	*0.2066*
SMOKER	0.0040*** (0.0010)	0.4010*** (0.0918)	1.5379*** (0.4844)
R^2	*0.2674*	*0.2545*	*0.2122*
Adj R^2	*0.2622*	*0.2492*	*0.2066*
LIGHTSMOKE	0.0035*** (0.0012)	0.4121*** (0.1103)	1.7633*** (0.5818)
MODSMOKE	0.0058*** (0.0016)	0.4358*** (0.1398)	1.2835* (0.7376)
R^2	*0.2657*	*0.2540*	*0.2122*
Adj R^2	*0.2606*	*0.2488*	*0.2067*
EVSMOKE	0.0027*** (0.0009)	0.3416*** (0.0824)	1.4223*** (0.4348)
R^2	*0.2644*	*0.2519*	*0.2112*
AdjR^2	*0.2592*	*0.2467*	*0.2057*
SMOKE16	0.0004 (0.0011)	0.2065** (0.0935)	1.1027** (0.4929)
R^2	*0.2645*	*0.2521*	*0.2112*
Adj R^2	*0.2594*	*0.2469*	*0.2057*
SMOKE18	0.0011 (0.0010)	0.2196** (0.0893)	1.0297** (0.4710)

Other variables included but not reported: married childlive disabled ind1 ind2 ind3 ind4 ind6 ind7 ind8 ind9 ind10 ind11 ind12 ind13 educ1 educ2 educ3 newemp overtime permanent age age^2 noemps noemps^2 supervise public presunion flexitime nohrs
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

As found in chapters 3 and 5, there are few variables significantly related to occupation-specific risk with the potential instruments *married*, *children* and *disability* all insignificant. There does however, appear to be a relationship between occupation-specific risk and smoking even after controlling for industry and education. Current smokers work in occupations with higher fatal and major injury rates, as predicted. The two variables reflecting whether a respondent is a light or moderate smoker are also working in the expected way, with *modsmoke* more significant and having a greater magnitude in all estimations. Whether the respondent has classed themselves as a smoker in any of the waves (*evsmoke*) is also significantly positive in all three estimations. *Smoke16* and *smoke18* are also tested to capture smoking behaviour at a common age for all respondents. Although insignificant in the fatal estimations, they are both significantly positive in the non-fatal injury regressions.

The above estimations are also tested separately for a sample of male workers and female workers. The smoking coefficient estimates are reported in Appendix 7.5. Results are similar to those reported for the whole sample.

7.5.1 Tests

Many papers have highlighted how using weak instruments will lead to biased results of the risk premium, and so to consider if smoking variables are appropriate instruments, a number of tests need to be conducted. F tests are conducted after each risk regression. Bound et al. (1995) acknowledge that very often potential instruments are only weakly correlated with the endogenous variable (p.443) and show that using weak instruments will result in estimates that are biased towards the original OLS estimation. Staiger and Stock (1997) recommend that when testing the strength of an instrument, the F statistic must take the value of at least 10. Similarly, Stock, Wright, and Yogo (2002) found that an F statistic of 9 or above is needed for an appropriate instrument. F statistics are reported for all smoking coefficients from all of the risk estimations (Table 7.8).

Table 7.8: F Tests

	FATAL	MAJOR INJURY	OVER 3-DAY INJURY
SMOKER	15.04	19.09	10.08
Prob>F	(0.0001)	(0.0000)	(0.0015)
LIGHTSMOKE	7.95	13.97	9.18
Prob>F	(0.0048)	(0.0002)	(0.0025)
MODSMOKE	13.81	9.72	3.03
Prob>F	(0.0002)	(0.0018)	(0.0819)
EVSMOKE	8.32	17.17	10.70
Prob>F	(0.0039)	(0.0000)	(0.0011)
SMOKE16	0.14	4.88	5.01
Prob>F	(0.7048)	(0.0273)	(0.0253)
SMOKE18	1.10	6.04	4.78
Prob>F	(0.2943)	(0.0140)	(0.0289)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

For the fatal risk regressions, the F statistic for smoking is greater than 10 for the *smoker* and *modsmoke* variables. For the major injury and over 3-day injury estimations both current smoking behaviour and *evsmoke* have large F statistics that are greater than 10 suggesting a strong correlation. The variables *smoke16* and *smoke18* however, have F statistics that do not satisfy the criteria laid out by Bound et al. (1995) for appropriate instruments. However, comparing these results to the F statistics obtained for the instruments in chapter 5 suggests smoking behaviour variables are much stronger instruments. For example, F statistics for *disability* and *marriage* were less than one.

We also need to consider if smoking behaviour has an independent impact upon wages. If smoking and wages are correlated, it will not be an appropriate instrument. Each smoking variable is used an explanatory variable in separate OLS wage regressions. Smoking coefficients are reported in Table 7.9.

Table 7.9: Wage Regression Smoking Estimates

	LNWAGE
SMOKER	-0.0561*** (0.0144)
LIGHTSMOKE	-0.0549*** (0.0174)
MODSMOKE	-0.0587*** (0.0219)
EVSMOKE	-0.0355*** (0.0129)
SMOKE16	-0.0206 (0.0150)
SMOKE18	-0.0192 (0.0142)

Other variables: educ1 educ2 educ3 racew disabled presunion age age² permanent supervise public newemp noemps noemps² perfpay flexitime nohrs overtime fatal major female.
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Results indicate that current smokers have significantly lower wages, even after controlling for personal characteristics such as education. *Evsmoke* has a similar magnitude. The impact upon wages is greatest for those who smoke more (indicated by *modsmoke*). However, whether a respondent smoked at age 16 or 18 has an insignificant impact upon wages, as may have been expected. *Smoke16* or *smoke18* therefore, would appear to be the most appropriate instruments as they uncorrelated with wages. Unfortunately, *smoke16* and *smoke18* are only weakly correlated with risk, as shown by the F statistics in Table 7.8. These tests suggest smoking variables may not be appropriate instruments, and results need to be interpreted with this in mind. The fact that few studies have investigated this issue however, means that this result is still of interest.

Most compensating wage differential estimates are restricted to manual workers as they face the highest risk of injury at work and so it is most likely that a significant premium will be estimated for this group. In chapter 5, significant risk premiums are only found for manual workers. Therefore, if smoking behaviour is to be used as an instrument for risk aversion in the compensating wage differential research, we need to test if it is significant in a sample of manual workers. All variables included in the previous regression are included, with smoking coefficients reported in Table 7.10.

Table 7.10: Risk Regression Smoking Estimates

Dependent variable	**FATAL**	**MAJOR INJURY**	**OVER 3-DAY INJURY**
No. Obs	*1615*	*1615*	*1615*
R^2	*0.2821*	*0.1763*	*0.1490*
Adj R^2	*0.2680*	*0.1602*	*0.1324*
SMOKER	0.0017 (0.0022)	0.1488 (0.1750)	0.1592 (0.9767)
R^2	*0.2823*	*0.1774*	*0.1499*
Adj R^2	*0.2678*	*0.1607*	*0.1327*
LIGHTSMOKE	0.0028 (0.0026)	0.3265 (0.2123)	1.0615 (1.1847)
MODSMOKE	0.0013 (0.0030)	-0.0571 (0.2419)	-0.8562 (1.3503)
R^2	*0.2819*	*0.1767*	*0.1492*
Adj R^2	*0.2679*	*0.1605*	*0.1325*
EVSMOKE	0.0013 (0.0021)	0.1947 (0.1667)	0.5385 (0.9303)
R^2	*0.2820*	*0.1760*	*0.1493*
AdjR^2	*0.2680*	*0.1599*	*0.1326*
SMOKE16	-0.0017 (0.0023)	0.0596 (0.1837)	0.6786 (1.0248)
R^2	*0.2819*	*0.1759*	*0.1491*
Adj R^2	*0.2679*	*0.1598*	*0.1324*
SMOKE18	-0.0013 (0.0022)	0.0053 (0.1762)	0.2110 (0.9831)

Other variables included but not reported: married childlive disabled ind1 ind2 ind3 ind4 ind6 ind7 ind8 ind9 ind10 ind11 ind12 ind13 educ1 educ2 educ3 newemp overtime permanent age age² noemps noemps² supervise public presunion flexitime nohrs.
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

The smoking variables are never significant in the manual workers sample. This could be for several reasons. The manual workers sample is small, with only 660 respondents who currently smoke. Given that accident risk is small, the compensating wage differential research requires a large sample size in order for a significant effect to be estimated. Alternatively, the relationship between smoking and risk may not be as strong for male manual workers as it is for all workers.

Results of the above tests suggest that although there is a relationship between smoking behaviour and occupation-specific risk, smoking may not be a good instrument for risk aversion in compensating wage differential estimations.

7.6 Tests for Compensating Wage Differentials

To consider if wage premiums are found for exposure to risk in this BHPS sample, wage regressions are estimated. In chapter 5, positive wage premiums were found for exposure to fatal accident risk in the manual workers and male manual workers sample. Results are reported in Table 7.11.

Fatal is either negative or insignificant in all regressions, that is, there is no evidence of a wage premium for exposure to risk of death in any sample, unlike that found in the previous chapter. This is likely to be because of the smaller sample sizes here. For instance, for male manual workers, there was a sample of 3897 workers in chapter 5, compared to only 1064 here. This is likely to affect *fatal* in particular, due to the fact that there are some workers who work in an occupation with a zero value for this variable. Frequency tables reported in Appendix 7.6 show 8 per cent of the all manual sample have a zero value for *fatal*. Furthermore, there are few workers in the most dangerous occupations, with less than 1 per cent of the sample assigned the highest fatal value. For this reason, and because fatal risk is very small, a large sample size is particularly important. In the two samples where positive fatal premiums are found in the WERS chapter (the manual workers and male manual workers samples) *major injury* is positive and significant. *Major injury* is highly correlated with *fatal* and there are no zero values. As fatal risk is so small in this sample therefore, we rely on *major injury* to reflect occupational accident risk.

Table 7.11: Wage Regression Risk Coefficients

Dependent variable: Lnwpay

	ALL WORKERS	**MANUAL WORKERS**	**MALE WORKERS**	**MALE MANUAL WORKERS**
Obs	*4017*	*1427*	*2366*	*1064*
R^2	*0.4792*	*0.4581*	*0.4617*	*0.3910*
Adj R^2	*0.4766*	*0.4504*	*0.4573*	*0.3800*
FATAL	-0.6820*** (0.1999)	-0.0504 (0.2095)	-0.8220*** (0.2095)	-0.2021 (0.2165)
R^2	*0.4797*	*0.4620*	*0.4619*	*0.3932*
Adj R^2	*0.4770*	*0.4540*	*0.4573*	*0.3816*
FATAL	-0.3587 (0.2594)	-0.4771* (0.0033)	-0.6683** (0.2710)	-0.4663* (0.2551)
MAJOR INJURY	-0.0059* (0.0030)	0.0105*** (0.0033)	-0.0030 (0.0033)	0.0069** (0.0024)
R^2	*0.4795*	*0.4606*	*0.4605*	*0.3913*
Adj R^2	*0.4769*	*0.4529*	*0.4561*	*0.3802*
MAJOR INJURY	-0.0086*** (0.0023)	0.0071*** (0.0027)	-0.0082*** (0.0026)	0.0135* (0.0030)

Other variables: educ1 educ2 educ3 racew disabled presunion age age² permanent supervise public newemp noemps noemps² perfpay flexitime nohrs overtime (and female dummy for all workers sample)
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

Following Hersch and Viscusi (1990) we first consider if smoking behaviour is a suitable proxy for risk preferences. Equation 1 is estimated by OLS. If smokers are relatively less risk averse compared to non-smokers, we would expect a significantly negative β_3 estimate, as smokers demand a smaller wage premium per unit of risk exposed to compared to non-smokers. Smoking behaviour variables are each interacted with *major injury* and included as regressors in separate estimations. Table 7.12 reports.

Table 7.12: Wage Estimation Results

Dependent Variable: Lnwage

	ALL MANUAL	MALE MANUAL
Obs	*1427*	*1067*
R^2	*0.4607*	*0.3921*
Adj R^2	*0.4526*	*0.3804*
MAJOR INJURY	0.0076** (0.0030)	0.0057* (0.0032)
MAJOR*SMOKER	-0.0013 (0.0032)	-0.0039 (0.0034)
R^2	*0.4609*	*0.3919*
Adj R^2	*0.4528*	*0.3803*
MAJOR INJURY	0.0067** (0.0028)	0.0029 (0.0030)
MAJOR*MODSMOKE	0.0036 (0.0043)	0.0046 (0.0045)
R^2	*0.4607*	*0.3927*
Adj R^2	*0.4527*	*0.3811*
MAJOR INJURY	0.0080*** (0.0031)	0.0057* (0.0033)
MAJOR*EVSMOKE	-0.0019 (0.0031)	-0.0050 (0.0033)
R^2	*0.4609*	*0.3913*
Adj R^2	*0.4529*	*0.3797*
MAJOR INJURY	0.0061** (0.0030)	0.0037 (0.0031)
MAJOR*SMOKE16	0.0033 (0.0035)	-0.0011 (0.0038)
R^2	*0.4610*	*0.3913*
Adj R^2	*0.4530*	*0.3796*
MAJOR INJURY	0.0060** (0.0030)	0.0035 (0.0031)
MAJOR*SMOKE18	0.0035 (0.0033)	-0.0002 (0.0036)

Other variables included in the estimation: educ1 educ2 educ3 racew disabled presunion age age^2 permanent supervise public newemp noemps noemps^2 perfpay flexitime nohrs overtime female (for all manual sample)
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

Major injury is significantly positive in all the manual worker estimations, reflecting a positive wage premium is received by workers for exposure to major injury risk. However, the *major*smoke* variables are all insignificant. Smoking behaviour does not, therefore, appear to be related to the wage premium workers receive for working in hazardous jobs.

As smoking behaviour has been found in some studies to have an adverse impact upon wages, the above estimations are repeated including a separate smoking explanatory variable. Results are reported in Appendix 7.7. The *major*smoke* interaction variables remain insignificant, although the separate smoker variables are often significantly negative. Overall therefore, although smokers are employed in more hazardous occupations, even after controlling for personal characteristics, wage compensation does not significantly vary by smoking behaviour.

Following Viscusi and Hersch (2001), labour demand and supply factors are examined together. Wage regressions (equation 1) are estimated separately for samples of smokers and non-smokers. The sample is first split according to current smoker status (*smoker*) with estimated risk coefficients reported in Table 7.13. It should be noted that splitting the samples according to smoking behaviour results in very small sample sizes, particularly male manual smokers, with just 391 observations.

The model is estimated separately for smokers and non-smokers and compared to the full model using a likelihood ratio test. A test statistic of 43.93 which is significant at the 1 per cent level is calculated. It is therefore appropriate to divide the model by smoking status. Results indicate significant injury premiums for smokers in both samples, with *major injury* insignificant in the non-smoker samples. Given that smokers face the highest risk, it is most likely that significant premiums will be estimated for this group of workers (the same argument applies here as to why significant premiums are observed for manual workers but not non-manual workers).

Table 7.13: Wage Estimation Risk Estimates (Split according to Smoker)

Dependent variable: Lnwpay

	ALL MANUAL		MALE MANUAL	
	SMOKER	**NON SMOKER**	**SMOKER**	**NON SMOKER**
Obs	*518*	*909*	*391*	*673*
R^2	*0.4739*	*0.4732*	*0.4264*	*0.3938*
Adj R^2	*0.4527*	*0.4613*	*0.3970*	*0.3762*
MAJOR INJURY	0.0127*** (0.0043)	0.0042 (0.0036)	0.0128* (0.0050)	0.0024 (0.0038)
R^2	*0.4784*	*0.4732*	*0.4338*	*0.3940*
Adj R^2	*0.463*	*0.4607*	*0.4032*	*0.3754*
MAJOR INJURY	0.0126*** (0.0043)	0.0042 (0.0036)	0.0101* (0.0050)	0.0026 (0.0038)
ACCIDENT	0.0830** (0.0404)	0.0017 (0.0371)	0.1005** (0.0458)	-0.0191 (0.0414)

Other variables included in the estimation: educ1 educ2 educ3 racew disabled presunion age age^2 permanent supervise public newemp noemps $noemps^2$ perfpay flexitime nohrs overtime (and female dummy for all workers)
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

For comparison, estimations are repeated splitting the sample according to the other smoking variables. Results splitting the sample according to *evsmoke* are reported in Appendix 7.8. Results splitting the sample according to *smoke16* are reported in Table 7.14[62].

[62] Likelihood ratio tests are performed splitting the model by *smoke16* and *evsmoke.* Test statistics of 38.40 for *smoke16* and 36.10 for *evsmoke* are estimated, both of which are significant at the 1 per cent level. Dividing the model by these variables is therefore appropriate.

Significant risk premiums are estimated in most of the estimations. However, the same pattern that is observed in Viscusi and Hersch (2001) is not shown here. Workers that smoked at age 16 are shown in many of the regressions to receive greater risk premiums than those that did not. The major injury premium is however often insignificant in the non-smoker samples. Risk premium estimates appear to be much stronger in the samples of smokers. Risk premiums are more likely to be estimated for smokers who work in relatively riskier jobs, and it is likely that this is driving the results given the small sample size.

Table 7.14: Wage Estimation Risk Estimates (Split according to Smoke16)

Dependent variable: Lnwpay

	ALL MANUAL		**MALE MANUAL**	
	SMOKED AT 16	**NON SMOKER AT 16**	**SMOKED AT 16**	**NON SMOKER AT 16**
Obs	*401*	*1026*	*253*	*811*
R^2	*0.4700*	*0.4754*	*0.3747*	*0.4179*
Adj R^2	*0.4421*	*0.4649*	*0.3238*	*0.4039*
MAJOR INJURY	0.0160*** (0.0049)	0.0038 (0.0033)	0.0082 (0.0063)	0.0028 (0.0034)
R^2	*0.4747*	*0.4755*	*0.3829*	*0.4181*
Adj R^2	*0.4456*	*0.4646*	*0.3297*	*0.4033*
MAJOR INJURY	0.0152*** (0.0049)	0.0037 (0.0033)	0.0077 (0.0062)	0.0027 (0.0034)
ACCIDENT	0.0899* (0.0488)	0.0180 (0.0332)	0.1066* (0.0609)	0.0154 (0.0357)

Other variables included in estimation: educ1 educ2 educ3 racew disabled presunion age age^2 permanent supervise public newemp noemps noemps^2 perfpay flexitime nohrs overtime female (for all manual sample)
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

7.7 Conclusion

Descriptive analysis alone reveals that smokers are more likely to work in hazardous occupations. This suggests there is potential to use smoking behaviour as an instrument in compensating wage differential studies to proxy risk aversion. After exploring the relationship, this chapter has highlighted many problems with this. Although F tests reveal a strong relationship between risk and smoking behaviour in a sample of all workers, when the sample is restricted to male manual workers, the sample most commonly used in the compensating wage differential literature, the relationship is weak. Furthermore, smoking is significantly related to wages. Smoking variables therefore appear to be unsuitable instruments for use in this area of research.

In an attempt to replicate the US studies Hersch and Viscusi (1990) and Viscusi and Hersch (2002) the relationship between smoking and the risk premium is explored. Unlike these two papers, no significant relationship is found. One potential reason for this is small sample size, which is particularly important given that accident risk is very small.

This chapter has highlighted problems with finding and using a relationship between smoking and risk aversion. The issues raised here could, however, be explored further using a data set with a greater number of manual workers respondents who have higher accident rates.

CHAPTER 8

CONCLUSION

Workplace health and safety remains a priority for government, with chapter 2 outlining numerous strategies that are directed at reducing hazards at both the UK and EU level. The nature of workplace hazards is continually changing as the labour market evolves, for instance with an increase in stress related illnesses and the movement away from the more physical injuries, and so it is essential policy also evolves to reflect such changes. The large literature reviewed in chapter 3 reflects the need for continuous research to inform policy.

Labour market changes also have an indirect impact upon workplace safety. For example, the decline in trade union membership, the emergence of new industrial relations institutions, increases in female participation, and the increase in flexible hours, will all potentially present new health risks whilst removing others. Chapter 4 investigates how such changes impact upon injuries and illnesses at the workplace level. Many workplace policies are found to have a potentially detrimental effect upon health and safety, such as night work, home work, working over 48 hours per week, and flexitime. However, there are also many positive points, with health and safety training found to reduce reported illnesses, and regular employee appraisals associated with fewer workplace injuries. Overall, this chapter highlights that even though deindustrialisation has seen an overall reduction in workplace accidents at the UK level, with the number of fatalities resulting from a workplace accident currently the lowest in Europe, the modern day labour market presents many new challenges for occupational health and safety.

Whereas chapter 4 is concerned with investigating how policy may be directed towards improving workplace health and safety, chapter 5 investigates if the market compensates workers for exposure to accident risk in the form of a wage premium. Chapter 3 discusses the large literature that examines this theory, although few UK papers have done so using recent data. Evidence that male manual workers receive a wage premium for exposure to risk of fatality is presented. Given the changing nature of industrial relations, in addition to considering the impact that trade unions have upon the risk premium, the health and safety committee impact is also considered. The trade union effect is negative, following the literature, although not always significant. A separate positive health and safety committee impact is found, and given that such institutions have no direct power to influence wages, this result suggests such committees have a positive impact upon the bargaining environment. Overall, this chapter points to the need to examine the impact that such institutions may have in addition to the trade union effect, which is especially important given the decline in union density. Research in this area would benefit from a closer examination into how health and safety committees operate, in order to have a clearer understanding of how they may influence the risk premium. The measurement error issues in this literature have been highlighted throughout, as two-stage estimation to control for the endogeneity of risk and unobserved heterogeneity suffers from a lack of appropriate instruments to proxy risk aversion. This problem can only be resolved with panel data that controls for heterogeneity, or with further research into how to proxy risk aversion which would require data with a wealth of information and manual worker respondents.

Variation in aversion to risk amongst workers is examined in the final two empirical chapters. Chapter 6 presents evidence that gender and family composition serve as proxies for risk aversion, with the hypothesis that women and single parents have a preference for occupations with lower accident rates supported. This finding is important and has many potential applications throughout the economic literature. In terms of the labour economics literature, this selection into occupations according to accident rates between men and women contributes to occupational gender segregation. There is also potential for the findings in chapter 6 to be applied to two-stage estimation with family composition a potential instrument to proxy risk aversion Chapter 7 then illustrates a relationship between smoking behaviour and risky work, although problems with this relationship are highlighted.. Both of these chapters however, highlight how workers appear to have different preferences for risky work, and demonstrate that personal characteristics and observed behaviour can be used to predict risk aversion, and consequently enable us to build a profile of workers that are likely to sort into hazardous occupations. Further work may try to apply this to two-stage estimation and examine other possible predictors of risk aversion.

It is essential that accurate data are available relating to accident rates of different occupations, and the Accident Risk Appendices discuss the many issues that need to be overcome to provide this. Both compensating wage differentials and risk preference research rely on the assumption that workers are aware of the hazards associated with their occupation relative to others. If workers are unaware of the risks, they are unable to sort themselves correctly into their preferred occupation. Given that chapter 4 highlighted the many factors that have an impact upon occupational health and safety, policy needs to be directed towards ensuring up to date statistics are available and communicated to firms and workers.

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APPENDIX

EMPIRICAL ESSAYS ON OCCUPATIONAL HEALTH AND SAFETY

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2007

VOLUME 2

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ACCIDENT VARIABLE APPENDICES

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ACCIDENT VARIABLE APPENDICES

Introduction

The literature chapter highlighted that how risk is measured in empirical tests of the theory of compensating wage differentials is extremely important, as it can "significantly influence the magnitude of the risk premium estimated" (Viscusi and Aldy, 2003, p.10). Sandy et al. (2001) comment that "measurement error may be as important as the issue of unobserved heterogeneity in the presence of risk, which has received much more attention" (p.49). Therefore, different measures need to be compared and tested to ensure the risk of a worker having a fatal and non-fatal accident is accurately captured before conducting empirical estimations. Although the major issues involved in measuring risk will not be discussed in detail (see chapter 3B for a discussion of this), here we discuss how risk variables are constructed in the UK literature, discussing the advantages and disadvantages of each. Fatal and non-fatal accident variables are then constructed for each occupation.

Calculation of Fatal Accident Risk in UK Studies

The risk variables calculated for UK estimations use data either from the OPCS Occupational Mortality Decennial Supplement, or from the HSE. The majority have used OPCS data, with only Siebert and Wei (1994) calculating risk from HSE data. However, OPCS risk data are unavailable after 1983, and as chapter 2 has highlighted, workplace risks have changed considerably since then, with there being a general downward trend in the rate of fatal injury at work as reported under RIDDOR.

Consider first the calculation of risk of work-related fatality variables using OPCS data. Marin and Psacharopoulos (1982) were the first to test empirically the theory of compensating wage differentials using UK data, and constructed two variables using OPCS data. The OPCS data used is based on detailed records of deaths broken down into 223 occupations between 1970 and 1972. Note that data for a three-year period is superior to data for a single year "because deaths in occupations with few workers can be rare events" (Sandy et al., 2001, p.42). The first variable *genrisk* is defined as the extra risk of dying in each occupational group and is calculated as shown by equation 1:

$$\text{Genrisk} = \frac{(\text{Deaths}\,1970\text{ - }72\text{ - Expected Deaths}\,1970\text{ - }72)/3}{\text{Workers}} \qquad [1]$$

Genrisk is therefore the actual death rate minus the death rate that could have been expected given the age and social class structure of workers in each occupational group. *Genrisk* is converted into a rate per 1000 workers per year by multiplying the entire measure by 1000. The authors acknowledge "Genrisk is subject to measurement error" (p.831). Specifically, there is the potential for accidents to be included that do not require compensation because they are not labour-market specific. There is also the possibility that people may contract a fatal disease in one occupation, and then move to another occupation before dying. Therefore "the estimate of the coefficient of Genrisk would be biased downward" (p.831).The second variable, *accrisk* is calculated as shown by equation 2:

$$\text{Accrisk} = \frac{(\text{Fatal accidents at work}\,1970-72-\text{Expected Fatal accidents at work}\,1970-72)/3}{\text{Workers}} \qquad [2]$$

Accrisk reflects the increase or decrease in the probability of a fatal accident at work for workers in a particular occupation, relative to the probability of a fatal accident at work for workers employed in all occupations. *Accrisk* is more labour-market-specific than *genrisk* as it specifically considers deaths at work. As this method of calculating the risk of death takes into account the average accidental workplace death rate in all occupations, the variable can have a positive or negative value. Occupations that have zero accidental deaths at work were assigned the population-wide death at work probability which is age adjusted. The expected number of fatal accidents at work for each occupation takes account of the occupational age structure, further strengthening this variable. As expected, in the empirical estimations "the more labour-market-specific measure of risk, Accrisk gives stronger results than Genrisk" (Marin and Psacharopoulos, 1982, p.834). This refers to a sample of all male workers, as female measures are considered inaccurate as discussed in chapter 3. When the sample is broken down to test for the presence of a wage premium separately for male-manual and male-non-manual workers, the manual sample produces significant results whereas the non-manual sample does not.

Sandy and Elliott (1996) construct similar variables, *accrisk* and *genrisk*, to Marin and Psacharopoulos (1982). They use later OPCS data, referring to 1979-83, and are able to break this down into 280 different occupations. After assigning fatal risk variables by occupation codes into the SCELI data set, they divide their data into separate samples for workers covered by union terms and conditions (covered workers) and those that are not (uncovered workers). A positive and significant compensating wage differential for male manual workers is estimated, with the regressions using *accrisk* giving stronger results (p.298). Arabsheibani and Marin (2000) also use OPCS 1979-

83 data to calculate *genrisk* and *accrisk* in a paper to test if Marin and Psacharopoulos's results are still relevant using later data. They conclude that "we should place little reliance on Genrisk" (p.13) but find evidence of a wage premium using *accrisk*, which is larger than that estimated by Marin and Psacharopoulos.

Siebert and Wei (1994) use accident records that are reported by law to the HSE between 1986 and 1988. The average number of accidents is taken for the three year period; as in other studies this increases the likelihood of capturing an occupation's true risk. Data is cross-classified by industry and occupation, with variables calculated for 50 occupation-industry cells. The denominator of the variable is the number of employees in each industry and occupation cell, with the numerator the number of reported fatal accidents.

Sandy et al. (2001) compare the calculation of risk measures using OPCS data in Sandy and Elliott (1996) and HSE data in Siebert and Wei (1994). A major difference between the two studies' calculation of risk concerns zero deaths in certain occupations with 42 per cent of Siebert and Wei's industry-occupation cells assigned a value of zero. By contrast, Sandy and Elliott assign the average accidental death rate for all occupations to occupations with zero deaths, emphasising that "these occupations generally had too few workers to be confident of the true risk and it was implausible that the risk was actually zero" (Sandy et al., 2001, p.42). This does, however, depend upon how finely risk is distinguished by occupation. The finer the occupation categories then the more relevant is Sandy et al.'s justification for assigning average risk, as there would be few workers in certain occupations. They take the SCELI data set that is used for labour market variables in their estimation, match the risk variables according to occupation, and then calculate the mean of the risk variable for that particular sample. They then take this value and substitute it for Fatal Accidents at Work in the *accrisk* formula (equation 2). *Accrisk* for that particular occupation is then calculated as before, enabling the variable to be adjusted for the age composition of the workforce in the same way as occupations that did not have zero deaths. The average risk assigned to occupations with zero deaths was 0.6 per 100 000 workers, calculated from the SCELI sample. Note that the age adjustment means "only a small number of the occupations which initially had zero at-work-deaths are ultimately set to the same risk value" (p.42). However, Sandy et al. (2001) note that this major difference in risk assignment does not cause a large difference because the average of 0.6 deaths per 100 000 workers is close to zero (p.42). A further advantage of the risk variable calculated by Sandy and Elliott concerns the greater number of risk categories (371 compared to 50 in Siebert and Wei) which allows risk to be more finely distinguished. However, Sandy et al. caution that categories that are too fine can be a disadvantage: "if the categories are too fine compared to the number of workers in the economy and the accidental death rate, most of the occupations will have zero recorded deaths" (p.55). Therefore, when deciding upon the appropriate occupation classification, the number of zero deaths should be considered.

To compare the risk variables calculated in the two studies, Sandy et al. assign the industry-occupation HSE measure used by Siebert and Wei to the SCELI data set that is used by Sandy and Elliott. They conclude that assigning risk by fine occupation codes is superior to assigning by industry or a mixture of industry and occupation codes (p.49). They comment that "workers in the same occupation have more similar levels of risk than do workers in the same industry" (p.49) and so assignment by occupation codes is to be preferred.

Overall, as this section has illustrated, "creating a reliable measure of fatal workplace risks remains a difficult task" (Sandy et al., 2001, p.49). When assigning fatality risk therefore, it is important to consider several alternatives.

Calculation of Non-Fatal Accident Risk in UK Studies

Few UK studies include a non-fatal injury risk variable in their estimations[1]. The two studies that do, Siebert and Wei (1994) and Arabsheibani and Marin (2001), both fail to find a significant wage premium for non-fatal risk. Siebert and Wei (1994) use the same data used to construct their fatality risk variable from the HSE. Their variable relates to injuries that result in the employee being absent from work for 3 or more days, with the average taken between 1986-88. They note the variable is not very satisfactory, "since serious accidents are lumped together with non-serious" (p.66). They include the variable however, "so as to provide a benchmark for future research using different injury measures" (p.66). Arabsheibani and Marin (2000) construct their non-fatal injury variable from the GHS 1987-89, and this relates to accidents during hours of work that resulted in a visit to a doctor or a hospital. The variable is calculated in the same way as their fatality variable (depicted by equation 2), and can be defined as the observed number of injuries minus the number of injuries expected given the number of employees, divided by the total in employment, as a rate per 1000 workers. The variable is calculated for 161 occupations. They comment that their failure to find a positive a significant wage premium for non-fatal injury risk "is

[1] Chapter 3B.5.2 discusses the reasons for this.

puzzling and remains to be investigated with data which distinguish non-fatal accidents by their degree of severity" (p.264).

Variable Calculations

Fatal risk is calculated here by occupation, following the findings of Sandy et al. (2001) that this is superior to assigning risk by industry or by a mix of industry and occupation codes. Data are provided by the HSE for the years 2002/03, 2003/04 and 2004/05. The risk data is therefore much more recent than that used by Siebert and Wei (1994). The LFS is used to provide data on the number of workers employed in each occupation (weighted). For comparison, data from the Annual Survey of Hours and Earnings (ASHE) is also considered. Rates can be calculated in two ways. Given the accident data runs from 2002-2004, we can calculate the average annual number of fatalities and divide that by the number employed in each occupation for a particular year. This is the method used by Siebert and Wei (equation 3):

$$\text{Fatal Risk} = \left[\frac{(\text{Work Fatalities 2002/03} - \text{2004/05})/3}{\text{Workers employed in occupation 2004}}\right] * 1000 \qquad [3]$$

Alternatively, we can use total number of accidents over the three year period and divide this by the total number of workers employed in each occupation over this same period (equation 4). Both methods are considered.

$$\text{Fatal Risk} = \left[\frac{\text{Work Fatalities 2002/03} - \text{2004/05}}{\text{Wokers employed in occupation 2002 - 2004}}\right] * 1000 \qquad [4]$$

Following Siebert and Wei and Sandy and Elliott, risk is calculated for the whole sample of male and female full-time and part-time workers as the HSE accident data is applicable to all such groups. For comparison, rates for just full time workers are also calculated. Risk is calculated for 3 digit (81 occupations), and 2 digit occupations (25 occupations). A 4 digit variable is not calculated because of the large number of zero deaths that are likely for many occupations. We would however, expect risk to be more accurately defined the finer the occupation breakdown, and so the 3 digit rate is preferred to the 2 digit rate.

Variables reflecting non-fatal injury accident risk are also constructed using HSE data. Under RIDDOR 95 employers have a responsibility to report major injuries at work and injuries that resulted in absence from work for 3 or more days to the HSE, as discussed in chapter 2. Siebert and Wei's non-fatal variable refers to both major injuries and injuries that resulted in 3 or more days off work; both serious and non-serious injuries are therefore considered together in their one non-fatal injury variable. The available data allows two separate variables to be created: one referring to major injuries, and another referring to injuries resulting in 3 or more days off work[2]. The variables created here therefore, split Siebert and Wei's one non-fatal injury variable into two and hence distinguish between severities of injury; no other study using UK data has been able to do this. The variables are constructed in the same way as the fatality variable, with the average number of injuries taken from 2002/03, 2003/04 and 2004/05. The variables created here therefore, refer to a much more recent risk that faces workers compared to other studies that have tested the effect of a non-fatal

[2] Injuries that resulted in 3 or more days off work but are included in the major injuries list are included as a major injury only, and not as an over 3-day injury.

injury variable. Table 1 presents the calculated variables using accident and LFS data for 2002-2004 for full and part time workers (equation 4).

Table 1: Accident Rates using LFS 2002-2004 Occupation Data: per 1000 Full Time and Part Time Workers

3 Digit SOC 2000

SOC 2000	Fatal	Major Injury	Over 3-Day Injury
111 Corporate managers and senior officials	0.0524	1.3178	1.5079
112 Production managers	0.0085	0.8517	1.5360
113 Functional managers	0.0012	0.1429	0.2967
114 Quality and customer care managers	0	0.4130	0.8135
115 Financial institution and office managers	0.0019	0.2618	0.5141
116 Managers in distribution, storage and retailing	0.0039	1.5233	4.0141
117 Protective service officers	0.0209	2.7965	9.3742
118 Health and social service managers	0	0.8889	2.9757
121 Managers in farming, horticulture, forestry and fishing	0.1468	2.0924	2.2759
122 Managers and proprietors in hospitality and leisure services	0.0111	1.4169	3.0384
123 Managers and proprietors in other service industries	0.0164	1.6557	3.311313
211 Science professionals	0	0.2487	0.8043
212 Engineering professionals	0.0348	3.8834	12.4210
213 Information and communication technology professionals	0	0.0528	0.1473
221 Health professionals	0	0.4492	1.2056
231 Teaching professionals	0	1.1256	2.1346
232 Research professionals	0	0.6316	1.6931
241 Legal professionals	0	0.2076	0.3789
242 Business and statistical professionals	0	0.1106	0.2082
243 Architects, town planners and surveyors	0.0046	0.3634	0.7957
244 Public service professionals	0.0042	1.3659	6.0184
245 Librarians and related professionals	0	0.6325	2.0971
311 Science and engineering technicians	0.0149	3.0919	12.4569
312 Draught persons and building inspectors	0.0104	0.4048	0.7474
313 IT service delivery occupations	0	0.3392	1.4229
321 Health associate professionals	0	0.2855	2.9799
322 Therapists	0	0.6027	2.8438
323 Social welfare associate professionals	0	0.6101	2.0419
331 Protective service occupations	0.0253	6.7604	37.4950

341 Artistic and literary occupations	0.0092	0.5178	0.5732
342 Design associate professionals	0	0.1114	0.1592
343 Media associate professionals	0	0.2834	0.8263
344 Sports and fitness occupations	0	1.7369	2.1030
351 Transport associate professionals	0.0125	0.5604	2.3413
352 Legal associate professionals	0	0.0853	0.3926
353 Business and finance associate professionals	0	0.2874	0.7406
354 Sales and related associate professionals	0	0.2517	0.7165
355 Conservation associate professionals	0	1.3888	5.2615
356 Public service and other associate professionals	0	0.4406	1.7625
411 Administrative occupations: government and related	0	0.4993	1.7216
412 Administrative occupations: finance	0	0.3985	1.0291
413 Administrative occupations: records	0	0.3745	1.4510
414 Administrative occupations: communications	0	0.8607	2.7362
415 Administrative occupations: general	0.0022	1.1780	3.6647
421 Secretarial and related occupations	0.0008	0.5025	1.1817
511 Agricultural trades	0.1817	2.8902	10.6713
521 Metal forming, welding and related trades	0.0530	6.8276	20.6949
522 Metal machining, fitting and instrument making trades	0.0242	3.2852	12.6186
523 Vehicle trades	0.0358	3.6377	13.0455
524 Electrical trades	0.0309	3.3670	10.1769
531 Construction trades	0.0637	5.3196	13.686
532 Building trades	0.0531	3.4329	6.6801
541 Textiles and garments trades	0	1.0614	4.9446
542 Printing trades	0	2.8425	14.3406
543 Food preparation trades	0.0068	2.4155	11.9852
549 Skilled trades NEC	0.0057	0.9098	3.3645
611 Healthcare and related personal services	0.0017	2.7545	19.2341
612 Childcare and related personal services	0	0.9309	2.6618
613 Animal care services	0.0426	9.9718	11.7874
621Leisure and travel service occupations	0.0042	1.6052	3.8979
622 Hairdressers and related occupations	0	0.1514	0.4790
623 Housekeeping occupations	0.0173	4.5611	16.3762
629 Personal service occupations NEC	0.0400	2.6412	10.7247
711 Sales assistants and retail cashiers	0.0013	1.8974	7.4001
712 Sales related occupations	0.0072	2.0845	7.7398
721 Customer service occupations	0	1.3005	5.3926
811 Process operatives	0.0710	16.0361	89.0381
812 Plant and machine operatives	0.0579	8.4679	34.4322
813 Assemblers and routine operatives	0.0079	1.9195	10.0258
814 Construction operatives	0.1948	11.9587	30.0048
821 Transport drivers and operatives	0.0532	6.0703	26.3449
822 Mobile machine drivers and operatives	0.0624	4.5739	14.3013
911 Elementary agricultural occupations	0.2523	5.8854	7.4809
912 Elementary construction occupations	0.1357	9.6719	20.3221

913 Elementary process plant occupations	0.0101	2.5480	11.5818
914 Elementary goods storage occupations	0.0369	9.7315	58.7631
921 Elementary administration occupations	0.0029	5.1498	56.9138
922 Elementary personal service occupations	0.0026	2.1826	9.6139
923 Elementary cleaning occupations	0.0272	3.3977	15.3837
924 Elementary security occupations	0.0147	3.1556	9.4620
925 Elementary sales occupations	0	1.0540	5.3810

2 Digit SOC 2000

SOC 2000	**Fatal**	**Major Injury**	**Over 3-Day Injury**
11 Corporate Managers	0.0052	0.6802	1.5874
12 Managers & Proprietors in Agriculture & Services	0.0208	1.6311	3.1663
21 Service & Technology Professionals	0.0156	1.7985	5.6126
22 Health Professionals	0	0.4648	1.2056
23 Teaching & Research Professionals	0	1.1211	2.1068
24 Business & Public Service Professionals	0.0018	0.4831	1.6250
31 Science & Technology Associate Professionals	0.0088	1.7179	6.7135
32 Health & Social Welfare Associate Professionals	0	1.1504	2.7446
33 Protective Service Occupations	0.0265	7.0791	37.4950
34 Culture, Media & Sports Occupations	0.0027	7.0791	0.8052
35 Business & Public Service Associate Professionals	0.0005	0.3538	1.1778
41 Administrative Occupations	0.0005	0.6233	1.9500
42 Secretarial & related Occupations	0.0008	0.5014	1.1817
51 Skilled Agricultural Trades	0.1886	3.0009	10.6713
52 Skilled Metal &Electrical Trades	0.0333	3.8961	12.7661
53 Skilled Construction & Building Trades	0.0631	5.0353	12.1029
54 Textiles, Printing & Other Skilled Trades	0.0051	2.0847	9.8001
61 Caring Personal Service Occupations	0.0023	2.2486	11.8924
62 Leisure & other Personal Service Occupations	0.0073	1.8632	5.7897
71 Sales Occupations	0.0020	1.9486	7.4376
72 Customer Service Occupations	0	1.3093	5.3926
81 Process Plant & Machine Operatives	0.0636	9.2697	43.2908
82 Transport & Mobile Machine Drivers & Operatives	0.0568	6.0828	24.5239
91 Elementary Trades, Plant & Storage Related Occupations	0.0716	7.474	32.3521
92 Elementary Admin & Service Occupations	0.0120	2.9944	16.2937

The 3 digit classification highlights the occupations with the highest fatality rate to be 911 Elementary agricultural occupations (0.2523 per 1000 workers), 814 Construction operatives (0.1948 per 1000 workers), and 511 Agricultural Trades (0.1817 per 1000 workers). Similar occupations are highlighted as the most dangerous in the 2 digit classification, with 51 Skilled Agricultural Trades having the greatest fatality rate (0.1886 per 1000 workers), followed by 91 Elementary Trades, Storage and Related Occupations (0.0716 per 1000 workers). The differences in magnitude of the 3 digit and 2 digit variables should be noted, with the 3 digit classification producing the higher rates, as the finer classification highlights the very risky occupations. Similarly, the 3 digit breakdown highlights the very safe occupations, with 32 occupations with a zero death rate (out of 81) compared to 4 in the 2 digit breakdown (out of 25).

Correlations between the fatal and non-fatal variables are considered. *Fatal* and *major injury* are positively correlated with a coefficient of 0.587 for the 3 digit breakdown which is significant at the 1 per cent level (0.446 for the 2 digit breakdown). The correlation is insignificant between *fatal* and o*ver 3-day injury* (0.300 for the 3 digit breakdown) indicating potential measurement problems with this variable that includes less severe injuries. This variable may be much more dependent upon the individual as to whether the injury is reported compared to more major injuries. Table 2 presents the derived variables for full-time workers only.

Table 2: Accident Rates using LFS 2002-2004 Occupation Data: per 1000 Full Time Workers

3 Digit SOC 2000

SOC 2000	Fatal	Major Injury	Over 3-Day Injury
111	0.0608	1.5284	1.7489
112	0.0087	0.8736	1.5754
113	0.0012	0.1523	0.3164
114	0	0.4419	0.8705
115	0.0021	0.2928	0.5749
116	0.0042	1.6317	4.2998
117	0.0225	3.0012	10.0603
118	0	1.0020	3.3548
121	0.1569	2.2364	2.4326
122	0.0126	1.6009	3.4330
123	0.0194	1.9551	3.9102
211	0	0.2764	0.8938
212	0.0367	4.1012	13.1175
213	0	0.0552	0.1542
221	0	0.5760	1.5457
231	0	1.5042	2.8527
232	0	0.7543	2.0220
241	0	0.2331	0.4253
242	0	0.1294	0.2435
243	0.0051	0.4040	0.8847
244	0.0052	1.6807	7.4054
245	0	0.8183	2.7132
311	0.0160	3.3250	13.3958
312	0.0111	0.4337	0.8006
313	0	0.3771	1.5821
321	0	0.4362	4.5526
322	0	1.1284	5.3239
323	0	1.0014	3.3516
331	0.0262	7.0099	38.8791
341	0.0130	0.7279	0.8059
342	0	0.1254	0.1792
343	0	0.3439	1.0027
344	0	3.0503	3.6932
351	0.0127	0.5697	2.3799
352	0	0.1011	0.4648
353	0	0.3226	0.8314
354	0	0.2895	0.8239
355	0	1.5239	5.7731
356	0	0.5368	2.1472
411	0	0.6750	2.3275

412	0	0.6097	1.5745
413	0	0.5224	2.0241
414	0	1.2441	3.9551
415	0.0035	1.8462	5.7435
421	0.0014	0.9154	2.1525
511	0.2231	3.5491	13.1039
521	0.0538	6.9261	20.9934
522	0.0249	3.3707	12.9470
523	0.0369	3.7447	13.4293
524	0.0318	3.4673	10.4798
531	0.0661	5.5183	14.1977
532	0.0568	3.6727	7.1467
541	0	1.3537	6.3064
542	0	3.2338	16.3148
543	0.0094	3.3468	16.6056
549	0.0072	1.1392	4.2130
611	0.0031	5.0444	35.2242
612	0	1.9476	5.5690
613	0.0582	13.6330	16.1153
621	0.0067	2.5594	6.2147
622	0	0.2501	0.7911
623	0.0293	7.7362	27.7759
629	0.0518	3.4181	13.8795
711	0.0042	5.9414	23.1723
712	0.0102	2.9818	11.0716
721	0	1.8836	7.8106
811	0.0793	17.8983	99.3776
812	0.0591	8.6528	35.1840
813	0.0090	2.1920	11.4491
814	0.1987	12.1974	30.6036
821	0.0596	6.7998	29.5111
822	0.0632	4.6292	14.4743
911	0.3101	7.2330	9.1938
912	0.1564	11.1515	23.4309
913	0.0121	3.0242	13.7461
914	0.0426	11.2492	67.9276
921	0.0039	7.0275	77.6646
922	0.0082	6.9579	30.6476
923	0.0827	10.3100	46.6797
924	0.0262	5.6202	16.8520
925	0	3.2357	16.5189

2 Digit SOC 2000

SOC 2000	Fatal	Major Injury	Over 3-Day Injury
11	0.0055	0.7180	1.7011
12	0.0234	1.8366	3.6619
21	0.0161	1.8621	5.9477
22	0	0.5760	1.5457
23	0	1.4518	2.7946
24	0.0020	0.5324	1.8977
31	0.0095	1.8408	7.3047
32	0	0.6407	4.3690
33	0.0262	7.0099	38.8791
34	0.0033	0.7106	1.0501
35	0.0006	0.4017	1.3599
41	0.0008	0.9019	2.8564
42	0.0014	0.9154	2.1525
51	0.2231	3.5491	13.1039
52	0.0334	3.9066	13.1076
53	0.0641	5.1110	12.6417
54	0.0064	2.6396	12.7789
61	0.0044	4.2173	22.7461
62	0.0113	2.8954	9.4198
71	0.0055	5.3099	20.5902
72	0	1.8836	7.8106
81	0.0683	9.9645	47.2808
82	0.0602	6.4423	27.0347
91	0.0826	8.6173	37.8490
92	0.0294	7.3556	40.9522

The accident rates are slightly higher when part time workers are excluded from the denominator, as would be expected. The same three occupations (SOC 511,814 and 911) are found to have the highest risk of having a fatal accident. The above rates will be used in estimations for comparison purposes.

An alternative method of deriving the accident variables is to take the average number of accidents over the 3 year period and use the number of workers employed in each occupation for just one particular year (equation 3). Table 3 presents the calculated variables.

Table 3: Accident Rates using LFS 2004 Occupation Data: per 1000 Full Time and Part Time Workers

3 Digit SOC 2000

SOC 2000	Fatal	Major Injury	Over 3-Day Injury
111	0.0245	0.6159	0.7047
112	0.0044	0.4414	0.7960
113	0.0006	0.0706	0.1465
114	0	0.2018	0.3976
115	0.0009	0.1233	0.2421
116	0.0021	0.8276	2.1810
117	0.0094	1.2522	4.1974
118	0	0.3995	1.3375
121	0.1131	1.6115	1.7528
122	0.0074	0.9477	2.0323
123	0.0156	1.5699	3.1398
211	0	0.1157	0.3740
212	0.0184	2.0500	6.5567
213	0	0.0275	0.0768
221	0	0.2977	0.7989
231	0	0.5318	1.0086
232	0	0.2991	0.8017
241	0	0.1564	0.2854
242	0	0.0648	0.1220
243	0.0027	0.2147	0.4702
244	0.0019	0.6472	2.8297
245	0	0.2961	0.9818
311	0.0078	1.6157	6.5093
312	0.0055	0.2142	0.3955
313	0	0.1570	0.6589
321	0	0.6623	5.4417
322	0	0.4287	2.0225
323	0	0.2766	0.9258
331	0.0116	3.1025	17.2074
341	0.0136	0.7598	0.8412
342	0	0.0820	0.1171
343	0	0.1923	0.5607
344	0	1.1303	1.3685
351	0.0059	0.2642	1.1037
352	0	0.0467	0.2146
353	0	0.1596	0.4113
354	0	0.1354	0.3852
355	0	0.6628	2.5109
356	0	0.2102	0.8406
411	0	0.2332	0.8043

412	0	0.2004	0.5174
413	0	0.1760	0.6821
414	0	0.4234	1.3461
415	0.0011	0.5682	1.7676
421	0.0004	0.2455	0.5772
511	0.2124	3.3791	12.4762
521	0.0295	3.8040	11.5303
522	0.0123	1.6699	6.4144
523	0.0215	2.1845	7.8340
524	0.0182	1.9792	5.9822
531	0.0651	5.4369	13.9884
532	0.0745	4.8170	9.3733
541	0	0.7677	3.5765
542	0	1.4502	7.3163
543	0.0036	1.2675	6.2890
549	0.0043	0.6782	2.5082
611	0.0008	1.2870	8.9869
612	0	0.4688	1.3405
613	0.0246	5.7710	6.8218
621	0	0.2347	0.8384
622	0	0.1187	0.3754
623	0.0082	2.1685	7.7856
629	0.0239	1.5777	6.4066
711	0.0006	0.8843	3.4489
712	0.0045	1.3098	4.8632
721	0	0.5946	2.4656
811	0.0343	7.7370	42.9584
812	0.0265	3.8770	15.7649
813	0.0039	0.9538	4.9820
814	0.1195	7.3343	18.4021
821	0.0324	3.6917	16.0222
822	0.0312	2.2873	7.1518
911	0.1603	3.7384	4.7519
912	0.0827	5.8980	12.3926
913	0.0050	1.2581	5.7187
914	0.0162	4.2884	25.8956
921	0.0014	2.5212	27.8638
922	0.0012	1.0303	4.5382
923	0.0149	1.8547	8.3974
924	0.0066	1.4231	4.2671
925	0	0.4845	2.4735

2 Digit SOC 2000

SOC 2000	Fatal	Major Injury	Over 3-Day Injury
11	0.0025	0.3337	0.7907
12	0.0165	1.2957	2.5834
21	0.0078	0.9053	2.8915
22	0	0.2977	0.7989
23	0	0.5172	0.9956
24	0.0010	0.2658	0.9483
31	0.0043	0.8451	3.3536
32	0	0.5465	4.0251
33	0.0116	3.1025	17.2074
34	0.0021	0.4401	0.6504
35	0.0003	0.1805	0.6112
41	0.0003	0.2971	0.9408
42	0.0004	0.2455	0.5772
51	0.2124	3.3791	12.4762
52	0.0182	2.1324	7.1546
53	0.0668	5.3282	13.1789
54	0.0028	1.1618	5.6246
61	0.0011	1.0700	5.7709
62	0.0032	0.8024	2.8893
71	0.0009	0.9201	3.5680
72	0	0.5946	2.4656
81	0.0311	4.5278	21.4842
82	0.0322	3.4417	14.4427
91	0.0353	3.6870	16.1941
92	0.0057	1.4363	7.9965

Compared to the variables derived using the three year period rather than the average, the same three occupations have the highest accident rates.

Table 4: T Tests

3 Digit SOC 2000

	Fatal		Major Injury		Over 3-Day Injury	
	LFS 2004	LFS 2002-2004	LFS 2004	LFS 2002-2004	LFS 2004	LFS 2002-2004
Mean	0.0159	0.0232	1.4190	2.4654	5.0697	9.2736
Std error	0.0040	0.0159	0.1916	0.3347	0.7896	1.5931
Std dev	19.708	44.49				
t	3.6000***		6.3238***		4.9989***	

2 Digit SOC 2000

	Fatal		Major Injury		Over 3-Day Injury	
	LFS 2004	LFS 2002-2004	LFS 2004	LFS 2002-2004	LFS 2004	LFS 2002-2004
Mean	0.0183	0.0236	1.5102	2.8757	5.9848	10.3874
Std error	0.0087	0.0083	0.2993	0.5201	1.2364	2.3760
t	2.1989**		3.9813***		3.4418***	

***=significant at 1% level; **=significant at 5% level.
T tests adjust for unequal variance.

To see if there are any significant differences between the two methods of calculating the rates, Table 4 compares means and reports results of t tests. These tests show there to be significant differences between the mean accident rates. The order of occupations in terms of riskiness however, remains largely unchanged. Both methods however, may need to be considered in empirical estimations.

Risk variables calculated so far have been for both men and women collectively. As we would expect women to choose safer jobs, we are therefore overstating the risk women face and understating the risk men face. Within the majority of the UK literature, gender-specific risk measures have not been used because of problems of measurement error. A female-specific risk measure would fail to capture the true risk women face at work; as DeLeire and Levy (2004) emphasise "there are too few fatalities and too few women in the occupations with the most fatalities" (p.942) to calculate reliable measures. Several studies in the US however, have attempted to estimate a wage premium for females, including Barry (1985), Filer (1985), Hersch (1998) and Leeth and Ruser (2003), with mixed results.

The HSE data does enable accidents to be split by gender. As predicted, female-specific rates are very inaccurate, due to the lack of female employees in the most risky occupations. Male-specific measures however, may give a better indication of the accident risk male workers face. Table 5 reports.

Table 5: Accident Rates using LFS 2002-2004 Occupation Data: per 1000 Male Full Time and Part Time Workers

3 Digit SOC 2000

SOC 2000	Fatal	Major Injury	Over 3-Day Injury
111	0.0658	1.2826	1.0359
112	0.0198	1.0828	1.6994
113	0.0008	0.1062	0.1964
114	0	0.3435	0.5889
115	0	0.1477	0.4126
116	0.0055	1.1896	3.1309
117	0.0235	2.6298	9.0046
118	0	0.7401	3.0473
121	0.1932	2.3670	2.6327
122	0.0212	1.3695	2.5907
123	0.0259	1.6617	3.0647
211	0	0.2214	0.6021
212	0.0368	4.0229	12.7835
213	0	0.0405	0.1195
221	0	0.3312	0.7486
231	0	0.7484	1.5469
232	0	0.6072	1.5919
241	0	0.0828	0.1324
242	0	0.0946	0.1261
243	0.0053	0.3640	0.8545
244	0	1.0171	4.1681
245	0	0.3972	1.4753
311	0.0191	3.3935	13.7534
312	0.0120	0.4324	0.8168
313	0	0.3165	1.4614
321	0	1.7870	20.1257
322	0	0.4639	2.1540
323	0	0.8529	2.6589
331	0.0309	6.8423	38.7532
341	0.0080	0.5421	0.5501
342	0	0.1230	0.1493
343	0	0.3482	1.0075
344	0	1.6478	1.8929
351	0.0134	0.5221	2.2892

352	0	0.0419	0.4612
353	0	0.1992	0.4590
354	0	0.2557	0.7002
355	0	1.7551	6.4355
356	0	0.6150	2.4989
411	0	0.4653	1.9902
412	0	0.3645	1.0116
413	0	0.4190	1.7814
414	0	0.7976	2.9727
415	0	1.1059	3.9971
421	0	1.2440	2.9135
511	0.1914	3.0437	11.3058
521	0.0541	6.8986	20.8137
522	0.0247	3.3041	12.6557
523	0.0359	3.6103	12.9469
524	0.0313	3.3606	10.1007
531	0.0641	5.3325	13.6891
532	0.0541	3.4806	6.7148
541	0	1.6525	7.4015
542	0	3.1045	15.6809
543	0.0077	2.6293	13.1192
549	0.0080	1.1355	4.2302
611	0.0131	4.6213	32.0155
612	0	2.2489	8.3038
613	0.2524	34.8352	41.1460
621	0	1.9012	4.8943
622	0	0.0739	0.2587
623	0.0326	5.9419	19.9331
629	0.0495	2.6210	11.1271
711	0.0016	2.2343	9.0964
712	0.0140	2.4265	8.5206
721	0	1.3065	5.7103
811	0.0912	18.6427	100.3125
812	0.0597	8.7819	34.6702
813	0.0129	2.6227	13.2422
814	0.1953	11.9251	29.8894
821	0.0549	6.1395	26.4293
822	0.0636	4.5822	14.3421
911	0.3075	6.6629	8.4567
912	0.1364	9.6738	20.3026
913	0.0150	2.9693	12.3240
914	0.0429	10.3054	60.7739
921	0	5.2234	61.8539
922	0.0027	2.4490	12.2101
923	0.0902	6.5511	34.0154
924	0.0251	4.2812	12.4039
925	0	0.9155	4.9493

2 Digit SOC 2000

SOC 2000	Fatal	Major Injury	Over 3-Day Injury
11	0.0094	0.6757	1.4462
12	0.0337	1.6081	2.8898
21	0.0178	1.9833	6.2884
22	0	0.3312	0.7486
23	0	0.7350	1.5512
24	0.0013	0.2924	0.8880
31	0.0112	1.8419	7.3826
32	0	1.3185	12.2024
33	0.0309	6.8423	38.7532
34	0.0022	0.5584	0.8064
35	0.0009	0.3655	1.2587
41	0	0.5443	2.0450
42	0	1.2440	2.9135
51	0.1914	3.0437	11.3058
52	0.0330	3.8085	12.7359
53	0.0619	4.9180	12.1280
54	0.0058	2.2768	10.9812
61	0.0205	5.4254	28.1764
62	0.0163	3.2738	10.5339
71	0.0039	2.2698	8.9898
72	0	1.3065	5.7103
81	0.0798	10.7208	48.6839
82	0.0563	5.8984	24.5584
91	0.0839	8.1584	34.4438
92	0.0246	4.0568	26.2709

Table 6 presents t tests to examine whether the male-specific measures are significantly different to the variables presented in Table 1. Male-specific accident variables, both fatal and non-fatal, are greater than the collective male and female measures, and t tests show this difference to be significant. Again however, the order of occupations in terms of their accident risk remains largely unchanged.

Table 6: T Tests

3 Digit SOC 2000

	Fatal		Major Injury		Over 3-Day Injury	
	LFS 2002-04 Male Specific	LFS 2002-04	LFS 2002-04 Male Specific	LFS 2002-04	LFS 2002-04 Male Specific	LFS 2002-04
Mean	0.0298	0.0232	2.9984	2.4654	10.8423	9.2736
Std error	0.0065	0.0051	0.5297	0.3347	1.8052	1.5931
t	2.3306**		1.7138*		3.0399***	

2 Digit SOC 2000

	Fatal		Major Injury		Over 3-Day Injury	
	LFS 2002-04 Male Specific	LFS 2002-04	LFS 2002-04 Male Specific	LFS 2002-04	LFS 2002-04 Male Specific	LFS 2002-04
Mean	0.0274	0.0236	2.9399	2.8757	12.5477	10.3874
Std error	0.0085	0.0083	0.5458	0.5201	2.6657	2.3760
t	3.2302***		0.2044		2.6313**	

***=significant at 1% level; **=significant at 5% level; *=significant at the 10% level
T tests adjust for unequal variance.

ASHE Occupation Data

The ASHE is also considered for data on the number of workers employed in each occupation. There are a number of differences between the ASHE and the LFS. The ASHE is a 1 per cent sample of the population, resulting in approximately 140 000 records per year. Data are provided by the employer through the use of employee records. Conversely, the LFS is a quarterly sample survey of about 60 000 households. Information about the household is provided by one member, and proxy respondents are often used. In an investigation into the use of both data sets, Ormerod and Ritchie (2007) note that the ASHE is thought to be more reliable for earnings data, due to the use of employee records, with the LFS more useful for breaking down data in terms of a range of personal characteristics (p.25). However, in their analysis that attempted to link both data sets in order to compare them, they found "against expectations, the major data sets are more consistent than thought" (p.30), concluding "researchers are justified in their continuing use of the LFS data where ASHE is not available or appropriate" (p.30). As just a small difference in the occupation numbers may make a difference to the risk variables, accident rates are also calculated using ASHE data, with the measures reported in Table 7.

Table 7: Accident Rates using ASHE 2004 Occupation Data: per 1000 Full Time and Part Time Workers

3 Digit SOC 2000

SOC 2000	Fatal	Major Injury	Over 3-Day Injury
111	0.0259	0.6505	0.7443
112	0.0048	0.4795	0.8648
113	0.0006	0.0767	0.1594
114	0	0.2588	0.5098
115	0.0007	0.0982	0.1928
116	0.0024	0.9561	2.5195
117	0.0155	2.0698	6.9380
118	0	0.6306	2.1111
121	0.1333	1.9000	2.0667
122	0.0089	1.1294	2.4220
123	0.0119	1.2050	2.4100
211	0	0.1632	0.5278
212	0.0186	2.0782	6.6471
213	0	0.0294	0.0821
221	0	0.2837	0.7612
231	0	0.5333	1.0114
232	0	0.2667	0.7148
241	0	0.1449	0.2645
242	0	0.0854	0.1608
243	0.0030	0.2394	0.5242
244	0.0023	0.7320	3.2252
245	0	0.4368	1.4483
311	0.0064	1.3232	5.3308
312	0.0055	0.2131	0.3934
313	0	0.1638	0.6874
321	0	0.1186	1.2382
322	0	0.5093	2.4028

323	0	0.2768	0.9266
331	0.0104	2.7822	15.4309
341	0.0180	1.0090	1.1171
342	0	0.1273	0.1818
343	0	0.2465	0.7188
344	0	1.6519	2.0000
351	0.0069	0.3125	1.3056
352	0	0.0595	0.2738
353	0	0.2306	0.5942
354	0	0.1330	0.3785
355	0	0.7879	2.9848
356	0	0.2849	1.1398
411	0	0.2492	0.8594
412	0	0.2180	0.5630
413	0	0.2303	0.8923
414	0	0.4653	1.4792
415	0.0008	0.4362	1.3571
421	0.0005	0.3496	0.8220
511	0.2342	3.7267	13.7598
521	0.0353	4.5417	13.7660
522	0.0105	1.4290	5.4891
523	0.0303	3.0758	11.0303
524	0.0226	2.4621	7.4418
531	0.0931	7.7686	19.9874
532	0.1000	6.4667	12.5833
541	0	0.8283	3.8586
542	0	1.9474	9.8246
543	0.0046	1.6361	8.1177
549	0.0057	0.8983	3.3220
611	0.0008	1.2852	8.9744
612	0	0.6327	1.8091
613	0.0556	13.0185	15.3889
621	0.0018	0.6827	1.6578
622	0	0.2606	0.8242
623	0.0098	2.5850	9.2810
629	0.0333	2.2000	8.9333
711	0.0008	1.0886	4.2457
712	0.0059	1.7168	6.3746
721	0	0.6238	2.5867
811	0.0343	7.7556	43.0616
812	0.0319	4.6727	19.0000
813	0.0039	0.9522	4.9737
814	0.1221	7.4951	18.8052
821	0.0392	4.4702	19.4006
822	0.0614	4.5000	14.0702
911	0.1914	4.4630	5.6728
912	0.1291	9.2042	19.3393

913	0.0049	1.2247	5.5665
914	0.0177	4.6776	28.2456
921	0.0013	2.4123	26.6600
922	0.0016	1.3375	5.8915
923	0.0150	1.8680	8.4576
924	0.0079	1.6943	5.0804
925	0	0.9534	4.8674

2 Digit SOC 2000

	Fatal	**Major Injury**	**Over 3-Day Injury**
11	0.0028	0.3614	0.8563
12	0.0153	1.2044	2.4015
21	0.0085	0.9825	3.1384
22	0	0.2837	0.7612
23	0	0.5143	0.9899
24	0.0012	0.3074	1.0957
31	0.0040	0.7773	3.0847
32	0	0.1833	1.2496
33	0.0104	2.7822	15.4309
34	0.0029	0.6109	0.9027
35	0.0003	0.2212	0.7487
41	0.0003	0.3023	0.9574
42	0.0005	0.3496	0.8220
51	0.2342	3.7267	13.7598
52	0.0201	2.3465	7.8730
53	0.0947	7.5514	18.6780
54	0.0036	1.4973	7.2486
61	0.0013	1.2175	6.5667
62	0.0047	1.2115	3.9415
71	0.0012	1.1385	4.4149
72	0	0.6238	2.5867
81	0.0323	4.7096	22.3468
82	0.0418	4.4737	18.7735
91	0.0396	4.1303	18.1411
92	0.0067	0.0017	9.4030

Occupations 511, 911 and 814 remain the most risky in terms of high fatality rates. Variables created using ASHE data give slightly larger estimates than those created using the LFS. For instance, occupation 511 has a fatality rate of 0.212 per 1000 workers using LFS data, compared to 0.234 per 1000 workers using ASHE data. In other words, the estimates of the number employed in each occupation are slightly smaller in ASHE.

Table 8: T Tests

3 Digit SOC 2000

	Fatal		Major Injury		Over 3-Day Injury	
	ASHE 2004	LFS 2004	ASHE 2004	LFS 2004	ASHE 2004	LFS 2004
Mean	0.0195	0.0159	1.7677	1.4190	5.8979	5.0697
Std error	0.0047	0.0040	0.2644	0.1916	0.8585	0.7896
t	3.6049***		3.2603***		4.0260***	

2 Digit SOC 2000

	Fatal		Major Injury		Over 3-Day Injury	
	ASHE 2004	LFS 2004	ASHE 2004	LFS 2004	ASHE 2004	LFS 2004
Mean	0.0211	0.0183	1.6604	1.5102	6.6469	5.9848
Std error	0.0098	0.0087	0.3778	0.2993	1.3986	1.2364
t	1.9919*		1.2585		2.0430*	

***=significant at 1% level; **=significant at 5% level; *=significant at the 10% level
T tests adjust for unequal variance.

Table 8 reports means and t tests to see if this has a significant difference upon the rates. Results reveal differences between the two sets of accident rates are statistically significant, although again the order of occupations in terms of their accident risk remains very similar. In estimations where the magnitude of the variables is particular important however, such as when calculating VSL from compensating wage differential estimates, both ASHE and LFS variables will be considered.

CHAPTER 4 APPENDICES

Appendix 4.1: Variable Definitions

VARIABLE	DEFINITION
INJURIES	Number of injuries employees in the establishment have sustained during working hours in the last 12 months.
ILLNESSES	Number of illnesses employees in the establishment have sustained during working hours in the last 12 months.
EMPLOYEES	Total number of employees in the workplace.
PART-TIME	Proportion of all workers that are part-time employees.
TURNOVER	Labour turnover rate (proportion of total employees that have left in the past 12 months).
AGE21	Proportion of workers that are aged 21 or younger.
AGE50	Proportion of workers that are aged 50 or over.
SHIFTS	Dummy variable equal to 1 if some employees work shifts.
OVERTIME	Proportion of largest occupational group that regularly work overtime, whether paid or unpaid. Where: 0=none, 1=1-19%, 2=20-39%, 3=40-59%, 4=60-79%, 5=80-99%, 6=all.
UNION	Proportion of workers that belong to a trade union (value as a fraction).
COMMITTEE	Dummy variable equal to 1 if there is a committee within the workplace that deals either with a range of issues or specifically health and safety.
JOINTCOMM	Dummy variable equal to 1 if above committee deals with a range of issues in addition to health and safety.
SPECIFICCOMM	Dummy variable equal to 1 if there is a committee that deals only with health and safety issues.
PAY	Average annual pay per employee (£ 000)
INDUSTRY DUMMY VARIABLES	Correspond to SIC 2003: Manufacturing (excluded in estimations); Electricity gas and water; Construction; Wholesale and retail; Hotels and restaurants; Transport and communication; Financial services; Other business service; Public administration; Education; Health; Other community services.
OCCUPATION VARIABLES	Correspond to SOC 2000. Variables calculated as a proportion of entire workforce: Managers and senior officials; Professional; Associate professional and technical; Administrative and secretarial (excluded in estimations); Skilled trades; Caring, leisure and personal service; Sales and customer service; Process, plant and machine operatives; Routine unskilled.
FEMALE	Proportion of workforce that is female.
'UNIONS HELP IMPROVE PERFORMANCE'	Value of 0-4 where 4=strongly disagree, and 0=strongly agree.
'NO EMPLOYEE CONSULTATION'	Value of 0-4 where 4=strongly disagree, and 0=strongly agree.
HSTRAIN	Dummy variable equal to 1 if largest occupational group had training that covered health and safety in the last 12 months.

RESULTSPAY	Dummy variable equal to 1 if there are some workers in the establishment that get paid by results.
SICKPAY	Dummy variable equal to 1 if largest occupational group is entitled to sick pay in excess of statutory requirements.
REDUNDANCY	Number of workers made redundant in the last 12 months.
FORTYEIGHTHRS	Proportion of non-managerial employees that, over the past 12 months have regularly worked in excess of 48 hours per week, where: 0=none, 1=1-19%, 2=20-39%, 3=40-59%, 4=60-79%, 5=80-99%, 6=all.
FORTYEIGHTMANGS	Proportion of managerial employees that, over the past 12 months have regularly worked in excess of 48 hours per week, where: 0=none, 1=1-19%, 2=20-39%, 3=40-59%, 4=60-79%, 5=80-99%, 6=all.
APPRAIS	Proportion of non-managerial employees that have their performance formally appraised, where: 0=none, 1=1-19%, 2=20-39%, 3=40-59%, 4=60-79%, 5=80-99%, 6=all.
DISCRETE	Extent to which individuals gave discretion over how they do their work, where: 0=none and 3=a lot.
CONTROL	Extent to which individuals have control over the pace at which they work, where: 0=none and 3=a lot.
TEAM	Proportion of largest occupational group that work in formally designated teams, where: 0=none, 1=1-19%, 2=20-39%, 3=40-59%, 4=60-79%, 5=80-99%, 6=all.
FLEX	Dummy variable equal to 1 if some workers are able to work flexitime.
NIGHT	Dummy variable equal to 1 if some employees work nights.
HOME	Dummy variable equal to 1 if some workers are able to work from home.

Appendix 4.2: Unweighted Negative Binomial Regression Results

Workplaces with 5 or more Employees

Variables	INJURIES			ILLNESSES		
No. of Obs	*1357*			*1296*		
LR chi²	*400.6*			*814.45*		
Log Pseudo-likelihood	*-1047.1432*			*-2241.0065*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.5592***	0.8343	-10.3	-2.9141***	0.4679	-6.23
Ln(Employees)	0.8075***	0.7373	11.0	0.8713***	0.0433	20.10
Part-time	-0.4565	0.5388	-0.85	-0.2906	0.3170	-0.92
Turnover	-0.9266	0.6008	-1.54	0.1957	0.3519	0.56
Age21	1.9016***	0.4714	2.56	-0.5851	0.4778	-1.22
Age50	-0.0619	0.6427	-0.10	-0.4684	0.3628	-1.29
Shifts	0.0484	0.2082	0.23	0.0860	0.1345	0.64
Overtime	0.0962*	0.0545	1.77	0.0988***	0.0319	3.10
Union	0.4680	0.3274	1.43	0.5413***	0.1948	2.78
Committee	0.5010**	0.2029	2.47	0.0734	0.1273	0.58

Pay	3.85e-05**	1.91e-05	2.02	-1.53e-05	1.24e-05	-1.23
Electricity	-0.2281	0.5920	-0.39	-0.1524	0.4235	-0.36
Construction	1.1556***	0.4141	2.79	0.2451	0.2766	0.89
Wholesale	0.4822	0.4497	1.07	0.4683*	0.2433	1.92
Hotel	-0.0246	0.5325	-0.05	-0.6747*	0.3757	-1.80
Transport	-0.5605	0.3872	-1.45	0.2357	0.2611	0.90
Financial	0.5022	0.5777	0.87	0.6226*	0.3315	1.88
Real estate	1.1009***	0.3589	3.07	-0.1608	0.2467	-0.65
Public admin	2.8137***	0.4545	6.19	0.8600***	0.3120	2.76
Education	0.5854	0.4966	1.18	-0.0086	0.3208	-0.03
Health	0.9837**	0.4600	2.14	0.8046***	0.2754	2.92
Community	1.0121***	0.4136	2.45	0.2754	0.2776	0.99
Skilled Trades	3.8015***	0.7369	5.16	-0.5093	0.4444	1.15
Managers	0.5974	1.3734	0.43	-1.8454***	0.6544	-2.82
Machine Operatives	3.6038***	0.7245	4.97	-0.5388	0.4084	-1.32
Professional	1.3130	0.8097	1.62	-0.3311	0.4349	-0.76
Service	2.3303***	0.7641	3.05	-07206**	0.3722	-1.94
Unskilled	3.6068***	0.6143	5.87	-0.0836	0.3564	-0.23
Sales	2.9738***	0.6434	4.62	0.3212	0.3458	-0.93
Technical	0.5320	0.6865	0.77	-0.6524*	0.3614	-1.81
TEST LNEMPS=1						
$Chi^2(1)$	6.81			8.81		
$Prob>chi^2$	0.0090			0.0030		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*1198*			*1138*		
LR chi²	*345.08*			*708.75*		
Log Pseudo-likelihood	*-1027.5227*			*-2142.777*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.3531***	0.8600	-9.71	-2.8761***	0.5031	-5.72
Ln(Employees)	0.7856***	0.0769	10.2	0.8878***	0.0466	19.06
Part-time	-0.4984	0.5516	-0.90	-0.1970	0.3330	-0.59
Turnover	-1.0007	0.6167	-1.62	0.2123	0.3738	0.57
Age21	2.0483***	0.7872	2.60	-0.4448	0.5170	-0.86
Age50	-0.0055	0.6642	-0.01	-0.7685*	0.3986	-1.93
Shifts	0.0857	0.2109	0.41	0.0811	0.1397	0.58
Overtime	0.0938	0.0563	1.66	0.0899***	0.0341	2.64
Union	0.4505	0.3296	1.37	0.5771***	0.2021	2.86
Committee	0.5233***	0.2033	2.57	0.0870	0.1293	0.67
Pay	3.52e-06*	1.96e-05	1.80	-1.36e-05	1.32e-05	-1.03
Electricity	-0.2660	0.5932	-0.45	-0.1604	0.4277	-0.37
Construction	1.1800***	0.4225	2.79	0.2802	0.2857	0.98
Wholesale	0.4514	0.4627	0.98	0.4509*	0.2538	1.78
Hotel	-0.4971	0.5452	-0.09	-0.8001**	0.3898	-2.05
Transport	-0.5674	0.3862	-1.47	0.2266	0.2655	0.85

Financial	0.5441	0.5787	0.94	0.6344*	0.3443	1.84
Real estate	1.0432***	0.3644	2.86	-0.2531	0.2538	-1.00
Public admin	2.7531***	0.4669	5.90	0.7659**	0.3209	2.39
Education	0.5356	0.5032	1.06	-0.0485	0.3334	-0.15
Health	0.9101**	0.4693	1.94	0.7077**	0.2887	2.45
Community	0.8815**	0.4413	2.00	0.3218	0.2938	1.10
Skilled Trades	3.8319***	0.7594	5.05	-0.6348	0.4692	-1.35
Managers	0.4698	1.4615	0.32	-2.3546***	0.7189	-3.28
Machine Operatives	3.4036***	0.7518	4.53	-0.6493	0.4323	-1.50
Professional	1.3512	0.8232	1.64	-0.3493	0.4487	-0.78
Service	2.3936***	0.7835	3.05	-0.7125*	0.3922	-1.82
Unskilled	3.5806***	0.6261	5.72	-0.1645	0.3733	-0.44
Sales	2.9639***	0.6550	4.53	-0.4090	0.3642	-1.12
Technical	0.6036	0.6986	0.86	-0.6412*	0.3744	-1.71
TEST LNEMPS=1						
$Chi^2(1)$	7.77			5.81		
Prob>chi^2	0.0053			0.0160		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 4.3: Reduced Form Regressions

Workplaces with 5 or more Employees

	UNION DENSITY		H&S COMMITTEE		AVERAGE PAY	
Obs	*1747*		*1984*		*1523*	
Log Likelihood	*-693.7580*		*-901.6808*			
Psuedo R^2	*0.4261*		*0.3019*		*0.7159*	
	Coefficient	**z**	**Coefficient**	**z**	**Coefficient**	**t**
Constant	-2.6605*** (0.6221)	-4.28	-2.9755*** (0.5661)	-5.26	9.9089*** (0.0685)	144.63
Ln(Employees)	0.6077*** (0.0566)	10.7	0.6808*** (0.0477)	14.3	0.0477*** (0.0054)	8.77
Female	0.1470 (0.4080)	0.36	-0.1821 (0.3915)	-0.47	-0.2502*** (0.0431)	-5.80
Part-time	0.6117* (0.3622)	1.69	-0.5394 (0.3647)	-1.48	-0.8381*** (0.0409)	-20.48
Turnover	-1.5578*** (0.4338)	-3.59	0.1571 (0.3957)	0.40	-0.1141*** (0.0454)	-2.51
Age21	-1.2707** (0.5876)	-2.16	-0.1973 (0.5601)	-0.35	-0.3427*** (0.0616)	-5.57
Age50	1.2651*** (0.4423)	2.86	0.2698 (0.4212)	0.64	-0.0766 (0.0487)	-1.57
Shifts	0.3873** (0.1666)	2.33	0.4337*** (0.1463)	2.97	-0.0307* (0.0183)	-1.68
Overtime	0.0328 (0.0397)	0.83	-0.0484 (0.0358)	-1.35	0.0153*** (0.0041)	3.73
'Unions help performance'	-0.5266*** (0.0706)	7.46	-1.7494*** (0.0604)	-2.90	-0.0053 (0.0071)	-0.74

'No employee consultation'	0.3198*** (0.0729)	4.39	0.1203* (0.0683)	1.76	0.0133* (0.0079)	1.67
Electricity			-0.2667 (0.3850)	-0.69	0.1975*** (0.0614)	3.22
Construction	0.1070 (0.3263)	0.33	-0.9847*** (0.3217)	-3.06	0.0395 (0.0404)	0.98
Wholesale	-0.6888** (0.2942)	-2.34	-1.1614*** (0.2863)	-4.06	-0.0885*** (0.0347)	-2.55
Hotel	-1.6627*** (0.4664)	-3.57	-0.9614** (0.4060)	-2.37	-0.0810* (0.0495)	-1.64
Transport	1.0488*** (0.3269)	3.21	-0.5535** (0.2723)	-2.03	0.0992*** (0.0364)	2.73
Financial	1.1469*** (0.3729)	3.08	-1.9167*** (0.3726)	-5.14	0.0573 (0.0430)	1.33
Real estate	-1.2357*** (0.2995)	-4.13	-1.3061*** (0.2758)	-4.74	-0.0843 (0.0334)	-0.25
Public admin	4.2657*** (1.0535)	4.05	0.4417 (0.3464)	1.28	-0.0720* (0.0424)	-1.70
Education	2.8597*** (0.4948)	5.78	0.3657 (0.3454)	1.06	0.0805* (0.0422)	1.91
Health	0.8411** (0.3531)	2.38	-0.4000 (0.3218)	-1.24	-0.0322 (0.0387)	-0.83
Community	0.5933* (0.3191)	1.86	-0.4183 (0.3075)	-1.36	-0.0465 (0.0379)	-1.23
Skilled Trades	0.4566 (0.5918)	0.77	-0.1299 (0.5568)	-0.23	-0.3107*** (0.0660)	-4.71
Managers	-2.2775*** (0.7999)	-2.85	0.5039 (0.7226)	0.70	0.2674*** (0.0808)	3.31
Machine Operatives	0.6911 (0.5486)	1.11	0.2226 (0.4971)	0.45	-0.4348*** (0.0601)	-7.24
Professional	-0.0789 (0.6179)	-0.13	-0.0971 (0.5065)	-0.19	0.3041*** (0.0605)	5.02
Service	-0.2900 (0.4536)	-0.64	-0.5032 (0.4323)	-1.16	-0.2537*** (0.0495)	-5.12
Unskilled	0.5613 (0.4647)	1.21	-0.2781 (0.4251)	-0.65	-0.4354*** (0.0503)	-8.66
Sales	0.5840 (0.4479)	1.30	-0.2648 (0.4421)	-0.60	-0.2500*** (0.0487)	-5.13
Technical	-0.1409 (0.4375)	-0.26	-0.5919 (0.4396)	-1.35	0.1872*** (0.0511)	3.67

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Workplaces with 10 or more Employees

	UNION DENSITY		H&S COMMITTEE		AVERAGE PAY	
Obs	*1533*		*1766*		*1361*	
Log Likelihood	*-603.1526*		*-846.4746*			
Psuedo R^2	*0.4245*		*0.2847*		*0.7341*	
	Coefficient	**z**	**Coefficient**	**z**	**Coefficient**	**t**
Constant	-3.3798*** (0.7010)	-4.82	-2.7947*** (0.5949)	-4.70	-9.9251*** (0.0705)	140.84
Ln(Employees)	0.6478*** (0.0649)	9.98	0.6833*** (0.0513)	13.3	0.0455*** (0.0056)	8.07
Female	0.3842 (0.4620)	0.83	-0.3014 (0.4119)	-0.73	-0.2741*** (0.0457)	-6.00
Part-time	0.3908 (0.4066)	0.96	-0.6762* (0.3826)	-1.77	-0.7938*** (0.0424)	-18.73
Turnover	-1.7982*** (0.4705)	-3.82	0.0982 (0.4145)	0.24	-0.1782*** (0.0474)	-3.76
Age21	-1.4480** (0.6585)	-2.20	-0.2818 (0.5896)	-0.48	-0.4353*** (0.0662)	-6.58
Age50	1.3802*** (0.5115)	2.70	0.3977 (0.4451)	0.89	-0.0757 (0.0513)	-1.48
Shifts	0.3722** (0.1756)	2.12	0.4622*** (0.1501)	3.08	-0.0324* (0.0181)	-1.79
Overtime	0.0522 (0.0443)	1.18	-0.0720* (0.0375)	-1.92	0.0125*** (0.0043)	2.95
'Unions help performance'	-0.5257** (0.0754)	-6.97	-0.1945*** (0.0623)	-3.12	-0.0052 (0.0072)	-0.73
'No employee consultation'	0.3756*** (0.0783)	4.80	0.1272* (0.0703)	1.81	0.0112 (0.0080)	1.40
Electricity			-0.2398 (0.3967)	-0.60	0.2042*** (0.0580)	3.52
Construction	0.0603 (0.3452)	0.17	-0.9698*** (0.3290)	-2.95	0.0402 (0.0402)	1.00
Wholesale	-0.5020 (0.3130)	-1.60	-1.1274*** (0.2958)	-3.81	-0.0978*** (0.0353)	-2.77
Hotel	-1.5679*** (0.5021)	-3.12	-0.7990* (0.4167)	-1.92	-0.0604 (0.0503)	-1.20
Transport	0.9969*** (0.3400)	2.93	-0.5788** (0.2777)	-2.08	0.0941*** (0.0350)	2.69
Financial	0.8051** (0.3997)	2.01	-2.0092*** (0.3829)	-5.25	0.0556 (0.0425)	1.31
Real estate	-1.3076*** (0.3179)	-4.11	-1.3497*** (0.2844)	-4.75	0.0077 (0.0332)	0.23
Public admin	4.1268*** (1.0592)	3.90	0.3801 (0.3545)	1.07	-0.0707* (0.0412)	-1.72
Education	3.0128*** (0.5516)	5.46	0.4431 (0.3562)	1.24	0.0694* (0.0416)	1.67
Health	1.0062*** (0.3879)	2.59	-0.3716 (0.3313)	-1.12	-0.0405 (0.0386)	-1.05
Community	0.6262*	1.79	-0.4014	-1.25	-0.0297	-0.78

	(0.3503)		(0.3214)		(0.0383)	
Skilled Trades	1.0071 (0.6643)	1.52	-0.2898 (0.5807)	-0.50	-0.3266*** (0.0679)	-4.81
Managers	-2.0568** (0.9261)	-2.22	0.8299 (0.7753)	1.07	0.4348*** (0.0908)	4.79
Machine Operatives	0.8421 (0.6034)	1.40	0.1301 (0.5164)	0.25	-0.4150*** (0.0606)	-6.85
Professional	0.3357 (0.6706)	0.50	-0.1328 (0.5206)	-0.26	0.3176*** (0.0596)	5.33
Service	-0.2266 (0.5101)	-0.44	-0.6685 (0.4526)	-1.48	-0.2371*** (0.0502)	-4.73
Unskilled	1.0292** (0.5205)	1.98	-0.3378 (0.4403)	-0.77	-0.4084*** (0.0503)	-8.12
Sales	0.9457* (0.5145)	1.84	-0.4135 (0.4595)	-0.90	-0.2159*** (0.0501)	-4.31
Technical	0.2450 (0.5865)	0.42	-0.7854* (0.4559)	-1.72	0.2120*** (0.0514)	4.12

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 4.4: Negative Binomial Regressions Results with Residuals

Workplaces with 5 or more Employees

	INJURIES			ILLNESSES		
No. of Obs	*1326*			*1267*		
Log pseudo-likelihood	*-18.3857*			*-56.2324*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.8538***	1.1636	-5.41	-3.5346***	0.5091	0.79
Ln(Employees)	0.8965***	0.1389	6.46	0.7818***	0.0982	7.96
Part-time	-0.6719	0.9052	-0.74	-0.3357	0.5923	-0.57
Turnover	-0.6591	0.7050	-0.93	-0.5135	0.4241	-1.21
Age21	0.4351	0.7401	0.59	-1.1088*	0.5949	-1.86
Age50	-0.6557	0.7310	-0.90	0.2762	0.4398	0.63
Shifts	0.3444	0.3163	1.09	0.3063	0.1895	1.62
Overtime	0.0667	0.0803	0.83	0.1243***	0.0422	2.94
Union	1.1636***	0.3854	3.02	-0.1548	0.2964	-0.52
Committee	0.6103	0.7849	0.82	0.6493	0.4905	1.32
Pay	3.44e-05	5.9e-05	0.58	3.56e-06	4.05e-05	0.09
Construction	-0.5042	0.5642	-0.89	-0.4656	0.4095	-1.14
Wholesale	0.3749	0.7150	0.52	0.2303	0.3366	0.68
Hotel	-0.2565	0.6972	-0.37	-0.5970	0.5091	-1.17
Transport	-1.7981***	0.5275	-3.41	0.2895	0.3690	0.78
Financial	-0.1572	0.9401	-0.17	0.7882	0.4961	1.59
Real estate	1.4307**	0.6484	2.21	-0.2976	0.3650	-0.82
Public admin	2.5618***	0.6939	3.69	1.2168***	0.4457	2.73
Education	1.0335	0.7344	1.41	0.2811	0.4394	0.64
Health	1.9942***	0.7266	2.74	0.9003**	0.3775	2.38
Community	0.8518	0.6078	1.40	0.2749	0.3458	0.79

Skilled Trades	4.1229***	1.1515	3.58	0.5626	0.6136	0.92
Managers	1.5615	1.8515	0.84	-0.8486	1.0166	-0.83
Machine Operatives	4.7102***	1.1574	4.07	-0.2740	0.6464	-0.42
Professional	0.5320	1.2619	0.42	-0.1727	0.7401	-0.23
Service	0.7922	1.0301	0.77	-0.4025	0.4721	-0.85
Unskilled	3.6125***	0.9882	3.66	0.6758	0.5487	1.23
Sales	3.4307***	1.3586	2.53	0.3998	0.5091	0.79
Technical	-0.5904	0.9553	-0.62	-0.3992	0.5783	-0.68
Runion	-0.1865*	0.0107	-1.78	0.2840***	0.0461	6.16
Rcomm	-0.1186	0.1046	-0.43	-0.2511	0.1806	-1.39
Rpay	-0.1435	1.0266	-0.14	0.1919	0.6102	0.31
TEST LNEMPS=1						
Chi²(1)	0.56			4.93		
Prob>chi²	0.4563			0.0263		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

	INJURIES			ILLNESSES		
No. of Obs	*1168*			*1110*		
Log pseudo-likelihood	*-14.8705*			*-39.2409*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.5152***	0.1593	-5.35	-2.3095***	0.8791	-2.63
Ln(Employees)	0.7318***	0.1875	3.91	0.8491***	0.1099	7.73
Part-time	-0.4975	0.9041	-0.55	-0.5672	0.5899	-0.96
Turnover	-1.3241*	0.7037	-1.88	-0.2432	0.4211	-0.58
Age21	1.0208	0.8190	1.25	-0.9491*	0.5269	-1.80
Age50	-0.2741	0.8682	-0.32	-0.6485	0.5182	-1.25
Shifts	0.5666*	0.3044	1.86	0.3618**	0.1789	2.02
Overtime	0.0668	0.0723	0.92	0.1071***	0.0395	2.71
Union	0.8569**	0.4033	2.12	0.0183	0.3002	0.06
Committee	0.6132	1.0838	0.57	0.5175	0.6436	0.80
Pay	6.4e-05	4.91e-05	1.30	-2.25e-05	3.77e-05	-0.60
Construction	-0.1953	0.4748	-0.41	0.0610	0.4332	0.14
Wholesale	0.4577	0.6326	0.72	-0.0573	0.3773	-0.15
Hotel	-0.2350	0.7073	-0.33	-1.1504***	0.4590	-2.51
Transport	-1.6525***	0.4998	-3.31	0.3865	0.3691	1.05
Financial	0.2753	0.9116	0.30	0.7491	0.5780	1.30
Real estate	1.3648**	0.5843	2.34	-0.5041	0.3833	-1.32
Public admin	2.7275***	0.7055	3.87	0.3681	0.4247	0.87
Education	1.2052*	0.7115	1.69	0.0613	0.4121	0.15
Health	2.0652***	0.7016	2.94	0.4071	0.3897	1.04
Community	0.4730	0.5579	0.85	0.3745	0.3780	0.99
Skilled Trades	3.7872***	1.1210	3.38	-0.7554	0.6550	-1.15
Managers	-0.3153	2.1998	-0.14	-2.2560**	1.0340	-2.18
Machine Operatives	4.0443***	1.1263	3.59	-1.6401**	0.7013	-2.34
Professional	0.2124	1.2403	0.18	-0.4358	0.6817	-0.64

Service	0.7890	1.0541	0.75	-0.8500*	0.5177	-1.64
Unskilled	3.7288***	0.8900	4.19	-0.3191	0.5569	-0.57
Sales	3.3594***	0.8734	3.85	-0.1354	0.5990	-0.23
Technical	-0.7897	0.9658	-0.82	-0.4567	0.6172	-0.74
Runion	-0.1039	0.1076	-0.97	0.1926***	0.0736	2.62
Rcomm	-0.0559	0.4433	-0.13	-0.1730	0.2628	-0.66
Rpay	-1.0341	0.7517	-1.38	0.6192	0.5731	1.08
TEST LNEMPS=1						
$Chi^2(1)$	2.05			1.89		
Prob>chi^2	0.1522			0.1697		

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 4.5: Negative Binomial Regression Results with New Workplace-Level Variables

Workplaces with 5 or more Employees

Variables	INJURIES			ILLNESSES		
No. of Obs	*1265*			*1209*		
Wald chi²	*408.39*			*413.80*		
Log pseudo-likelihood	*-16.5279*			*-52.8138*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.9821***	1.2896	-6.96	-3.354***	0.7090	-4.73
Ln(Employees)	0.8565***	0.1306	6.56	0.8123***	0.0784	10.4
Part-time	-0.9315	0.6635	-1.40	-0.3890	0.4189	-0.93
Turnover	-0.6924	0.6512	-1.06	0.0307	0.6159	0.05
Age21	1.4320*	0.7446	1.92	-1.0286*	0.5982	-1.72
Age50	-1.0819	0.8316	-1.30	0.4287	0.4880	0.88
Shifts	0.2274	0.3251	0.70	0.1017	0.1774	0.57
Overtime	0.0911	0.0945	0.96	0.1161***	0.0423	2.74
Union	0.8630**	0.3863	2.23	0.5882**	0.2977	1.98
Committee	0.2765	0.2573	1.07	0.0271	0.1619	0.17
Pay	4.52e-05*	2.59e-05	1.74	-0.124e-05	1.67e-05	-0.74
Fixed	0.5563	0.5832	0.34	-0.1973	0.4391	-0.45
Hstrain	0.3962	0.2918	1.36	-0.3490**	0.1554	-2.25
Resultspay	-0.7654**	0.3260	-2.35	0.2126	0.2079	1.02
Sickpay	-0.0009	0.2963	0.10	0.4392***	0.1713	2.56
Redundancy	-0.0114*	0.0067	-1.71	0.0010	0.0056	0.17
Fortyeighthrs	0.0330	0.0918	0.72	0.0272	0.0502	0.54
Apprais	-0.1700***	0.0534	-3.19	0.0322	0.0331	0.97
Discrete	-0.1205	0.1630	0.46	-0.1837*	0.0984	-1.87
Control	0.0139	0.1870	0.07	0.0168	0.0910	0.18
Team	0.0421	0.0801	0.60	-0.0055	0.0391	-0.14
Flex	-0.1868	0.2403	-0.78	-0.1134	0.1711	-0.66
Night	0.6146*	0.3317	1.85	0.3102	0.1984	1.56
Home	-0.0864	0.4228	0.84	0.3248*	0.1739	1.87

Electricity	-0.2132	0.7515	-0.28	-0.7101	0.6476	-1.10
Construction	-0.2903	0.5913	-0.49	-0.4911	0.4338	-1.13
Wholesale	0.6083	0.6690	0.91	-0.0918	0.3494	-0.26
Hotel	0.1894	0.7282	0.26	-0.5937	0.5098	-1.16
Transport	-2.3129	0.5522	-4.19	0.3435	0.3976	0.86
Financial	0.6595	0.9945	0.66	0.0909	0.5103	0.18
Real estate	1.5751***	0.5707	2.76	-0.0366	0.3602	-0.10
Public admin	3.0409***	0.7413	4.10	0.8445*	0.4528	1.87
Education	1.6027**	0.7600	2.11	0.3102	0.4879	0.64
Health	2.1606***	0.6780	3.19	0.7889**	0.3995	1.97
Community	1.2272*	0.6567	1.87	0.0950	0.3618	0.26
Skilled Trades	3.6064***	1.1507	3.13	0.5937	0.6299	0.94
Managers	2.3782	1.7619	1.35	-0.2594	0.9467	-0.27
Machine Operatives	4.7524***	0.9628	4.94	-0.5022	0.6269	-0.80
Professional	-0.0908	1.0417	-0.09	-0.5194	0.6601	-0.79
Service	0.2097	1.0714	0.20	-0.4343	0.4949	-0.88
Unskilled	2.8307***	0.8990	3.15	0.2332	0.5349	0.44
Sales	3.4136***	1.1583	2.95	0.4606	0.5220	0.88
Technical	-0.5876	0.8419	-0.70	-.5147	0.5301	-0.97

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*1121*			*1066*		
Wald chi²	*268.29*			*368.87*		
Log pseudo-likelihood	*-13.098*			*-37.0765*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-7.8746***	1.2596	-6.25	-3.0791***	0.6775	-4.54
Ln(Employees)	0.8150***	0.1313	6.21	0.8274***	0.0831	9.95
Part-time	-1.365**	0.6781	-2.01	-0.0532	0.4283	-0.12
Turnover	-1.4148**	0.7136	-1.98	-0.1666	0.4383	-0.38
Age21	1.6546*	0.9518	1.74	-0.8041	0.5222	-1.54
Age50	-0.5185	0.8929	-0.58	-0.3829	0.5451	-0.68
Shifts	0.3588	0.2996	1.20	0.2450	0.1715	1.43
Overtime	0.0471	0.0881	0.54	0.0707*	0.0414	1.71
Union	0.8076**	0.4012	2.01	0.5374*	0.2886	1.86
Committee	0.4839**	0.2406	2.01	0.1267	0.1674	0.76
Pay	2.23e-05	2.46e-05	0.91	2.18e-06	1.94e-05	0.11
Fixed	1.1495**	0.5186	2.22	0.0986	0.4409	0.22
Hstrain	0.5560**	0.2741	2.03	-0.2519	0.1612	-1.56
Resultspay	-0.3324	0.2858	-1.16	-0.0550	0.1845	-0.30
Sickpay	-0.2683	0.3096	-0.87	0.1998	0.1744	1.15
Redundancy	-0.0042	0.0079	-0.53	0.0027	0.0059	0.46
Fortyeighthrs	0.1397**	0.0762	1.83	0.0786	0.0508	1.55
Apprais	-0.1680***	0.0601	-2.80	0.0378	0.0348	1.09
Discrete	-0.1120	0.1499	-0.75	-0.0053	0.0946	-0.06
Control	0.0920	0.1635	0.56	-0.0378	0.0905	-0.42
Team	-0.0705	0.0611	-1.16	0.0178	0.0390	0.46

Flex	-0.3502	0.2689	-1.30	-0.1949	0.1788	-1.09
Night	0.7309**	0.2892	2.53	0.2148	0.1793	1.20
Home	-0.5383	0.3307	-1.63	0.5216***	0.1796	2.90
Electricity	0.5362	0.7505	0.71	-0.7248	0.5821	-1.25
Construction	0.0048	0.5258	0.01	-0.0496	0.4317	-0.11
Wholesale	0.4548	0.5852	0.78	-0.0032	0.3487	-0.01
Hotel	0.1488	0.6952	0.21	-1.1316**	0.4593	-2.46
Transport	-2.2898***	0.5518	-4.15	0.3187	0.3815	0.84
Financial	0.9065	0.8506	1.07	0.6133	0.5615	1.09
Real estate	1.3156***	0.4832	2.72	-0.4547	0.3350	-1.36
Public admin	3.1095***	0.7454	4.17	0.4060	0.4227	0.96
Education	1.3758*	0.7770	1.77	-0.0340	0.4543	-0.07
Health	2.1080***	0.7066	2.98	0.4288	0.3889	1.10
Community	0.7397	0.5805	1.27	0.1933	0.3635	0.53
Skilled Trades	2.3143**	1.1039	2.10	-0.6167	0.6615	-0.93
Managers	0.9003	1.8975	0.47	-2.5873**	1.0343	-2.50
Machine Operatives	3.1099***	1.1605	2.68	-1.2824**	0.6528	-1.96
Professional	0.0793	1.1040	0.07	-0.9650	0.6365	-1.52
Service	-0.5301	1.2378	-0.43	-0.6777	0.5159	-1.31
Unskilled	2.2118**	0.9941	2.22	-0.1368	0.5107	-0.27
Sales	2.7840***	0.8785	3.17	0.0753	0.5544	0.14
Technical	-0.4855	1.003	-0.48	-0.7174	0.5579	-1.29

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

<u>Appendix 4.6: Endogeneity Test Results Including New Variables</u>

Workplaces with 5 or more Employees: Reduced Form Regression

	UNION DENSITY		H&S COMMITTEE		AVERAGE PAY	
Obs	*1625*		*1845*		*1422*	
Log Likelihood	*-614.5630*		*-820.5871*			
Psuedo R^2/Adj R^2	*0.4536*		*0.3156*		*0.7185*	
	Coefficient	**z**	**Coefficient**	**z**	**Coefficient**	**t**
Constant	-3.0079*** (0.7514)	-4.00	-3.4800*** (0.6853)	-5.08	9.7640*** (0.0779)	125.40
Ln(Employees)	0.5487*** (0.0678)	8.09	0.6116*** (0.0547)	11.17	0.0379*** (0.0064)	5.90
Female	0.3952 (0.4483)	0.88	-0.0330 (0.4182)	-0.08	-0.2730*** (0.0451)	5.90
Part-time	0.5915 (0.3928)	1.51	-0.5003 (0.3891)	-1.29	-0.7923*** (0.0421)	-18.82
Turnover	-1.7701*** (0.4748)	-4.73	0.0499 (0.4273)	0.12	-0.1292*** (0.0471)	-2.74
Age21	-1.1000* (0.6364)	-1.73	-0.0893 (0.6049)	-0.15	-0.3643*** (0.0649)	-5.61
Age50	1.2705*** (0.4758)	2.67	0.1866 (0.4472)	0.42	-0.0641 (0.0500)	-1.28
Shifts	0.2104	1.09	0.2480	1.53	-0.0430**	-2.13

	(0.1926)		(0.1624)		0.0202)	
Overtime	0.0527 (0.0453)	1.16	-0.0293 (0.0405)	-0.72	0.0131*** (0.0045)	2.88
'Unions help performance'	-0.4958*** (0.0763)	-6.50	-0.1256** (0.0638)	-1.97	-0.0024 (0.0074)	-0.33
'No employee consultation'	0.2939*** (0.0801)	3.67	0.0128 (0.0738)	0.17	0.0092 (0.0084)	1.10
Fixed	0.1107 (0.4456)	0.25	-0.4026 (0.4704)	-0.86	-0.0002 (0.0476)	-0.00
Hstrain	0.1454 (0.1667)	0.87	0.4842*** (0.1480)	3.27	-0.0375** (0.0167)	-2.25
Resultspay	-0.2697 (0.1814)	-1.49	0.1546 (0.1588)	0.97	0.0145 (0.0185)	0.78
Sickpay	0.8965*** (0.1786)	5.02	0.2020 (0.1589)	1.27	0.0534*** (0.0181)	2.95
Redundancy	0.0043 (0.0047)	0.91	0.0019 (0.0033)	0.58	1.86e-05 (0.0004)	0.04
Fortyeighthrs	-0.0588 (0.0584)	-1.01	0.0080 (0.0481)	0.17	0.0064 (0.0059)	1.08
Apprais	0.0808** (0.0356)	2.27	0.0660** (0.0333)	1.98	0.0013*** (0.0036)	3.13
Discrete	-0.2706*** (0.0959)	-2.82	-0.3047*** (0.0860)	-3.54	0.0024 (0.0100)	0.24
Control	-0.2201*** (0.0844)	-2.61	-0.0690 (0.0804)	-0.86	0.0205** (0.0091)	2.25
Team	-0.0160 (0.0393)	-0.41	0.0889** (0.0400)	2.22	0.0108*** (0.0041)	2.62
Flex	0.4253*** (0.1579)	2.69	0.3939*** (0.1394)	2.83	-0.0218 (0.0163)	-1.33
Night	0.4253** (0.2064)	2.06	0.2282 (0.1655)	1.38	0.0064 (0.0206)	0.31
Home	-0.7471*** (0.1847)	-4.04	-0.1099 (0.1478)	-0.74	0.0589*** (0.0174)	3.40

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Workplaces with 10 or more Employees: Reduced Form Regression

	UNION DENSITY		**H&S COMMITTEE**		**AVERAGE PAY**	
Obs	*1427*		*1643*		*1274*	
Log Likelihood	*-535.2560*		*-768.6940*			
Psuedo R^2	*0.4525*		*0.3005*		*0.7333*	
	Coefficient	**z**	**Coefficient**	**z**	**Coefficient**	**t**
Constant	-3.9419*** (0.8518)	-4.63	-3.4785*** (0.7245)	-4.80	9.8097*** (0.0806)	121.70
Ln(Employees)	0.5999*** (0.0779)	7.70	0.6196*** (0.0590)	10.50	0.0378*** (0.0067)	5.66
Female	0.6751	1.33	-0.1954	-0.44	-0.2860***	-6.00

	(0.5081)		(0.4416)		(0.0477)	
Part-time	0.2973 (0.4446)	0.67	-0.6519 (0.4112)	-1.59	-0.7462*** (0.0438)	-17.04
Turnover	-1.9761*** (0.5195)	-3.80	-0.0066 (0.4510)	-0.01	-0.1874*** (0.0492)	-3.81
Age21	-1.1057 (0.7114)	-1.55	-01944 (0.6381)	-0.30	-0.4486*** (0.0689)	-6.51
Age50	1.2684** (0.5460)	2.32	0.2383 (0.4720)	0.50	-0.0614 (0.0527)	-1.16
Shifts	0.2185 (0.2020)	1.08	0.2716 (0.1667)	1.63	-0.0466** (0.0197)	-2.36
Overtime	0.0840* (0.0507)	1.66	-0.0502 (0.0423)	-1.19	0.0086* (0.0047)	1.81
'Unions help performance'	-0.4894*** (0.0820)	-5.97	-0.1456** (0.0659)	2.21	-0.0040 (0.0074)	-0.54
'No employee consultation'	-0.4894*** (0.0863)	4.05	0.0208 (0.0760)	0.27	0.0073 (0.0084)	0.87
Fixed	0.2103 (0.4870)	0.43	-0.3914 (0.4888)	-0.80	0.0200 (0.0475)	0.42
Hstrain	0.1417 (0.1805)	0.78	0.5351*** (0.1533)	3.49	-0.0525*** (0.0168)	-3.13
Resultspay	-0.3432* (0.1918)	-1.79	0.1391 (0.1633)	0.85	0.0156 (0.0186)	0.84
Sickpay	0.8199*** (0.1968)	4.17	0.1541 (0.1650)	0.93)	0.0520*** (0.0186)	2.79
Redundancy	0.0041 (0.0047)	0.86	0.0018 (0.0034)	0.53)	0.0001 (0.0004)	0.29
Fortyeighthrs	-0.0696 (0.0632)	-1.10	0.0032 (0.0498)	0.06	0.0103* (0.0060)	1.73
Apprais	0.0580 (0.0388)	1.50	0.0602* (0.0346)	1.74	0.0091** (0.0037)	2.45
Discrete	-0.227** (0.1053)	-2.16	-0.2782*** (0.0896)	-3.10	0.0090 (0.0101)	0.89
Control	-0.1965** (0.0987)	-1.99	0.0020 (0.0866)	0.02	0.0146 (0.0096)	1.51
Team	0.0094 (0.0435)	0.22	0.1035** (0.0425)	2.44	0.0067 (0.0043)	1.56
Flex	0.4605*** (0.1698)	2.71	0.3888*** (0.1438)	2.71	-0.0275* (0.0163)	-1.69
Night	0.3578* (0.2132)	1.68	0.2546 (0.1694)	1.50	0.0159 (0.0200)	0.79
Home	-0.6817*** (0.2000)	-3.41	-0.1213 (0.1524)	-0.80	0.0478*** (0.0173)	2.76

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Negative Binomial Regression with Residuals: Workplaces with 5 or more Employees

	INJURIES			ILLNESSES		
No. of Obs	*1237*			*1183*		
Log pseudo-likelihood	*-16.3145*			*-51.7408*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-9.2779***	2.6922	-3.45	-3.5420***	0.8350	-4.24
Ln(Employees)	0.8730***	0.1804	4.84	0.7746***	0.0967	8.01
Part-time	-0.4213	1.9420	-0.22	-0.2620	0.5842	-0.45
Turnover	-0.6316	0.7768	-0.81	-0.6820	0.4422	-1.54
Age21	1.7047	1.1030	1.55	-0.8541	0.5881	-1.45
Age50	-1.0480	0.8161	-1.28	0.4825	0.4746	1.02
Shifts	0.1269	0.3626	0.35	0.1627	0.1773	0.92
Overtime	0.0816	0.0899	0.91	0.1232***	0.0440	2.80
Union	1.0713**	0.4469	2.40	-0.1502	0.3211	0.47
Committee	1.9789**	0.8768	2.26	0.6134	0.4750	1.29
Pay	7.66e-05	0.0002	0.48	-7.82e-06	3.97e-05	-0.20
Fixed	0.6079	0.5732	1.06	-0.2448	0.3897	-0.63
Hstrain	0.3091	0.2933	1.05	-0.3413**	0.1534	-2.23
Resultspay	-0.7802**	0.3630	-2.15	0.1140	0.1940	0.59
Sickpay	-0.0800	0.3098	-0.26	0.5730***	0.1646	3.48
Redundancy	-0.0121*	0.0069	-1.76	0.0019	0.0054	0.36
Fortyeighthrs	0.0195	0.0994	0.20	0.0441	0.0515	0.86
Apprais	-0.1848***	0.0578	-3.20	0.0311	0.0336	0.93
Discrete	-0.0372	0.1737	-0.21	-0.1412	0.0952	-1.48
Control	-0.0148	0.1911	-0.08	0.0207	0.0881	0.23
Team	0.0141	0.0845	0.17	0.0044	0.0397	0.11
Flex	-0.2746	0.2695	-1.02	-0.1899	0.1697	-1.12
Night	0.6214*	0.3321	1.87	0.2577	0.1956	1.32
Home	-0.0714	0.4113	-0.17	0.3396*	0.1742	1.95
Runion	-0.1656	0.1233	-1.34	0.2712***	0.0503	5.39
Rcomm	-0.7499**	0.3362	-2.23	-0.2412	0.1731	-1.39
Rpay	-3.47e-05	0.0002	-0.21	0.0098	0.6149	0.02

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Negative Binomial Regression: Workplaces with 10 or more employees

	INJURIES			ILLNESSES		
No. of Obs	*1094*			*1041*		
Log pseudo-likelihood	*-12.8826*			*-36.6907*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.4830***	1.5444	-5.49	-2.3656***	0.8250	-2.87
Ln(Employees)	0.9416***	0.1611	5.85	0.7472***	0.1103	6.77
Part-time	-0.6227	0.8689	-0.72	-0.4067	0.5356	-0.72
Turnover	-1.4143**	0.7008	-2.02	-0.3691	0.4503	-0.82
Age21	2.0142**	1.0071	2.00	-0.9634*	0.5613	-1.72

Age50	-0.4903	0.8833	-0.56	-0.3590	0.5539	-0.65
Shifts	0.2554	0.2817	0.91	0.2516	0.1740	1.45
Overtime	0.0302	0.0881	0.34	0.0932**	0.0423	2.21
Union	0.8947*	0.4627	1.93	0.146	0.3357	0.43
Committee	1.9584**	0.8952	2.19	1.2742**	0.6239	2.04
Pay	7.21e-05	5.66e-05	1.27	-3.49e-05	3.66e-05	-0.95
Fixed	1.1589**	0.5104	2.27	0.0525	0.1004	0.52
Hstrain	0.4700	0.2910	1.61	-0.3365**	0.1673	-2.01
Resultspay	-0.3286	0.2770	-1.19	-0.0837	0.1874	-0.45
Sickpay	-0.3290	0.3018	-1.09	0.1987	0.1740	1.14
Redundancy	-0.0046	0.0082	-0.57	0.0022	0.0059	0.38
Fortyeighthrs	0.1299	0.0803	1.62	0.0837	0.0511	1.64
Apprais	-0.1868***	0.0594	-3.15	0.0366	0.0353	1.04
Discrete	-0.0706	0.1605	-0.44	0.0525	0.1004	0.52
Control	0.0994	0.1666	0.60	-0.0443	0.0872	-0.51
Team	-0.0975	0.0606	-1.61	0.0095	0.0403	0.24
Flex	-0.4130	0.2806	-1.47	-0.2803	0.1820	-1.54
Night	0.7449***	0.2787	2.67	0.1330	0.1859	0.72
Home	-0.5653*	0.3367	-1.68	0.5631***	0.1803	3.12
Runion	-0.1348	0.1373	-0.98	0.1661**	0.0785	2.11
Rcomm	-0.6643*	0.3637	-1.83	-0.4793*	0.2518	-1.90
Rpay	-0.9204	0.9599	-0.96	0.6603	0.5576	1.18

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 4.7: Negative Binomial Regression Results includingFortyeighthrs and Fortyeightmangs

Workplaces with 5 or more Employees

	INJURIES			ILLNESSES		
No. of Obs	*1251*			*1195*		
Wald chi²	*410.67*			*425.50*		
Log pseudo-likelihood	*-16.0496*			*-51.8563*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-9.2887***	1.3324	-6.97	-3.6106***	0.7280	-4.96
Ln(Employees)	0.9671***	0.1265	7.65	0.8240***	0.0802	10.28
Part-time	-0.6433	0.6753	-0.95	-0.2314	0.4183	-0.55
Turnover	-0.8279	0.6556	-1.26	-0.0771	0.5756	-0.13
Age21	1.3629*	0.7792	1.75	-1.0249*	0.6030	-1.70
Age50	-1.2911	0.8454	-1.53	0.4385	0.5035	0.87
Shifts	0.1265	0.3366	0.38	0.0187	0.1762	0.11
Overtime	0.0781	0.1059	0.74	0.0946**	0.0440	2.15
Union	0.9346**	0.4021	2.32	0.6978**	0.3153	2.21
Pay	4.87e-05*	2.6e-05	1.87	-9.12e-06	1.68e-05	-0.54
Resultspay	-0.7712**	0.3287	-2.35	0.2007	0.2080	0.96

Sickpay	-0.0736	0.2963	-0.25	0.4578***	0.1709	2.68
Fixed	0.5450	0.5891	0.93	-0.2756	0.4213	-0.65
Hstrain	0.3522	0.2975	1.18	-0.3992**	0.1617	-2.47
Committee	0.3632	0.2507	1.45	0.0312	0.1623	0.19
Redundancy	0.0121*	0.0066	-1.84	0.0005	0.0052	0.10
Fortyeighthrs	0.0067	0.0913	0.07	-0.0206	0.0548	-0.38
Fortyeightmangs	0.1078*	0.0618	1.75	0.1192***	0.0341	3.50
Apprais	-0.1590***	0.0561	-2.83	0.0508	0.0340	1.49
Discrete	-0.1686	0.1673	-1.01	-0.1693*	0.0999	-1.69
Control	0.0724	0.1795	0.40	0.0289	0.0906	0.32
Team	0.0362	0.0773	0.47	0.0066	0.0400	0.17
Flex	-0.1816	0.2453	-0.74	-0.1234	0.1673	-0.74
Night	0.5879*	0.3333	1.76	0.3377*	0.1991	1.70
Home	-0.0382	0.4040	-0.09	0.2786*	0.1691	1.65
Electricity	-0.0927	0.7677	-0.12	-0.6690	0.6737	-0.99
Construction	-0.3044	0.5933	-0.51	-0.5534	0.4171	-1.33
Wholesale	0.7288	0.6503	1.12	0.0065	0.3448	0.02
Hotel	0.1148	0.7244	0.16	-0.5965	0.4882	-1.22
Transport	-2.3571***	0.5573	-4.23	0.2772	0.4125	0.67
Financial	0.5576	1.0448	0.53	-0.1069	0.5115	-0.21
Real estate	1.4485***	0.5534	2.62	-0.1099	0.3585	-0.31
Public admin	2.7490***	0.7427	3.70	0.7242	0.4767	1.52
Education	1.3544*	0.7877	1.72	-0.0697	0.5036	-0.14
Health	1.9215***	0.7065	2.72	0.6610	0.4169	1.59
Community	1.1252*	0.6418	1.75	0.0670	0.3807	0.18
Skilled Trades	3.5132***	1.1481	3.06	0.4689	0.6535	0.72
Managers	2.3480	1.6338	1.44	-0.8837	0.9357	-0.94
Machine Operatives	4.6513***	0.9798	4.75	-0.6499	0.6268	-1.04
Professional	-0.7117	1.1091	-0.64	-0.5527	0.6993	-0.79
Service	0.4408	1.2315	0.36	-0.4559	0.5075	-0.90
Unskilled	2.8241***	0.9826	2.87	0.0947	0.5360	0.18
Sales	3.2659***	1.1547	2.83	0.2945	0.5212	0.57
Technical	-0.4036	0.8747	-0.46	-0.6178	0.5412	-1.14

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

	INJURIES			**ILLNESSES**		
No. of Obs	*1108*			*1053*		
Wald chi²	*294.00*			*401.95*		
Log pseudo-likelihood	*-12.6855*			*-36.3187*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-8.1302***	1.3718	-5.93	-3.6105***	0.7064	-5.11
Ln(Employees)	0.9607***	0.1324	7.26	0.8764***	0.0857	10.23
Part-time	-1.2554*	0.6756	-1.9	0.1539	0.4253	0.36
Turnover	-1.5184**	0.7353	-2.07	-0.2347	0.4236	-0.55
Age21	1.7306*	0.9631	1.80	-0.7005	0.5028	-1.39
Age50	-0.3824	0.8738	-0.44	-0.3319	0.5542	-0.60
Shifts	0.3334	0.3063	1.09	0.1507	0.1735	0.87

Overtime	0.0469	0.0983	0.48	0.0599	0.0419	1.43
Union	0.8398**	0.4169	2.01	0.4959*	0.2919	1.70
Pay	1.61e-05	2.49e-05	0.64	7.51e-06	1.93e-05	0.39
Resultspay	-0.3139	0.2885	-1.09	-0.1042	0.1781	-0.59
Sickpay	-0.3438	0.3226	-1.07	0.1944	0.1757	1.11
Fixed	1.1870**	0.5341	2.22	-0.0459	0.4222	-0.11
Hstrain	0.5217*	0.2826	1.85	-0.3096*	0.1622	-1.91
Committee	0.5306**	0.2488	2.13	0.1067	0.1671	0.64
Redundancy	-0.0047	0.0082	-0.57	0.0022	0.0057	0.39
Fortyeighthrs	0.1601**	0.0773	2.07	0.0311	0.0546	0.57
Fortyeightmangs	0.0119	0.0584	0.20	0.1061***	0.0346	3.07
Apprais	-0.1645**	0.0661	-2.49	0.0642*	0.0346	1.85
Discrete	-0.1573	0.1537	-1.02	-0.0042	0.0954	-0.04
Control	0.1103	0.1747	0.63	-0.0239	0.0915	-0.26
Team	-0.0754	0.0632	-1.19	0.0332	0.0393	0.85
Flex	-0.3057	0.2803	-1.09	-0.1797	0.1749	-1.03
Night	0.6935**	0.2937	2.36	0.1732	0.1785	0.997
Home	-0.4339	0.3335	-1.30	0.5051***	0.1784	2.83
Electricity	0.6103	0.7874	0.78	-0.6117	0.5663	-1.08
Construction	0.0392	0.5397	0.07	-0.0503	0.4177	-0.12
Wholesale	0.5242	0.6079	0.86	0.1001	0.3234	0.31
Hotel	0.0927	0.7011	0.13	-1.0769**	0.4449	-2.42
Transport	-2.3181***	0.5710	-4.06	0.3995	0.4109	0.97
Financial	0.9837	0.8597	1.14	0.4757	0.5458	0.87
Real estate	1.2183**	0.4901	2.49	-0.4652	0.3317	-1.40
Public admin	2.9408***	0.7701	3.82	0.3653	0.4318	0.85
Education	1.3971*	0.8108	1.72	-0.1881	0.4662	-0.40
Health	1.8837**	0.7843	2.40	0.4342	0.4018	1.08
Community	0.7453	0.5763	1.29	0.2311	0.3837	0.60
Skilled Trades	2.5070**	1.1626	2.16	-0.7120	0.6784	-1.05
Managers	1.2979	1.9160	0.68	-2.9293***	1.0314	-2.84
Machine Operatives	3.2472***	1.2322	2.64	-1.1745*	0.6798	-1.73
Professional	-0.1316	1.1051	-0.12	-1.1604*	0.6531	-1.78
Service	-0.2186	1.4258	-0.15	-0.7857	0.5291	-1.48
Unskilled	2.3501**	1.0694	2.20	-0.1811	0.5423	-0.33
Sales	2.8155***	0.9207	3.06	-0.0938	0.5578	-0.17
Technical	-0.0930	1.0273	-0.09	-0.8398	0.5669	-1.48

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 4.8: Negative Binomial Regressions Results with UnionPay Variable

Workplaces with 5 or more Employees

	INJURIES			ILLNESSES		
No. of Obs	*1251*			*1195*		
Wald chi²	*411.35*			*428.28*		
Log pseudo-likelihood	*-16.0274*			*-51.7144*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-9.0347***	1.3120	-6.89	-3.3109***	0.7289	-4.54
Ln(Employees)	1.0932***	0.1278	8.55	0.8282***	0.0796	10.41
Part-time	-0.6571	0.6878	-0.96	-0.2647	0.4178	-0.63
Turnover	-0.8426	0.6562	-1.28	-0.0786	0.5681	-0.14
Age21	1.2379	0.7804	1.59	-1.1757**	0.5988	-1.96
Age50	-1.2585	0.8405	-1.50	0.4186	0.5019	0.83
Shifts	0.0979	0.3336	0.29	-0.0271	0.1760	-0.15
Overtime	0.0803	0.1058	0.76	0.1006**	0.0437	2.30
Union	-0.2349	1.2384	-0.19	-0.7107	0.7598	-0.94
Union-pay	6.61e-05	6.40e-05	1.03	8.26e-05**	3.82e-05	2.17
Pay	3.09e-05	3.02e-05	1.03	-2.49e-05	2.04e-05	-1.22
Resultspay	-0.7459**	0.3299	-2.26	0.2100	0.2050	1.02
Sickpay	-0.0335	0.3001	-0.11	0.4843***	0.1715	2.82
Fixed	0.5204	0.5833	0.89	-0.2543	0.4137	-0.61
Hstrain	0.3478	0.2958	1.18	-0.4094**	0.1602	-2.56
Committee	0.3609	0.2506	1.44	0.0203	0.1634	0.12
Redundancy	-0.0116*	0.0070	-1.66	0.0018	0.0058	0.30
Fortyeighthrs	0.0001	0.0927	0.00	-0.0235	0.0546	-0.43
Fortyeightmangs	0.1092*	0.0623	1.75	0.1192***	0.0341	3.49
Apprais	-0.1591***	0.0558	-2.85	0.0563	0.0344	1.64
Discrete	-0.1696	0.1667	-1.02	-0.1750*	0.0992	-1.76
Control	0.0814	0.1792	0.45	0.0336	0.0912	0.37
Team	0.0359	0.0760	0.47	0.0068	0.0393	0.17
Flex	-0.1741	0.2416	-0.72	-0.1386	0.1669	-0.83
Night	0.6134*	0.3286	1.87	0.3602*	0.1975	1.82
Home	-0.0331	0.3993	-0.08	0.2857*	0.1698	1.68

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

	INJURIES			ILLNESSES		
No. of Obs	*1108*			*1053*		
Wald chi²	*291.85*			*400.44*		
Log pseudo-likelihood	*-12.6780*			*-36.2977*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-7.9453***	1.3779	-5.77	-3.4531***	0.7044	-4.90
Ln(Employees)	1.1573***	0.1333	8.68	0.8753***	0.0858	10.20
Part-time	-1.2796*	0.6841	-1.87	0.1485	0.4306	0.34
Turnover	-1.5450**	0.7238	-2.13	-0.2391	0.4195	-0.57
Age21	1.6416*	0.9611	1.71	-0.8010	0.4952	-1.62
Age50	-0.3730	0.8688	-0.43	-0.3534	0.5506	-0.64
Shifts	0.3062	0.2981	1.03	0.1283	0.1731	0.74
Overtime	0.0463	0.0994	0.47	0.0607	0.0418	1.45
Union	0.1092	0.9242	0.91	-0.1880	0.8037	0.815
Union-pay	4.14e-05	4.81e-05	0.86	3.94e-05	4.22e-05	0.35
Pay	2.37e-06	2.91e-05	0.08	-9.17e-07	2.17e-05	0.966
Resultspay	-0.2984	0.2897	-1.03	-0.0995	0.1777	-0.56
Sickpay	-0.3125	0.3144	-0.99	0.2116	0.1750	1.21
Fixed	1.1419**	0.5323	2.15	-0.0443	0.4197	-0.11
Hstrain	0.5105*	0.2833	1.80	-0.3156*	0.1620	-1.95
Committee	0.5356**	0.2506	2.14	0.1009	0.1660	0.61
Redundancy	-0.0041	0.0084	-0.48	0.0029	0.0060	0.48
Fortyeighthrs	0.1579**	0.0784	2.01	0.0307	0.0547	0.56
Fortyeightmangs	0.0144	0.0588	0.24	0.1072***	0.0349	3.07
Apprais	-0.1637**	0.0659	-2.49	0.0666*	0.0349	1.91
Discrete	-0.1580	0.1541	-1.03	-0.0040	0.0946	-0.04
Control	0.1176	0.1771	0.66	-0.062	0.0918	-0.29
Team	-0.0735	0.0631	-1.16	0.0354	0.0393	0.90
Flex	-0.2989	0.2785	-1.07	-0.1838	0.1737	-1.06
Night	0.7047**	0.2912	2.42	0.1867	0.1786	1.05
Home	-0.4311	0.3332	-1.29	0.5078***	0.1786	2.84

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 4.9: Endogeneity Tests: Tobit Model

Tobit Model with Residuals: Workplaces with 5 or more Employees

	INJRISK			ILLRISK		
No. of Obs	*1224*			*1170*		
Log likelihood	*-205.7827*			*-302.9364*		
Psuedo R²	*0.3730*			*0.3038*		
	Coefficient	**Std error**	**t**	**Coefficient**	**Std error**	**t**
Constant	-0.1751***	0.0594	-2.95	-0.0072	0.0469	-0.015
Ln(Employees)	-0.0292***	0.0071	-4.12	-0.0315***	0.0067	-4.69
Part-time	-0.0063	0.0311	-0.20	-0.0267	0.0284	-0.94

Turnover	-0.0138	0.0261	-0.53	-0.0488*	0.0261	-1.87
Age21	0.0544	0.0337	1.61	-0.0227	0.0342	-0.67
Age50	-0.0734**	0.0321	-2.29	0.0559**	0.0244	2.29
Shifts	-0.0057	0.0130	-0.44	0.0073	0.0133	0.55
Overtime	0.0043*	0.0026	1.65	0.0077***	0.0024	3.28
Union	0.0537**	0.0248	2.16	-0.0028	0.0203	-0.14
Committee	0.0593	0.0413	1.44	0.0309	0.0370	0.84
Pay	1.58e-06	1.98e-06	0.80	-2.61e-07	1.91e-06	-0.14
Fixed	0.0271	0.0273	0.99	-0.0212	0.0296	-0.72
Hstrain	0.0079	0.0103	0.77	-0.0296***	0.0098	-3.02
Resultspay	-0.0292**	0.0120	-2.43	0.0101	0.0110	0.92
Sickpay	-0.0019	0.0102	-0.18	0.0473***	0.0098	4.84
Redundancy	-0.0010	0.0008	-1.27	0.0005	0.0010	0.48
Fortyeighthrs	-0.0024	0.0033	-0.71	-0.0022	0.0031	-0.71
Fortyeightmangs	0.0041**	0.0021	1.97	0.0090***	0.0019	4.64
Apprais	-0.0054***	0.0020	-2.72	0.0035*	0.0019	1.85
Discrete	-0.0079	0.0060	-1.35	-0.0165***	0.0063	-2.61
Control	-0.0012	0.0057	-0.20	0.0061	0.0057	1.06
Team	0.0029	0.0023	1.25	-0.0004	0.0021	-0.17
Flex	-0.0028	0.0105	-0.27	-0.0178*	0.0099	-1.80
Night	0.0335**	0.0146	2.30	0.0351**	0.0153	2.30
Home	0.0143	0.0124	1.15	0.0206*	0.0114	1.81
Runion	-0.0076	0.0063	-1.21	0.0231***	0.0034	6.72
Rcomm	-0.0185	0.0163	-1.14	-0.0123	0.0122	-1.00
Rpay	-0.0030	0.0282	-0.11	-0.0068	0.02824	-0.24
s.e	0.0704	0.0037		0.1093	0.0036	

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Tobit Model with Residuals: Workplaces with 10 or more Employees

	INJRISK			**ILLRISK**		
No. of Obs	*1082*			*1029*		
Log likelihood	*-97.2839*			*-89.7343*		
Psuedo R^2	*0.5204*			*0.4599*		
	Coefficient	**Std error**	**t**	**Coefficient**	**Std error**	**t**
Constant	-0.0647	0.0436	-1.48	0.0625	0.0419	1.49
Ln(Employees)	-0.0178***	0.0056	-3.19	-0.0209***	0.0063	-3.34
Part-time	-0.0138	0.0231	-0.60	-0.0316	0.0244	-1.29
Turnover	-0.0332	0.0219	-1.52	-0.0069	0.0224	-0.31
Age21	0.0575**	0.0266	2.16	-0.0227	0.0293	-0.78
Age50	-0.0247	0.0237	-1.04	-0.0236	0.0235	-1.00
Shifts	0.0086	0.0086	0.99	0.0097	0.0097	1.00
Overtime	0.0017	0.0021	0.80	0.0048**	0.0022	2.19
Union	0.0265	0.0174	1.53	0.0199	0.0166	1.20
Committee	0.0509	0.0311	1.64	0.0831**	0.0334	2.49
Pay	9.31e-07	1.52e-06	0.61	-2.12e-06	1.61e-06	-1.32
Fixed	0.0365**	0.0173	2.11	-0.0066	0.0218	-0.30

Hstrain	0.0098	0.0079	1.24	-0.0279***	0.0082	-3.41
Resultspay	-0.0058	0.0085	-0.68	-0.0124	0.0093	-1.33
Sickpay	-0.0076	0.0077	-0.98	0.0097	0.0083	1.16
Redundancy	-0.0004	0.0005	-0.77	8.52e-05	0.0007	0.13
Fortyeighthrs	0.0058**	0.0025	2.29	0.0006	0.0028	0.20
Fortyeightmangs	-0.0009	0.0016	-0.55	0.0071***	0.0017	4.25
Apprais	-0.0056***	0.0015	-3.84	0.0035**	0.0017	2.12
Discrete	-0.0066	0.0044	-1.50	0.0051	0.0051	0.99
Control	0.0031	0.0042	0.75	-0.0007	0.0045	-0.16
Team	-0.0026	0.0018	-1.44	-0.0004	0.0019	-0.19
Flex	-0.0108	0.0079	-1.37	-0.0207**	0.0083	-2.50
Night	0.0249***	0.0097	2.58	0.0033	0.0116	0.28
Home	-0.0117	0.0097	-1.15	0.0378***	0.0092	4.10
Runion	-0.0060	0.0052	-1.15	0.0078**	0.0035	2.26
Rcomm	-0.0129	0.0129	1.00	-0.0306**	0.0130	-2.36
Rpay	-0.0231	0.0218	1.06	0.0325	0.0260	1.25
s.e	0.0547	0.0029		0.0882	0.0030	

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 4.10: Tobit Results Including Union-Pay

Workplaces with 5 or more Employees

	INJRISK			ILLRISK		
No. of Obs	*1251*			*1195*		
Log likelihood	*-212.7141*			*-333.5110*		
Psuedo R^2	*0.3694*			*0.2586*		
	Coefficient	**Std error**	**t**	**Coefficient**	**Std error**	**t**
Constant	-0.1794***	0.0506	-3.55	0.0229	0.0401	0.57
Ln(Employees)	-0.0235***	0.0054	-4.32	-0.0289***	0.0057	-5.03
Part-time	-0.0103	0.0248	-0.42	-0.0409*	0.0226	-1.81
Turnover	-0.0157	0.0239	-0.66	-0.0166	0.0245	-0.68
Age21	0.0508	0.0325	1.56	-0.0412	0.0339	-1.22
Age50	-0.0714**	0.0308	-2.32	0.0505**	0.0248	2.03
Shifts	-0.0030	0.0123	-0.24	-0.0039	0.0134	-0.29
Overtime	0.0044*	0.0123	-0.24	0.0085***	0.0023	3.63
Union	0.0271	0.0431	0.63	-0.05556	0.0413	-1.35
Committee	0.0118	0.0128	0.92	-0.0013	0.0141	-0.09
Pay	1.42e-06	1.08e-06	1.31	-2.51e-06**	1.06e-06	-2.37
Fixed	0.0270	0.0259	1.04	-0.0142	0.0296	-0.48
Hstrain	0.0120	0.0096	1.25	-0.0307***	0.0095	-3.24
Resultspay	-0.0295**	0.0115	-2.56	0.0197*	0.0109	1.81
Sickpay	0.0027	0.0097	0.27	0.0371***	0.0096	3.85
Redundancy	-0.0009	0.0007	-1.26	0.0004	0.0010	0.43
Fortyeighthrs	-0.0026	0.0032	-0.82	-0.0042	0.0031	-1.35
Fortyeightmangs	0.0040**	0.0020	2.02	0.0087***	0.0019	4.50
Apprais	-0.0051***	0.0019	-2.71	0.0037**	0.0019	1.95

Discrete	-0.0095*	0.0055	-1.71	-0.0189***	0.0062	-3.06
Control	-3.79e-05	0.0054	-0.01	0.0071	0.0058	1.23
Team	0.0035	0.0021	1.62	-0.0009	0.0021	-0.41
Flex	-0.0012	0.0099	-0.12	-0.0135	0.0098	-1.38
Night	0.0344**	0.0136	2.52	0.0449***	0.0155	2.89
Home	0.0120	0.0117	1.03	0.0227**	0.0112	2.03
Unionpay	7.45e-07	2.3e-06	0.32	7.12e-06***	2.2e-06	3.20
s.e	0.0696	0.0035		0.1123	0.0037	

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

	INJRISK			**ILLRISK**		
No. of Obs	*1108*			*1053*		
Log likelihood	*-100.5519*			*-101.0767*		
Psuedo R^2	*0.5131*			*0.4208*		
	Coefficient	**Std error**	**t**	**Coefficient**	**Std error**	**t**
Constant	-0.0489	0.0371	-1.32	0.0355	0.0351	1.01
Ln(Employees)	-0.0138***	0.0044	-3.15	-0.0145***	0.0051	-2.84
Part-time	-0.0310*	0.0186	-1.66	-0.0175	0.0190	-0.92
Turnover	-0.0344*	0.0207	-1.66	-0.0020	0.0219	-0.09
Age21	0.0452*	0.0247	1.83	-0.0218	0.0285	-0.77
Age50	-0.0242	0.0228	-1.06	-0.0259	0.0232	-1.11
Shifts	0.0109	0.0082	1.33	0.0082	0.0096	0.85
Overtime	0.0020	0.0020	0.99	0.0038*	0.0022	1.76
Union	0.0157	0.0298	0.53	-0.0052	0.0328	-0.16
Committee	0.0201**	0.0088	2.29	0.0066	0.0102	0.65
Pay	-4.10e-07	8.83e-07	-0.46	-1.06e-06	9.05e-07	-1.17
Fixed	0.0367**	0.0166	2.22	-0.0081	0.0214	-0.38
Hstrain	0.0125*	0.0073	1.71	-0.0221***	0.0077	-2.88
Resultspay	-0.0063	0.0082	-0.77	-0.0080	0.0092	-0.88
Sickpay	-0.0053	0.0075	-0.71	0.0107	0.0082	1.31
Redundancy	-0.0003	0.0005	-0.73	0.0001	0.0007	0.22
Fortyeighthrs	0.0056**	0.0024	2.34	0.0002	0.0027	0.06
Fortyeightmangs	-0.0011	0.0016	-0.71	0.0068***	0.0016	4.16
Apprais	-0.0052***	0.0014	-3.68	0.0035**	0.0016	2.17
Discrete	-0.0073*	0.0040	-1.82	0.0006	0.0048	0.12
Control	0.0029	0.0040	0.73	0.0002	0.0044	0.04
Team	-0.0019	0.0017	-1.13	0.0008	0.0018	0.43
Flex	-0.0087	0.0075	-1.17	-0.0154*	0.0080	-1.92
Night	0.0250***	0.0092	2.73	0.0106	0.0114	0.93
Home	-0.0106	0.0093	-1.14	0.0361***	0.0090	4.03
Unionpay	1.22e-07	1.6e-06	0.07	2.55e-06	1.70e-06	1.50
s.e	0.0538	0.0028		0.0883	0.0030	

Other variables included in estimation: Electricity, Construction, Wholesale, Hotel, Transport, Financial, Real estate, Public admin, Education, Health, Community, Skilled Trades, Managers, Machine Operatives, Professional, Service, Unskilled, Sales, Technical
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 4.11: Negative Binomial Regresion Results including Worker Survey Variables

Workplaces with 5 or more Employees

Variables	INJURIES			ILLNESSES		
No. of Obs	*1268*			*1212*		
Wald chi²	*448.44*			*454.86*		
Log pseudo-likelihood	*-16.0381*			*-52.4740*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-11.4704***	2.0724	-5.53	-2.6222***	0.8729	-3.00
Ln(Employeess)	1.0270***	0.1278	8.04	0.7765***	0.0810	9.59
Part-time	-1.0217	0.6572	-1.55	-0.0871	0.4211	-0.21
Turnover	-0.9573*	0.5572	-1.72	-0.0563	0.5425	-0.10
Age21	1.6785**	0.7285	2.30	-0.9338*	0.5670	-1.65
Age50	-1.0288	0.9605	-1.07	0.2411	0.4843	0.50
Shifts	0.1935	0.3253	0.59	0.0402	0.1818	0.22
Overtime	0.0433	0.0830	0.52	0.1053***	0.0395	2.67
Union	0.8082**	0.4004	2.02	0.5581*	0.3044	1.83
Committee	0.2560	0.2583	0.99	0.0127	0.1620	0.08
Pay	4.73e-05*	2.57e-05	1.84	-2.29e-05	1.74e-05	-1.32
Fixed	0.2764	0.5508	0.50	-0.2353	0.4591	-0.51
Hstrain	0.4196	0.2897	1.45	-0.3661**	0.1503	-2.44
Resultspay	-0.7730**	0.3275	-2.36	0.2513	0.2000	1.26
Sickpay	-0.0643	0.3019	-0.21	0.3649**	0.1615	2.26
Redundancy	-0.0109	0.0069	-1.57	-0.0008	0.0050	-0.16
Apprais	-0.1424***	0.0554	-2.57	0.0437	0.0324	1.35
Discrete	-0.1645	0.1458	-1.13	-0.1236	0.1030	-1.20
Control	0.1097	0.1729	0.63	-0.0180	0.0942	-0.19
Team	0.0718	0.0720	1.00	0.0110	0.0328	0.34
Flex	-0.0907	0.2393	-0.38	-0.1014	0.1637	-0.62
Night	0.5996*	0.3361	1.78	0.3028	0.1953	1.55
Home	0.0353	0.4436	0.08	0.4043**	0.1767	2.29
Electricity	-0.4975	0.8230	-0.60	-0.6674	0.6261	-1.07
Construction	-0.2885	0.7045	-0.41	-0.6362	0.4420	-1.44
Wholesale	0.9507	0.7060	1.35	-0.0280	0.3501	-0.08
Hotel	0.2514	0.7685	0.33	-0.7721	0.5286	-1.46
Transport	-2.2412***	0.5480	-4.09	0.0823	0.3649	0.23
Financial	0.9532	0.9887	0.96	0.1270	0.4857	0.26
Real estate	1.6187***	0.5619	2.88	-0.0467	0.3338	-0.14
Public admin	3.2408***	0.8726	3.71	0.7985*	0.4275	1.87
Education	1.7249**	0.8119	2.12	0.2216	0.4642	0.48
Health	1.7718***	0.6730	2.63	0.8092**	0.3772	2.15
Community	1.1247	0.7945	1.42	0.1407	0.36227	0.39
Skilled Trades	4.4171***	1.1451	3.86	0.7309	0.6405	1.14
Managers	3.1172*	1.7419	1.79	-0.2821	0.9054	-0.31
Machine Operatives	5.3162***	0.9407	5.65	-0.5382	0.6334	-0.85
Professional	0.6033	0.9979	0.60	-0.4404	0.6319	-0.70

Service	1.4651*	0.8586	0.60	-0.6060	0.4979	-1.22
Unskilled	3.4151***	0.8658	3.94	0.1309	0.5238	0.25
Sales	3.8465***	1.1554	3.33	0.2508	0.5144	0.49
Technical	-0.3360	0.9172	-0.37	-0.6582	0.5074	-1.30
Avskill	0.6682*	0.3605	1.85	0.0446	0.1782	0.25
Avrelations	-0.0464	0.2478	-0.19	-0.3227**	0.1305	-2.47
Avsecurity	-0.0913	0.2933	-0.31	0.0072	0.1348	0.05
Avforty	0.2510	0.2103	1.19	0.2815**	0.1243	2.26

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Workplaces with 10 or more Employees

Variables	**INJURIES**			**ILLNESSES**		
No. of Obs	*1124*			*1069*		
Wald chi²	*285.82*			*376.44*		
Log pseudo-likelihood	*-12.4605*			*-37.0148*		
	Coefficient	**Std error**	**z**	**Coefficient**	**Std error**	**z**
Constant	-11.9317***	1.5859	-7.52	-2.1377**	0.8689	-2.46
Ln(Employeess)	1.1372***	0.1323	8.60	0.8041***	0.0828	9.72
Part-time	-1.3243**	0.5967	-2.22	0.1389	0.4333	0.32
Turnover	-1.7796***	0.6084	-2.92	-0.1837	0.4191	-0.44
Age21	1.9445**	0.9658	2.01	-0.6182	0.4746	-1.30
Age50	-0.2124	0.9374	-0.23	-0.4076	0.5289	-0.77
Shifts	0.3000	0.2718	1.10	0.2106	0.1710	1.23
Overtime	0.0097	0.0666	0.14	0.0882**	0.0387	2.28
Union	0.5192	0.4223	1.23	0.3753	0.2756	1.36
Committee	0.5151**	0.2467	2.09	0.1306	0.1658	0.79
Pay	3.51e-05	2.48e-05	1.42	-5.29e-06	1.97e-05	-0.27
Fixed	0.7068	0.4938	1.43	-0.0156	0.4446	-0.04
Hstrain	0.5779**	0.2727	2.12	-0.2495	0.1556	-1.60
Resultspay	-0.3495	0.2814	-1.24	0.0153	0.1808	0.08
Sickpay	-0.3554	0.2876	-1.24	0.1601	0.1696	0.94
Redundancy	-0.0059	0.0085	-0.69	-0.0006	0.0050	-0.11
Apprais	-0.1262**	0.0548	-2.30	0.0439	0.0335	1.31
Discrete	-0.1882	0.1463	-1.29	0.0515	0.0929	0.55
Control	0.2596*	0.1352	1.92	-0.0470	0.0928	-0.51
Team	-0.0309	0.0525	-0.59	0.0249	0.0328	0.76
Flex	-0.2522	0.2639	-0.96	-0.1998	0.1763	-1.13
Night	0.8425***	0.2596	3.25	0.2332	0.1730	1.35
Home	-0.4956	0.3392	-1.46	0.5562***	0.1769	3.14
Electricity	0.3852	0.6516	0.59	-0.6512	0.5639	-1.15
Construction	0.4110	0.5123	0.80	-0.0461	0.4297	-0.11
Wholesale	1.1183*	0.6032	1.85	0.0544	0.3580	0.15
Hotel	0.4286	0.6968	0.62	-1.2373***	0.4710	-2.63
Transport	-1.9576***	0.5260	-3.72	0.1479	0.3676	0.40
Financial	1.5350*	0.8596	1.79	0.6535	0.5324	1.23
Real estate	1.4400***	0.4775	3.02	-0.3548	0.3403	-1.04
Public admin	3.7439	0.8059	4.65	0.5376	0.4163	1.29
Education	1.9926**	0.7878	2.53	0.1072	0.4494	0.24
Health	1.7799**	0.7253	2.45	0.5622	0.3832	1.47

Community	0.8022	0.6112	1.31	0.3932	0.3855	1.02
Skilled Trades	2.9918***	1.0415	2.87	-0.7116	0.6458	-1.10
Managers	1.7096	1.8617	0.92	-2.7153***	1.0103	-2.69
Machine Operatives	4.0673***	1.0889	3.74	-1.1958*	0.6435	-1.86
Professional	0.7365	1.0198	0.72	-0.9709	0.6208	-1.56
Service	1.0492	1.0075	1.04	-0.8474*	0.5031	-1.68
Unskilled	2.9564***	0.9669	3.06	-0.1781	0.5048	-0.35
Sales	3.1512***	0.8701	3.62	-0.0372	0.5485	-0.07
Technical	-0.0545	1.0674	-0.05	-0.8657	0.5452	-1.59
Avskill	1.1368***	0.2872	3.96	-0.0315	0.1957	-0.16
Avrelations	0.1897	0.2202	0.86	-0.2500*	0.1311	-1.91
Avsecurity	-0.5636**	0.2297	-2.45	-0.1331	0.1414	-0.94
Avforty	0.3573**	0.1442	2.48	0.2317*	0.1237	1.87

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

CHAPTER 5 APPENDICES

Appendix 5.1: VSL Estimates

STUDY	COUNTRY	VSL (MILLION 2000 US$)
Marin and Psacharopoulos (1982)	UK	$4.2
Siebert and Wei (1994)	UK	$9.4-$11.5
Sandy and Elliott (1996)	UK	$5.2-$69.4
Arabsheibani and Marin (2000)	UK	$19.9
Sandy et al. (2001)	UK	$5.7-$74.1
Thaler and Rosen (1975)	US	$1
Brown (1980)	US	$1.9
Moore and Viscusi (1988)	US	$3.2-$9.4
Herzog and Schlottman (1990)	US	$11.7
Leigh (1991)	US	$7.1-$15.3
Dorman and Hagstrom (1998)	US	$8.7-$20.3

Source: Viscusi and Aldy (2003)

Appendix 5.2: Fatal Descriptive Statistics Assigning Average Risk

	3 DIGIT FATAL
ALL WORKERS	
Number	17079
Mean	0.0185
Standard Deviation	0.0251
MANUAL WORKERS	
Number	5580
Mean	0.0350
Standard Deviation	0.0372
MALE WORKERS	
Number	9313
Mean	0.0272
Standard Deviation	0.0299
MALE MANUAL WORKERS	
Number	3956
Mean	0.0422
Standard Deviation	0.03937

Appendix 5.3: Explanatory Variables Constructed Using WERS

VARIABLE	DEFINITION
EDUC1	Dummy variable equals one if highest qualification is GCSE level.
EDUC2	Dummy variable equals one if highest qualification A level.
EDUC3	Dummy variable equals one if respondent has a degree or postgraduate degree.
EDUC4	Dummy variable equals one if respondent has no academic qualifications (excluded in estimation).
TENURE1	Dummy variable equals one if respondent has worked for the firm for less than 1 year (excluded in estimation).
TENURE2	Dummy variable equals one if respondent has worked for the firm for between 1 to less than 2 years.
TENURE3	Dummy variable equals one if respondent has worked for the firm for between 2 to less than 6 years.
TENURE4	Dummy variable equals one if respondent has worked for the firm for between 5 to less than 10 years.
TENURE5	Dummy variable equals one if respondent has worked for the firm for 10 years or more.
OVERTIME	Corresponds to the overtime or extra hours the respondent usually works each week, paid or unpaid.
FLEXITIME	Dummy variable equal to one if respondent has a flexitime arrangement available to them if needed.
SUPERVISE	Dummy variable equal to one if respondent supervises other employees.
PERMANENT	Dummy variable equal to one if the respondent is a permanent employee.
AGE	Equal to between 0-8, with 8 indicating the employee is aged between 16-17 and a value of 8 indicating they are aged 65 or over.
NEMPS	Equal to the number of employees on the payroll in the firm.
MERITPAY	Dummy variable equal to one if some employees receive merit pay.
PUBLIC	Dummy variable equal to one if the respondent works in the public sector.
RECOGUNION	Dummy variable equal to one if management report recognising a trade union for negotiating pay and conditions
UNIONCOV	Dummy variable equal to one of the respondent works for a firm where there is a trade union.
HS1	Dummy variable equal to one if there is a consultative committee exclusively for health and safety matters with all employee representatives chosen by unions.
HS2	Dummy variable equal to one if there is a consultative committee exclusively for health and safety matters with some employee representatives chosen by unions.
HS3	Dummy variable equal to one if there is a consultative committee exclusively for health and safety matters with no employee representatives chosen by unions.
HS4	Dummy variable equal to one if there is a consultative committee for health and safety and other matters with all employee representatives chosen by unions.

HS5	Dummy variable equal to one if there is a consultative committee for health and safety and other matters with some employee representatives chosen by unions.
HS6	Dummy variable equal to one if there is a consultative committee for health and safety and other matters with no employee representatives chosen by unions.
HS7	Dummy variable equal to one if there is no committee but there is a workforce representative.
HS8	Dummy variable equal to one if management deals with health and safety matters without any form of consultation.
EMPREP	Dummy variable equal to one if the workplace has a safety representative
COMM GENERAL	Dummy variable equal to one if the workplace has a consultative committee that deals with a range of issues including health and safety.
COMM SPECIFIC	Dummy variable equal to one if the workplace has a specific health and safety committee.
NO HSCONSULT	Dummy variable equal to one if management deals with health and safety matters without any form of consultation.

Appendix 5.4: Interval Regression Results (Fatal and Fatal²)

Dependent Variables: Lnwpayl Lnwpayh

	MANUAL WORKERS	**MALE MANUAL WORKERS**
Obs	*5474*	*3897*
Wald chi²	*3124.12*	*1284.72*
Log pseudo likelihood	*10972.553*	*-7767.1885*
Constant	4.8170*** (0.0444)	4.6670*** (0.0582)
Educ1	0.1276*** (0.0104)	0.1237*** (0.0121)
Educ2	0.0508*** (0.0161)	0.0452** (0.0189)
Educ3	0.2143*** (0.0188)	0.2105*** (0.0215)
Tenure2	-0.0002 (0.0188)	-0.0214 (0.0224)
Tenure3	0.0482*** (0.0157)	0.0529*** (0.0182)
Tenure4	0.0676*** (0.0164)	0.0599*** (0.0190)
Tenure5	0.1410*** (0.0163)	0.1415*** (0.0188)
Overtime	0.0067*** (0.0008)	0.0076*** (0.0010)
Flexitime	0.0014 (0.0109)	0.0008 (0.0128)

Supervise	0.1374*** (0.0119)	0.1319*** (0.0138)
Runion	0.0777*** (0.0114)	0.0554*** (0.0132)
Commspecific	0.0370*** (0.0102)	0.0446*** (0.0118)
Permanent	0.0630*** (0.0231)	0.0653** (0.0287)
Age	0.2211*** (0.0171)	0.2789*** (0.0223)
Age²	-0.0210*** (0.0019)	-0.0256*** (0.0024)
Nemps	4.47e-05*** (1.32e-05)	5.33e-05*** (1.55e-05)
Nemps²	-5.28e-09** (2.46e-09)	-6.60e-09** (3.13e-09)
Meritpay	0.0537*** (0.0113)	0.0477*** (0.0128)
Public	-0.0546*** (0.0128)	-0.0907*** (0.0149)
Female	-0.3111*** (0.0120)	
Fatal	2.1217*** (0.3281)	2.3083*** (0.3664)
Fatal²	-10.3406*** (1.9443)	-11.1342*** (2.1311)
Lnsigma	*-1.1082**** *(0.0135)*	*-1.1408**** *(0.01622)*
Sigma	*0.3302* *(0.0044)*	*0.3196* *(0.0052)*

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 5.5: Interval Regression Results (Fatal, Major Injury, Over 3-Day Injury)

Dependent Variables: Lnwapyl Lnwpayh

	ALL WORKERS	MANUAL WORKERS	MALE WORKERS	MALE MANUAL WORKERS
Obs	*16791*	*5474*	*9191*	*3897*
Wald chi²	*13033.85*	*3185.88*	*6679.77*	*1387.64*
Log pseudo likelihood	*-34309.312*	*-10966.354*	*-18414.398*	*-7750.0498*
Constant	4.8163*** (0.0322)	4.8451*** (0.0444)	4.6199*** (0.0513)	4.7032*** (0.0585)
Educ1	0.1079*** (0.0072)	0.1239*** (0.0104)	0.1213*** (0.0095)	0.1192*** (0.0121)
Educ2	0.1205*** (0.0074)	0.0475*** (0.0104)	0.1110*** (0.0105)	0.0438** (0.0186)

Educ3	0.2863*** (0.0077)	0.2040*** (0.0186)	0.2569*** (0.0105)	0.1972*** (0.0211)
Tenure2	0.0202* (0.0117)	-0.0028 (0.0189)	0.0282* (0.0169)	-0.0233 (0.0225)
Tenure3	0.0531*** (0.0100)	0.0460*** (0.0157)	0.0833*** (0.0141)	0.0494*** (0.0182)
Tenure4	0.0428*** (0.0109)	0.0683*** (0.0164)	0.0594*** (0.0150)	0.0604*** (0.0189)
Tenure5	0.1032*** (0.0108)	0.1424*** (0.0163)	0.1198*** (0.0148)	0.1412*** (0.0188)
Overtime	0.0095*** (0.0006)	0.0069*** (0.0008)	0.0097*** (0.0008)	0.0080*** (0.0010)
Flexitime	0.0207*** (0.0063)	-0.0032 (0.0108)	0.0234*** (0.0088)	-0.0071 (0.0127)
Supervise	0.2389*** (0.0067)	0.1297*** (0.0119)	0.2530*** (0.0092)	0.1188*** (0.0137)
Runion	0.0194** (0.0083)	0.0968*** (0.0144)	0.0527*** (0.0118)	0.0768*** (0.0180)
Commspecific	0.0293*** (0.0064)	0.0441*** (0.0103)	0.0327*** (0.0087)	0.0498*** (0.0118)
Permanent	0.0524*** (0.0149)	0.0715*** (0.0230)	0.0496** (0.0215)	0.0751*** (0.0283)
Age	0.3063*** (0.0136)	0.2272*** (0.0171)	0.3720*** (0.0221)	0.2883*** (0.0225)
Age^2	-0.0274*** (0.0015)	-0.0218*** (0.0019)	-0.0321*** (0.0024)	-0.0269*** (0.0024)
Nemps	5.64e-05*** (7.29e-06)	4.49e-05*** (1.34e-05)	7.15e-05*** (1.09e-05)	5.0e-05*** (1.62e-05)
$Nemps^2$	-7.44e-09*** (1.20e-09)	-6.08e-09** (2.56e-09)	-1.08e-08*** (2.08e-09)	-7.38e-09** (1.62e-05)
Meritpay	0.1037*** (0.0069)	0.0538*** (0.0113)	0.0968*** (0.0093)	0.0469*** (0.0127)
Public	0.0060 (0.0076)	-0.0614*** (0.0132)	-0.0320*** (0.0106)	-0.0848*** (0.0161)
Female	-0.2518*** (0.0066)	-0.3311*** (0.0115)		
Fatal	-0.0494 (0.2615)	0.3636 (0.2639)	-0.8305*** (0.2700)	0.0410 (0.2775)
Major Injury	-0.0168*** (0.0045)	0.0132*** (0.0048)	-0.0065 (0.0050)	0.0200*** (0.0054)
Over 3-day Injury	-0.0017*** (0.0006)	-0.0030*** (0.0006)	-0.0024*** (0.0007)	-0.0043*** (0.0007)
Fatal*Runion	1.0250*** (0.2250)	-0.4246* (0.2543)	1.1716*** (0.2452)	-0.2951 (0.2946)
Lnsigma	*-0.9797*** (0.0078)*	*-1.1094*** (0.0135)*	*-0.9759*** (0.0113)*	*-1.1454*** (0.0162)*
Sigma	*0.3754 (0.0029)*	*0.3298 (0.0045)*	*0.3769 (0.0043)*	*0.3181 (0.0052)*

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 5.6: Interval Regression Results (Average Fatal Value Assigned to Occupations with Zero Death Rate)

Dependent Variables: Lnwpayl Lnwpayh

	MANUAL WORKERS	MALE MANUAL WORKERS
Obs	*5474*	*3897*
Wald chi²	*3089.55*	*1261.57*
Log pseudo likelihood	*-10988.186*	*7785.0845*
Constant	4.8381*** (0.0444)	4.7037*** (0.0584)
Educ1	0.1264*** (0.0105)	0.1223*** (0.0122)
Educ2	0.0464*** (0.0160)	0.0396** (0.0189)
Educ3	0.2119*** (0.0188)	0.2089*** (0.0215)
Tenure2	-0.0005 (0.0190)	-0.0211 (0.0226)
Tenure3	0.0480*** (0.0158)	0.0532*** (0.0183)
Tenure4	0.0684*** (0.0165)	0.0609*** (0.0191)
Tenure5	0.1425*** (0.0164)	0.1421*** (0.0189)
Overtime	0.0007*** (0.0008)	0.0076*** (0.0010)
Flexitime	-0.0002 (0.0109)	-0.0021 (0.0129)
Supervise	0.1338*** (0.0119)	0.1253*** (0.0138)
Runion	0.0882*** (0.0140)	0.0561*** (0.0175)
Commspecific	0.0412*** (0.0103)	0.0475*** (0.0119)
Permanent	0.0675*** (0.0231)	0.0695** (0.0286)
Age	0.2235*** (0.0171)	0.2814*** (0.0223)
Age²	-0.0212*** (0.0019)	-0.0259*** (0.0024)
Nemps	4.7e-05*** (1.33e-05)	5.46e-05*** (1.57e-05)
Nemps²	-5.88e-09** (2.49e-09)	-7.16e-09** (3.22e-09)
Meritpay	0.0545*** (0.0114)	0.0483*** (0.0129)
Public	-0.0749*** (0.0123)	-0.1135*** (0.0145)

Female	-0.3311*** (0.0113)	
Fatal	0.6290*** (0.1775)	0.4340** (0.2016)
Fatal*Runion	-0.3380** (0.1461)	-0.0490 (0.2840)
Lnsigma	*-1.1053**** *(0.0135)*	*-1.1360**** *(0.0163)*
Sigma	*0.3311* *(0.0045)*	*0.3211* *(0.0052)*
VSL (2004 £)	£10,285,823	£7,838,057
VSL (2000 US$)	$14,779,073	$11,280,827

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 5.7: Interval Regression Results (Fatal, Unioncov)

	ALL WORKERS	MANUAL WORKERS	MALE WORKERS	MALE MANUAL WORKERS
Obs	*16791*	*5474*	*9191*	*3897*
Wald chi²	*12392.55*	*3053.87*	*6315.91*	*1262.62*
Log pseudo likelihood	*-34501.792*	*-10980.699*	*-18515.954*	*-7780.9814*
Constant	4.7550*** (0.0322)	4.8455*** (0.0440)	4.5712*** (0.0515)	4.6993*** (0.0577)
Educ1	0.1191*** (0.0073)	0.1247*** (0.0104)	0.1301*** (0.0097)	0.1214*** (0.0121)
Educ2	0.1289*** (0.0075)	0.0463*** (0.0160)	0.1202*** (0.0106)	0.0410** (0.0188)
Educ3	0.3036*** (0.0077)	0.2110*** (0.0187)	0.2769*** (0.0105)	0.2064*** (0.0215)
Tenure2	0.0205* (0.0118)	-0.0050 (0.0190)	0.0289* (0.0171)	-0.0260 (0.0226)
Tenure3	0.0552*** (0.0101)	0.0434*** (0.0157)	0.0880*** (0.0142)	0.0483*** (0.0183)
Tenure4	0.0393*** (0.0111)	0.0609*** (0.0164)	0.0579*** (0.0152)	0.0540*** (0.0191)
Tenure5	0.0982*** (0.0109)	0.1334*** (0.0163)	0.1168*** (0.0150)	0.1349*** (0.0189)
Overtime	0.0092*** (0.0006)	0.0067*** (0.0008)	0.0094*** (0.0008)	0.0076*** (0.0010)
Flexitime	0.0310*** (0.0064)	0.0030 (0.0109)	0.0352*** (0.0089)	-0.0010 (0.0128)
Supervise	0.2530*** (0.0067)	0.1341*** (0.0119)	0.2710*** (0.0092)	0.1274*** (0.0138)
Unioncov	0.0058 (0.0078)	0.1008*** (0.0138)	0.0387*** (0.0114)	0.0730*** (0.0173)
Commspecific	0.0173***	0.0395***	0.0212**	0.0465***

	(0.0064)	(0.0103)	(0.0087)	(0.0118)
Permanent	0.0523*** (0.0151)	0.0639*** (0.0231)	0.0466** (0.0217)	0.0705** (0.0285)
Age	0.3036*** (0.0136)	0.2227*** (0.0170)	0.3663*** (0.0221)	0.2816*** (0.0222)
Age²	-0.0268*** (0.0015)	-0.0212*** (0.0019)	-0.0312*** (0.0024)	-0.0259*** (0.0024)
Nemps	5.5e-05*** (7.32e-06)	4.38e-05*** (1.31e-05)	6.89e-05*** (1.08e-05)	5.20e-05*** (1.56e-05)
Nemps²	-6.97e-09*** (1.21e-09)	-5.14e-09** (2.39e-09)	-9.45e-09*** (2.02e-09)	-6.70e-09** (3.13e-09)
Meritpay	0.1066*** (0.0070)	0.0548*** (0.0113)	0.0997*** (0.0094)	0.0488*** (0.0128)
Public	-0.0049 (0.0072)	-0.0666*** (0.0120)	-0.0489*** (0.0100)	-0.1123*** (0.0141)
Female	-0.2409*** (0.0067)	-0.3250*** (0.0114)		
Fatal	-1.6639*** (0.1516)	0.6765*** (0.1784)	-1.6931*** (0.1682)	0.5812*** (0.2009)
Fatal*Unioncov	0.7845*** (0.2091)	-0.4773* (0.2544)	0.9554*** (0.2375)	-0.2782 (0.2902)
Lnsigma	*-0.9677**** *(0.0077)*	*-1.1066**** *(0.0133)*	*-0.9639**** *(0.0112)*	*-1.1371**** *(0.0161)*
Sigma	*0.3800* *(0.0029)*	*0.3307* *(0.0044)*	*0.3814* *(0.0043)*	*0.3208* *(0.0052)*
VSL (2004 £)		£11,062,574		£10,496,495
VSL (2000 US$)		$15,921,674		$15,106,951

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 5.8: Descriptive Statistics By Union Status (Mean and Standard Deviation)

	ALL MANUAL		MALE MANUAL	
	Covered	**Uncovered**	**Covered**	**Uncovered**
Obs.	3111	2469	2278	1678
Wkincome	333.1531 (132.472)	290.8539 (137.1949)	362.3650 (129.8704)	326.7213 (137.4774)
Anincome	17323.96	15124.40	18842.98	16989.51
Wpayl	302.7724 (118.2643)	263.6879 (125.1147)	329.1103 (115.2189)	296.7959 (124.56)
Wpayh	361.7016 (142.9971)	314.4329 (143.2844)	393.2336 (140.5282)	352.3882 (143.8491)
Commspecific	0.5558 (0.4970)	0.2463 (0.4309)	0.5929 (0.4914)	0.2473 (0.4316)
Fatal	0.0310 (0.0374)	0.0350 (0.0391)	0.0383 (0.0391)	0.0451 (0.0407)
Major Injury	5.0293 (3.8257)	5.0110 (3.8399)	5.6544 (3.8227)	5.6438 (3.7803)

Appendix 5.9: Interval Regression (Fatal, Commspecific, Commgeneral)

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	MALE MANUAL
Obs	*5474*	*3897*
Wald chi²	*3111.46*	*1269.82*
Log pseudo likelihood	*-10984.538*	*-7780.6166*
Constant	4.8419*** (0.0443)	4.7042*** (0.0585)
Educ1	0.1265*** (0.0105)	0.1216*** (0.0122)
Educ2	0.0461*** (0.0160)	0.0396** (0.0188)
Educ3	0.2119*** (0.0188)	0.2073*** (0.0216)
Tenure2	-0.0003 (0.0189)	-0.0215 (0.0225)
Tenure3	0.0486*** (0.0158)	0.0530*** (0.0183)
Tenure4	0.0686*** (0.0165)	0.0610*** (0.0191)
Tenure5	0.1438*** (0.0164)	0.1441*** (0.0190)
Overtime	0.0066*** (0.0008)	0.0076*** (0.0010)
Flexitime	0.0004 (0.0109)	-0.0011 (0.0129)
Supervise	0.1341*** (0.0119)	0.1252*** (0.0138)
Runion	0.0925*** (0.0145)	0.0581*** (0.0181)
Commspecific	0.0274* (0.0142)	0.0430** (0.0180)
Commgeneral	0.0334 (0.0252)	0.0618** (0.0304)
Permanent	0.0664*** (0.0231)	0.0680** (0.0286)
Age	0.2225*** (0.0171)	0.2801*** (0.0223)
Age²	-0.0211*** (0.0019)	-0.0258*** (0.0024)
Nemps	4.41e-05*** (1.35e-05)	4.99e-05*** (1.58e-05)
Nemps²	-5.45e-09** (2.49e-09)	-6.42e-09** (3.18e-09)
Meritpay	0.0555*** (0.0113)	0.0497*** (0.0128)
Public	-0.0749*** (0.0124)	-0.1159*** (0.0145)

Female	-0.3279*** (0.0115)	
Fatal	0.5452*** (0.1980)	0.4572** (0.2195)
Fatal*Runion	-0.5692** (0.2700)	-0.2363 (0.3077)
Fatal*Commspecific	0.5939** (0.2844)	0.3604 (0.3255)
Fatal*Commgeneral	0.0420 (0.5040)	-0.2213 (0.5443)
Lnsigma	*-1.1059**** *(0.0135)*	*-1.1372**** *(0.0163)*
Sigma	*0.3309* *(0.0045)*	*0.3207* *(0.0052)*
VSL (2004 £)	£8,915,470	£8,257,050
VSL (2000 US$)	$12.831,480	$11,883,858

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 5.10: Descriptive Statistics by Health and Safety Committee Presence (Mean and Standard Deviation)

	ALL MANUAL		MALE MANUAL	
	Commspecific	**No Commspecific**	**Commspecific**	**No Commspecific**
Obs.	*2336*	*3244*	*1765*	*2191*
Wpay	338.9095 (139.7704)	296.8606 (130.7706)	368.2719 (136.1913)	330.3674 (130.3059)
Annual pay	17623.2940 (7628.061)	15436.7510 (6800.071)	19150.1390 (7081.948)	17179.1050 (6775.905)
Fatal	0.0323 (0.0327)	0.0331 (0.0417)	0.0375 (0.0328)	0.0441 (0.0446)
Major Injury	5.4315 (4.1609)	4.7258 (3.5473)	5.8433 (4.0835)	5.4941 (3.5568)

Appendix 5.11: Union Instrumental Variables and Descriptive Statistics (Mean and Standard Deviation)

VARIABLE	DEFINITION
MGRF	Taken from the management survey equals 1 if manager reports they are in favour of trade unions.
MGRNF	Equals 1 if the manager reports they are not in favour of trade unions
MGRNET	Equals 1 if managers report a neutral attitude towards trade unions (excluded in probit).
WRKMGRF	Taken from the worker survey equals 1 if the worker reports managers are in favour of trade unions
WRKMGRNF	Equals 1 if worker reports managers are not in favour of unions.
WRKMGRNET	Equals1 if workers report managers have a neutral attitude towards

	trade unions (excluded in probit).
WRKAGREE	Taken from the worker survey, equals 1 if workers agree or strongly agree that unions make a difference to the firm (nearest proxy for worker attitude)
WRKDIS	Equals 1 if workers disagree of strongly disagree that unions make a difference to the firm.
WRKNET	Equals 1 if workers are neutral to the above statement (excluded in probit).

VARIABLE	ALL MANUAL	MALE MANUAL
Recogunion	0.5575 (0.4967)	0.5758 (0.4943)
Mgrf	0.3563 (0.4789)	0.3567 (0.4791)
Mgrnf	0.1120 (0.3154)	0.1226 (0.3280)
Mgrnet	0.5303 (0.4991)	0.5187 (0.4997)
Wrkmgrf	0.1658 (0.3719)	0.1752 (0.3802)
Wrkmgrnf	0.1729 (0.3782)	0.1951 (0.3964)
Wrkmgrnet	0.1957 (0.3968)	0.2123 (0.4090)
Wrkagree	0.2204 (0.4146)	0.2437 (0.4294)
Wrkdis	0.1106 (0.3136)	0.1229 (0.3283)
Wrknet	0.1765 (0.3813)	0.1782 (0.3827)

Appendix 5.12: Union Selection Instrument check

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	MALE MANUAL
Obs	*5474*	*3897*
Wald chi²	*3168.21*	*1325.83*
Log pseudo likelihood	*-10963.968*	*-7763.7556*
Constant	4.8631*** (0.0443)	4.6964*** (0.0583)
Educ1	0.1236*** (0.0104)	0.1203*** (0.0121)
Educ2	0.0499*** (0.0161)	0.0433** (0.0188)
Educ3	0.2109*** (0.0187)	0.2065*** (0.0214)
Tenure2	0.0004 (0.0190)	-0.0190 (0.0227)

Tenure3	0.0498*** (0.0159)	0.0559*** (0.0185)
Tenure4	0.0724*** (0.0166)	0.0663*** (0.0192)
Tenure5	0.1419*** (0.0166)	0.1413*** (0.0192)
Overtime	0.0065*** (0.0008)	0.0075*** (0.0010)
Flexitime	-0.0050 (0.0109)	-0.0082 (0.0129)
Supervise	0.1329*** (0.0119)	0.1250*** (0.0138)
Runion	0.0741*** (0.0159)	0.0314 (0.0203)
Commspecific	0.0372*** (0.0102)	0.0423*** (0.0117)
Permanent	0.0645*** (0.0231)	0.0679** (0.0287)
Age	0.2254*** (0.0171)	0.2839*** (0.0222)
Age^2	-0.0216*** (0.0019)	-0.0263*** (0.0024)
Nemps	4.31e-05*** (1.34e-05)	5.04e-05*** (1.57e-05)
$Nemps^2$	-5.23e-09** (2.54e-09)	-6.18e-09* (3.20e-09)
Meritpay	0.0540*** (0.0113)	0.0516*** (0.0128)
Public	-0.0854*** (0.0125)	-0.1279*** (0.0144)
Female	-0.3250*** (0.0114)	
Fatal	0.6806*** (0.1846)	0.5110** (0.2050)
Fatal*Runion	-0.4830* (0.2570)	-0.2120 (0.2915)
Mgrf	0.0280** (0.0118)	0.0542*** (0.0140)
Mgrnf	0.0427*** (0.0157)	0.0280 (0.0175)
Wrkmgrf	0.0541*** (0.0133)	0.0347** (0.0153)
Wrkmgrnf	-0.0062 (0.0122)	-0.0136 (0.0138)
Wrkagree	0.0302** (0.0126)	0.0245* (0.0146)
Wrkdis	-0.0222 (0.0146)	-0.0353** (0.0159)
Lnsigma	*-1.1098******	*-1.1417******

	(0.0136)	*(0.0164)*
Sigma	*0.3296* *(0.0045)*	*0.3193* *(0.0052)*

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 5.13: Health and Safety Committee Instrumental Variables and Descriptive Statistics (Mean and Standard Deviation)

VARIABLE	DEFINITION
HSMEET	Taken from the management survey equal to 1 if health and safety issues are discussed at meetings between senior managers and the whole workforce
HSDISPROC	Taken from the management survey equal to 1 if there are formal procedures for dealing with health safety collective disputes raised by employees
HSGRIEV	Taken from the management survey equal to 1 if health and safety grievances have been raised in the past year

VARIABLE	ALL MANUAL	MALE MANUAL
Hsmeet	0.5776 (0.4940)	0.5536 (0.4972)
Hsdisproc	0.5125 (0.4999)	0.5185 (0.4997)
Hsgriev	0.1654 (0.3716)	0.1681 (0.3740)

Appendix 5.14: Health and Safety Committee Selection Instrument check

Dependent Variables: Lnwpayl Lnwpayh

	ALL MANUAL	MALE MANUAL
Obs	*5474*	*3897*
Wald chi²	*3107.75*	*1267.88*
Log pseudo likelihood	*-10985.839*	*-7781.4111*
Constant	4.8275*** (0.0445)	4.6880*** (0.0583)
Educ1	0.1271*** (0.0105)	0.1220*** (0.0122)
Educ2	0.0471*** (0.0160)	0.0401** (0.0188)
Educ3	0.2117*** (0.0188)	0.2075*** (0.0215)
Tenure2	-0.0004 (0.0189)	-0.0217 (0.0226)
Tenure3	0.0485*** (0.0158)	0.0533*** (0.0184)
Tenure4	0.0685*** (0.0165)	0.0609*** (0.0191)

Tenure5	0.1428*** (0.0164)	0.1421*** (0.0189)
Overtime	0.0066*** (0.0008)	0.0076*** (0.0010)
Flexitime	-0.0009 (0.0109)	-0.0027 (0.0128)
Supervise	0.1337*** (0.0119)	0.1249*** (0.0138)
Runion	0.0871*** (0.0146)	0.0560*** (0.0183)
Commspecific	0.0397*** (0.0103)	0.0485*** (0.0120)
Permanent	0.0648*** (0.0231)	0.0675** (0.0285)
Age	0.2239*** (0.0171)	0.2827*** (0.0223)
Age^2	-0.0212*** (0.0019)	-0.0260*** (0.0024)
Nemps	4.69e-05*** (1.35e-05)	5.65e-05*** (1.59e-05)
$Nemps^2$	-5.93e-09** (2.51e-09)	-7.44e-09** (3.27e-09)
Meritpay	0.0541*** (0.0114)	0.0474*** (0.0129)
Public	-0.0750*** (0.0125)	-0.1143*** (0.0148)
Female	-0.3287*** (0.0115)	
Fatal	0.6724*** (0.1834)	0.5203** (0.2034)
Fatal*Runion	-0.4111** (0.1552)	-0.1489 (0.2903)
Hsmeet	0.0103 (0.0095)	0.0209* (0.0110)
Hsdisproc	0.0105 (0.0098)	-0.0010 (0.0115)
Hsgriev	0.0168 (0.0120)	0.0192 (0.0138)
Lnsigma	*-1.1057**** *(0.0135)*	*-1.1370**** *(0.0163)*
Sigma	*0.3310* *(0.0045)*	*0.3208* *(0.0052)*

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Robust standard errors in parenthesis

Appendix 5.15: Risk Instrumental Variables and Descriptive Statistics (Mean and Standard Deviation)

VARIABLE	DEFINITION
MARRIED	Equal to 1 if the worker is married or living with a partner.
CHILDREN	Equal to 1 if the worker has dependent children (aged 0-18)
DISABILITY	Equal to 1 if the worker describes themselves as having a long-term illness, health problem, or disability.
PENSION	Equal to 1 if manager reports workers in the largest occupational group are entitled to an employee pension scheme.
CAR	Equal to 1 if manager reports workers in the largest occupational group are entitled to a company car or car allowance.
HEALTHINS	Equal to 1 if manager reports workers in the largest occupational group are entitled to private health insurance.
IND1	Equal to 1 if workplace in manufacturing industry.
IND2	Equal to 1 if workplace in electricity industry.
IND3	Equal to 1 if workplace in construction industry.
IND4	Equal to 1 if workplace in wholesale industry (excluded).
IND5	Equal to 1 if workplace in hotel industry.
IND6	Equal to 1 if workplace in transport industry.
IND7	Equal to 1 if workplace in financial industry.
IND8	Equal to 1 if workplace in other industry.
IND9	Equal to 1 if workplace in public industry.
IND10	Equal to 1 if workplace in education industry.
IND11	Equal to 1 if workplace in health industry.
IND12	Equal to 1 if workplace in other community industry.

VARIABLE	ALL MANUAL	MALE MANUAL
Married	0.6683 (0.4709)	0.6903 (0.4624)
Children	0.3737 (0.4838)	0.4200 (0.4936)
Disability	0.1385 (0.3455)	0.1413 (0.3484)
Pension	0.7776 (0.4159)	0.7912 (0.4065)
Car	0.1204 (0.3255)	0.1198 (0.3248)
Healthins	0.1398 (0.3255)	0.15091 (0.3580)
Ind1	0.3142 (0.4642)	0.3678 (0.4823)
Ind2	0.0201 (0.1403)	0.0265 (0.1608)
Ind3	0.0692 (0.2538)	0.0948 (0.2930)
Ind4	0.0713 (0.2574)	0.0872 (0.2822)

Ind5	0.0367 (0.1881)	0.0255 (0.1578)
Ind6	0.1344 (0.3411)	0.1663 (0.3724)
Ind7	0.0036 (0.0598)	0.0033 (0.0572)
Ind8	0.0665 (0.2492)	0.0756 (0.2644)
Ind9	0.0181 (0.1333)	0.0187 (0.1355)
Ind10	0.0525 (0.2231)	0.0245 (0.1547)
Ind11	0.1522 (0.3592)	0.0485 (0.2149)
Ind12	0.0613 (0.2400)	0.0612 (0.2397)

CHAPTER 6 APPENDICES

Appendix 6.1: Occupation Characteristic Variable Means

SOC code	Streng.	Stamin.	Hands	Tools	Writelg	Calc	Stat	Caring	Spec.	Analy.	My time	Use PC	Speech	Pers.	List.	Moti.	Future	Percent C
11	0.97	1.32	1.36	1.80	2.43	3.04	1.74	2.88	3.39	2.70	3.51	3.20	2.08	2.96	3.31	3.46	2.5	22.3
12	1.78	2.15	2.33	2.31	1.61	2.96	1.37	3.02	3.06	2.47	3.36	2.10	1.34	2.76	3.16	3.42	2.56	18.9
21	0.92	1.09	1.82	2.63	2.46	2.86	2.36	2.13	3.66	3.17	3.15	3.54	1.65	2.38	3.21	2.98	1.73	32.27
22	0.77	1.57	2.91	2.84	2.66	2.29	1.83	3.67	3.93	3.37	3.30	2.80	2.16	2.83	3.40	3.39	2.47	58.81
23	1.19	1.92	1.49	1.80	2.94	2.73	1.76	3.33	3.74	2.59	3.66	3.00	2.84	3.00	3.48	3.48	2.36	72.32
24	0.49	1.08	0.96	1.41	2.95	2.67	1.65	3.10	3.59	3.16	3.61	3.15	2.41	2.97	3.33	3.32	2.13	35.35
31	1.13	1.42	2.50	2.92	1.87	2.53	1.92	2.14	3.46	2.68	3.19	3.45	1.30	2.26	3.36	2.93	1.41	38.79
32	1.80	2.08	2.40	2.62	2.26	2.41	1.08	3.78	3.64	2.56	3.46	2.21	1.60	2.53	3.53	3.36	1.54	63.13
33	2.22	2.57	1.58	1.94	2.63	1.42	0.85	3.02	3.57	2.43	2.92	2.49	1.92	2.71	3.29	3.25	0.85	63.94
34	1.52	2.02	2.62	2.62	2.12	1.81	0.97	2.21	3.54	2.53	3.27	3.05	3.25	3.50	2.33	3.04	1.87	26.4
35	0.67	1.11	1.20	1.82	2.48	2.81	1.82	2.90	3.45	2.66	3.33	3.28	2.22	2.99	3.30	3.34	2.01	34.12
41	0.86	0.98	1.76	1.91	1.84	2.81	1.50	2.36	2.81	1.93	3.00	3.56	0.82	1.82	3.15	3.05	1.15	42.97
42	0.62	1.05	2.32	2.53	2.10	1.89	0.99	2.87	2.51	1.28	2.98	3.55	0.48	1.50	3.24	3.03	1.07	24.15
51	3.54	3.22	3.18	3.45	1.86	1.59	1.00	2.11	3.18	2.04	3.10	0.93	0.90	1.57	2.93	3.33	2.00	18.57
52	2.51	2.54	3.49	3.61	1.34	2.48	1.61	1.74	3.32	2.56	2.81	1.94	0.86	1.84	2.88	2.88	1.39	33.64
53	3.03	2.93	3.58	3.55	1.18	2.50	1.28	2.26	3.14	2.03	2.97	0.90	0.58	1.70	2.63	3.12	1.72	20.39
54	2.69	2.79	3.29	3.13	1.04	2.17	0.82	1.66	2.94	1.74	2.81	0.94	0.44	1.65	2.74	3.11	1.24	19.52
61	2.30	2.46	2.07	1.96	1.51	1.68	0.95	3.43	2.91	1.72	2.72	1.19	0.93	2.11	3.28	2.97	1.33	32.91
62	1.70	2.28	2.81	2.71	1.74	1.90	0.94	3.13	3.10	1.77	2.81	1.31	1.06	1.92	2.93	3.54	2.04	28.2
71	1.96	2.04	2.09	2.10	1.09	2.60	1.07	2.93	2.71	1.49	2.46	2.36	0.80	1.90	2.96	3.17	1.44	17.92
72	0.55	1.00	1.57	2.02	1.29	2.67	1.03	3.55	3.07	2.05	2.63	3.55	1.25	2.29	3.37	3.07	0.86	36.13
81	2.36	2.54	3.09	3.29	1.07	2.24	1.26	1.34	2.72	1.83	2.33	1.66	0.72	1.73	2.88	3.26	1.24	36.76
82	2.28	2.54	2.18	2.78	0.88	1.90	0.64	2.01	2.47	1.36	2.69	1.04	0.41	1.24	2.74	2.84	1.05	37.57
91	2.92	2.81	2.76	2.88	1.08	2.11	0.96	1.38	2.33	1.38	2.51	1.33	0.61	1.48	2.66	3.07	1.44	28.37
92	2.42	2.51	2.06	2.24	1.00	1.20	0.67	1.84	1.87	1.10	2.43	0.82	0.41	1.33	2.57	3.23	1.16	28.84

Variable Abbreviations: Streng. - Strength, Stamin. – Stamina, Spec.-Special, Analy.-Analyse, Pers.-Persuade, List. – Listen, Moti.-Motivate. Created Using the Skills Survey 2001

Appendix 6.2: Occupation Characteristic Variable Correlations

	Strength	Stamina	Hands	Tools	Writelg	Calc	Stat	Caring	Spec.	Analy.	My time	Use PC
Strength	1											
Stamina	0.968879	1										
Hands	0.670474	0.666852	1									
Tools	0.629605	0.596537	0.942621	1								
Writelg	-0.61488	-0.5367	-0.53517	-0.49012	1							
Calc	-0.52443	-0.5755	-0.29456	-0.23321	0.266172	1						
Stat	-0.553	-0.58602	-0.25748	-0.12885	0.581731	0.73326	1					
Caring	-0.53732	-0.43308	-0.47854	-0.58007	0.560178	0.207687	0.129451	1				
Spec	-0.39905	-0.31494	-0.16353	-0.11245	0.778736	0.41289	0.637948	0.487701	1			
Anal	-0.4893	-0.43538	-0.24349	-0.15975	0.762336	0.523741	0.789841	0.367655	0.921047	1		
Mytime	-0.49646	-0.43181	-0.36654	-0.33344	0.837974	0.467062	0.579819	0.490759	0.766192	0.766643	1	
Use pc	-0.89326	-0.91271	-0.60198	-0.51882	0.648754	0.561369	0.62818	0.392602	0.492324	0.554573	0.512054	
Speech	-0.5302	-0.41175	-0.47434	-0.46553	0.815568	0.285318	0.472045	0.462629	0.780838	0.760163	0.751208	0.57906
Pers	-0.56629	-0.45793	-0.48387	-0.50742	0.768653	0.402347	0.495848	0.546918	0.790397	0.790438	0.753084	0.6041
Listen	-0.61808	-0.59249	-0.54793	-0.50435	0.64506	0.447227	0.510345	0.726622	0.537273	0.519785	0.527564	0.59138
Motiv	-0.1382	-0.01984	-0.20452	-0.2994	0.460956	0.146606	0.117428	0.466265	0.316645	0.280779	0.435008	0.00641
Future	-0.21754	-0.12985	-0.08083	-0.12616	0.524548	0.432594	0.518079	0.318535	0.531759	0.593607	0.705873	0.13642
Percentc	-0.28643	-0.16931	-0.29562	-0.26519	0.533781	0.010162	0.210538	0.43494	0.480926	0.395575	0.331952	0.29589
Log(major)	0.762978	0.766414	0.511913	0.533519	-0.57483	-0.5041	-0.4964	-0.60593	-0.33118	-0.39655	-0.57926	-0.603
Female	-0.45203	-0.42158	-0.35181	-0.52551	0.164686	-0.01389	-0.17325	0.625039	-0.10735	-0.21789	0.056851	0.30053
Log (fatal)	0.764954	0.750272	0.576649	0.684468	-0.41466	-0.26862	-0.1992	-0.5418	-0.10915	-0.10202	-0.32007	-0.6213

	Speech	Pers.	Listen	Motiv.	Future	PercentC	Log(major)	Female	Log(fatal)
Strength									
Stamina									
Hands									
Tools									
Writelg									
Calc									
Stat									
Caring									
Spec									
Anal									
Mytime									
Use pc									
Speech	1								
Pers	0.954062	1							
Listen	0.349712	0.434119	1						
Motiv	0.408321	0.42598	0.32118	1					
Future	0.578143	0.589541	0.208872	0.6732	1				
Percentc	0.444714	0.367053	0.558805	0.20518	-0.02029	1			
Log(major)	-0.30509	-0.36759	-0.68774	-0.35605	-0.39606	-0.14345	1		
Female	0.054133	0.110359	0.410739	0.180185	-0.09372	0.172952	-0.52065	1	
Log(fatal)	-0.33083	-0.38412	-0.38725	-0.03777	-0.03226	-0.02754	0.757544	-0.76678	1

Appendix 6.3: Standardised Scores

	Strength	Stamina	Hands	Tools	Writelg	Calca	Stats	Caring	Special	Analyse
1	-.67915	-.82782	.27914	.66405	.08040	.47219	1.42114	-.62534	.66944	.79190
2	.08177	.11289	.14177	.17240	.67424	.23531	-.45230	1.6456*1	1.02849	.60031
3	.55876	.81129	-.98468	-.94200	1.23762	-1.71900*	-.96527	.59322	.88886	.39276
4	-.23623	.02737	.44399	.17240	.46106	-.94912	-.69763	-.52841	.82902	.55242
5	-1.20157	-1.26967	-1.50669	-1.13866	1.00922	1.02493	1.19811	.42705	.64949	.75997
6	-.98579	-1.45496	-.73741	-.99116	.03472	1.02493	.48442	-.32070	-.62715	-.40553
7	-1.25835	-1.35519	.03187	.02491	.43061	-.79120	-.65303	.38551	-1.22558	-1.44331
8	2.05788***	1.73775*	1.21327	1.53263	.06517	-1.38341	-.63073	-.66688	.11091	-.22991
9	.88812	.76853	1.63912*	1.79484*	-.72661	.37349	.72975	-1.17923	.39017	.60031
10	1.47868	1.32440	1.76275*	1.69652*	-.97024	.41297	-.00624	-.45917	.03112	-.24587
11	1.09254	1.12486	1.36438	1.00821	-1.18341	-.23847	-1.03218	-1.29001	-.36783	-.70888
12	.64962	.65451	-.31156	-.90922	-.46776	-1.20575	-.74224	1.16095	-.42767	-.74081
13	-.03180	.39795	.70499	.31990	-.11755	-.77146	-.76454	.74554	-.04867	-.66098
14	.26348	.05587	-.28408	-.67979	-1.10728	.61038	-.47461	.46859	-.82662	-1.10803
15	-1.33785	-1.42646	-.99842	-.81089	-.80275	.74856	-.56382	1.32712	-.10851	-.21394
16	.71776	.76853	1.08963	1.27042	-1.13773	-.10028	-.05085	-1.73312*	-.80668	-.56519
17	.62691	.76853	-.16045	.43462	-1.42704	-.77146	-1.43363	-.80536	-1.30537	-1.31558
18	1.35375	1.15337	.63631	.59850	-1.12251	-.35691	-.71994	-1.67773*	-1.58463	-1.28365
19	.78590	.72577	-.32530	-.45035	-1.24432	-2.15329***	-1.36672	-1.04076	-2.50222	-1.73069*
20	-.67915	-.82782	.27914	.66405	.08040	.47219	1.42114	-.62534	.66944	.79190
21	.08177	.11289	.14177	.17240	.67424	.23531	-.45230	1.64561*	1.02849	.60031
22	.55876	.81129	-.98468	-.94200	1.23762	-1.71900*	-.96527	.59322	.88886	.39276
23	-.23623	.02737	.44399	.17240	.46106	-.94912	-.69763	-.52841	.82902	.55242
24	-1.20157	-1.26967	-1.50669	-1.13866	1.00922	1.02493	1.19811	.42705	.64949	.75997
25	-.98579	-1.45496	-.73741	-.99116	.03472	1.02493	.48442	-.32070	-.62715	-.40553

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

	Mytime	Usepc	Speech	Persuade	Listen	Motivate	Future	Percentc
1	.49775	1.14154	-.02684	.09699	.91031	-1.28012	-.40760	.25883
2	1.20657	-.08295	.34592	.52488	1.43740	.87345	-.15813	1.87452*
3	-.21107	.19355	.74352	.81014	.69327	.32254	-1.48225	1.92829*
4	.70777	.74654	2.39607***	2.06212***	-2.28322***	-.72921	.47515	-.56362
5	.86529	.97367	1.11628	1.25388	.72428	.77328	.74381	-.05117
6	-.00105	1.25017	-.62325	-.60032	.25920	-.67913	-.90655	.53630
7	-.05356	1.24029	-1.04570	-1.10745	.53825	-.77929	-1.06007	-.71297
8	.26148	-1.34694	-.52385	-.99651	-.42291	.72320	.72462	-1.08338
9	-.49985	-.34957	-.57355	-.56862	-.57794	-1.53054	-.44598	-.08303
10	-.07981	-1.37656	-.92145	-.79049	-1.35306	-.32855	.18730	-.96256
11	-.49985	-1.33707	-1.09540	-.86973	-1.01201	-.37863	-.73383	-1.02031
12	-.73612	-1.09019	-.48657	-.14073	.66227	-1.07979	-.56112	-.13149
13	-.49985	-.97169	-.32504	-.44184	-.42291	1.77495*	.80138	-.44414
14	-1.41869	.06517	-.64810	-.47353	-.32989	-.07813	-.35003	-1.12652
15	-.97240	1.24029	-.08896	.14453	.94132	-.57896	-1.46306	.08226
16	-1.75998*	-.62607	-.74750	-.74295	-.57794	.37262	-.73383	.12408
17	-.81488	-1.23832	-1.13268	-1.51949	-1.01201	-1.73087*	-1.09845	.17785
18	-1.28743	-.95194	-.88418	-1.13914	-1.26005	-.57896	-.35003	-.43285
19	-1.49745	-1.45556	-1.13268	-1.37686	-1.53909*	.22237	-.88736	-.40165
20	.49775	1.14154	-.02684	.09699	.91031	-1.28012	-.40760	.25883
21	1.20657	-.08295	.34592	.52488	1.43740	.87345	-.15813	1.87452*
22	-.21107	.19355	.74352	.81014	.69327	.32254	-1.48225	1.92829*
23	.70777	.74654	2.39607***	2.06212***	-2.28322**	-.72921	.47515	-.56362
24	.86529	.97367	1.11628	1.25388	.72428	.77328	.74381	-.05117
25	-.00105	1.25017	-.62325	-.60032	.25920	-.67913	-.90655	.53630

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 6.4: Full Male Conditional Logit Results (Full and Part Time Workers of All Ages)

	MEN	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No. of obs *Log Likelihood* *Psuedo* R^2	*42326* *-125645.27* *0.078*	*9718* *-29236.07* *0.065*	*3800* *-10533.593* *0.184*	*11477* *-33709.450* *0.088*	*13222* *-37941.839* *0.109*	*3064* *-9013.120* *0.086*	*883* *-2542.427* *0.1055*
Strength	6.026*** (0.167)	3.298*** (0.249)	5.575*** (0.683)	4.838*** (0.307)	9.176*** (0.322)	7.217*** (0.642)	6.706*** (1.212)
Stamina	-7.581*** (0.253)	-3.720*** (0.379)	-5.572*** (1.028)	-6.338*** (0.472)	-12.354*** (0.484)	-9.793*** (0.963)	-8.816*** (1.844)
Hands	-1.526*** (0.046)	-0.613*** (0.010)	-0.774*** (0.215)	-1.712*** (0.089)	-2.039*** (0.083)	-1.749*** (0.172)	-1.934*** (0.336)
Tools	-2.362*** (0.132)	-1.018*** (0.188)	-2.297*** (0.498)	-1.506*** (0.251)	-4.364*** (0.262)	-2.795*** (0.501)	-2.664*** (0.963)
Writelg	-6.559*** (0.193)	-3.019*** (0.257)	-6.209*** (0.716)	-5.400*** (0.355)	-10.314*** (0.387)	-7.805*** (0.739)	-7.454*** (1.367)
Calca	-2.196*** (0.088)	-0.544*** (0.136)	-1.765*** (0.345)	-1.715*** (0.166)	-3.936*** (0.166)	-2.737*** (0.329)	-2.742*** (0.638)
Stats	-0.505*** (0.063)	0.585*** (0.133)	0.717*** (0.277)	-0.610*** (0.119)	-1.347*** (0.112)	-0.886*** (0.231)	-0.443 (0.463)
Caring	-1.504*** (0.053)	-0.556*** (0.076)	-0.560*** (0.191)	-1.474*** (0.101)	-2.749*** (0.106)	0.205*** (0.205)	-1.912*** (0.392)
Special	6.217*** (0.225)	1.600*** (0.310)	3.701*** (0.841)	5.266*** (0.423)	11.350*** (0.434)	7.919*** (0.857)	8.381*** (1.657)
Analyse	1.423*** (0.059)	0.835*** (0.109)	1.789*** (0.247)	1.156*** (0.111)	1.901*** (0.116)	1.282*** (0.228)	0.525 (00.442)
Mytime	1.689*** (0.072)	1.165*** (0.148)	1.584*** (0.295)	1.851*** (0.139)	1.939*** (0.134)	1.820*** (0.228)	2.415*** (0.542)

Usepc	0.280*** (0.040)	0.233*** (0.078)	0.968*** (0.154)	0.042 (0.081)	0.032 (0.074)	-0.275* (0.144)	-0.100 (0.266)
Speech	0.159** (0.080)	0.967*** (0.168)	1.873*** (0.355)	-0.013 (0.158)	-0.981*** (0.145)	-0.301 (0.311)	-0.688 (0.611)
Persuade	-2.262*** (0.091)	-1.681*** (0.193)	-4.000*** (0.445)	-1.957*** (0.175)	-1.943*** (0.164)	-1.605*** (0.350)	-1.501** (0.668)
Listen	-2.311*** (0.084)	-1.591*** (0.152)	-2.045*** (0.304)	-2.007*** (0.166)	-3.120*** (0.162)	-2.314*** (0.321)	-2.563*** (0.625)
Motivate	3.235*** (0.090)	1.953*** (0.165)	4.159*** (0.316)	2.571*** (0.177)	4.224*** (0.179)	3.007*** (0.330)	3.371*** (0.612)
Future	3.831*** (0.126)	1.008*** (0.198)	2.015*** (0.528)	3.586*** (0.235)	6.597*** (0.229)	4.835*** (0.482)	4.512*** (0.985)
Fatal	-165.416*** (4.567)	-87.731*** (9.864)	-201.841*** (20.059)	-151.900*** (8.630)	-186.466*** (8.373)	-163.888*** (17.193)	-199.728*** (33.687)
Major Injury	2.964*** (0.083)	1.152*** (0.173)	2.235*** (0.371)	2.783*** (0.156)	4.352*** (0.144)	3.485*** (0.305)	4.503*** (0.571)
Percentc	0.079*** (0.003)	0.028*** (0.004)	0.037*** (0.013)	0.068*** (0.006)	0.147*** (0.007)	0.108*** (0.013)	0.088*** (0.026)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

Full Female Conditional Logit Results (Full and Part Time Workers of All Ages)

	WOMEN	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No. of Obs	*38456*	*7344*	*4385*	*10270*	*10537*	*3406*	*2374*
Log Likelihood	*-105311.010*	*-20647.331*	*-10530.944*	*-27952.729*	*-28508.339*	*-9358.235*	*-6390.861*
Psuedo R^2	*0.149*	*0.127*	*0.254*	*0.154*	*0.160*	*0.146*	*0.164*
Strength	4.587*** (0.081)	4.502*** (0.183)	5.215*** (0.322)	4.397*** (0.154)	4.915*** (0.157)	4.129*** (0.257)	4.614*** (0.326)
Stamina	-6.462*** (0.125)	-6.912*** (0.286)	-7.268*** (0.487)	-6.277*** (0.242)	-6.928*** (0.245)	-0.624*** (0.401)	-6.756*** (0.514)
Hands	2.778*** (0.118)	1.408*** (0.206)	3.746*** (0.479)	3.747*** (0.252)	3.447*** (0.257)	3.081*** (0.383)	1.593*** (0.392)
Tools	-2.357*** (0.106)	-1.225*** (0.196)	-3.621*** (0.452)	-3.106*** (0.221)	-2.794*** (0.225)	-2.597*** (0.360)	-1.644*** (0.390)
Write	0.062 (0.096)	0.184 (0.199)	-0.665* (0.404)	-0.056 (0.191)	0.227 (0.188)	-0.049 (0.325)	-0.361 (0.398)
Calca	-0.140** (0.068)	-0.281* (0.148)	-0.407 (0.297)	-0.058 (0.132)	-0.032 (0.133)	-0.011 (0.227)	-0.502* (0.277)
Stats	0.407*** (0.135)	-0.176 (0.277)	1.198*** (0.463)	0.647** (0.273)	0.421 (0.286)	0.579 (0.432)	-0.287 (0.523)
Caring	-0.344*** (0.055)	-0.299** (0.123)	0.161 (0.187)	-0.634*** (0.111)	-0.384*** (0.113)	-0.498*** (0.178)	-0.580*** (0.224)
Special	-1.642*** (0.121)	-0.126 (0.241)	-1.423*** (0.466)	-2.447*** (0.256)	-2.197*** (0.255)	-1.924*** (0.398)	-0.344 (0.443)
Analyse	-1.590*** (0.060)	-1.874*** (0.121)	-1.922*** (0.259)	-1.626*** (0.123)	-1.438*** (0.116)	-1.800*** (0.208)	-2.048*** (0.257)
Mytime	-0.059 (0.147)	-0.606** (0.307)	-0.405 (0.558)	0.515* (0.302)	0.022 (0.295)	0.876* (0.503)	0.374 (0.642)

Usepc	-0.741*** (0.040)	-0.680*** (0.081)	-0.692*** (0.167)	-0.819*** (0.084)	-0.942*** (0.080)	-0.982*** (0.132)	-0.805*** (0.158)
Speech	2.138*** (0.124)	0.896*** (0.239)	2.548*** (0.495)	2.839*** (0.266)	2.678*** (0.262)	2.158*** (0.401)	1.218*** (0.457)
Persuade	0.042 (0.112)	0.812*** (0.230)	-0.161 (0.478)	-0.188 (0.226)	-0.164 (0.221)	0.278 (0.364)	0.314 (0.464)
Listen	3.197*** (0.121)	1.322*** (0.250)	2.339*** (0.455)	4.543*** (0.253)	4.089*** (0.254)	3.617*** (0.409)	3.064*** (0.468)
Motivate	2.292*** (0.161)	0.910*** (0.311)	4.359*** (0.631)	3.123*** (0.324)	2.199*** (0.348)	2.767*** (0.540)	1.427** (0.573)
Future	-0.035 (0.141)	1.075*** (0.270)	-0.676 (0.534)	-0.617** (0.286)	-0.284 (0.300)	-0.493 (0.456)	0.854 (0.522)
Fatal	-216.274*** (8.932)	-242.929*** (26.218)	-235.515*** (43.221)	-164.324*** (13.675)	-207.882*** (16.383)	-247.424*** (41.592)	-279.922*** (45.792)
Major Injury	0.187 (0.158)	0.990** (0.400)	0.640 (0.646)	-0.161 (0.289)	-0.165 (0.309)	1.332** (0.605)	1.039 (0.730)
Percentc	0.006*** (0.002)	0.027*** (0.004)	0.001 (0.009)	-0.006 (0.005)	0.004 (0.005)	-0.002 (0.007)	0.016* (0.008)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

Appendix 6.5: Conditional Logit Results Excluding Major Injury

	MEN	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No of obs.	*42326*	*9718*	*3800*	*11477*	*13222*	*3064*	*883*
Log Likelihood	*-126296.530*	*-29258.387*	*-10552.405*	*-33868.815*	*-38400.226*	*-9079.283*	*-2574.399*
Pseudo R^2	*0.073*	*0.065*	*0.137*	*0.083*	*0.098*	*0.079*	*0.094*
Fatal	-88.418***	-49.499***	-122.741***	-83.483***	-93.016***	-67.656***	-76.161***
Standard error	(3.869)	(7.977)	(15.284)	(7.416)	(7.286)	(14.375)	(27.954)

	WOMEN	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No of obs.	*38456*	*7344*	*4385*	*10270*	*10537*	*3406*	*2374*
Log Likelihood	*-105311.72*	*-20650.662*	*-10531.46*	*-27952.883*	*-28508.482*	*-9360.958*	*-6391.96*
Pseudo R^2	*0.149*	*0.126*	*0.254*	*0.154*	*0.160*	*0.146*	*0.1647*
Fatal	-210.436***	-204.086***	-207.210***	-167.650***	-212.476***	-195.157***	-243.490***
Standard error	(7.236)	(16.748)	(28.137)	(12.447)	(14.262)	(25.161)	(31.121)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Conditional Logit Results Excluding Fatal

	MEN	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No of obs.	*42326*	*9718*	*3800*	*11477*	*13222*	*3064*	*883*
Log Likelihood	*-126315.550*	*-29275.47*	*-10582.678*	*-33867.483*	*-38197.744*	*-9060.082*	*-2560.846*
Pseudo R^2	*0.073*	*0.0644*	*0.135*	*0.083*	*0.103*	*0.081*	*0.099*
Major Injury	1.583***	0.274*	-0.019	1.584***	3.154***	2.049***	2.891***
Standard error	(0.072)	(0.142)	(0.282)	(0.140)	(0.132)	(0.263)	(0.491)

	WOMEN	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No of obs.	*38456*	*7344*	*4385*	*10270*	*10537*	*3406*	*2374*
Log likelihood	*-105804.53*	*-20748.*	*-10558.832*	*-28046.528*	*-28634.493*	*-9401.441*	*-6433.836*
Pseudo R^2	*0.145*	*0.122*	*0.252*	*0.152*	*0.156*	*0.143*	*0.158*
Major Injury	-1.795***	-1.331***	-1.840***	-1.540***	-1.965***	-0.932**	-1.557***
Standard error	(0.128)	(0.276)	(0.457)	(0.261)	(0.259)	(0.428)	(0.536)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 6.6: Conditional Logit Results for Full-time workers Aged 25-34 (Note all variables included as before, but only risk variable parameters reported)

	MEN	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No of obs	*8227*	*3682*	*838*	*1073*	*2289*	*243*	*102*
Log likelihood	*-24421.794*	*-11005.982*	*-2375.538*	*-3092.467*	*-6601.680*	*-711.112*	*-292.773*
Pseudo R^2	*0.078*	*0.071*	*0.119*	*0.105*	*0.104*	*0.091*	*0.108*
Fatal							
Coefficient	-83.229***	-50.543***	-99.790***	-91.304***	-117.271***	-91.708*	-229.426**
Standard error	(8.449)	(12.284)	(31.722)	(24.141)	(17.386)	(53.689)	(105.462)
Major Injury							
Coefficient	1.875***	0.776***	1.161	2.736***	3.786***	0.515	3.710*
Standard error	(0.198)	(0.278)	(0.744)	(0.571)	(0.411)	(1.255)	(1.935)

	WOMEN	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No of obs	*5368*	*2642*	*490*	*1059*	*859*	*149*	*169*
Log likelihood	*-14949.855*	*-7377.367*	*-1355.404*	*-2834.078*	*-2356.482*	*-390.581*	*-460.394*
Pseudo R^2	*0.135*	*0.133*	*0.141*	*0.169*	*0.148*	*0.186*	*0.154*
Fatal							
Coefficient	-158.0411***	-172.899***	11.184	-228.725***	-191.139***	-81.448	-426.069*
Standard error	(23.436)	(37.335)	(56.233)	(80.293)	(60.552)	(97.412)	(248.285)
Major Injury							
Coefficient	1.771***	1.682**	4.629***	1.966	1.222	-1.539	4.016
Standard error	(0.466)	(0.687)	(1.516)	(1.344)	(1.183)	(3.529)	(3.229)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 6.7: Conditional Logit Fatal rate and Major Injury rate Estimates by Family Group Excluding Writelong, Stats, Special, Usepc, and Future (Full-Time and Part-Time Workers of all Ages)

	MEN	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No of obs *Log likelihood* *Pseudo R^2*	42326 -126938.9 0.068	9718 -29409.148 0.060	3800 -10672.694 0.128	11477 -34012.81 0.079	13222 -38581.856 0.094	3064 -9118.069 (0.076)	883 -2567.012 0.097
Fatal							
Coefficient Standard error	-98.726*** (3.7666)	-48.299*** (7.881)	-98.062*** (15.072)	-88.519*** (7.165)	-142.184*** (6.970)	-106.525*** (14.154)	-174.250*** (28.621)
Major Injury							
Coefficient Standard error	0.556*** (0.062)	-0.461*** (0.132)	-1.066*** (0.249)	0.715*** (0.118)	1.720*** (0.111)	0.940*** (0.229)	2.153*** (0.440)

Death Rate	**WOMEN**	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No of obs *Log likelihood* *Pseudo R^2*	38456 -106079.06 0.143	7344 -20775.51 0.121	4385 -10592.132 0.250	10270 -28185.067 0.147	10537 -28763.419 0.152	3406 -9443.207 0.139	2374 -6444.602 (0.157)
Fatal							
Coefficient Standard error	-162.899*** (5.586)	-161.091*** (13.219)	-143.802*** (21.179)	-136.142*** (10.217)	-165.955*** (10.604)	-164.719*** (19.113)	-185.682*** (23.149)
Major Injury							
Coefficient Standard error	-1.192*** (0.088)	-0.866*** (0.199)	-1.813*** (0.328)	-0.982*** (0.167)	-1.593*** (0.176)	-0.604** (0.293)	-1.225*** (0.359)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 6.8: Nested Logit Model Results

	MEN	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No of obs	42326	9718	3800	11477	13222	3064	883
Log likelihood	-125428.51	-29245.546	-10508.243	-33429.412	-37956.672	-9156.140	-2545.021
Fatal	-166.9376***	-111.8682***	-372.6673***	-126.494***	-145.7691***	-103.0052***	-169.751***
Standard error	(4.586924)	(9.492244)	(83.82282)	(9.329762)	(8.922286)	(17.34447)	(37.34692)

	WOMEN	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No of obs	38456	7344	4385	10270	10537	3406	2374
Log likelihood	-108159.26	-20684.31	-10328.648	-26248.228	-26866.445	-9533.248	-6456.234
Fatal	-527.5402***	-454.2167***	-403.9141***	-442.0163***	-897.4741***	-656.5646***	-221.7047***
Standard error	(27.46957)	(54.50833)	(102.8746)	(54.32277)	(86.8988)	(122.1501)	(81.80089)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 6.9: Demographic Dummy Variable Descriptives

	DEGREE	ALEVEL	GCSE	NOQUAL	WHITE	NONWHITE	TUNION	NONUNION
MEN								
Mean	0.3006	0.2866	0.1876	0.2251	0.9334	0.0664	0.2683	0.6579
Standard Deviation	0.4585	0.4522	0.3904	0.4177	0.2494	0.2490	0.4431	0.4744
SINGM								
Mean	0.3281	0.2624	0.2207	0.1888	0.9292	0.0704	0.1980	0.7023
Standard Deviation	0.4695	0.4399	0.4147	0.3914	0.2564	0.2559	0.3985	0.4572
SINGMCH								
Mean	0.1525	0.2837	0.3923	0.1715	0.9197	0.0799	0.1422	0.7885
Standard Deviation	0.3595	0.4508	0.4883	0.3769	0.2717	0.2712	0.3492	0.4083
MARM								
Mean	0.2906	0.3139	0.1210	0.2745	0.9561	0.0438	0.3168	0.6240
Standard Deviation	0.4541	0.4641	0.3261	0.4462	0.2049	0.2646	0.4652	0.4844
MARMCH								
Mean	0.3610	0.2765	0.1688	0.1937	0.9117	0.0880	0.3197	0.6221
Standard Deviation	0.4803	0.4473	0.3746	0.3952	0.2837	0.2833	0.4664	0.4849
SDWM								
Mean	0.2539	0.3027	0.1575	0.2859	0.9500	0.0500	0.2899	0.6368
Standard Deviation	0.4333	0.4594	0.3742	0.4518	0.2179	0.2179	0.4537	0.4809
SDWMCH								
Mean	0.2154	0.2967	0.1906	0.2967	0.9573	0.0427	0.3069	0.6077
Standard Deviation	0.4111	0.4568	0.3931	0.4568	0.2021	0.2021	0.4612	0.4883

	DEGREE	ALEVEL	GCSE	NOQUAL	WHITE	NONWHITE	TUNION	NONUNION
WOMEN								
Mean	0.3085	0.1837	0.2809	0.2269	0.9399	0.0599	0.2790	0.6602
Standard Deviation	0.4619	0.3872	0.4494	0.4188	0.2377	0.2373	0.4485	0.4736
SINGF								
Mean	0.4195	0.2296	0.2264	0.1246	0.9376	0.0622	0.2226	0.6815
Standard Deviation	0.4935	0.4206	0.4185	0.3302	0.2418	0.2415	0.4160	0.4659
SINGFCH								
Mean	0.1525	0.2837	0.3923	0.1715	0.9197	0.0799	0.1422	0.7885
Standard Deviation	0.3595	0.4508	0.4883	0.3760	0.2717	0.2712	0.3492	0.4083
MARF								
Mean	0.2858	0.1327	0.2361	0.3454	0.9565	0.0435	0.3193	0.6243
Standard Deviation	0.4518	0.3392	0.4247	0.4755	0.2040	0.2041	0.4662	0.4843
MARFCH								
Mean	0.3401	0.1734	0.3177	0.1688	0.9335	0.0662	0.3393	0.6209
Standard Deviation	0.6209	0.3786	0.4656	0.3746	0.2491	0.2486	0.4735	0.4852
SDWF								
Mean	0.2700	0.1411	0.2385	0.3504	0.9510	0.0485	0.2965	0.6473
Standard Deviation	0.4440	0.3481	0.4262	0.4771	0.2158	0.2149	0.4567	0.4778
SDWFCH								
Mean	0.2634	0.1685	0.3327	0.2353	0.9270	0.0730	0.2640	0.6860
Standard Deviation	0.4405	0.3743	0.4712	0.4242	0.2602	0.2602	0.4408	0.4641

Appendix 6.10: Conditional Logit Results including Demographic Interaction Variables (only interaction variable coefficients reported)

EDUCATION

	Men	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No. of Obs.	*30426*	*6982*	*2719*	*8348*	*9386*	*2220*	*640*
Log Likelihood	*-88163.948*	*-20509.998*	*-7540.993*	*-23804.021*	*-26187.361*	*-6398.491*	*-1811.740*
Pseudo R^2	*0.010*	*0.087*	*0.149*	*0.114*	*0.133*	*0.105*	*0.121*
Fatal*Degree							
Coefficient	-525.004***	-409.110***	-421.756***	-558.318***	-585.948***	-459.419***	-479.569***
Standard error	(9.155)	(18.115)	(36.998)	(18.270)	(16.971)	(32.283)	(59.835)
Fatal*A level							
Coefficient	-182.811***	-110.132***	-270.012***	-167.225***	-194.666***	-173.292***	-271.441***
Standard error	(6.147)	(13.316)	(27.122)	(11.380)	(11.187)	(22.971)	(46.559)
Fatal*GCSE							
Coefficient	-178.273***	-71.014***	-233.425***	-223.041***	-185.688***	-187.186***	-244.315***
Standard error	(6.605)	(12.902)	(25.880)	(15.204)	(12.035)	(26.492)	(48.098)
Fatal*No qualification							
Coefficient	-98.105***	-16.338	-114.108***	-93.128***	-124.049***	-83.476***	-167.778***
Standard error	(5.585)	(12.153)	(23.838)	(10.450)	(10.451)	(20.528)	(40.986)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

	Women	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No. of Obs.	*27541*	*5268*	*3161*	*7406*	*7449*	*2428*	*1720*
Log Likelihood	*-74884.062*	*-14739.282*	*-7619.429*	*-19975.898*	*-19970.917*	*-6610.405*	*-4580.244*
Pseudo R^2	*0.155*	*0.131*	*0.251*	*0.162*	*0.167*	*0.154*	*0.173*
Fatal*Degree							
Coefficient	-630.069***	-462.506***	-629.755***	-657.343***	-753.313***	-841.370***	-694.660***
Standard error	(22.018)	(40.578)	(92.301)	(45.927)	(30.936)	(107.771)	(98.537)
Fatal*A level							
Coefficient	-349.067***	-314.671***	-354.834***	-265.894***	-426.095***	-503.113***	-354.116***
Standard error	(16.847)	(38.409)	(59.343)	(29.441)	(38.227)	(92.532)	(69.472)
Fatal*GCSE							
Coefficient	-318.647***	-270.897***	-288.609***	-291.775***	-336.427***	-498.126***	-349.951***
Standard error	(14.876)	(36.476)	(54.191)	(26.520)	(30.936)	(87.298)	(61.017)
Fatal*No qualification							
Coefficient	-146.711***	-135.662***	-132.004***	-109.246***	-152.839***	-264.534***	-163.576***
Standard error	(11.090)	(30.181)	(47.289)	(16.128)	(24.162)	(78.013)	(46.967)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

RACE

	Men	Single men no children	Single men with children	Married men no children	Married men with children	SDW men no children	SDW men with children
No. of Obs.	*42317*	*9714*	*3799*	*11475*	*13220*	*3064*	*883*
Log Likelihood	*-125522.64*	*-29190.532*	*-10511.06*	*-33683.965*	*-37916.365*	*-9011.060*	*-2539.711*
Pseudo R^2	*0.079*	*0.066*	*0.140*	*0.088*	*0.109*	*0.086*	*0.106*
Fatal*White							
Coefficient	-162.029***	-84.323***	-197.324***	-149.354***	-182.648***	-162.079***	-197.331***
Standard error	(4.568)	(9.869)	(20.062)	(8.623)	(8.382)	(17.204)	(33.692)
Fatal*Non white							
Coefficient	-260.579***	-207.585***	-350.965***	-260.313***	-249.886***	-220.049***	-351.279***
Standard error	(8.992)	(19.685)	(34.431)	(21.061)	(13.889)	(33.752)	(80.281)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

	Women	Single women no children	Single women with children	Married women no children	Married women with children	SDW women no children	SDW women with children
No. of Obs.	38449	7342	4384	10270	10535	85100	2374
Log Likelihood	-105290.35	-20639.706	-10528.395	-27948.798	-28496.244	-9353.209	-6390.798
Pseudo R^2	0.149	0.127	0.254	0.155	0.160	0.146	0.164
Fatal*White							
Coefficient	-218.456***	-240.107***	-233.038***	-169.205***	-219.277***	-247.437***	-281.421***
Standard error	(9.014)	(26.209)	(43.243)	(13.921)	(17.102)	(41.661)	(46.042)
Fatal*Non white							
Coefficient	-187.290***	-334.835***	-278.810***	-101.432***	-136.519***	-239.373***	-261.667***
Standard error	(14.773)	(50.847)	(62.865)	(23.658)	(22.418)	(65.042)	(67.567)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

UNION STATUS

	Men	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No. of Obs. *Log Likelihood* *Pseudo R^2*	*40037* *-118985.16* *0.077*	*9009* *-27098.577* *0.066*	*3544* *-9849.749* *0.137*	*10935* *-32164.962* *0.086*	*12687* *-36451.517* *0.107*	*2888* *-8521.798* *0.083*	*829* *-2390.337* *0.104*
Fatal*Union							
Coefficient Standard error	-134.985*** (4.766)	-83.126*** (10.902)	-123.858*** (19.242)	-124.167*** (8.854)	-157.728*** (8.578)	-117.295*** (17.155)	-155.674*** (34.231)
Fatal*Non union							
Coefficient Standard error	-114.834*** (3.927)	-51.605*** (8.488)	-135.859*** (14.921)	-111.169*** (7.675)	-132.428*** (7.207)	-105.449*** (14.726)	-134.967*** (28.780)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

	Women	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No. of Obs. *Log Likelihood* *Pseudo R^2*	*36695* *-100369.05* *0.150*	*6840* *-19246.902* *0.126*	*4150* *-9945.356* *0.256*	*9815* *-26673.211* *0.156*	*10201* *-27549.798* *0.161*	*3262* *-8939.867* *0.149*	*2290* *-6161.643* *0.164*
Fatal*Union							
Coefficient Standard error	-312.743*** (12.586)	-229.134*** (26.221)	-296.874*** (52.493)	-270.879*** (21.215)	-392.657*** (27.821)	-341.121*** (42.892)	-309.903*** (48.960)
Fatal*Non union							
Coefficient Standard error	-163.767*** (7.430)	-161.296*** (17.376)	-156.659*** (27.537)	-136.352*** (13.091)	-157.348*** (14.124)	-199.566*** (31.164)	-187.558*** (31.202)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 6.11: Conditional Logit Results Excluding Occupations 53 and 82

	MEN	**Single men no children**	**Single men with children**	**Married men no children**	**Married men with children**	**SDW men no children**	**SDW men with children**
No. of Obs.	36281	8640	3296	9635	11356	2502	701
Log Likelihood	103538.54	-25087.319	-8702.004	-27114.272	-30988.663	-7130.163	-1936.389
Pseudo R^2	0.090	0.074	0.158	0.103	0.130	0.091	0.119
Fatal							
Coefficient	-205.843***	-100.746***	-217.313***	-228.027***	-268.102***	-226.968***	-334.795***
Standard error	(4.717)	(9.952)	(19.876)	(9.538)	(9.019)	(18.750)	(38.135)
Major Injury							
Coefficient	0.391*	1.121**	2.712***	2.422***	-0.931*	3.033***	9.836***
Standard error	(0.226)	(0.446)	(0.979)	(0.441)	(0.509)	(0.860)	(2.845)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

	WOMEN	**Single women no children**	**Single women with children**	**Married women no children**	**Married women with children**	**SDW women no children**	**SDW women with children**
No. of Obs.	38295	7312	4373	10225	10504	3388	2357
Log Likelihood	-103849.53	-20370.72	-10399.954	-27517.978	-28199.738	-9193.349	-6264.5098
Pseudo R^2	0.135	0.112	0.242	0.142	0.144	0.135	0.152
Fatal							
Coefficient	-275.272***	-188.094***	-265.148***	-237.848***	-296.192***	-179.909***	-217.897***
Standard error	(7.778)	(21.555)	(32.075)	(12.750)	(14.979)	(28.451)	(35.451)
Major Injury							
Coefficient	2.328***	3.772***	4.198***	1.596***	1.570***	3.285***	2.816***
Standard error	(0.209)	(0.496)	(0.882)	(0.407)	(0.397)	(0.749)	(0.939)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

CHAPTER 7 APPENDICES

Appendix 7.1: Derived Variables

VARIABLE	DEFINITION
SMOKER	Equals 1 if respondent smokes.
NOCIGS	Usual number of cigarettes smoked per day.
LIGHTSMOKE	Dummy equals 1 if respondent smokes 1-15 cigarettes per day.
MODSMOKE	Dummy equals 1 if respondent smokes more than 16 cigarettes per day.
EVSMOKE	Dummy equals 1 if respondent has ever reported being a smoker in any of the waves.
SMOKE16	Dummy equals 1 if the respondent began to smoke at 16 or younger.
SMOKE18	Dummy equals 1 if the respondent began to smoke at 18 or younger.
FATAL	Average fatality rate of respondent's occupation (over 3 year period) matched according to 3 digit SOC 2000 (LFS 2002-2004 per 1000 full time and part time workers).
MAJOR	As above, major injury rate.
OVER 3-DAY INJURY	As above, over 3-day injury rate.
ACCIDENT	Dummy variable equals1 if respondent had any kind of accident as a result of which had to see a doctor or go to hospital in last 12 months.
NOACCIDENTS	Number of above accidents in last 12 months.
AGE	Age at interview.
RACEW	Dummy variable, white.
RACEB	Dummy variable, black.
RACEO	Dummy variable, other.
EDUC0	Dummy variable, respondent has no academic qualifications.
EDUC1	Dummy variable, respondent has a degree.
EDUC2	Dummy variable, respondent's highest qualification A level.
EDUC3	Dummy variable, respondent's highest qualification GCSE/O LEVEL.
MARRIED	Dummy variable, respondent married.
COHABMARR	Dummy variable, respondent married or cohabiting.
SDW	Respondent separated, divorced or widowed.
NEVERMARR	Respondent never married.
DISABLED	Dummy variable, respondent considers themselves to be disabled.
NOCHILD	Number of children respondent parent to.
HEALTH	Health status over 12 months values 0-4, 4= excellent 0= very poor.
WORKHEALTH	Dummy equals 1 if difficulty performing work or other activities because of health problems.
PERMANENT	Dummy equals 1 if job permanent.
SUPERVISE	Dummy equals 1 if a manager or supervise other workers.
PUBLIC	Dummy equals 1 of work in the public sector.
NOEMPS	Number of employees at current workplace: 1=1-24 workers, 2=25-99 workers, 3=100-199 workers, 4=200-499 workers, 5=500-999 workers, 6=1000+.
NOHRS	Number of hours usually worked per week.
PAIDOVER	Amount of paid overtime hours in usual week.
OVERTIME	Usual overtime hours per week (paid and unpaid).

WKGROSSPAY	Weekly gross pay.
BONUS	Dummy equals 1 of pay includes bonuses or profit share.
PERFPAY	Dummy equals 1 of pay includes performance related pay.
PRESUNION	Dummy equals 1 of union or staff association at workplace.
UNIONMEMB	Equals 1 if respondent a union member.
FLEXITIME	Dummy equals 1 if flexible working hours in main job.
REGIONAL VARIABLES	Dummy variables for region.
OWNHOUSE	Dummy variable equals 1 if respondent owns a house outright of with a mortgage.
NEWEMP	Dummy equals 1 if employed at current workplace for 1 year or less.

Appendix 7.2: Descriptive Statistics (Mean, Standard Deviation and T test)

Male Sample

VARIABLES	WHOLE SAMPLE	SMOKERS	NON-SMOKERS	T TEST
Obs	*2873*	*795*	*2078*	
Age	39.0056 (12.0886)	36.5648 (11.7731)	39.9394 (12.0801)	6.7457***
Racew	0.9008 (0.2990)	0.8805 (0.3246)	0.9086 (0.2883)	2.1393**
Raceb	0.0059 (0.0767)	0.0088 (0.0935)	0.0048 (0.0692)	1.0968
Raceo	0.0191 (0.1371)	0.0164 (0.1269)	0.0202 (0.1408)	0.6961
Educ0	0.1389 (0.3459)	0.2013 (0.4012)	0.1150 (0.3191)	5.4421***
Educ1	0.1898 (0.3922)	0.0860 (0.2806)	0.2293 (0.4205)	10.5605***
Educ2	0.3393 (0.4736)	0.3107 (0.4631)	0.3502 (0.4772)	2.0011**
Educ3	0.3298 (0.4702)	0.3979 (0.4898)	0.3039 (0.4601)	4.6788***
Married	0.5468 (0.4979)	0.4075 (0.4917)	0.6001 (0.4900)	9.4163***
Cohabmarr	0.7264 (0.4459)	0.6704 (0.4703)	0.7478 (0.4344)	4.0291***
SDW	0.0581 (0.2340)	0.0742 (0.2623)	0.0520 (0.2220)	2.1142**
Nevermarr	0.2155 (0.4112)	0.2553 (0.4363)	0.2002 (0.4002)	3.0971***
Disabled	0.0237 (0.1520)	0.0277 (0.1641)	0.0221 (0.1472)	0.8414
Fatal	0.0261 (0.0411)	0.0342 (0.0017)	0.0231 (0.0008)	6.4830***
Major Injury	3.2033	3.9046	2.9352	6.7635***

	(3.4470)	(0.1295)	(0.0735)	
Over3-Day Injury	12.9764 (17.6021)	15.5135 (0.6461)	12.0067 (0.3814)	4.7720***
Childlive	0.6227 (0.9506)	0.5912 (0.9707)	0.6347 (0.9427)	1.0974
Health	3.0247 (0.7985)	2.8742 (0.8288)	3.0823 (0.7792)	6.1200***
Workhealth	0.0655 (0.2474)	0.0792 (0.2703)	0.0602 (0.2379)	1.7407*
Accident	0.1218 (0.3271)	0.1484 (0.3557)	0.1116 (0.3150)	2.5584**
Noaccident	0.1351 (0.3859)	0.1673 (0.4357)	0.1227 (0.3643)	2.5637***
Permanent	0.9718 (0.1656)	0.9635 (0.1876)	0.9750 (0.1562)	1.5366
Supervise	0.4186 (0.4934)	0.3389 (0.4736)	0.4491 (0.4975)	5.5015***
Public	0.1861 (0.3893)	0.1298 (0.3363)	0.2077 (0.4057)	5.2346***
Noemps	2.7283 (1.6822)	2.5344 (1.6180)	2.8016 (1.7004)	3.9040***
Nohrs	39.9567 (6.4302)	40.7608 (7.3959)	39.6493 (5.9938)	3.7881***
Paidover	2.6523 (5.4752)	3.8101 (6.8738)	2.2093 (4.7624)	6.0355***
Overtime	4.7584 (6.6974)	5.1585 (7.2841)	4.6054 (6.4542)	1.8775*
Wkgrosspay	481.8103 (419.2101)	405.8805 (236.8930)	510.3918 (466.7226)	7.8909***
Bonus	0.3621 (0.4807)	0.3274 (0.4696)	0.3754 (0.4844)	2.3962***
Perfpay	0.1708 (0.3764)	0.1465 (0.3538)	0.1801 (0.3844)	2.2225**
Presunion	0.4839 (0.4998)	0.4172 (0.4934)	0.5093 (0.5000)	4.4331***
Unionmemb	0.6067 (0.4887)	0.5524 (0.4980)	0.6236 (0.4847)	3.4957***
Flexitime	0.1344 (0.1344)	0.0868 (0.2817)	0.1526 (0.3596)	5.1690***
Scotland	0.2050 (0.4038)	0.2277 (0.4196)	0.1963 (0.3973)	1.8207*
Wales	0.1772 (0.3819)	0.1811 (0.3854)	0.1756 (0.3806)	0.3543
Northeast	0.0442 (0.2056)	0.0365 (0.1876)	0.0472 (0.2120)	1.3181
Northwest	0.0769 (0.2665)	0.0755 (0.2643)	0.0775 (0.2674)	0.1799
Yorkshire	0.0661 (0.2486)	0.0730 (0.2602)	0.0635 (0.2440)	0.8905

Eastmids	0.0623 (0.2417)	0.0579 (0.2336)	0.0640 (0.2448)	0.6051
Westmids	0.0560 (0.2300)	0.0491 (0.2161)	0.0587 (0.2351)	1.0392
Easteng	0.0271 (0.1625)	0.0352 (0.1845)	0.0241 (0.1533)	1.5087
Southwest	0.0658 (0.2479)	0.0528 (0.2238)	0.0707 (0.2565)	1.8398*
London	0.0533 (0.2246)	0.0541 (0.2263)	0.0529 (0.2240)	0.1281
Southeast	0.1298 (0.3362)	0.1321 (0.3388)	0.1290 (0.3352)	0.2211
Ownhouse	0.8131 (0.3899)	0.6843 (0.4651)	0.8624 (0.3446)	9.8153
Newemp	0.2826 (0.4504)	0.3421 (0.4747)	0.2599 (0.4387)	4.2388***

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
T tests adjust for unequal variance where appropriate.

<u>Female Sample</u>

VARIABLES	**WHOLE SAMPLE**	**SMOKERS**	**NON-SMOKERS**	**T TEST**
Obs	*1971*	*475*	*1496*	
Age	38.0380 (12.0691)	36.4968 (12.6049)	38.3924 (11.8592)	2.8958***
Racew	0.8850 (0.3191)	0.8632 (0.3440)	0.8957 (0.3057)	1.8411*
Raceb	0.0086 (0.0921)	0.0084 (0.0915)	0.0080 (0.0892)	0.0846
Raceo	0.0147 (0.1205)	0.0021 (0.0459)	0.0194 (0.1379)	4.1779***
Educ0	0.1778 (0.3824)	0.1937 (0.3956)	0.0996 (0.2996)	4.7682***
Educ1	0.2205 (0.4147)	0.1368 (0.3440)	0.2667 (0.4424)	6.6641***
Educ2	0.2785 (0.4484)	0.2674 (0.4431)	0.3068 (0.4613)	1.6371
Educ3	0.3232 (0.4678)	0.2674 (0.4908)	0.3269 (0.4692)	2.3810**
Married	0.4369 (0.4988)	0.3389 (0.4739)	0.4947 (0.5001)	5.9894***
Cohabmarr	0.6711 (0.4699)	0.6021 (0.4900)	0.6872 (0.4638)	3.4362***
SDW	0.1136 (0.3174)	0.1389 (0.3463)	0.1090 (0.3117)	1.6783*
Nevermarr	0.2153 (0.4111)	0.2589 (0.4385)	0.2039 (0.4030)	2.4274**
Disabled	0.0181	0.0147	0.0194	0.7140

	(0.1332)	(0.1206)	(0.1379)	
Fatal	0.0042 (0.0139)	0.0055 (0.0006)	0.0038 (0.0004)	2.2856**
Major Injury	1.3837 (1.8299)	1.8708 (0.1104)	1.2076 (0.0379)	7.2420***
Over3-Day Injury	5.9992 (10.3303)	8.9954 (0.6432)	4.8798 (0.2052)	8.0117***
Childlive	0.4007 (0.7476)	0.3895 (0.7334)	0.4111 (0.7612)	0.5435
Health	2.9948 (0.8230)	2.8587 (0.8193)	3.0261 (0.8303)	3.8403***
Workhealth	0.1055 (0.3073)	0.1074 (0.3099)	0.1049 (0.3066)	0.1544
Accident	0.0868 (0.2816)	0.1011 (0.3017)	0.0822 (0.2748)	1.2147
Noaccident	0.0903 (0.3211)	0.1179 (0.3771)	0.0896 (0.3146)	1.4802
Permanent	0.9640 (0.1864)	0.9558 (0.2058)	0.9666 (0.1798)	1.0261
Supervise	0.4018 (0.4904)	0.4136 (0.4930)	0.4036 (0.4908)	0.3865
Public	0.4061 (0.4912)	0.3059 (0.4613)	0.4346 (0.4959)	5.2008***
Noemps	2.7298 (1.7258)	2.6825 (1.7071)	2.7398 (1.7392)	0.6283
Nohrs	36.460 (5.6003)	36.4852 (6.2706)	36.3099 (5.3616)	0.5489
Paidover	1.3042 (3.6073)	1.9368 (4.3613)	1.2193 (3.4624)	3.2730***
Overtime	3.4259 (5.4046)	3.6442 (5.6421)	3.6611 (5.4664)	0.0582
Wkgrosspay	375.1874 (442.4847)	320.6982 (180.7469)	392.6288 (496.8047)	4.7047***
Bonus	0.2446 (0.4300)	0.2426 (0.4291)	0.2453 (0.4304)	0.1192
Perfpay	0.1399 (0.3470)	0.0930 (0.2908)	0.1549 (0.3619)	3.7983***
Presunion	0.5924 (0.4915)	0.5408 (0.4989)	0.6086 (0.4882)	2.6230***
Unionmemb	0.6551 (0.4755)	0.6245 (0.4852)	0.6636 (0.4727)	1.5605
Flexitime	0.1697 (0.3754)	0.1600 (0.3670)	0.1878 (0.3907)	1.4157
Scotland	0.2205 (0.4147)	0.2482 (0.4326)	0.2112 (0.4083)	1.6458*
Wales	0.1782 (0.3828)	0.1684 (0.3746)	0.1745 (0.3796)	0.3061
Northeast	0.0428 (0.2024)	0.0358 (0.1860)	0.0455 (0.2084)	0.9611

Northwest	0.0789 (0.2696)	0.0842 (0.2780)	0.0762 (0.2654)	0.5523
Yorkshire	0.0613 (0.2400)	0.0568 (0.2318)	0.0655 (0.2475)	0.7009
Eastmids	0.0547 (0.2274)	0.0589 (0.2358)	0.0575 (0.2328)	0.1138
Westmids	0.0532 (0.2245)	0.0442 (0.2058)	0.0528 (0.2237)	0.7766
Easteng	0.0285 (0.1665)	0.0316 (0.1751)	0.0274 (0.1633)	0.4628
Southwest	0.0499 (0.2178)	0.0568 (0.2318)	0.0508 (0.2197)	0.4976
London	0.0680 (0.2517)	0.0632 (0.2435)	0.0668 (0.2498)	0.2790
Southeast	0.1326 (0.3392)	0.1326 (0.3395)	0.1344 (0.3412)	0.1003
Ownhouse	0.7719 (0.4197)	0.7263 (0.4463)	0.8443 (0.3627)	3.6408***
Newemp	0.2267 (0.4188)	0.2800 (0.4495)	0.2299 (0.4209)	2.1484**

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
T tests adjust for unequal variance where appropriate.

Appendix 7.3: Industry Dummy Variables Descriptive Statistics (Mean and Standard Deviation)

		Whole sample	**Manual sample**
Obs		*4977*	*1876*
IND1	Agriculture hunting forestry mining	0.0113 (0.1055)	0.0203 (0.0203)
IND2	Manufacturing	0.1609 (0.3675)	0.2452 (0.4303)
IND3	Electricity	0.0086 (0.0926)	0.0091 (0.0948)
IND4	Construction	0.0619 (0.2410)	0.1178 (0.3225)
IND5	Wholesale (excluded in estimation)	0.1073 (0.3095)	0.0938 (0.2917)
IND6	Hotels	0.0325 (0.1775)	0.0560 (0.2299)
IND7	Transport	0.0619 (0.2410)	0.1066 (0.3087)
IND8	Financial	0.0366 (0.1877)	0.0027 (0.0516)
IND9	Real estate	0.1019 (0.3025)	0.0485 (0.2149)
IND10	Public admin and defence	0.0908 (0.2874)	0.0155 (0.1234)
IND11	Education	0.0743 (0.2624)	0.0336 (0.1802)

IND12	Health	0.1089 (0.3115)	0.1023 (0.3032)
IND13	Other com social and personal	0.0235 (0.1515)	0.0293 (0.1687)

Appendix 7.4: Risk Regression Estimates

	FATAL	**MAJOR INJURY**	**OVER 3-DAY INJURY**
No. of Obs	*4478*	*4478*	*4478*
R^2	*0.2668*	*0.2543*	*0.2191*
Adj R^2	*0.2617*	*0.2491*	*0.2066*
Constant	-0.0061 (0.0064)	1.2431** (0.5677)	4.8393 (2.9958)
Married	-2.39e-05 (0.0010)	0.0646 (0.0931)	0.0240 (0.4915)
Child	0.0011 (0.0206)	0.1035 (0.0701)	0.4023 (0.2646)
Disabled	-0.0012 (0.0029)	0.2129 (0.2615)	1.1546 (1.3799)
Ind1	0.0683*** (0.0042)	1.6233*** (0.3723)	0.2699 (1.9645)
Ind2	0.0064*** (0.0015)	1.1725*** (0.1295)	5.8756*** (0.6835)
Ind3	0.0083* (0.0048)	0.6356 (0.4255)	0.2467 (2.2455)
Ind4	0.0431*** (0.0020)	2.2037*** (0.1801)	2.3982** (0.9505)
Ind6	-0.0087*** (0.0027)	-0.3855 (0.2388)	-1.5259 (1.2604)
Ind7	0.0042** (0.0020)	0.9916*** (0.1775)	8.7313*** (0.9369)
Ind8	-0.0102*** (0.0025)	-1.5747*** (0.2239)	-7.0546*** (1.1812)
Ind9	-00033** (0.0017)	-0.5530*** (0.1473)	-2.8217*** (0.7773)
Ind10	-0.0060*** (0.0022)	0.0962 (0.1959)	0.8414 (1.0340)
Ind11	-0.0127*** (0.0022)	-0.9360*** (0.1973)	-6.1603*** (1.0411)
Ind12	-0.0124*** (0.0018)	-0.7853*** (0.1635)	-1.7845** (0.8626)
Ind13	-0.0024 (0.0030)	-0.5833** (0.2638)	-3.5084** (1.3919)
Educ1	-0.0135*** (0.0017)	-1.7389*** (0.1548)	-8.1666*** (0.8170)
Educ2	-0.0100*** (0.0015)	-1.2107*** (0.1360)	-5.4985*** (0.7175)

Educ3	-0.0075*** (0.0015)	-0.6204*** (0.1327)	-2.0973*** (0.7001)
Newemp	0.0001 (0.0010)	-0.0136 (0.0931)	-0.5709 (0.4911)
Overtime	0.0002*** (0.0001)	0.0336*** (0.0063)	0.1566*** (0.0334)
Permanent	0.0005 (0.0027)	-0.0139 (0.2426)	-0.3910 (1.2801)
Age	4.39e-05 (0.0003)	-0.0340 (0.0235)	-0.1557 (0.1240)
Age^2	9.82e-07 (3.25e-06)	0.0005 (0.0003)	0.0019 (0.0015)
Noemps	-7.4e-05 (0.0012)	0.3748*** (0.1111)	2.7642*** (0.5862)
$Noemps^2$	-7.83e-05 (0.0002)	-0.0608*** (0.0162)	-0.4124*** (0.0856)
Supervise	-0.0052*** (0.0009)	-0.8077*** (0.0832)	-4.1789*** (0.4390)
Public	0.0031* (0.0016)	-0.1320 (0.1467)	-0.1473 (0.7739)
Presunion	0.0023** (0.0011)	0.6313*** (0.0999)	3.6849*** (0.5272)
Flexitime	-0.0043*** (0.0013)	-0.7989*** (0.1157)	-4.1684*** (0.6106)
Nohrs	0.0007*** (7.27e-05)	0.0521*** (0.0065)	0.2122*** (0.0342)
Smoker	0.0040*** (0.0010)	0.4010*** (0.0918)	1.5379*** (0.4844)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

Appendix 7.5: Risk Regression Smoking Estimates

Male Sample

	FATAL	**MAJOR INJURY**	**OVER 3-DAY INJURY**
No. Obs	*2641*	*2641*	*2641*
R^2	*0.2677*	*0.2576*	*0.2217*
Adj R^2	*0.2590*	*0.2488*	*0.2124*
SMOKER	0.0046*** (0.0016)	0.2670** (0.1363)	0.3324 (0.7179)
R^2	*0.2678*	*0.2576*	*0.2218*
Adj R^2	*0.2589*	*0.2485*	*0.2123*
LIGHTSMOKE	0.0048** (0.0020)	0.3053* (0.1673)	0.7001 (0.8814)
MODSMOKE	0.0048**	0.2159	-0.1868

	(0.0023)	(0.1976)	(1.0408)
R^2	*0.2663*	*0.2576*	*0.2218*
Adj R^2	*0.2576*	*0.2488*	*0.2126*
EVSMOKE	0.0027* (0.0014)	0.2431** (0.1231)	0.5781 (0.6486)
R^2	*0.2662*	*0.2579*	*0.2224*
AdjR^2	*0.2574*	*0.2491*	*0.2132*
SMOKE16	0.0031* (0.0019)	0.3510** (0.1550)	1.3457* (0.8162)
R^2	*0.2661*	*0.2573*	*0.2219*
Adj R^2	*0.2573*	*0.2485*	*0.2126*
SMOKE18	0.0026 (0.0016)	0.2361* (0.1405)	0.6688 (0.7399)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

Female Sample

	FATAL	**MAJOR INJURY**	**OVER 3-DAY INJURY**
No. Obs	*1837*	*1837*	*1837*
R^2	*0.1125*	*0.1761*	*0.1635*
Adj R^2	*0.0972*	*0.1620*	*0.1492*
SMOKER	0.0011 (0.0007)	0.4743*** (0.0897)	2.7754*** (0.5144)
R^2	*0.1130*	*0.1775*	*0.1646*
Adj R^2	*0.0972*	*0.1629*	*0.1498*
LIGHTSMOKE	0.0015* (0.0008)	0.5582*** (0.1041)	3.1157*** (0.5972)
MODSMOKE	0.0006 (0.0013)	0.3485** (0.1566)	2.4389*** (0.8980)
R^2	*0.1128*	*0.1745*	*0.1613*
Adj R^2	*0.0975*	*0.1603*	*0.1469*
EVSMOKE	0.0011* (0.0006)	0.3940*** (0.0798)	2.2544*** (0.4579)
R^2	*0.1148*	*0.1734*	*0.1602*
AdjR^2	*0.0996*	*0.1592*	*0.1458*
SMOKE16	0.0019*** (0.0007)	0.4175*** (0.0893)	2.3949*** (0.5121)
R^2	*0.1135*	*0.1668*	*0.1537*

Adj R^2	*0.0983*	*0.1525*	*0.1392*
SMOKE18	0.0018** (0.0008)	0.2862*** (0.1043)	1.6696*** (0.5983)

***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis

Appendix 7.6: Fatal Variable Frequencies

	ALL MANUAL	MALE MANUAL
Sample Size	*1818*	*1332*
FATAL VALUE	Frequency	Frequency
0	144 (8%)	33 (2.5%)
0.001691	152	30
0.002578	89	36
0.002858	41	32
0.004191	32	48
0.005722	24	58
0.006773	73	21
0.007859	101	45
0.010162	66	33
0.014723	38	19
0.017299	18	98
0.024238	99	25
0.027238	42	97
0.030904	98	60
0.035839	60	80
0.036868	91	2
0.040018	2	3
0.042554	9	33
0.053087	19	18
0.053206	142	137
0.057875	78	70
0.062412	32	32
0.063739	112	112
0.071012	75	63
0.135691	43	42
0.181659	27	26
0.194836	50	49
0.252348	17 (1%)	15 (1%)

Appendix 7.7: Wage Estimation Results

	ALL MANUAL	MALE MANUAL
Obs	*1432*	*1067*
R^2	*0.4495*	*0.3944*
Adj R^2	*0.4404*	*0.3822*
SMOKER	-0.0315 (0.0215)	-0.0805** (0.0405)
MAJOR INJURY	0.0061** (0.0028)	0.0011 (0.0037)
MAJOR*SMOKER	-0.0141 (0.0087)	0.0064 (0.0062)
R^2	*0.4609*	*0.3923*
Adj R^2	*0.4524*	*0.3800*
MODSMOKE	-0.0004 (0.0449)	-0.0404 (0.0535)
MAJOR INJURY	0.0067** (0.0029)	0.0021 (0.0032)
MAJOR*MODSMOKE	0.0036 (0.0076)	-0.0404 (0.0535)
R^2	*0.4608*	*0.3939*
Adj R^2	*0.4523*	*0.3817*
EVSMOKE	-0.0113 (0.0312)	-0.0555 (0.0389)
MAJOR INJURY	0.0073** (0.0037)	0.0025 (0.0040)
MAJOR*EVSMOKE	-0.0004 (0.0052)	0.0020 (0.0059)
R^2	*0.4613*	*0.3923*
Adj R^2	*0.4528*	*0.3801*
SMOKE16	-0.0321 (0.0340)	-0.0591 (0.0452)
MAJOR INJURY	0.0049 (0.0032)	0.0019 (0.0034)
MAJOR*SMOKE16	0.0075 (0.0056)	0.0064 (0.0068)
R^2	*0.4610*	*0.3914*
Adj R^2	*0.4526*	*0.3791*
SMOKE18	-0.0087 (0.0330)	-0.0166 (0.0428)
MAJOR INJURY	0.0056* (0.0033)	0.0029 (0.0035)
MAJOR*SMOKE18	0.0046 (0.0055)	0.0019 (0.0066)

Other variables included in estimation: educ1 educ2 educ3 racew disabled presunion age age2 permanent supervise public newemp noemps noemps2 perfpay flexitime nohrs overtime female
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level

Appendix 7.8: Wage Estimation Risk Coefficients

Dependent variable: Lnwage

	ALL MANUAL		MALE MANUAL	
	SMOKED	**NEVER SMOKED**	**SMOKED**	**NEVER SMOKED**
Obs	*673*	*754*	*510*	*554*
R^2	*0.4456*	*0.4929*	*0.4068*	*0.4014*
Adj R^2	*0.4286*	*0.4790*	*0.3838*	*0.3801*
MAJOR INJURY	0.0089** (0.0039)	0.0059 (0.0039)	0.0036 (0.0044)	0.0048 (0.0041)
R^2	*0.4511*	*0.4931*	*0.4144*	*0.4020*
Adj R^2	*0.4334*	*0.4785*	*0.3904*	*0.3796*
MAJOR INJURY	0.0084** (0.0039)	0.0060 (0.0039)	0.0033 (0.0412)	0.0049 (0.0041)
ACCIDENT	0.0930** (0.0365)	-0.0213 (0.0412)	0.1039** (0.0412)	-0.0331 (0.0461)

Other variables included in estimation: educ1 educ2 educ3 racew disabled presunion age age2 permanent supervise public newemp noemps noemps2 perfpay flexitime nohrs overtime female
***=significant at the 1% level; **=significant at the 5% level; *=significant at the 10% level
Standard errors in parenthesis