An Analysis of Temporal and National Variations in Reported Workplace Injury Rates

A Report prepared on behalf of the Health and Safety Executive

Rhys Davies and Peter Elias

April 2000

INSTITUTE FOR EMPLOYMENT RESEARCH

CONTENTS

ACKNOWLEDGEMENTS

We wish to acknowledge the many thoughtful comments made by Abigail McKnight during the course of this research. We are also grateful to John Walls, Jacqui Bailey and their colleagues within the Strategy and Analytical Support Division of HSE for their comments and suggestions on an earlier draft of this document. All remaining errors are the responsibility of the authors. Finally, we are also grateful to Lynne Conaghan and Matthew Roberts for their assistance in the preparation of this document.

PREFACE

The two main sources of workplace injury information in Great Britain are the flow of injury reports made under the Reporting of Injury, Diseases and Dangerous Occurrences Regulations (RIDDOR) and the results of questions included in the Labour Force Survey. The Health and Safety Executive regards data from both sources as having complementary roles to play in the direction of resources, guidance of operations and the monitoring of safety performance in Great Britain, and in making comparisons with other countries.

The availability of data at the individual level within the Labour Force Survey has enabled researchers to analyse correlations that exist between the occurrence of a work related accident, the characteristics associated with an individuals job and their personal characteristics. However, there is a lack of empirical evidence in Britain considering the determinants of industrial injuries at an aggregate level compared to other countries. The reports made under RIDDOR provide a unique opportunity to construct an aggregate time series of industrial injury data and to undertake an analysis of any temporal and national variations in industrial injuries witnessed therein.

This document provides a final report as to the analysis of temporal and national variations in the incidence of workplace injuries reported under RIDDOR. The plan of the report is as follows. Chapter 1 provides a review of the theoretical literature regarding the cyclical and structural determinants of industrial injuries. Chapter 2 provides an outline of empirical studies that have attempted to estimate the determinants of industrial injuries. Chapter 3 discusses the construction of an aggregate time series database of industrial injuries from reports made under RIDDOR. Simple graphical and statistical analysis of the aggregate injury data is undertaken. Chapter 4 describes a modelling strategy for the further analysis of this aggregate injury data that can explain the nature of observed temporal and geographical variations in workplace injuries. Chapter 5 outlines the construction of injury rate time series that are amenable to further statistical analysis. Chapter 6 outlines the results of statistical analyses undertaken on the injury rate data.

SUMMARY OF KEY FINDINGS

Previous research utilising individual level data has analysed the effects of specific personal and job related characteristics upon the risk of workplace injury. The aim of the present analysis is to explain variations in injury rates reported under RIDDOR at an aggregate level. Multivariate analysis of temporal and geographical variations in employee injury rates resulted in the following key findings:

Time Series Variations in Injury Rates

- injury rates for both males and females move pro-cyclically over the economic cycle. The response of male injury rates to the effects of the economic cycle are larger than those of female injury rates;
- employee injury rates for males and females are following divergent trends. In contrast to a downward trend for males, an upward trend in employee injury rates was estimated for females;
- strong seasonal variations are observed in workplace injury rates. Injury rates are highest during October. Workplace injury rates are generally higher during the Autumn and Winter months.

In contrast to previous empirical studies of workplace injuries, the present analysis attempted to fully identify the causal mechanism behind these movements in injury rates.

- lower levels of opportunity in the labour market are associated with a decline in the rate of workplace injuries;
- variations in the average work experience of those in employment are not found to influence aggregate employee injury rates;
- employee injury rates increase with the number of hours worked. Variations in hours worked were found to explain seasonal movements in workplace injury rates.

Geographical Variations in Injury Rates

Geographical variations in employee injury rates reflect the distribution of workplace hazards that emerge from structural differences between the regions. These structural differences reflect differences in industry structure, occupational structure, personal characteristics, workplace characteristics and the nature of employment. Analysis of structural influences upon the risk of a workplace injury revealed the following relationships:

- employment within manufacturing, construction, and the distribution and transport sector is associated with a higher employee injury rates;
- employment within certain occupations is associated with higher rates of workplace injuries. Employment within Personal and Protective Service

Occupations was estimated to exert the largest influence upon the employee injury rate;

- both high and low levels of educational attainment are associated with low workplace injury rates relative to the attainment of intermediate level qualifications;
- employee injury rates are negatively related to the average age of those in employment;
- increases in female participation in employment are related to increases in employee injury rates;
- the level of employment within workplaces with fewer than 25 employees was associated with lower workplace injury rates;
- the incidence of temporary employment was estimated to have a positive influence upon employee injury rates.

The calibration of a model of employee injury rates that controlled for the effects of the economic cycle and structural differences between the regions was able to account for 94% of the temporal and geographical variations observed in employee injury rates. The industrial and occupational composition of employment accounts for a majority of regional variation in the risk of a workplace injury. Variations in employee injury rates are a national or regional issue only in so far as certain occupations and industries are concentrated within certain geographical areas. It would appear more appropriate to target resources aimed at reducing workplace injuries by industry or occupation rather than by geographical location. Continued growth in atypical forms of employment also presents a challenge for the future.

1 THE ECONOMIC CYCLE, STRUCTURAL CHANGE AND INDUSTRIAL INJURIES: A THEORETICAL OVERVIEW

This chapter reviews the range of theories and hypothesis associated with the incidence of industrial injuries. Section A considers how the incidence of workplace injuries may be expected to vary over the course of the economic cycle. Section B considers the influence of structural changes within the economy that may correlate both with trends and geographical variations in injury rates. Section C considers the role of personal and workplace characteristics. Section D offers concluding comments.

A Industrial Injuries and the Economic Cycle

Business cycle approaches to industrial injuries

1.1 The early literature on the relationship between the economic cycle and industrial accidents dates back to the 1930s and 1940s. Kossoris (1938) examined the relationship between employment and workplace injuries for 29 manufacturing sectors in the United States using data spanning the period 1929 to 1935. Utilising two measures for workplace injuries (the rate of disabling injuries and the frequency of one-week injuries), Kossoris (1938) found a pro-cyclical relationship between injuries in manufacturing and the number of people employed in the sector. These observations were confirmed in a later study (Kossoris, 1943) covering the period between 1936 and 1941. Kossoris (1938) provided 3 explanations for the observed pro-cyclical relationship:

Recruitment, redundancy and work experience

1.2 During a period of economic downturn, redundancies tend to be concentrated amongst the most recent hires. Such workers will naturally be less experienced in their current job and may be less familiar with equipment and machinery, with the work system and the signals of system failure, and with the work habits and routines of fellow workers. The average job tenure of those remaining in employment will increase leaving a relatively more experienced workforce who are less prone to accidents. Conversely, periods of economic expansion will lead to an increase in the recruitment and employment of less experienced workers. This will reduce the average tenure of those in employment and increase the risks of workplace accidents.

Working hours and work intensity

1.3 During a period of economic downturn, redundancies tend to lag behind reductions in the level of production. During such periods, the level of hours worked will exceed those required to meet production demand. The level of work intensity will decline until the size of the workforce is reduced in line with demand. The decline in work intensity may reduce the likelihood of workplace accidents due to fatigue and stress. Alternatively, firms may adjust the level of hours downwards in line with demand. Despite the level of work intensity remaining unchanged, the level of industrial injuries associated with the fatigue of working long hours may fall. Conversely, during periods of economic expansion, increases in work intensity or the hours worked to meet increases in demand may increase the risk of workplace accidents.

Vintage capital hypothesis

1.4 During a period of economic downturn, firms operating beneath full capacity are likely to use their most efficient operating machinery first. As a rule, such machinery is likely to be the most modern and embody the latest safety measures. The increased utilisation of modern machinery in periods of economic decline will therefore reduce the likelihood of workplace accidents. During periods of increased economic activity, the utilisation of older, less efficient machinery to meet demand will be expected to increase the level of workplace injuries.

1.5 The above hypotheses point to the existence of a pro-cyclical relationship between industrial injuries and the economic cycle. However, Nichols (1986) considers the possibility of counter-cyclical relationship between the business cycle and industrial injury rate due to changes in the balance of power between employees and employers over the economic cycle. The increased probability of losing employment and the lack of employment opportunities elsewhere in the labour market reduces job security and increases the vulnerability of labour during downturns in economic activity. During such periods, labour may become less resistant to attempts by management to introduce unsafe working practices or to increase the intensification of the production process to maintain competitiveness. A deterioration in the bargaining strength of workers in periods of high or rising unemployment suggests that workers may have little choice but to accept working practices which might increase the likelihood of injury. This suggests that a counter-cyclical relationship may emerge between the business cycle and industrial injury rates.

The economic cycle and the labour market

1.6 The business cycle approach to industrial injuries is based upon certain assumptions as to the relationship between the economic cycle and the labour market which might be expected to have an influence upon workplace injuries. Hillage, Bates and Rick (1998) review two labour market studies that consider the relevance of these assumptions to the British labour market. Millard, Scott and Sensier's (1997) study of the impact of the UK business cycle on the labour market reached the following conclusions:

- hours worked and employment both move pro-cyclically;
- the adjustments to total hours worked are divided equally between changes in average hours worked and changes in employment;
- changes in employment usually lag changes in output whilst changes in average hours worked lead changes in output;
- real wages show little correlation with output;
- unemployment and vacancies show the most variability with output.

1.7 The study by Millard et al (1997) covers a relatively long period of time and it is arguable that labour market responsiveness has been greater since the 1980s than it had been in the previous twenty years. Beatson (1995) considers changes in labour market sensitivity for two periods, 1960 to 1979 and 1980 to 1994 and arrives at the following conclusions:

- the majority of short term adjustment occurs via variations in output per capita rather than employment levels;
- employment has become more responsive to output changes over time.

1.8 These labour market studies suggest that an increased demand for goods and services does not lead to an immediate increase in the numbers of people employed. Instead demand is first met through increasing the amount of work conducted by existing employees through increasing the number of hours worked. This points to the potential importance of variations in work intensity upon workplace injuries over the economic cycle. Employment is however becoming increasingly responsive to changes in output over time. In terms of the effects of employment tenure, this points to the possibility of an increasing impact of the economic cycle upon workplace injuries. These influences take place against a background of varying labour market conditions that may influence the behaviour of employees and employers. Regardless of the causal mechanism involved, these labour market studies point to the continued potential influence of the economic cycle upon the incidence of workplace accidents and industrial injuries.

An economic model of industrial injuries

1.9 The business cycle approaches to workplace injuries provide intuitively plausible explanations as to how injury rates may be expected to vary over the course of the economic cycle. However, these approaches do not explicitly consider the view that the workplace accident rates are determined by decisions made by employers and employees in response to economic incentives. The risk of an accident is determined by the interaction of choices made by employers between safety and profits and the choices of employees between safety and wages. This market orientated approach to workplace accidents has been developed by Oi (1979), Smith (1973), Thaler and Rosen (1975) and Sider (1985). A simplified representation of this approach is outlined in figure 1.1.

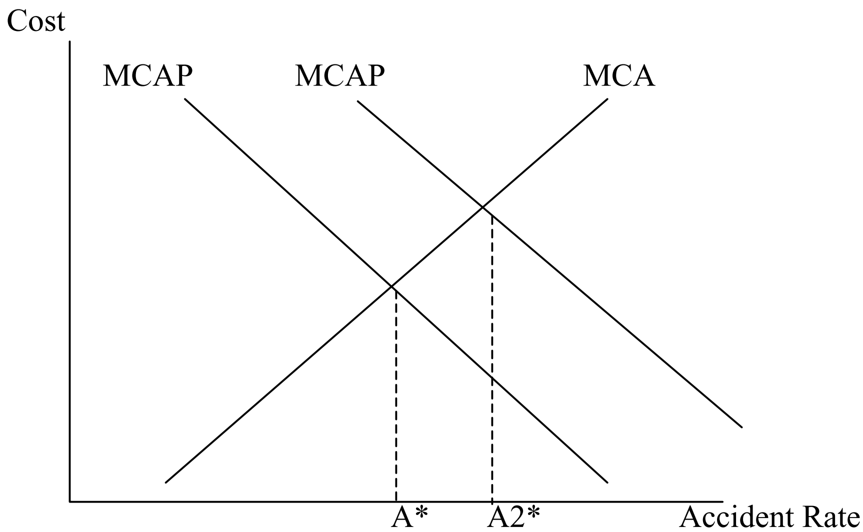
The costs of accident prevention

1.10 The costs associated with accident prevention include the costs of obtaining information about the workplace risk, the purchase of protective clothing and safety equipment, providing occupational health and medical facilities at the workplace, the costs of removing hazards from the workplace, initiating practices designed to motivate safe behaviour and the indirect costs of foregone production which result from operating machinery more slowly. The marginal cost of accident prevention is illustrated in figure 1.1 by the downward sloping curve MCAP. The shape of this curve assumes that within establishments with high rates of workplace injuries, it is relatively inexpensive to make a small improvement in workplace safety and reduce workplace accident rates. As accident rates decline, further improvements in workplace safety become increasingly costly.

The costs of industrial accidents

1.11 Even in the absence of government intervention, firms have an incentive to improve workplace safety. Reducing the incidence of accidents may reduce employee turnover and the associated costs of hiring new workers to replace injured members of staff. Furthermore, the skills and knowledge of the injured employees will be lost leading to a reduction in output and increased expenditure on training. Accidents are often accompanied by the destruction of machinery and materials, and disruptions in production schedules. Fewer accidents may mean a reduced likelihood of legal action against the firm and lower legal costs. The marginal cost of an accident to a firm is represented in figure 1.1 by the upward sloping curve MCA. This assumes that the cost of an industrial accident increases with the injury rate. Firms with higher levels of risk will have to induce employees to accept the increased risk exposure through the payment of a wage premium. Safer working conditions enable the firm to attract employees at a lower wage rate.

Figure 1.1: An Economic Model of Industrial Accidents



The optimal accident rate

1.12 A firm will minimise accident costs by taking care up to the point where the marginal cost of an industrial accident is equal to the marginal cost of accident prevention. Adopting this approach suggest that there is an "optimal" rate of accidents given by A*. At accident rates greater than A*, additional expenditure on accident prevention brings returns which exceed these expenditures (MCA>MCAP). At a rate of accidents less than A*, the cost of investment in accident prevention measures is not off-set by the amount gained from any reduction in accidents (MCAP>MCA). An important point to note from this discussion is that the optimal rate of accidents is unlikely to be zero. The optimal accident rate will also vary between industries. The MCAP curve will be higher for more hazardous industries where firms have to allocate more to safety expenditures to achieve a given injury rate. The higher costs of accident prevention in such industries lead to higher rates of workplace accidents.

The optimal accident rate and the economic cycle

1.13 Wooden (1989) uses this framework to consider how the optimal accident rate will vary over the economic cycle. Drawing upon the business cycle approaches above, the recruitment of relatively inexperienced workers, increased work intensity and the utilisation of older machinery to meet increased demand increase the risk of workplace injuries. The cost of accident prevention will therefore increase during periods of economic expansion, as more resources are required to maintain accident rates at their original levels. A new higher equilibrium accident rate will be established at A2*, consistent with the predictions of the business cycle approaches.

1.14 However, the cost of industrial accidents may also vary over the economic cycle. Steele (1974) suggests that we should observe an inverse relationship between accident rates and the state of economic activity because the cost of injuries in terms of interrupted production and the replacement of injured workers will increase with the upswing in the business cycle. In terms of figure 1.1, an increase in economic activity may also lead to an upward shift in the MCA curve, leaving the direction of change in the equilibrium accident rate indeterminate. The market orientated approach therefore cannot predict the direction of movements in injury rates over the economic cycle. The issue therefore becomes an empirical matter.

B Industrial Injuries and Structural Influences

Introduction

1.15 The preceding section considered the importance of the economic cycle in determining the incidence of industrial injuries. Such cyclical factors however cannot be considered in isolation of structural influences acting independently of the economic cycle. There have been a number of structural changes in the British economy that are likely to have had an influence on occupational health and safety. These include a shift in the industrial mix from the manufacturing to the service sectors, a decline in union density and changes in the pattern of employment. Government polices relating to regulatory enforcement and compensatory benefits will also influence the rate of industrial injuries.

Trade unions and industrial injuries

1.16 Over the last twenty years it has become increasingly popular to view trade unions as organisations whose primary function is to raise wages above market clearing levels. As such raises are socially deleterious, unions are judged to have negative impacts upon efficiency. Freeman and Medoff (1979) however identify two potential mechanisms through which trade unions may enhance efficiency at the workplace. Firstly, unions provide an effective vehicle for collective voice at the workplace. Secondly, unions act as a barrier to managers pursuing adversarial routes to profitability. These mechanisms also suggest that trade unions may promote occupational health and safety at the workplace.

Unions as a vehicle for collective voice

1.17 Unions act as a means for direct communication between management and the workforce. The union therefore provides an adjustment mechanism through which actual and desired conditions at the workplace can be brought closer together. It is assumed that unions are primarily concerned with issues of wage bargaining. However, if workers place a value on reducing the risk of workplace injuries then unions can provide a collective voice for workers in terms of occupational health and safety.

1.18 There are two reasons why collective rather than individual voice is necessary for effective communication. Firstly, a prerequisite for workers having an effective voice in the employment contract is protection from dismissal. Individual workers are unlikely to reveal their true concerns over health and safety issues to their bosses through fear of punishment. Secondly, health and safety measures may benefit many members of the workforce. However, single workers acting in their own self-interest are unlikely to have the incentive to express their concerns over such health and safety issues.

Unions as a source of worker power

1.19 As a voice unions alter social relations at the workplace. Unions constitute sources of worker power diluting managerial authority. Unionised workers are therefore more willing and able to express discontent and object to managerial decisions. The presence of a unionised workforce may sharpen the incentive for employers to adopt best practice health and safety measures. In the absence of organised labour, employers may have the incentive to adopt more adversarial routes to profitability. Such routes to profitability may be characterised by the deferral in new capital equipment that embodies the latest safety features or the absence of direct investments in occupational health and safety measures.

1.20 However, the presence of unions may have a positive effect upon the incidence of reported industrial injuries. Borooah et al (1997) suggest that although such organisations may improve safety standards at work, they may increase the propensity of workers to report accidents. Unions may provide health and safety information to their members, which increases the awareness of workers regarding their rights if a workplace injury is sustained and encourage workers to report accidents as and when they occur. These opposing influences are further complicated by the likelihood that union representation may be perceived as more attractive to workers in relatively dangerous industries (Wooden and Robertson, 1997).

1.21 The Labour Force Survey has collected information on the union membership status of all those in employment in each year since 1989. Table 1.1 presents evidence from the LFS indicating trends in union membership and union density (the proportion of all those in employment who are union members) reported by Cully and Woodland (1998). The table shows that trade union membership fell by 1.85 million since 1989 to stand at 7.1 million during 1997, a fall of 20.6%. This pattern is repeated in the estimates of union density amongst those in employment. Trade union density fell from 34.1% in 1989 to 27.3% in 1997. Cully and Woodland (1998) note that whilst the largest decline in union membership occurred in 1992, a period of substantial job losses, unions have failed to recover membership loss as employment growth has recovered since 1994.

Table 1.1: Union Membership in Great Britain

	Union membership (thousands)	Percentage change in membership since previous year	Union density (percentage of all in employment)
1989	8,964		34.1
1990	8,854	-1.2	33.4
1991	8,633	-2.5	33.3
1992	7,999	-7.3	32.1
1993	7,808	-2.4	31.3
1994	7,553	-3.3	30.0
1995	7,275	-3.7	28.8
1996	7,215	-0.8	28.2
1997	7,117	-1.4	27.3
Change since 1989	-1,847	-20.6	-6.8

Source: Cully and Woodland (1998).

1.22 Cully and Woodland (1998) also present evidence of wide variations in trade union density between industrial sectors. Estimates for 1997 indicate that trade union density varies from 7% within the Hotel and Restaurant sector, to 63% within Electricity, Gas and Water Supply. Changes in the industrial composition of employment over time will therefore be a significant determinant of changes in total union density. However, the impact of compositional effects should not be overstated. Green (1992) considers the influence of the changing composition of employment upon union density according to gender, full time or part time status, establishment size, age, region and industry between 1983 and 1990. The total effect of compositional change was only estimated to account for 30 per cent of the fall in aggregate density, pointing to the importance of 'within group' changes in union density. The legal framework and the macro economic environment will also underlie observed trends in table 1.1.

Changes in the pattern of employment

1.23 In recent years there has been an increasing awareness of the persistence and growth of "atypical" or "non-standard" forms of employment. Atypical employment is more easily defined by what it is not rather than by what it is and is usually considered to be any type of work that is not full-time and permanent. The following definition is provided by Delsen (1991): Atypical employment relations are those that deviate from full-time open-ended wage employment: part-time work, labour on-call contracts, min-max contracts, fixed term contracts, seasonal work, agency work, home based work, telework, apprenticeship contracts, freelancers, self employment and informal work. (Delsen, 1991, p123).

1.24 An analysis of the growth of atypical employment within the UK is provided by Rubery (1989) and is discussed at a European level within Delsen (1991), Treu (1992) and De Grip et al (1997). Table 1.2 presents evidence of recent trends in atypical employment within the United Kingdom. Part-time employment increased from 6.1 million in 1993 to 6.7 million in 1998, an increase of 10.3%. The share of part time employment within total employment increased from 23.8% to 24.8% between 1993 and 1998. Temporary employment increased from 1.4 million to 1.7 million during this period, representing an increase of 28.3%. The share of temporary employment within total employment increased from 5.3% to 6.4% over this period.

Table 1.2: Part-time and Temporary Employment in the United Kingdom (thousands)

	Part time workers	**Percentage change since previous year**	**Temporary workers**	**Percentage change since previous year**
1993	6091		1355	
1994	6246	2.54%	1490	9.96%
1995	6293	0.75%	1623	8.93%
1996	6526	3.70%	1660	2.28%
1997	6672	2.24%	1777	7.05%
1998	6718	0.69%	1739	-2.14%
Change since 1993	627	10.29%	384	28.34%

Source: Labour Force Survey

1.25 The potential effects of atypical employment relations upon occupational health and safety will naturally vary depending upon the nature of atypical employment. Mayhew and Quinlan (1997) report the results of four surveys on the health and safety record of subcontractors in the UK and Australia. They suggest that subcontracting redefines work practices in four ways that adversely affect health and safety. These are:

- changes to the systems of economic reward;

- reducing the levels of planning and organisation in the workplace;
- inadequate attention paid to health and safety regulation;
- reduced union density and recognition.

1.26 It is clear that such factors are of relevance for various forms of atypical and typical employment.

Payment and incentive influences

1.27 Many forms of atypical employment are characterised by the utilisation of reward systems that are based upon output. The reward system can therefore contribute to the production of industrial accidents through the use of financial incentives to increase work intensification. Dwyer and Rafferty (1991) however note that reward systems in themselves do not lead to industrial injuries. For incentives to be effective, people must be orientated to work harder to earn them, and for incentives to produce more industrial accidents, greater risks must be taken. It is not the incentive as such that produces accidents, but the actions of workers when faced with these incentives.

1.28 Numerous studies have reported a positive relationship between incentive systems and accident rates (Beaumont, 1980; Wrench and Lee, 1982; Dwyer and Rafferty, 1991). Hillage et al (1998) suggest that the self-employed and sub-contractors are unlikely to see health and safety as an important consideration when under pressure to complete tasks within budget. Subcontracting within the construction industry has often been associated with cost cutting measures that place health and safety at direct risk, e.g. the failure to use scaffolding, proper trenching or safety harnesses. More generally, others have argued that positive associations exist between injury rates and pressures placed on workers to meet production deadlines and quotas (e.g. Nichols and Armstrong, 1973, Hofmann and Stetzer, 1996).

Disorganisation effects

1.29 Dwyer and Rafferty (1991) suggest that work is produced at the organisational level through employer control over the division of labour. Employer control over the task structure, the relationship between tasks and the knowledge of employees as to the relationships between tasks can influence the likelihood of workplace accidents, particularly for certain forms of atypical employment. Hillage et al (1998) provide the example of subcontractors working on sites characterised by multiple subcontractors and complex pyramids of control between contract workers. These work arrangements may result in a lack of co-operation, communication and confusion. Further, in sites with multiple work groups, the actions of workers in one group may endanger the safety of workers in another.

Inadequate regulatory controls

1.30 Subcontractors, the self-employed and other small firms may be unaware of their legal health and safety responsibilities leading to a lack of regulatory control at such workplaces. Burchell (1989) also suggests that whilst the health and safety legislation generally gives equal rights to all employees, those in atypical employment may not receive such rights in practice. Many temporary employees may not be classified as an employee at their place of work because they are technically self-employed or their employer is an agency. Whilst employers are also meant to give details of home-workers they employ to local authorities so health and safety inspections can be carried out, it is unlikely that the true extent of home-working will become known to inspectors. However, whilst the lack of regulatory control may lead to a higher incidence of industrial accidents, the effect upon official figures may be offset by a lower propensity to report.

The industrial composition of employment

1.31 The past 40 years have seen major changes in the industrial composition of employment across all developed economies. Wilson (1999) notes that a complex mix of interdependent factors such as technological change, productivity growth, international competition, specialisation and sub-contracting, and economic growth have resulted in very large increases in real incomes and dramatic shifts in patterns of expenditure. These in turn have resulted in the demise of many major areas of employment including agriculture, coal mining and substantial parts of manufacturing. In contrast there have been major increases in employment in other areas, especially those sectors involved in the processing and handling of information, and those providing services to both consumers and businesses.

Table 1.3: Employment Projections by Industrial Sector

Industrial Sector	Share of Total Employment (%)		
	1971	1997	2006
Primary and utilities	6.5	2.9	2.5
Manufacturing	31.2	16.5	13.7
Construction	6.5	6.2	5.8
Distribution, transport etc	25.2	28.2	29.3
Business and misc. services	11.5	22.2	25.5
Non-marketed services	19.0	24.0	23.1
All industries	100	100	100

Source: IER Estimates.

1.32 Table 1.3 provides information as to the industrial composition of employment in the UK since 1971. Since 1971 it can be seen that there has been a clear shift in employment away from primary industries, utilities and manufacturing towards the service sectors. Between 1971 and 1997, employment in manufacturing fell from 31.2% to 16.5% of the workforce. Wilson (1999) suggests that future prospects for this sector are not optimistic given the appreciation of sterling and doubts over UK participation in EMU. Consequently, the share of manufacturing employment in total employment is expected to decline to 13.7% by 2006. In contrast, employment within business and miscellaneous services increased from 11.5% to 22.2% between 1971 and 1997. Despite increased competition and pressures to reduce costs within banking, finance and insurance services, employment prospects within this sector remain optimistic due to growth in computing services, various media activities and other service industries. The share of employment is expected to increase from 22.2% to 25.5% by 2006.

1.33 The likelihood of an industrial accident will depend upon the degree of exposure to hazards. Exposure to risks of injury will vary between industries. Shifts in employment from manufacturing to service sector industries are likely to have a significant impact upon the incidence of industrial injuries. Table 1.4 provides estimates for rates of reportable injury[1] estimated to have occurred utilising data from the Labour Force Survey. Injury rates are expressed per 100 thousand employees by industrial sector. Table 1.4 indicates that the risk of incurring a workplace injury is greatest within the Construction and the Transport, Storage and Communication sectors. The rates of workplace injury are lowest within the Finance and Business, and the Education sectors.

Table 1.4: Rates of Non Fatal Reportable Injury from the Labour Force Survey[a]

Industry	Injury Rate
Agriculture	1,830
Extraction and utility supply	1,860
Manufacturing	1,980
Construction	2,430
Distribution and repair	1,320
Hotels and restaurants	1,450
Transport, storage and communication	2,230
Finance and business	610
Public admin & defence	1,670
Education	750
Health and social work	1,680
Other community, social & personal	1,370

Source: Labour Force Survey
a. Rate of injury expressed per 100 000 workers (employees and self employed combined).

The occupational composition of employment

1.34 Changing patterns of industrial employment have had profound implications for the demand for different types of occupations. Wilson (1999) suggests the decline of employment in primary and manufacturing industries has resulted in a reduction in the need for many skills associated with the production of the output of these industries. For example, estimates in table 1.3 indicate a decline in the share of manufacturing employment from 31.2% in 1971 to 16.5% in 1997. This much smaller manufacturing sector therefore no longer

[1] See chapter 3 for a discussion of the definition of a reportable injury under the Reporting of Injury, Diseases and Dangerous Occurrences Regulations (RIDDOR).

requires the same number of skilled engineering and other types of specific craft skills as previously. In contrast, the growth in service sector employment has lead to the expansion of jobs in a number of occupations. For example, estimates in table 1.3 indicate an increase in the share of non-marketed public service employment from 19.0% in 1971 to 24% in 1997. Wilson (1999) suggests this growth in employment has lead to additional jobs for professional, managerial and clerical workers in public administration; for doctors and nurses in health services; and for teachers in education services.

1.35 These developments have taken place against a background of technological change that has lead to significant changes in the nature of particular jobs within industries and a restructuring of the way in which work is organised. The wider application of information technology has been of particular importance. The application of IT has lead to the displacement of many clerical and secretarial jobs previously concerned with information processing using paper technology. The application of IT in manufacturing has also lead to the displacement of many skilled workers whose jobs have been taken over by computer controlled machinery. On the other hand, information technology has opened up many new areas in which information services can be provided that were previously not feasible. This has tended to create jobs of a professional, associate professional and managerial nature.

Table 1.5: Employment Projections by Occupational Structure

Occupation	**Share of Total Employment (%)**		
	1981	**1997**	**2006**
Managers and Administrators	12.4	17.3	17.8
Professional Occupations	7.8	9.9	11.7
Associate Professional and Technical Occupations	7.4	9.6	10.5
Clerical and Secretarial Occupations	17.7	15.4	14.1
Craft and Skilled Manual Occupations	17.1	13.1	11.1
Personal and Protective Service Occupations	7.0	10.1	12.0
Sales Occupations	6.9	7.6	7.6
Plant and Machine Operatives	12.5	9.7	9.3
Other Occupations	11.3	7.3	5.9
Total	100	100	100

Source: IER Estimates.

1.36 Table 1.5 provides information as to the occupational composition of employment in the UK since 1981. Since 1981 it can be seen that there has been a clear shift in employment away from more traditional, blue collar manual occupations. Between 1981 and 1997, employment within Craft and Skilled Manual Occupations fell from 17.1% to 13.1%, whilst employment amongst Plant and Machine Operatives fell from 11.3% to 7.3%. In contrast, employment amongst Managers and Administrators increased from 12.4% to 17.3% between 1981 and 1997. The share of employment within Personal and

Protective Service Occupations also increased from 7.0% to 10.1% between 1981 and 1997. Projections indicate that the highest rates of employment growth are expected to occur within Professional Occupations and Personal and Protective Service Occupations. However, the total number of jobs within Craft and Skilled Manual Occupations is projected to fall by around 360 thousand between 1997 and 2006.

Table 1.6: Rates of Non Fatal Reportable Injury from the Labour Force Survey[a]

Occupation	Injury Rate
Managers and Administrators	640
Professional Occupations	400
Associate Professional and Technical Occupations	990
Clerical and Secretarial Occupations	750
Craft and Skilled Manual Occupations	2,860
Personal and Protective Service Occupations	2,170
Sales Occupations	970
Plant and Machine Operatives	3,140
Other Occupations	2,690
Total	1,510

Source: Labour Force Survey
a. Rate of injury expressed per 100 000 workers (employees and self employed combined).

1.37 As discussed above, exposure to risks of workplace injury will vary between industries. However, within industries there are occupations with varying degrees of exposure to hazards associated with the occurrence of a workplace accident. Shifts in employment from traditional manual employment will have a significant impact upon the incidence of industrial injuries, both over time and between regions. Table 1.6 provides estimates for rates of reportable injury estimated to have occurred utilising data from the Labour Force Survey. Injury rates are expressed per 100 thousand employees for the 9 Major Groups of the standard occupational classification. It can be seen that the risk of workplace injury is greatest amongst those employed as Plant and Machine Operatives, and within Craft and Related Trades. The lowest rates of reportable workplace injuries are observed amongst Professionals, Clerical and Secretarial Occupations, and Managers and Administrators.

Government policy and industrial injury

Generosity and structure of compensation benefits

1.38 There are two mechanisms through which the level of compensation paid to victims of industrial accidents may increase the reported incidence of workplace injuries. Firstly, an increase in the level of benefits reduces the costs to employees associated with the industrial accidents in terms of foregone earnings during the period where an employee is unable to return to work. The effective reduction in the cost of workplace injuries reduces the incentive of workers to avoid workplace accidents and encourages less cautious behaviour at the workplace. Secondly, given that leisure is preferred to work, a reduction in the cost of leisure in terms of foregone earnings following an increase in compensation benefits will be accompanied by a rise in the demand for leisure and a reduction in the supply working hours. Therefore, under circumstances where the responsibility to report workplace accidents lies with the employee, employees may be encouraged to make fraudulent claims for compensation or report injuries that previously they would not have. Therefore, a rise in the level of workers' compensation benefits (relative to earnings) will be associated with an increase in reported accident rates.

1.39 Lanoie (1992) however notes that an increase in the level of compensation benefits may have a depressing effect on accident rates under systems of self insurance as found in Canada and Australia. Under such arrangements, firms are liable for workplace accidents and pay insurance premiums that in turn pay compensation benefits to accident victims. Via an experience rating system, these premiums are adjusted to reflect the firms own claim experience. An increase in premiums associated with benefit levels and claims made by employees will increase the costs of accidents to firms. This may encourage employers to devote more resources towards health and safety. The net effect of changes in benefits on the risk of accident depends upon whether employer responses dominate employee responses.

1.40 Wooden (1989) however suggests that self-insurance schemes are unlikely to encourage employers to adopt health and safety measures as insurance premiums will not accurately reflect the safety records of firms. Firstly, it is impracticable to adjust premiums in the case of small employers and so typically premiums reflect the claims experience of large employers. Secondly, many claims are outside the control of the employer such as fraudulent claims. Thirdly, insurance premiums are likely to constitute only a small proportion of variable costs and are unlikely to induce changes in behaviour. Employee responses are therefore likely to dominate employer responses.

Government prevention policies

1.41 Intensification of government prevention policies should lead to a reduction in the risk of accident by encouraging employers to devote more resources to health and safety. Enforcement measures may include fines, improvement notices or immediate prohibitions to prevent further activity in the unsafe area of work. Firms may incur substantial costs as a result of inspections that detect non-compliance with health and safety regulations. Lanoie (1992) however suggests that intensification of such enforcement measures could have an adverse impact upon the incidence of industrial accidents. The improved working environment could lead to more careless behaviour amongst employees. Viscusi (1986) also notes that the impact of any intensification of safety enforcement measures can occur with a lag due to the time involved in making the capital investments or organisational changes required for compliance with safety standards.

1.42 Accident rates provide an objective measure of workplace safety. As such, it is desirable to measure the effectiveness of regulatory activity by considering the impact upon workplace accident rates. However, regulatory regimes are likely to impact upon workplace safety through a variety of complex mechanisms including legislation, standard setting, research and development, campaigns, initiatives, as well as inspection, investigation and enforcement measures. It is unlikely to be feasible to evaluate the effectiveness of all such regulatory activities in terms of their impact upon workplace injury rates. However, a number of evaluation studies have been undertaken that focus upon particular aspects of the regulatory regime. These evaluations tend to employ intermediate outcome measures that can be related to real objectives. Such measures include increased levels of compliance with legal requirements, number of safety helmets purchased, exposure levels to toxic substances and numbers of workers who have access to occupational health and safety services. Reviews of these studies point to a variety of positive impacts of the regulatory regime within Great Britain upon workplace safety (see HSE (1985, 1991)).

Shifts in the balance of power

1.43 Nichols (1986) considers the importance of changes in the balance of power between employees and employers over the business cycle upon workplace injury rates. During periods of high unemployment, those in employment may become vulnerable to the introduction of unsafe working practices, or the intensification of the production process to maintain competitiveness. However, it is also necessary to consider the potential importance of changes in the balance of power between employees and managers outside of the economic cycle. Tombs (1990) discusses the impact of the strength of organised labour within the UK upon industrial injuries before and after 1979. In the aftermath of the Donovan Commission, labour in Britain was politically strong in relation to capital. However political power moved in favour of employers during the 1980s. The Conservative government removed regulations that were felt to place excess burdens upon the wealth creating activities of business. Tombs (1990) suggests that a decline in the resources available to the health and safety inspectorate and a decline in union density are indicative of a more general shift in the balance of power which enabled employers to avoid meeting health and safety requirements.

C Worker and Firm Characteristics

Worker characteristics

1.44 A number of principal worker characteristics may be correlated with the likelihood of industrial injury. Work experience and union membership have been considered above in the context of cyclical and structural changes within the economy. Other characteristics that may be correlated with workplace injuries include age, sex and educational attainment.

Age

1.45 A comprehensive review of ageing and occupational accidents literature is provided in Laflame and Menckel (1995). The relationship between age and accident frequency is debatable. Because of the hypothesised relationship between work injury frequency and experience, most research has typically found that young workers are at most risk of injury at the workplace. Nevertheless it is widely believed that, independent of experience, the risk of injury should rise with age as a result of the deterioration in both physical and mental capacities. This view is supported by studies which estimate a U shaped relationship between age and the incidence of workplace injuries. Laflame and Menckel (1995) also suggest that the severity of workplace injuries increases with age. This may reflect changes in the causes of injuries with age.

Sex and educational attainment

1.46 Studies of industrial injury rates commonly consider the influence of gender and the educational attainment of the employees upon industrial injuries. Significant results are usually explained as reflecting differences in the distribution of safe jobs, between men and women, and between workers with different levels of educational attainment. For example, industries with a higher proportion of female employees may be expected to involve less physical strain and pose a lower risk of injury. The inclusion of such variables is therefore justified on the grounds that they may be correlated with unobserved differences in exposure to work hazards and not because workers of different sex and educational attainment behave differently.

Firm characteristics

1.47 A variety of firm characteristics may be expected to have an effect on the incidence of workplace injuries. These factors may be divided into workplace factors and management practice systems. Workplace factors relate to issues such as the size of the firm and the capital intensiveness of the production process. Management practice systems relate to issues as payment systems, the utilisation of atypical employment, the presence of consultation committees at the workplace and patterns of work. Issues of atypical employment and payment systems have been considered above.

Capital intensity of the production process

1.48 Currington (1986) suggests that among the major non-wage injury costs are the costs of damage to physical capital and lost production time which may accompany an injury. It can be expected that in more capital intensive firms there is a greater probability that an injury will be accompanied by damage to equipment. Similarly, firms with interdependent production processes (e.g. assembly line operations) are more likely to experience lost production time when an injury occurs. Such firms are likely to be more capital intensive. Marginal non-wage injury costs are therefore likely to be higher in more capital intensive firms, thus increasing the incentive of firms to invest in safety inputs in an attempt to reduce the incidence of workplace injuries.

Firm size

1.49 Currington (1986) notes that for most injuries, injury rates tend to be low for very large and very small firms and highest for medium sized firms. Furthermore, industries with higher average firm size have lower injury rates. This pattern provides evidence to support the common assumption that expenditure on health and safety measures is subject to returns to scale. The average cost of health and safety measures per employee will be lower in larger firms, increasing the incentive of firms to invest in these areas. It is worth noting that direct measures of employer commitment to safety management, such as expenditure on health and safety measures, are likely to be positively correlated with industrial injuries. This does not mean that higher expenditure causes accidents but rather that the direction of causality runs in the opposite direction, i.e. high injury rates lead to expenditures on health and safety.

Table 1.7: Distribution of Workplaces and Employment, by Workplace Size

Number of Employees at Workplace	Workplaces	Employees
25 to 49 employees	52	17
50 to 99 employees	25	16
100 to 199 employees	12	16
200 to 499 employees	8	22
500 or more employees	3	30

Source: Cully et al (1999), figure 2.1
a. All workplaces with 25 or more employees

1.50 Table 1.7 presents evidence from the 1998 Workplace Employment Relations Survey regarding the distribution of workplaces and employment, by workplace size. The distribution of workplaces is highly skewed. Workplaces employing between 25 and 49 employees account for 52% of all workplaces. In contrast, workplaces employing 500 or more employees only account for 3% of workplaces. The distribution is more even when considering employment by workplace size. Establishments employing 500 or more employees account for almost a third of all workers. Considering small establishments, whilst workplaces employing between 25 and 49 employees account for 52% of all workplaces, these workplaces only account for 17% of workers.

The presence of consultation committees

1.51 The potential importance of trade unions in reducing the incidence of industrial accidents through providing a collective voice for employees was discussed earlier. The role of unions in matters of health and safety is underpinned through the Health and Safety at Work Act (1978) which provided recognised unions the right to appoint safety representatives and, after consultation with employers, the right to institute safety committees. Under the Health and Safety Regulations (1996), employers are obliged to consult with their employees in good time about health and safety matters. This legislation filled the gap in the Health and Safety at Work Act which had not provided for consultation in workplaces without recognised unions. Savery and Wooden (1995) argue that health and safety issues will be taken more seriously where the persons most effected by such issues exert an influence over plant level decision making. What therefore may be of benefit to employees is not necessarily that workers are members of trade unions, but that consultative committees provide an effective voice for workers in terms of health and safety issues.

1.52 Cully et al (1999) present evidence from the 1998 Workplace Employment Relations Survey regarding mechanisms adopted by workplaces for employee consultation about health and safety matters. They report that 39% of workplaces operated joint health and safety committees, 29% consulted with safety representatives and 30% consulted directly with employees. Therefore, only in 2% of firms were no steps taken to consult employees about health and safety issues. In workplaces with union recognition, 47% operated joint health and safety committees. This points to some degree of complementarity between joint consultation on health and safety issues, and union recognition. However, Cully et al (1999) note that even amongst workplaces without any union members, 31% had a joint committee and 27% had elected safety representatives. Therefore, it can be seen that even in non-union workplaces, representative structures surrounding issues of health and safety have been established.

Working arrangements

1.53 It is often suggested that shift-working is associated with higher rates of workplace injury. This is due to effects of shift work upon circadian rhythms, giving rise to both higher levels of stress and fatigue (Minors, Scott and Waterhouse, 1986). It has also been claimed that shift work may induce higher levels of stress, thereby increasing the likelihood of accident, through creating increased tensions in an employees home life (Hood and Milazzo, 1984). Evidence also exists to indicate that the monotony and boredom associated with the performance of routine work may be responsible for industrial accidents.

1.54 The 1998 Workplace Employment Relations Survey asked employees to assess the level of influence they had over three aspects of their work: the range of tasks involved in their job; the pace at which they work; and how they went about doing their work. Cully et al (1999) combine these responses to create an overall measure of perceived job influence. Table 1.8 shows how this measure of job influence varies by occupation. Overall, 30% of employees felt they had a lot of influence over their job, 43% had some influence, while the remaining quarter had little or no influence. It can be seen that 58% of Managers and Administrators reported having a lot of influence over their job, compared to only 22% of Plant and Machine Operatives.

Table 1.8: Levels of Job Influence

Occupation	Level of Job Influence			
	A lot	Some	A little	None
Managers and Administrators	58	35	6	0
Professional	33	49	16	1
Associate Professional and Technical	30	50	17	2
Clerical and Secretarial	28	45	21	6
Craft and Related	28	45	21	6
Personal and Protective Services	26	43	25	6
Sales	26	40	25	9
Plant and Machine Operatives	22	39	27	12
Other Occupations	27	39	24	10
All Employees	30	43	21	6

Source: Cully et al (1999), figure 7.2
a. All workplaces with 25 or more employees

The Propensity to Report Workplace Injuries

Table 1.9: Trends in levels of reporting injuries, 1989/90 &1997/98

Industry	Percentage of injuries reported to enforcing authorities	
	1989/90	1997/98
Finance & business	7%	21%
Hotels & restaurants	10%	23%
Health & social work	19%	39%
Agriculture	20%	36%
Distribution & repair	20%	39%
Other community, social and personal	24%	41%
Education	29%	47%
Transport, storage & communication	37%	68%
Construction	38%	55%
Manufacturing	46%	63%
Extraction and utility supply	76%	95%
Public admin and defence	81%	75%
All industries	34%	47%

Source: HSE Estimates

1.55 The probability of an establishment reporting a workplace injury can be considered in terms of two composite elements. Firstly, the risk of occurrence of a workplace injury will be determined by various influences that contribute to workplace hazards. Assuming the occurrence of a workplace injury that is deemed reportable under a specific regulatory regime (e.g. RIDDOR), the issue then becomes what factors influence the likelihood that the workplace injury will be reported. Depending upon where the responsibility to report lies, a variety of workplace and personal characteristics will co-determine both the level of reportable workplace injuries and the propensity to report such injuries. For example, heightened publicity surrounding the introduction of new regulatory mechanisms may increase reporting propensities as employers are made more aware of their reporting obligations. In terms of the impact of new regulatory mechanisms upon workplace injury rates, real improvements in workplace safety may be obscured by changes in reporting propensities.

1.56 Table 1.9 highlights variations in reporting propensities both over time and between industries in Great Britain under RIDDOR. Between 1989/90 and 1997/98, the reporting propensity rate is estimated to have increased from 34% to 47%. Considering figures for 1997/8, industrial reporting rates vary between 21% within Finance and Business, to 95% in Extraction and Utility supply. It can be seen that the largest proportionate increases in reporting have occurred among those industries that had the lowest levels of reporting in 1989/1990. Such improvements in reporting propensity may therefore obscure real improvements in workplace safety in terms of reduction in workplace injury rates reported under RIDDOR.

D Concluding Comments

1.57 This chapter has reviewed the theoretical literature regarding the relationship between the incidence of industrial injuries and the economic cycle, structural changes within the economy and a variety of workplace and individual characteristics. The early business cycle approach to industrial injuries developed by Kossoris (1938) suggests that movements in industrial injuries are pro-cyclical. This approach is based upon the movement of certain labour market related variables over the economic cycle that are of continued relevance within the modern labour market. However, the development of market orientated models of industrial injuries casts doubt upon the predictive power of simple business cycle approaches. The movement of industrial injuries over the business cycle becomes an empirical issue.

1.58 Structural factors within the British economy are likely to have important implications for the incidence of industrial accidents both over time and between regions. Increases in the incidence of atypical employment and decreases in trade union membership may have adverse effects upon injury rate trends. However, these issues are closely related to changes in the industrial composition of employment which have reduced exposure to workplace hazards. Such changes in the pattern of employment will also be related to changes in workplace characteristics and the introduction of new management practice systems that will effect the level of exposure to workplace hazards. Government policy will also have an impact upon injury rates through influencing the behaviour of individuals and firms.

1.59 What emerges from this discussion is that in order to understand changes in the incidence of industrial injuries over time and between regions, one cannot consider the impact of the economic cycle and the effects of structural change in isolation. To identify the impact of cyclical and structural factors on the incidence of industrial injuries, it is necessary to use a modelling approach that can control for these factors simultaneously. The following chapter provides a review of this empirical literature.

2. MULTIVARIATE ANALYSES OF INDUSTRIAL INJURIES: A REVIEW OF THE EMPIRICAL EVIDENCE

Introduction

Chapter 1 considered the theoretical importance of cyclical economic forces, structural influences within the economy, personal characteristics and firm characteristics in determining the incidence of workplace injuries. Rather than acting in isolation of each other, many of these factors can be considered as having an interdependent effect upon the incidence of industrial injuries. For example, the observed decline in trade union membership is a product not only of legislative changes, but also of broader structural changes in the economy which have lead to the contraction of industries where trade union membership was traditionally strong.

This chapter provides a review of the empirical evidence regarding the incidence of industrial injuries. Section A discusses the empirical methodologies typically employed. Section B considers the evidence regarding workplace injuries and the economic cycle. Section C considers the empirical influence of various structural characteristics, including trade unions, workplace characteristics, government interventions and personal characteristics. Section D offers concluding comments.

A Empirical Methodologies

2.1 Numerous empirical studies have attempted to estimate the impact of these factors upon the incidence of workplace injuries. The emphasis of the empirical analyses varies between studies. A number of studies have considered the impact of the business cycle, union membership, the implementation of safety enforcement regulations and the level of worker compensation payments upon injury rates. However, in order to consider the effects of such factors upon workplace injuries, most analyses rely upon the specification and estimation of a multivariate statistical model. Such models attempt to control for all other determinants of industrial accidents in order to address the study hypothesis. Consequently, there is a high degree of uniformity in the control variables used within empirical analyses that consider the determinants of workplace injuries.

2.2 The empirical literature can be divided into three areas according to the type of data used.

Cross sectional analysis

2.3 Cross sectional analysis is undertaken where information on workplace injuries is available for a cross section of agents at a given point in time. Worral and Butler (1983) consider individual data from the 1978 US Social Security Survey of Disability and Work which asked respondents about work status, health conditions caused by industrial accidents and various socio-economic characteristics. Reilly, Paci and Holl (1994) and Nichols, Dennis and Guy (1995) both utilise data from the 1990 British Workplace Industrial Relations Survey which provided information on industrial injuries at establishment level, enabling the exploration of relations between a number of establishment variables and injury rates. McKnight and Elias (1998) utilise individual level data from the Labour Force Survey which enquires whether or not a respondent has had any accident at work, or in the course of their work, in the preceding year which resulted in injury. This information enables an assessment of the extent to which various characteristics of individuals and their jobs contribute towards the relative risk of workplace injury.

Time series analysis

2.4 Due to a general lack of workplace injury data at individual or firm level, a majority of empirical analyses utilise aggregate injury data. Time-series analysis of annual injury data for US manufacturing industries have been conducted by Robinson (1988) for the period 1946 to 1985 and by Fairris (1998) for fatality data covering the period 1960 to 1985. Wooden (1990) considers annual injury data for South Australia for the period 1960 to 1980. Finally, Nichols (1990) conducts a multivariate analysis of fatalities within British manufacturing industries between 1960 and 1985. These time series analyses are however constrained by the availability of a sufficiently lengthy and consistent time series of workplace injury data. For example, Hillage et al (1998) suggest that interest in the business cycle and occupational safety has been higher in the US due to the greater availability of aggregate time series data.

Pooled time series/cross sectional analysis

2.5 In order to overcome the problems of data availability associated with longitudinal analyses, a number of studies have conducted multivariate analyses on pooled time series/cross sectional data. The cross sectional unit of analysis is typically defined by industrial sector. For example, Currington (1986) conducts a multivariate analysis of compensated claims for workplace injuries in New York State for the period 1964 to 1976. By aggregating injury records by 2 digit SIC codes, the number of injury rate observations for the 13 year period increases to 234. The pooled time series/cross sectional methodology is also employed by Viscusi (1986): 22 sectors over 10 years, Lanoie (1992): 28 sectors, 5 years, Wooden and Robert (1997): 16 sectors, 3 years and Barooah et al (1997), 17 sectors, 11 years.

2.6 The following discussion reviews the available empirical evidence regarding cyclical economic forces, structural changes within the economy, the institutional environment, firm characteristics and personal characteristics in determining the incidence of industrial injuries.

B Industrial Injuries and the Economic Cycle

Time series studies

2.7 Drawing upon the early analysis of Kossoris (1934), workplace injuries may be expected to increase during periods of economic expansion due to a reduction in the average experience of the workforce and increased levels of work intensity. However, increases in the level of employment during such periods may have a depressing effect upon industrial accidents due to the increased power of workers to resist unsafe working practices. Robinson (1988) considers these issues in a time-series analysis of US manufacturing accident rates for the period 1948 to 1985. Robinson (1988) estimates a regression equation relating manufacturing injury rate to the accession rate (recruitment rate), the rate of productivity (as measured by output per hour) and the rate of unemployment. It is estimated that a 10% increase in the accession rate increases the accident rate by 10.4%, a 10% increase in productivity leads to a 1.8% increase in the injury rate and a 10% increase in the unemployment rate leads to a 2.2% rise in the accident rate.

2.8 Not all multivariate analyses control for all potential cyclical influences upon injury rates. The omission of potentially relevant explanatory variables can lead to seemingly inconsistent results between different empirical analyses. Wooden (1989) undertakes a time series analysis of compensated industrial accidents within South Australia for the period 1960 to 1980. The effects of the business cycle upon the average experience of the workforce is proxied by the rate of change in employment, whilst the unemployment rate is included to control business cycle effects upon worker power. The rate of change in employment is not estimated to have a significant effect upon the injury rate whilst a 1% increase in the unemployment rate is associated with a decline in accident rates of 0.2-0.3%. Fairris (1998) also estimates a negative relationship between unemployment and workplace injuries. Wooden (1990) and Fairris (1998) however do not control for changes in work intensity over the economic cycle. As such, the unemployment measure captures changes in work intensity leading to the estimation of a negative relationship between unemployment and industrial injuries.

Pooled time series/cross sectional analyses

2.9 Of the pooled time-series/cross sectional studies that consider the influence of the economic cycle upon injury rates, Currington (1986) estimates a significant positive relationship between the rate of new hires and compensated claims for workplace injures in New York State for the period 1964 to 1976. No significant relationship was estimated between average weekly hours worked by production workers and the rate of industrial injuries. Viscusi (1986) estimates a significant positive relationship between both the annual change in industry employment and average weekly overtime hours, and the rate of industrial accidents for 20 US manufacturing industries between 1973 and 1983. Lanoie (1992) fails to find a significant relationship between hours worked and the rate of workplace accidents within Quebec for the period 1983 to 1987. Barooah at al (1997) estimate a significant positive relationship between the level of unemployment and compensated claims for workplace injuries using Australian data. Also utilising Australian data, Wooden and Robertson (1997) estimate a significant positive relationship between the level of paid overtime and compensated claims. No significant relationship was found between occupational injuries and mean duration of employee tenure.

Evidence for Great Britain

2.10 Little British evidence exists as to the impact of the economic cycle upon the incidence of industrial injuries. Steele (1974) conducts an analysis on quarterly data of all accidents notified to H.M District Inspector of Factories for the period 1964 to 1971. Steele (1974) estimates a significant positive relationship between the number of hours of overtime worked and reported accidents. A significant negative relationship is estimated between an index of labour scarcity (vacancies/unemployment) and reported accidents. Steele (1974) suggests that as the scarcity of labour increases, the cost of replacing injured labour increases promoting safer behaviour on the part of employers. More recently, Nichols (1990) attempts to model the fatality rate in British manufacturing between 1960 and 1985. The fatality rate is taken to depend upon working hours, the engagement rate and the introduction of new (safer) capital equipment at the workplace. Estimates suggest that hours worked by operatives and the engagement rate are both positively related to the fatality rate, whilst the introduction of a lagged investment term is estimated to have a negative effect. Diagnostic tests however raise questions as to the robustness of statistical results.

C Industrial Injuries and Structural Characteristics

Trade Unions

2.11 The impact of trade union membership upon industrial injuries is ambiguous. Unions may improve workplace safety by offering a collective voice to workers and acting as a barrier against working practices. However, unions may increase the propensity of workers to report industrial injuries that do occur. The effect of unions upon the rate of industrial accidents is therefore indeterminate. Analyses by Currington (1986), Wooden (1990) and Wooden and Robertson (1997) all fail to establish a statistically significant relationship between the incidence of trade union membership and industrial injuries. Lanoie (1992) estimates a significant positive relationship between the rate of unionisation and industrial injuries. Utilising individual level data from the 1978 US Social Security Survey of Disability and Work, Worrall and Butler (1983) estimate that union members are 23% more likely to report having a health condition caused either by a job accident or bad working conditions.

2.12 Evidence as to the influence of unionisation upon industrial injuries is provided by Reilly, Paci and Holl (1994) and Nichols, Dennis and Guy (1995) who utilise firm level data from the 1990 British Workplace Industrial Relations Survey. Reilly et al (1994) estimate that the proportion of an establishments workforce who are union members has a positive, although statistically insignificant, effect upon the risk of workplace injuries as defined by establishment injury rate. Nichols et al (1995) estimate a statistically significant positive relationship between establishment injury rates and the proportion of employees within an establishment who were covered by negotiating groups.

2.13 A variety of empirical studies suggest that the potential beneficial effects of unions in reducing the incidence of industrial injuries is likely to be more than offset by unions increasing the propensity of workers to report industrial accidents. The picture is further complicated by the hypothesis of Beaumont and Harris (1993) that employees subject to high rates of injury have historically favoured membership of trade unions as a mechanism to try and reduce injuries. However, limited empirical evidence as to the potential beneficial effects of trade unions on workplace safety is provided by Barooah et al (1997) who estimate injury rate regressions for different categories of injury. The rate of unionisation was estimated to have a statistically significant negative effect upon the incidence of workplace fatalities, suggesting that unions improve safety at the workplace. However, the rate of trade union coverage was estimated to have a statistically significant positive effect upon compensation claims for non-severe accidents. This emphasises the importance of unions in enhancing the voice of injured workers who are still left with one.

Firm Characteristics

Size

2.14 Several multivariate analyses conducted on pooled time series/cross sectional data incorporate a measure of firm size as a control variable. Currington (1986) and Lanoie (1992) estimate that average industry firm size has a statistically significant negative impact upon the rate of industrial accidents. Wooden and Robertson (1997) and Barooah, Mangan and Hodges (1997) however fail to find evidence of a relationship between firm size and industrial accidents. Reilly, Paci and Holli (1994) and Nichols, Dennis and Guy (1995) utilising firm level data from the 1990 Workplace Industrial Relations Survey provide evidence for Britain. Reilly, Paci and Holl (1994) find a statistically significant inverse relationship between firm size and employee injury rates. They estimate that a 1% rise in an establishments' employment lowers injuries by, on average, 1.4 per 1000 employees. Nichols, Dennis and Guy (1995) estimate that accident rates are significantly lower in establishments with over 250 employees compared to those with less. Empirical evidence seems to support the view that larger establishments face economies of scale in accident prevention.

Capital intensity of the production process

2.15 We may expect to observe an inverse relationship between the capital intensity of the production process and the incidence of industrial accidents due to the increased costs of disruption and damage to machinery in capital intensive establishments. However, Currington (1986) and Lanoie (1992) both estimate a significant positive relationship between measures of the capital intensity of the production process and industrial injuries. Lanoie (1992) suggests that exposure to risk of industrial injuries increases as workers face greater contact with machinery.

Management practice systems

2.16 The implementation of mechanisms that enhance the voice of employees in health and safety matters is found to have an ambiguous effect upon the rate of industrial accidents. Barooah et al (1997) estimate a significant positive relationship between the appointment of health and safety officers by employers and the incidence of severe industrial injuries. However, no relationship was found to exist for fatalities and non-severe injuries. Wooden and Robertson (1997) estimate a positive, although insignificant, relationship between an index of employee involvement in decision making and the rate of compensation claims for industrial injuries. In contrast, Reilly et al (1994) estimate that the presence of consultation committees within British firms has a significant negative impact upon the incidence of workplace injuries. Those establishments with consultation committees exclusively for health and safety – and with all the employee representatives chosen by unions – have, on average, 5.7 fewer injuries per 1000 employees compared to establishments where management deals with health and safety issues without consultation. Where unions are not involved in such committees, their comparative advantage falls to 4.9 fewer injuries per 1000 workers.

Patterns of employment

2.17 Very little attention has been paid within multivariate analyses as to the influence of varying forms of employment and employment contracts upon the incidence of industrial injuries. These issues are considered by Wooden and Robertson (1997) who include variables to control for the incidence of part time and casual employment within an industry, the proportion of workplaces within an industry where a majority of non-managerial employees received some form of performance related pay and the proportion of employees who worked shifts. Only the incidence of shift work was found to exert a significant effect on the injury rate. A 10% higher share of shift-workers within total employment was associated with a 1.8% higher rate of injury claims.

Industrial Injuries and Government Policy

The generosity of compensation benefits

2.18 Currington (1986) finds a significant positive relationship between a replacement rate measuring the maximum weekly benefit for disability relative to the weekly industry wage and the incidence of industrial injuries. Lanoie (1992) estimates a significant positive relationship between the net wage replacement ratio obtained by a disabled worker in case of total temporary disability and industry injury rates. An increase of 1% in the net wage replacement ratio is associated with an increase of between 0.9 and 1.5% in the accident rate. Wooden (1990) estimates a significantly larger effect of benefit compensation levels upon injury rates. A 1% rise in the rate at which compensation benefits replace wage income is estimated to lead to a 3.3% rise in the frequency of work accidents. Empirical evidence therefore suggests that the availability of compensation benefits reduces the incentive of workers to avoid unsafe behaviour and/or provides incentives for workers to make fraudulent claims or to report injuries which they would not have otherwise.

Prevention policies

2.19 Viscusi (1986) estimates the impact of the American Occupational Safety and Health Administration in reducing workplace injuries for the period 1973 to 1983. Two aspects of OSHA's enforcement effort are considered; the annual frequency of OSHA inspections and the level of assessed penalties within an industry. Estimates fail to find a significant relationship between the level of assessed penalties within an industry and the industry injury rate. However, the injury rate was positively related to the level of OSHA inspections undertaken in the current year and negatively related to the level of OSHA inspections undertaken in the previous year. This pattern can be explained by the prioritisation of inspections within more hazardous injuries and the delay in response of firms to the level of inspections in their industry. OSHA inspections were estimated to only have a minimal effect upon the injury rate. However, inspections were estimated to reduce the total lost workdays injury rate by an average of 5%. Viscusi (1986) suggests these results indicate that inspections had the largest effect upon the incidence of long duration injuries.

2.20 Lanoie (1992) presents similar findings in a study of the effectiveness of the Canadian Board of Occupational Safety and Health. Whilst penalties imposed for infractions were not found to have a significant effect upon the injury rate, the industry inspection rate was found to have a significant negative effect upon the injury rate. In line with the earlier American study by Viscusi (1986), enforcement policies are only found to have a minor effect upon workplace safety. Lanoie (1992) estimates that an increase in the inspection rate of 1% leads to a decline in the industry injury rate of between 0.2 and 0.3%. Lanoie (1992) also estimates that the experience rating which sets the level of insurance premiums for firms, and are partially related to the claims experience of firms, do not have a significant effect upon the incidence of workplace injuries.

Individual Characteristics

2.21 As noted earlier, a variety of explanatory variables to control for worker characteristics are included in multivariate analyses of aggregate injury data to control for unobserved differences in exposure to work hazards. To briefly outline results that are common to many studies, the incidence of workplace injuries is typically found to be negatively related to the proportion of workers who are female, the average age of the workforce and the educational attainment of the workforce. Injury rates are typically positively related to the proportion of production workers in an industry.

2.22 McKnight and Elias (1998) provide a detailed analysis of how the characteristics of individuals and their jobs contribute towards the risk of an industrial injury. Utilising multivariate logistic regression techniques on individual level data from the Labour Force Survey, McKnight and Elias (1998) estimate that:

- males have a 20% higher risk of workplace injuries than females;
- workers aged 16 to 24 have over a 20% higher risk of injury than older workers;
- the relative risk of injury declines with tenure;
- workers with intermediate and low level qualifications face a higher risk of workplace injury relative to those with high level qualifications and no qualifications;
- the risk of workplace injury increases with the length of hours usually worked;
- the permanency of employment contract has no effect upon the relative risk of injury;
- private sector workers have a 20% lower risk of workplace injury than public sector workers;
- the relative risk of workplace injury varies between occupations, most notably workers employed in metal and vehicle trades have nearly a 500% higher risk of workplace injury than clerical workers.

D Concluding Comments

2.23 The above review indicates that a variety of empirical studies utilising establishment, individual and aggregate level data have been conducted to analyse the determinants of industrial injuries. The emphasis of these studies varies. Empirical analyse have focused upon the generosity of compensation benefits, the influence of trade unions and the incidence of industrial injuries over the economic cycle. However, whilst the emphasis of these multivariate analyses varies, there is a high degree of uniformity in the choice of control variables included.

2.24 The empirical methodology employed does however vary between countries. Multivariate analyses that utilise aggregate time series data tend to focus upon Australia and the US. This can probably be attributed to the presence of insurance based compensation schemes in these countries and hence the greater availability of consistent aggregate injury data. Recent research within Britain has been limited to the cross sectional analysis of firm level data (e.g. Reilly, Paci and Holl, 1994, Nichols, Dennis and Guy 1995), or the cross sectional analysis of individual level data (McKnight and Elias, 1998).

2.25 What emerges from this review of the empirical literature is a lack of British evidence that utilises aggregate injury data. Aggregate industrial injury data is collected for Britain through reports made under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR). The utilisation of this data within a multivariate empirical analysis faces difficulties in terms of the length of time series available as a result of inconsistencies introduced as a result of changes in reporting definitions. However, there is a clear need to undertake empirical analysis of this data in order to develop a more "complete" body of empirical evidence for Great Britain. Such an analysis needs to consider the influence of the economic cycle upon industrial injuries and how structural differences between the regions may explain geographical variations in workplace accidents.

3 CONSTRUCTION OF AGGREGATE INJURY DATA

Introduction

This chapter describes the construction of the aggregate injury data files that will provide the basis for subsequent analysis of temporal and national variations in reported workplace injuries. Section A provides a brief outline of the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) and the collation of workplace injury data by the Health and Safety Executive. Section B outlines the construction of the aggregate data files. Exploratory analysis of the aggregate injury data is undertaken in Section C, incorporating simple descriptive statistics and graphical analysis of the aggregate time series.

A Workplace Injury Data

3.1 The study utilises workplace injury data collected by the Health and Safety Executive (HSE) for the period 1986/7 to 1997/8. The source of the data are reports made to enforcing authorities under the Reporting of Injuries, Diseases, and Dangerous Occurrences Regulations (RIDDOR). There is a degree of discontinuity in injury data before and after April 1996. Data collected prior to April 1996 is based upon the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1985 (RIDDOR 85). These reporting regulations were replaced by the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR 95) which came into force from April 1996. Under the new reporting regulations, the definitions of fatal, major and over-3-day injuries were expanded[2].

3.2 Work undertaken by HSE indicates that the introduction of RIDDOR 95 resulted in substantial changes in the published numbers of workplace injuries. The expansion of the major injury definition was estimated to account for approximately 70% of the increase in major injuries between 1995/6 and 1996/7, and to have had a depressing effect upon the incidence of over-3-day injuries. Due to recording definitions utilised, it is not possible to identify all new injuries reported under RIDDOR 95, or major injuries which would have been categorised as over-3-day injuries under RIDDOR 85.

3.3 The duty to report workplace injuries lies with 'responsible persons'. Under current reporting regulations, employers are responsible for reporting workplace accidents where employees or self employed subcontractors are killed or sustain a major injury or injuries that result in an absence from normal work of more than three days. Employers must also report accidents where a member of the public is killed or requires hospital attention as a result of operations under the control of an employer. The self-employed are also

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2 Details of injuries that became reportable under RIDDOR 95 are provided in appendix 1.

required to report injuries that occurred whilst working on their own premises[3].

3.4 Workplace injuries are notified either to the Field Operations Division / Directorate and Chemical and Hazardous Installations Division (FOD), or to Local Authorities (LA) depending upon the industrial sector in which the accident occurred. The Field Operations Division covers a variety of sectors including construction, agriculture, general manufacturing, education, health, local government, fire and police. There are six principal Local Authority enforced industries: retail, wholesale, hotel and catering, residential care homes and the consumer leisure industry. Workplace injury data collated by the Operations Unit of the HSE is held on three separate databases. The content of these is outlined below:

SHIELD: Major and over-3-day injuries reported to FOD from 1986/7 to 1995/6.
Fatal, major and over-3-day injuries reported to Local Authorities from 1986/7 to 1995/6.

COFFIN: Fatal injuries reported to FOD from 1986/7 to 1995/6.

RAID: Fatal, major and over-3-day injuries reported to FOD and Local Authorities from 1996/7 to 1997/8.

3.5 Workplace injury data is held in the form of individual accident records. Information contained in these records includes a unique case identifier, the date of the accident, the sex and age of the injured person, the severity of the injury, information on the type and site of the injury, industrial sector, geographical location and the number of employees at the workplace. This information enables the construction of aggregate time series of workplace injuries, facilitating the analysis of temporal and geographical variations in workplace injuries.

B Construction of Aggregate Injury Data Files

3.6 Two files of aggregated time series injury data have been created. The first consists of a monthly time series of aggregate injury data. The second file consists of a quarterly time series of aggregate injury data. The quarterly file matches the date of occurrence with quarterly definitions utilised within the Labour Force Survey: Spring (March to May), Summer (June to August), Autumn (September to November) and Winter (December to February). The aggregation of injury data by the quarterly definitions utilised by the Labour Force Survey reflects the temporal availability of information from this source that may explain national and cyclical variations in injury rates.

3.7 Within each of the files, the aggregate injury data has been broken down by gender, age, type of accident (fatal, major and over-3-day), geographical

3 See Health and Safety Statistics 1997/8 for a complete list of current injury definitions.

location, industrial classification, and size of establishment. An overview of the contents of the aggregate data files is provided in table 3.1. Given the different methods of recording the geographical location, industrial sector and size of establishment between the SHIELD, COFFIN and RAID databases, the creation of these aggregate categories warrants further discussion.

Table 3.1: Overview of Aggregate Data Files

Date of Accident	**Monthly** **Quarterly (LFS Quarters)**
Count	number of accidents
Categories	
Sex	male, female
Age	7 age bands
Type of accident	fatal, major, over-3-day
Industry	17 industry groups
	6 industry sectors
Geographical location	11 standard regions
Size of firm	7 employee total bands

Geographical location

3.8 All injuries reported to Local Authorities under RIDDOR 85 and major and over-3-day injuries reported to FOD under RIDDOR 85 (i.e. injuries recorded within the SHIELD database) are coded according to the Local Authority structure that existed prior to reorganisation in 1995/96. Fatal injuries reported to FOD under RIDDOR 85 (i.e. injuries recorded within the COFFIN database) are allocated county codes. All injuries reported under RIDDOR 95 (i.e. injuries recorded within the RAID database) are coded according to the 1997/98 local authority structure.

3.9 To achieve continuity in geographical coding, injuries were re-coded to the 11 Standard Regions: South East, East Anglia, London, South West, West Midlands, East Midlands, Yorkshire & Humberside, North West, Northern, Wales and Scotland. This level of aggregation avoids the problem of Local Authority boundaries straddling county boundaries that occurred within Wales and Scotland after changes made to the Local Authority structure mentioned above. These districts also reflect the availability of regional data within the Labour Force Survey that may potentially be used to explain geographical variations in injury rates.

Industrial sector

3.10 All injuries reported under RIDDOR 85 were coded according to the 4 digit SIC80 Standard Industrial Classification until 1994/95. Injuries reported under RIDDOR 95 in 1995/96 were coded according to the SIC92 Standard Industrial Classification at the 4 digit level. All injuries reported under RIDDOR 95 have been coded according to SIC92 Standard Industrial Classification of Economic Activities at the 5 digit level.

3.11 To aggregate the injury data by a classification of economic activity that is consistent between the 1980 and 1992 Standard Industrial Classifications, injuries were initially re-coded to a consistent classification of 50 industries. The industrial classification used is based on the results of a conversion process using data published with the 1993 Census of Employment. Data for 1991 was re-classified under both 1980 and 1992 Standard Industrial Classifications so enabling a detailed cross-classification. The 50 industry codes were then coded to the 17 'Industry Groups' and 6 'Industry Sectors' as defined in appendix 2 for inclusion within the aggregate files.

Firm size

3.12 Information on the number of employees at an establishment is recorded for all injuries reported under RIDDOR 85 and RIDDOR 95 to FOD (i.e. information on establishment size is not collected for industrial injuries reported to Local Authorities). For fatalities reported to FOD from 1986/7 to 1995/6 (injuries recorded within the COFFIN database), information on establishment size is recorded as a letter representing a size band. For major and over-3-day injuries reported to FOD between 1986/7 and 1995/6 under RIDDOR 85 (i.e. injuries recorded within the SHIELD database) and all injuries reported to FOD under RIDDOR 95 (i.e. injuries recorded within the RAID database), establishment size is recorded as a numeric value.

3.13 To enable the aggregation of injury data by a consistent measure of establishment size, injuries were initially re-coded to the employee size bands measure utilised within the COFFIN database. These 19 size band codes were then combined to produce 8 codes of larger bandwidth for inclusion into the aggregate data files.

C Exploratory Analysis of Aggregate Injury Data

Descriptive statistics

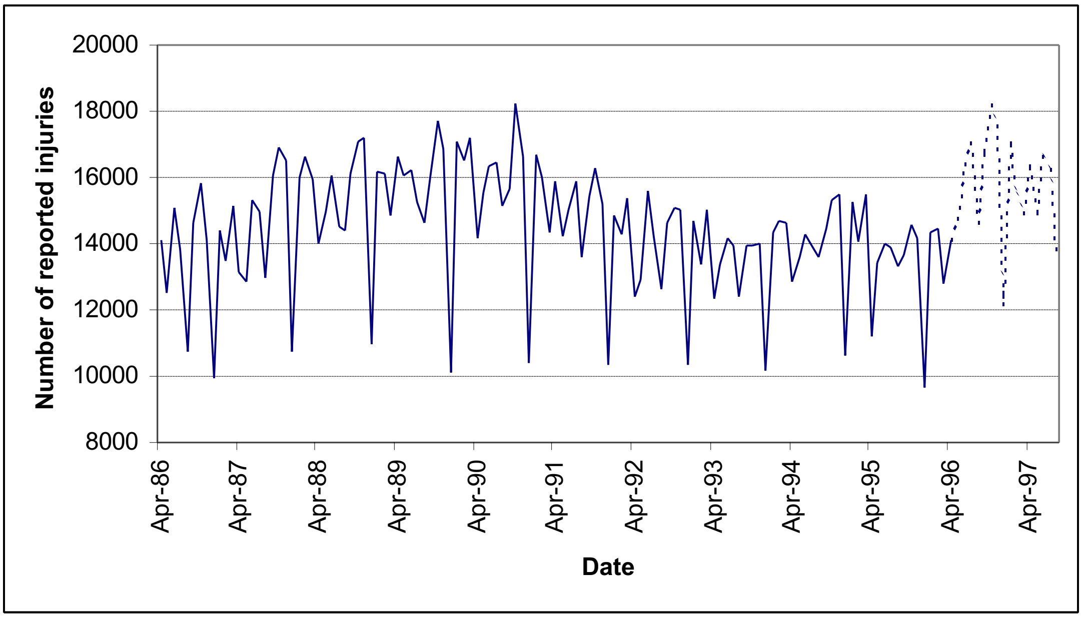
3.14 Descriptive statistics for the 2 aggregate data files are provided in table 3.2. Data was available from 1st April 1986 to the 31st August 1997. The monthly time series therefore contains aggregated injury data for 137 months. The quarterly time series contains aggregated injury data for 45 'complete' quarters from Summer 1986 to Summer 1997 based on LFS definitions. Summary statistics are provided for the total number of workplace injuries and for the three categories of accident severity (i.e. fatalities, major, over-3-day). It can be seen that approximately 14,600 workplace injuries are reported under RIDDOR per month. On average, 80.3% of all workplace injuries are defined as over-3-day injuries, 19.5% are defined as major injuries and 0.2% are fatalities.

Table 3.2: Descriptive Statistics for Aggregate Injury Data

Aggregate series	Injury definition	Obs	Mean	Minimum	Maximum
Monthly					
	All	137	14595.34	9659	18237
	Fatalities	137	33.74	12	139
	Major	137	2844.36	1588	6093
	Over-3-day	137	11717.23	7441	15384
Quarterly[1] (LFS)					
	All	45	43843.96	37823	52496
	Fatalities	45	101.33	62	212
	Major	45	8553.04	29938	42284
	Over-3-day	45	35189.58	6650	17887

Notes:
1. LFS quarterly definition: Spr (Mar-May), Sum (Jun-Aug), Aut (Sep-Nov), Win (Dec-Feb).

Figure 3.1: Monthly Time Series of Aggregate Injury Data



Time series of aggregate injury data

3.15 Figure 3.1 provides a plot of monthly aggregate injury data for the period April 1986 to August 1997. The time series plots refer to all categories of injury reported under RIDDOR (i.e. fatalities, major and over-3-day injuries. Figure 3.1 indicates the presence of a clear cyclical pattern in the number of industrial injuries reported under RIDDOR. The number of accidents reported per month shows a general increase from April 1986 until October 1990, when the monthly total peaked at 18,237 workplace accidents reported. The monthly total then shows a general decline, reaching a low of 9659 in December 1995. The number of workplace injuries reported per month show an increase following the introduction of RIDDOR 95 in April 1996 and the subsequent expansion of injury definitions (period covered by the dashed line). Within the cyclical pattern observed in figure 3.1, seasonal variations can also be identified. The lowest number of workplace injuries notified to HSE consistently occurs during December. The highest numbers of industrial injuries are generally reported during October.

Analyses of aggregate injury data by personal and workplace characteristics

3.16 The likelihood of an individual suffering a workplace injury will depend upon the level of exposure to workplace hazards. This exposure will depend upon a variety of personal and workplace characteristics. Tables 3.3 to 3.7 provide information on the average number of workplace injuries reported per month by a number of personal and workplace characteristics as recorded in the accident records held by HSE.

3.17 The tables refer to aggregate injury data rather than injury rates. It is therefore not possible to make inferences regarding the relative risks of suffering a workplace injury between the different categories considered. However, the tables provide a useful insight as to the characteristics of individuals who suffer workplace injuries and of the workplaces in which these occur over the study period. The tables also provide information on the completeness with which information on these personal and workplace characteristics is collected over the study period.

3.18 The tables provide the following insights:

- three quarters of workplace injuries are incurred by males;
- approximately one quarter of workplace injuries are incurred by people between the ages of 25 to 34 and decline with age thereafter;
- the incidence of industrial injuries varies between regions with the highest number of workplace injuries occurring within the North West and South East;
- approximately 30% of reported workplace injuries are incurred both within the manufacturing and non-marketed services sectors. Reported injuries are lowest within the primary sector and business and miscellaneous services;
- the highest number of workplace injuries are reported in firms with less than 20 employees and between 100 and 499 employees;
- the completeness of data varies across categories. The number of missing cases is low for gender and industrial sector. Missing cases are highest for firm size as this information is not collected for injuries reported to local authorities.

Table 3.3: Average Monthly Workplace Injuries by Gender

	Mean	Percentage
Male	10905	75%
Female	3652	25%
Missing Cases	38	0%
Number of accidents	14595	100%

Table 3.4: Average Monthly Workplace Injuries by Age Group

	Mean	Percentage
0-15 yrs	818	6%
16-24 yrs	2227	15%
25-34 yrs	3336	23%
35-44 yrs	2924	20%
45-54 yrs	2581	18%
55-64 yrs	1454	10%
65+ yrs	255	2%
Missing Cases	1001	7%
Number of accidents	14595	100%

Table 3.5: Average Monthly Workplace Injuries by Region

	Mean	Percentage
South East	2066	14%
East Anglia	549	4%
London	1288	9%
South West	1044	7%
West Midlands	1445	10%
East Midlands	1203	8%
Yorkshire and Humberside	1651	11%
North West	2024	14%
Northern	1130	8%
Wales	777	5%
Scotland	1419	10%
Missing Cases	433	3%
Number of Accidents	14595	100%

Table 3.6: Average Monthly Workplace Injuries by Industrial Sector

	Mean	Percentage
Primary Sector and Utilities	598	4%
Manufacturing	4694	32%
Construction	1491	10%
Distribution, Transport	2667	18%
Business and Miscellaneous Services	746	5%
Non-Marketed Services	4265	29%
Missing Cases	134	1%
Number of Accidents	14595	100%

Table 3.7: Average Monthly Workplace Injuries by Size of Workplace

	Mean	Percentage
1 to 19	2192	15%
20 to 49	1192	8%
50 to 99	1150	8%
100 to 499	3042	21%
500 to 999	1149	8%
1000 to 4999	1277	9%
5000 or more	214	1%
Missing Cases	4378	30%
Number of Accidents	14595	100%

4 MODELLING GEOGRAPHICAL AND TEMPORAL VARIATIONS IN INDUSTRIAL INJURIES USING RIDDOR DATA

Introduction

Graphical analysis of aggregated RIDDOR injury data revealed the presence of cyclical and seasonal variations in the incidence of workplace injuries. Further analysis of the data revealed further variations in the incidence of reported workplace accidents by gender, age, firm size and industrial sector. This preliminary examination of the RIDDOR data highlights the need for a more detailed examination of factors that determine temporal and geographical variations in the incidence of industrial injuries within Great Britain.

This brief chapter provides a discussion of how the modelling of temporal and geographical variations in the incidence of industrial injuries can be practically addressed. Section A considers issues surrounding the modelling of temporal variations in workplace injuries. Section B considers the analysis of geographical variations in workplace injuries. Finally, section C provides a specification of the modelling strategy to be followed.

A Modelling Time Series Variations in Industrial Injuries

4.1 Drawing upon the early analysis of Kossoris (1938), workplace injuries may be expected to move pro-cyclically due to changes in the average experience of the workforce and in the level of work intensity over the economic cycle. The influence of the economic cycle upon workplace injuries has accordingly been considered within empirical analyses through the inclusion of variables that attempt to control for the level of work experience and work intensity. Such variables include the rate of change in employment (used as a proxy for the accession rate), mean duration of tenure, average hours worked per week and measures of productivity.

4.2 Other authors have however considered the possibility of workplace injury rates moving counter-cyclically over the course of the economic cycle. Steele (1974) and Nichols (1986) provide two different explanations of how variations in labour scarcity over the economic cycle may lead to a counter-cyclical pattern. Steele (1974) suggests that as the scarcity of labour increases, the cost of replacing injured labour increases promoting safer behaviour on the part of employers. Nichols (1986) suggests that the balance of power between capital and labour moves in favour of labour during periods of economic expansion. During such periods, labour is better able to resist the introduction of unsafe work practices or work intensification measures by management. However, labour scarcity could also have a pro-cyclical impact upon the incidence of workplace accidents. During periods of high unemployment, those in work will be more fearful of losing their jobs. This may promote safer behaviour on the part of those in employment.

4.3 To empirically model movements in injury rates over the economic cycle, it is therefore desirable to control for changes in employee tenure, work intensity and labour scarcity. It is hypothesised that employment tenure and work intensity effects will lead to a pro-cyclical movement in workplace injury rates. Depending upon the behavioural responses of employees and employers to market conditions, labour scarcity may have a positive or negative influence upon the rate of workplace injuries. The omission of any of these factors from an empirical model may lead to specification errors and biased estimates of coefficients. The results of empirical studies that have considered the influences of the economic cycle upon the rate of workplace accidents are outlined in table 4.1. A fuller description of these empirical analyses is provided in Chapter 2.

4.6 The omission of relevant explanatory variables may be a factor in explaining some inconsistencies that emerge between the results of previous empirical analyses. Steele (1974) and Robinson (1988) estimate a significant positive relationship between labour scarcity and the incidence of workplace injuries. These studies both incorporate variables that attempt to control for changes in the level of work intensity over the economic cycle. Wooden (1989) and Fairris (1998) both estimate a negative relationship between labour scarcity and the industrial injury rate. This inconsistency may be explained by the absence of variables that control for the level of work intensity within these analyses. The unemployment rate within these studies may be capturing the effects of changes in the level of work intensity over the economic cycle. This could dominate any offsetting positive influence of labour scarcity upon the incidence of industrial injuries.

Table 4.1: The Economic Cycle and Workplace Injuries: Previous Findings[1]

Study	*Experience*	*Intensity*	*Labour Scarcity*
Steele (1974)		Overtime (+)	Vacancy : Unemployment Ratio (-)
Robinson (1988)	Recruitment Rate (+)	Productivity (+)	Unemployment (+)
Wooden (1989)	Change in Employment (?)		Unemployment (-)
Fairris (1998)			Unemployment (-)
Currington (1986)	Recruitment Rate (+)	Hours (?)	
Viscusi (1986)	Change in Employment (+)	Overtime (+)	
Lanoie (1992)		Overtime (?)	
Barroah et al (1997)			Unemployment (+)
Wooden and Robertson (1997)	Tenure (?)	Overtime (+)	

Notes:
1. +/-/? refers to the estimation of a statistically significant positive/negative/insignificant relationship.

4.7 Only the analysis of Robinson (1998) attempts to simultaneously control for the effects of experience, work intensity and labour scarcity. However, the utilisation of a recruitment rate or measure of change in employment as proxy for the experience of the workforce is not appropriate for these analyses. The inclusion of such variables is justified on the basis that as employment increases, the average experience of the workforce declines and injury rates should increase. However, all of the above studies estimate injury rate equations in levels, rather than in a dynamic form. In a dynamic specification, employment growth may be correlated with an increase in injury rates from one period to the next. However, when analysing injury rates in levels rather than differences, employment growth may not be correlated with high rates of industrial injuries. For example, employment growth is zero during both a peak and a trough in employment. Zero employment growth could therefore be associated with high and low rates of workplace injuries.

B Modelling National Variations in Industrial Injuries

4.8 Analysis of the aggregate injury data indicates that variations exist in the incidence of industrial injuries by sex, age, firm size and industrial sector. In modelling geographical variations in injury rates, the aim is to determine the extent to which the observed differences in injury rates can be explained by structural differences between the regions. The analysis will focus upon:

- industrial composition of employment;
- occupational structure;
- personal characteristics of those in employment (including education, age, gender, ethnicity);
- workplace characteristics (including size of workplace, provision of job related training);
- the incidence of atypical employment (including part time employment, temporary employment).

4.9 Previous econometric analyses of aggregate injury data typically estimate a pooled time series cross sectional model with the cross sectional unit of analysis defined by industrial sector (see Chapter 2 for a discussion of empirical methodologies). A similar approach will be employed in the analysis of national variations in injuries reported under RIDDOR. However, unlike previous empirical analyses, the cross sectional unit of analysis will be defined by region instead of the industrial sector of employment. Injury data within the aggregate files is broken down into the 11 Standard Regions, incorporating Scotland and Wales. These 11 geographical areas correspond to the availability of regional level data within the Labour Force Survey. This will act as the primary source of information for structural differences between the regions that may be expected to contribute to variations in the incidence of industrial injuries.

C Specification of an Injury Rate Model

Specification of the Dependent Variable

4.10 The dependent variable for the subsequent empirical analysis will be the logistic transformation of the injury rate odds ratio during a time period t. The logistic transformation of the injury rate ($logIR_t$) can be expressed as:

$$logIR_t = \ln (IR_t/(1- IR_t)$$

4.11 The quantity $IR_t/(1- IR_t)$ is the odds ratio of the injury rate. This equals the probability of an individual experiencing a workplace injury, divided by the probability of not experiencing a workplace injury. The workplace injury rate is modelled in this way so as to ensure that estimates of employee injury rates provided by the model can only take values of between 0 and 1[4]. This restriction upon the dependent variable is valid if it is assumed that the chance of multiple accidents for a particular worker is small and that injury rates cannot take negative values.

Specification of Injury Rate Equation

4.12 The first stage of the modelling process will be to estimate a general injury rate equation utilising aggregate data for Great Britain. The logistic transformation of the injury rate odds ratio will be modelled as a function of variables to control for the effects of the economic cycle, a seasonality term, time and a stochastic disturbance term. The general form of the injury rate equation is given by:

$$1. \qquad logIR_t = \sum \beta_i X_t + \Pi t + \alpha S_t + \mu_t$$

4.13 Where $\sum \beta_i X_t$ represents the inclusion of chosen economic indicators X, Πt represents a deterministic linear time trend and αS_t represents a vector of seasonal adjustment factors. The aim of this stage of the econometric analysis is to estimate an econometric equation that most effectively models the cyclical and seasonal elements noted in these time series.

4.14 The second stage of the modelling procedure is the specification and estimation of a general model that will attempt to control for both temporal and regional variations in injury rates. The general form of the regional injury rate equation to be estimated using the pooled time series/cross sectional data is given by:

$$2. \qquad logIR_{kt} = \sum \beta_i X_t + \delta Z_{kt} + \Pi t + \alpha S_t + \mu_t$$

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[4] The logistic transformation of the injury rate avoids the unboundedness problem. As IR_t tends towards 1 (an injury rate of 100%), the log odds ratio tends towards infinity. Similarly, as IR_t tends towards zero (an injury rate of 0%), the log odds ratio tends towards minus infinity. Therefore, modelling in terms of the log odds ratio ensures that derived estimates of workplace injury rates are bound between 0 and 1.

4.15 where $logIR_{kt}$ is the logistic transformation of the injury rate odds ratio in region k at time t and Z_{kt} is a vector of n regional control variables. The vector of explanatory variables Z will contain variables to control for structural differences between the regions. The statistical performance of this final specification utilising the regional injury data will enable an evaluation of the validity of including the vector of external factor variables Z to explain regional variations in injury rates. The initial stage of the modelling procedure is therefore the specification and construction of an injury rate time series for Great Britain and an injury rate time series of pooled regional data. These issues are considered in the following chapter.

5 CONSTRUCTION OF THE INJURY RATE TIME SERIES

Introduction

Graphical analysis identified both cyclical and seasonal variations in the incidence of workplace injuries reported under RIDDOR. Simple statistical analysis indicates that further variations exist in the incidence of industrial injuries by gender, age, firm size, industrial sector and region. However, such temporal and structural variations in the reporting of workplace accidents may simply reflect variations in the size of the population at risk over time, between regions or across the other categories identified.

To consider whether the risk of workplace accidents varies over time or between regions, it is necessary to calculate an injury rate by deflating the aggregate injury data by an appropriate employment base. This chapter outlines the construction of the injury rate time series that will form the basis of subsequent econometric analysis. Section A describes the employment base utilised in the construction of the injury rate time series. Section B outlines the specifications of the injury rate series. Exploratory data analysis of the injury rate time series is provided in section C.

A Development of an Employment Base

5.1 Construction of the injury rate time series requires an appropriate employment base that is available for the time period covered by the aggregate injury data files. The employment base must also be available at a geographical level consistent with the regional definitions utilised in the aggregate injury data files to enable the construction of regional injury rates. The employment bases utilised in the present analysis are taken from the *Estimates of Workforce in Employment* data series. This series is derived from the Census of Employment and provides quarterly estimates of the civilian workforce in employment. The civilian workforce in employment includes people aged 16 or over who are in employment, whether as an employee, self-employed or on work-related government training programmes. Separate employment estimates are available for these three categories.

5.2 The *Estimates of Workforce in Employment* data series is however only available quarterly, estimates being provided for March, June, September and December. In order to provide an employment base from which to calculate a monthly time series of injury rates, it is assumed that the quarterly point estimate also applies to adjacent months. For example, the point estimate for March provides an employment base for February, March and April. Injury rates for February, March and April are therefore calculated by dividing aggregate injury data for each of these months by the employment base for March. Constructing the employment base in this way faces the disadvantage of a step shift in the denominator of the injury rate every three months. However as rate changes are typically driven by movements in the numerator, such a construction of the employment base should not lead to shifts in the injury rate at three monthly intervals.

5.3 The monthly employment series created in this manner are then used to calculate an employment base for the quarterly injury data. The quarterly definitions utilised in the *Estimates of Workforce in Employment* differ to those used in the Labour Force Survey. The value of the employment base for a given quarter is therefore estimated as the mean value of the monthly employment base for the three months during that quarter. For example, the employment base for the summer quarter based on the Labour Force Survey definition is calculated as the mean value of the employment base for the months June, July and August.

Table 5.1: Mean Values of Monthly Employment Base Estimates

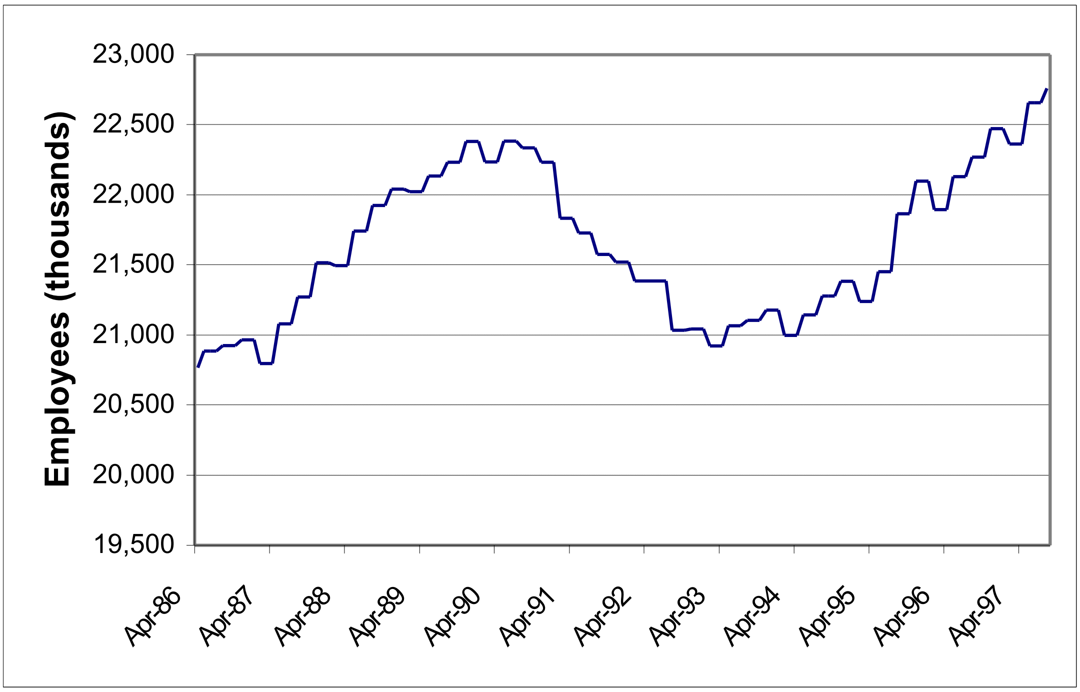
	Male	Female	All
All			
Employees	11,250,000 (52%)	10,387,000 (48%)	21,638,000
Workforce	14,020,000 (55%)	11,410,000 (45%)	25,430,000
1987[1]			
Employees	11,463,000 (54%)	9,656,000 (46%)	21,120,000
Workforce	14,043,000 (57%)	10,635,000 (43%)	24,678,000
1996[1]			
Employees	11,132,000 (50%)	11,028,000 (50%)	22,159,000
Workforce	13,842,000 (54%)	12,024,000 (46%)	25,866,000

Source: Estimates of Workforce in Employment

1. 1987 and 1996 correspond to the first and last years covered by the analysis for which 12 months of injury data is available.

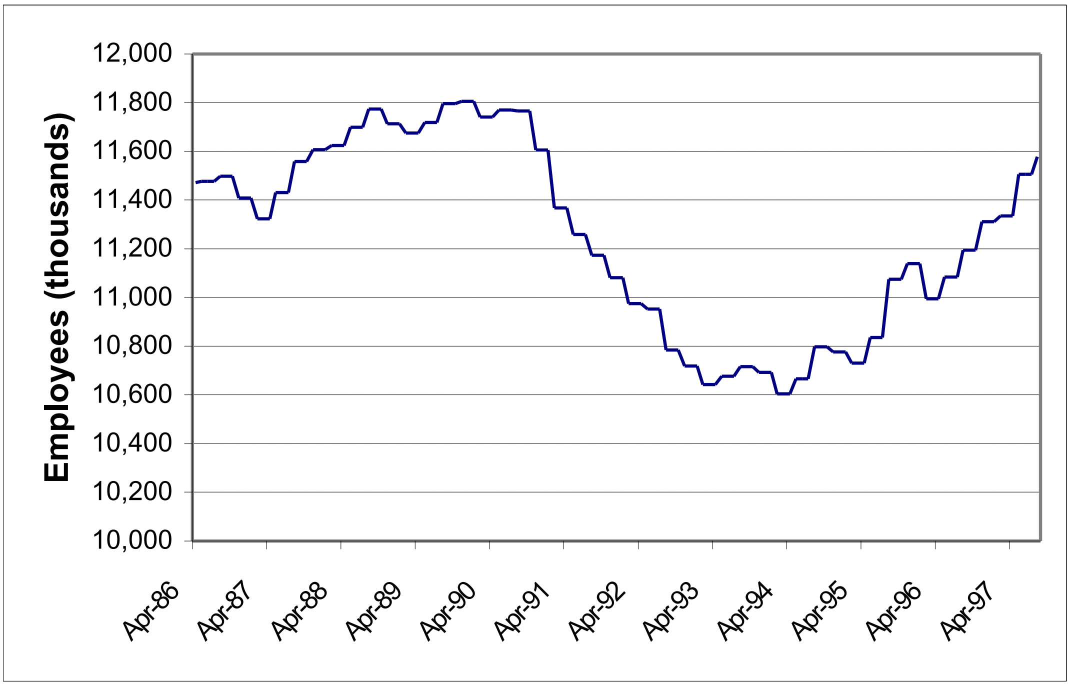
5.4 Table 5.1 provides mean values of monthly employment base estimates for Great Britain over the study period. The average size of the civilian workforce in employment is approximately 25.4 million over the study period. The average number of employees in employment is approximately 21.6 million. Males constitute 55% of the workforce and 52% of employees in employment over the study period. However, there is a movement in the gender composition of employment during the period of analysis. In 1987, 46% of those in employment were female. By 1996, females accounted for half of all employees in employment. Similarly in 1987, 43% of the workforce in employment were female. By 1996, 46% of the workforce in employment were female.

Figure 5.1: Employees in Employment



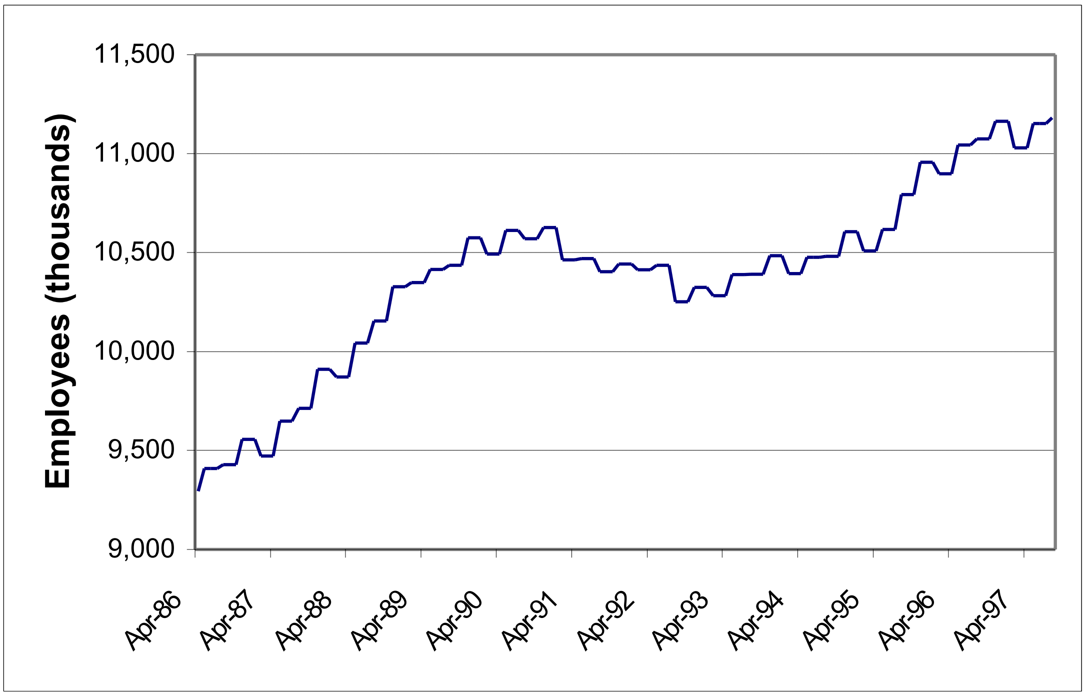
Source: Estimates of Workforce in Employment

Figure 5.2: Male Employees in Employment



Source: Estimates of Workforce in Employment

Figure 5.3: Female Employees in Employment



Source: Estimates of Workforce in Employment

5.5 The movement in employment during the study period is shown in figures 5.1, 5.2 and 5.3. Figure 5.1 considers all employees in employment. From April 1986, employment rises to a peak of 22.4 million during June 1990 and then contracts to a low of 20.9 million during March 1993. Employment then increases for the remainder of the study period. A similar pattern is exhibited for male employment, as shown in figure 5.2. Male employment rises to a peak of 11.8 million in December 1989 and then declines to a low of 10.6 million in March 1995. It is not possible to identify a trend in male employment over the study period. This is in contrast to the situation for female employment presented in figure 5.3. A cyclical pattern is observed, with female employment increasing to a peak of 10.6 million in December 1990 and then declining to a low of 10.3 million in September 1992. This cyclical pattern is however dominated by an upward trend in female employment during the study period.

B Specification of Workplace Injury Rates

Workforce and Employee Injury Rates

5.6 Within each of the aggregate injury data files, the data has been broken down by the employment status of the injured person. Information is recorded as to whether the injured person was an employee, self-employed, a trainee or other. The other category incorporates members of the public or persons injured in the course of their work but who were employed by somebody other than the person responsible for reporting the accident. The ability to breakdown the aggregate injury data and *Estimates of Workforce in Employment* by employment status enables the specification of two injury rate definitions;

(a) the number of industrial injuries to employees per 100,000 employees,

(b) the number of industrial injuries to the civilian workforce in employment per 100, 000 workers.

5.7 The performance of these injury rate measures will vary in terms of their completeness of coverage. Work undertaken by the Government Statistical Service on behalf of the Health and Safety Executive suggests that in 1995/6, employers only reported approximately 40% of non fatal injuries to employees that they should have reported under RIDDOR. The position is worse for self-employed people where reporting levels are estimated to be less than 10%. The employee injury rate will therefore be more complete in its coverage compared to the workforce injury rate, which includes the self-employed.

Full Time Equivalent Injury Rates

5.8 The shift to a more flexible labour market over recent years means that a simple count of the number of people in employment is a less satisfactory indicator of the amount of work done in the economy. It is clear that there has been a rise in part time working, but variations in working patterns among both full and part time workers cloud the picture both of levels and trends in the use of labour. In terms of the calculation of an injury rate time series, the increasing incidence of part time employment may lead to an increase in the employment base over time, and hence have a depressing effect upon the employee injury rate. However, the exposure to risk in terms of work done may remain unchanged (e.g. a full time job may be replaced by two part time jobs).

5.9 A different way to measure labour inputs is required. The total number of hours worked is less likely to be affected by changes in the pattern of work. Where, for example, full time employees have been replaced by more part time workers, the number of employees will have risen and the average number of hours worked will have fallen. However, the total hours figure will indicate whether or not more work is being undertaken. By dividing total hours worked for a given period by the number of hours worked by a full time employee, the employment base can be represented in terms of "full time equivalents". Such a specification of the employment base can control for differences in the patterns of work between males and females and changes in the pattern of employment over time.

5.10 Information from the Labour Force Survey has been utilised to estimate full time equivalent adjustment factors. The Labour Force Survey collects information on the number of people in employment and the average weekly hours of work for those in employment. This information is provided by full time/part time status and is available annually from Spring 1984 to Spring 1992, and quarterly thereafter. Using this information it is possible to calculate a weighted average of the number of hours worked by an employee in employment.

5.11 The calculation of full time equivalent adjustment factors for employees in employment is outlined in table 5.2. The average number of hours worked by male, female and all employees are shown in columns 2 to 4. The number of hours worked by an average full time employee is shown in column 5. The adjustment factors are calculated by dividing the average number of hours worked by the average number of hours worked by full time employees. These factors are then applied to the employment base to provide employment estimates for males and females based on full time equivalents. As the Labour Force Survey was only conducted annually between Spring 1984 and Spring 1992, annual adjustment factors are applied to monthly and quarterly employment base estimates for the study period.

Table 5.2: Employment Base Full Time Equivalent Adjustment Factors

	Average Hours			Average Full	Adjustment Factors		
Year	All	Male	Female	Time Hours	All	Male	Female
1986	33.1	38.6	26.2	37.9	0.8722	1.0185	0.6919
1987	32.7	38.4	25.7	37.7	0.8676	1.0196	0.6819
1988	33.6	39.2	26.7	38.7	0.8668	1.0139	0.6890
1989	33.2	39.2	26.3	38.4	0.8649	1.0208	0.6839
1990	32.9	38.6	26.1	37.9	0.8669	1.0196	0.6895
1991	32.9	38.6	26.2	38.1	0.8617	1.0139	0.6878
1992	32.1	37.8	25.7	37.4	0.8585	1.0112	0.6881
1993	32.5	38.3	26.1	38.0	0.8540	1.0068	0.6859
1994	32.7	38.5	26.3	38.2	0.8552	1.0077	0.6890
1995	32.9	38.8	26.3	38.5	0.8542	1.0071	0.6820
1996	32.8	38.7	26.2	38.6	0.8489	1.0024	0.6796
1997	32.4	38.1	26.0	38.1	0.8491	0.9996	0.6826

Source: Labour Market Trends

5.12 From table 5.2 it can be seen that there is a considerable difference in adjustment factors between males and females. Adjustment factors for males are close to unity, indicating that average hours worked by male employees are close to the average number of hours worked by all full time employees. The adjustment factors for females are approximately 70%. Due to the higher incidence of part time employment amongst females, the number of jobs held by female employees has to scaled down to provide estimates of employees in employment based on full time equivalents. It can be seen that adjustment factors decline slightly for males and females between 1986 and 1997. This is likely to reflect the increasing incidence of part time employment for both males and females. Note also that the adjustment factors control for changes in the relative incidence of full- and part-time employment, and not changes in the total hours worked over time. For example, holding employment levels constant, if the number of hours worked by both full and part time employees doubled, the size of the adjustment factor would remain constant.

C Exploratory Data Analysis of Injury Rate Time Series

5.13 The following discussion provides descriptive statistics and graphical analysis of the injury rate time series. To avoid repetition, the analysis will focus upon monthly injury rates. Emphasis is given to the difference between workforce and employee injury rates, movements in injury rates over the economic cycle, the effects of expressing injury rates in terms of full time equivalents and regional variations in injury rates.

Table 5.3: Average Monthly Unadjusted Injury Rates[1,2]

	Male	Female	All
All			
Employees	87.53	28.68	59.46
Workforce	73.55	26.57	52.64
1987			
Employees	90.44	25.23	60.75
Workforce	76.66	23.35	53.82
1996			
Employees	81.61	30.31	56.12
Workforce	68.63	28.22	49.87

Notes
1. Injury rates not based upon full time equivalents
2. Injury rates expressed per 100,000 workers

5.14 Table 5.3 provides average unadjusted injury rates for (a) the number of industrial injuries to employees per 100,000 employees and (b) the number of industrial injuries to the civilian workforce in employment per 100,000 workers during the study period. Provisional injury data for 1997/98 was excluded from the calculation of injury rates due to the depressing effects upon injury rates of late reporting. Workplace injury rates are therefore available from April 1986 to March 1997.

5.15 Two main themes emerge from table 5.3. Firstly, female injury rates are considerably lower than those for males. However, the unadjusted injury rates do not take into account differences in hours worked between males and females. Secondly, it can be seen that workforce injury rates are consistently lower than employee injury rates, the difference being more pronounced for males. This difference is likely to reflect the lower propensity for the self employed to report workplace accidents, which in turn will have a depressing effect upon the workforce injury rate.

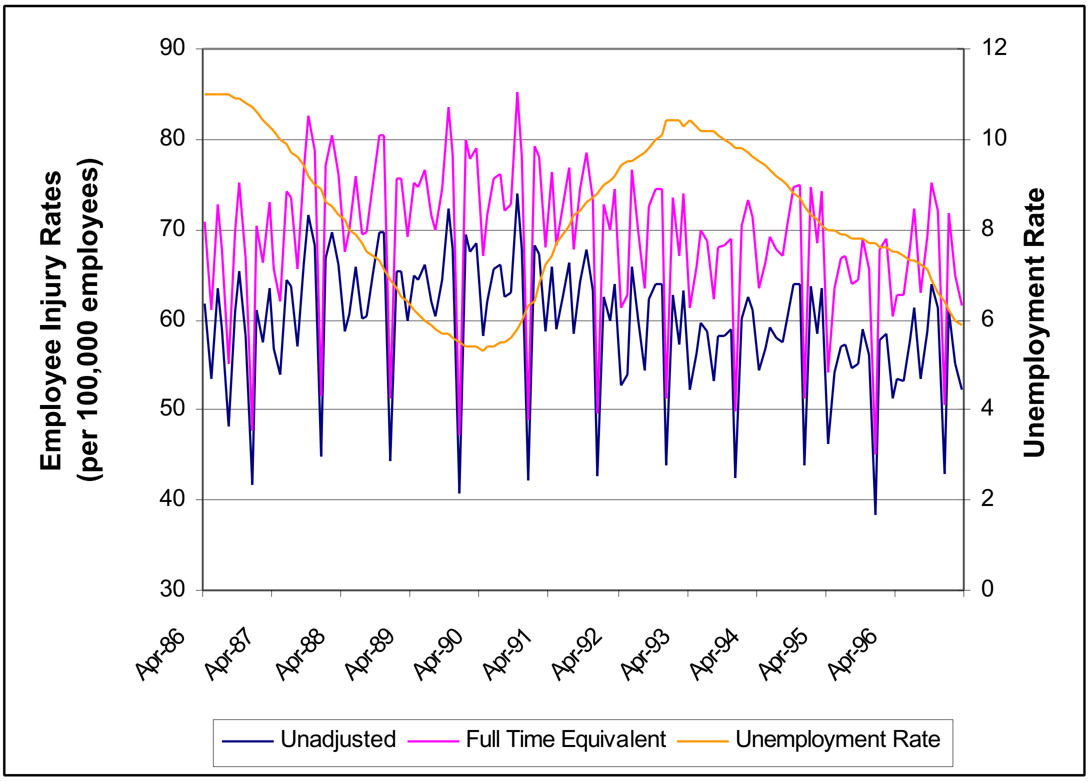
Temporal Variations in Employee Injury Rates

5.16 Figures 5.3, 5.4 and 5.5 provide time series plots of injury rates over the study period. Due to the under reporting of injuries by the self employed, the time series plots focus upon employee injury rates (expressed per 100 thousand employees). The figures provide plots for adjusted and unadjusted injury rates to consider the effect of expressing injury rates in terms of full time equivalents. The claimant unemployment rate is also shown to consider the potential importance of the economic cycle upon accident rates. Unemployment can be seen to fall during an initial period of economic expansion, reaching a low of 5.3% in April 1990. Unemployment rose to a peak of 10.4% during the early months of 1993 (this peak in unemployment followed a trough in economic activity that occurred during the second quarter of 1992). Unemployment is then observed to decline for the remainder of the study period.

5.17 Figure 5.3 indicates the presence of a cyclical pattern in the injury rate for all employees, although controlling for the level of employment leads to less pronounced cyclical pattern compared to the analysis of injuries expressed in levels in Chapter 3. From April 1986, the unadjusted injury rate rises to a peak of 73.9 injuries per 100 thousand employees during October 1990. The employee injury rate then shows a decline, although discontinuities in the injury definition as a result of the introduction of RIDDOR 95 makes it difficult to establish the position of any trough in injury rates. Seasonal influences can also be observed. Employee injury rates are lowest during December, and tend to peak during October. Figure 5.3 also highlights the effect of expressing injury rates in terms of full time equivalents. Average monthly injury rates increase from 59.5 to 69.2 injuries per 100,000 employees when utilising a full time equivalent employment base.

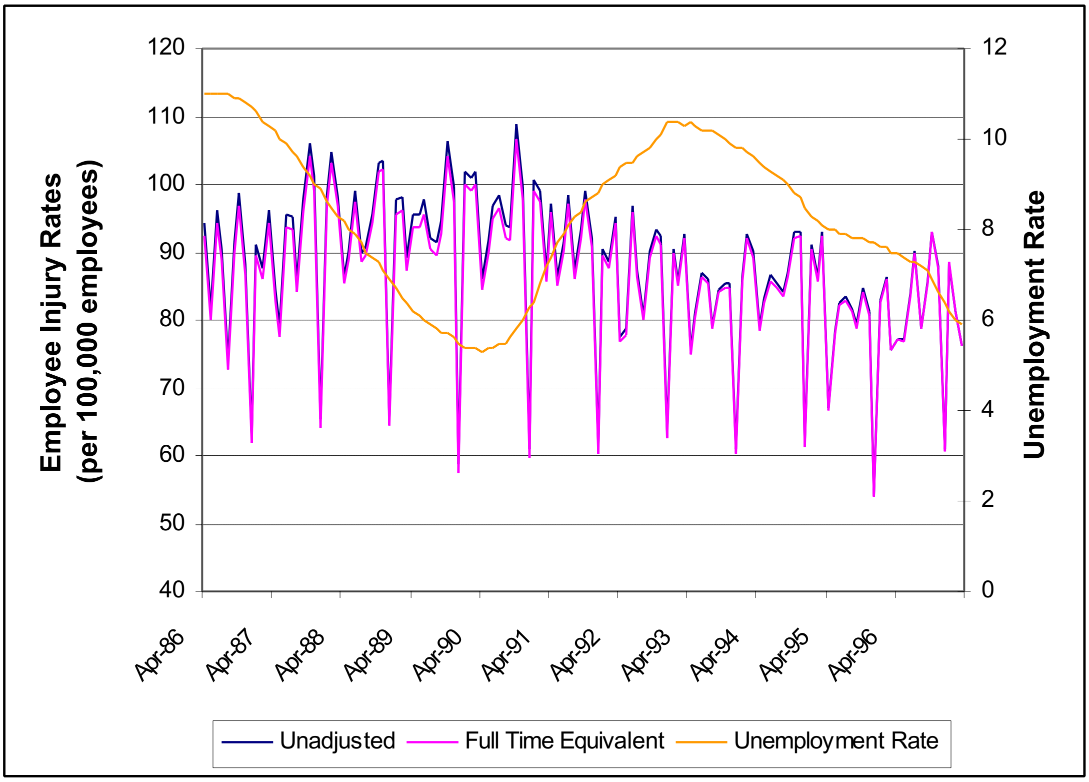
5.18 Considering the effects of the economic cycle upon workplace injury rates, injury rates are demonstrated to move in the opposite direction to the claimant unemployment rate. The peak in accident rates that occurred during 1990 coincides with a trough in the claimant unemployment rate. This observation is consistent with the business cycle approaches that predict a pro-cyclical pattern in the risk to employees of experiencing a workplace injury over the economic cycle.

Figure 5.3: Employee Workplace Injury Rates – All Employees



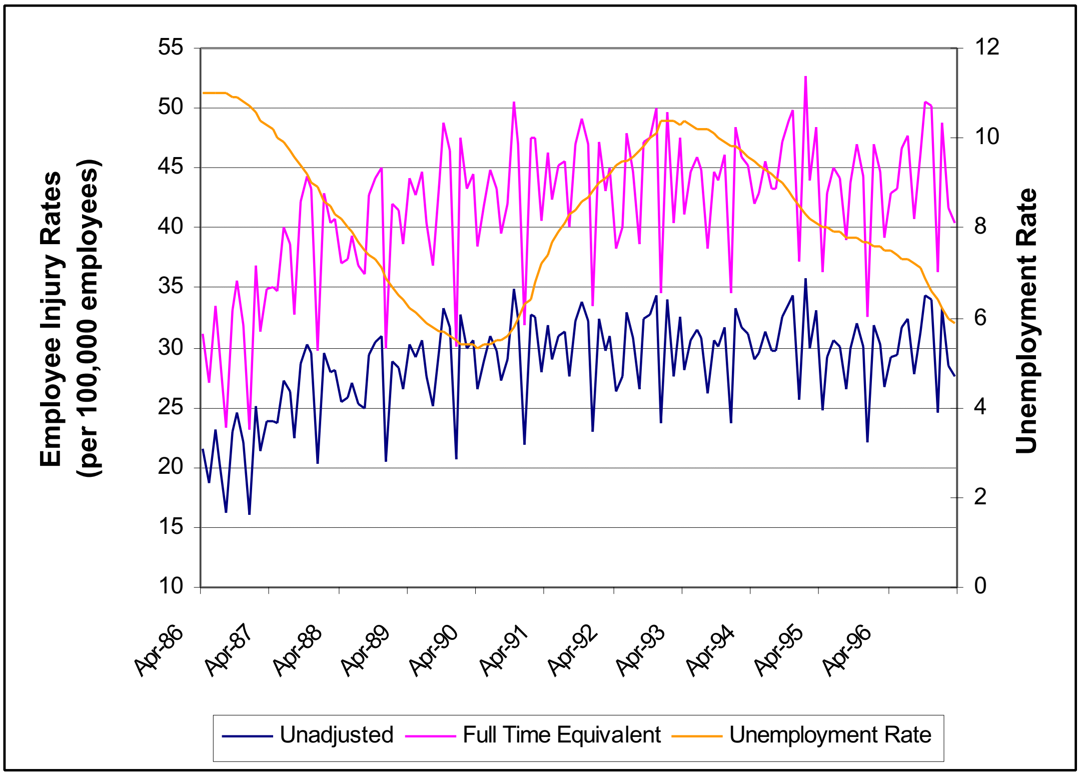
5.19 Figures 5.4 and 5.5 provide plots of injury rates for males and females respectively. A cyclical pattern is exhibited for the male injury rate series. Figure 5.4 also provides tentative evidence as to the possibility of a downward trend in male injury rates. However, the introduction of new reporting regulations under RIDDOR 95 again makes it difficult to establish the position of a trough in male injury rates. Strong seasonal influences can also be identified. Figure 5.4 also shows that the utilisation of a full time equivalent employment base has very little effect upon the level of male injury rates. Considering the average monthly injury rate, injury rates decrease from 87.5 to 86.6 injuries per 100,000 employees. This small change reflects that the average hours worked by males is approximately equal to the average full time hours worked by all employees. As in the case of all employees, it can be seen that the male employee injury rate moves in the opposite direction to the claimant unemployment rate.

Figure 5.4: Employee Injury Incidence Rates – Males



5.20 Figure 5.5 clearly highlights the importance of utilising female employee injury rates based upon full time equivalents. Considering the average monthly injury rate, injury rates increase from 28.6 to 41.7 injuries per 100,000 employees when utilising a full time equivalent employment base. Unadjusted female injury rates fail to take into account the lower exposure of females to workplace hazards due to the prevalence of part time employment. In contrast to male injury rates, female injury rates do not show an obvious cyclical pattern over the study period. Any cyclical pattern is being disguised by a general upward trend in injury rates amongst female employees. This is further highlighted by comparisons with the claimant unemployment rate over the study period. No obvious peak in female employee injury rates can be observed during the trough in unemployment in 1990 (although the rate of increase in female injury rates does decline after 1990 during a period of rising claimant unemployment). Seasonal effects are also observed for female injury rates, although the degree of variation is less than that observed for male injury rates.

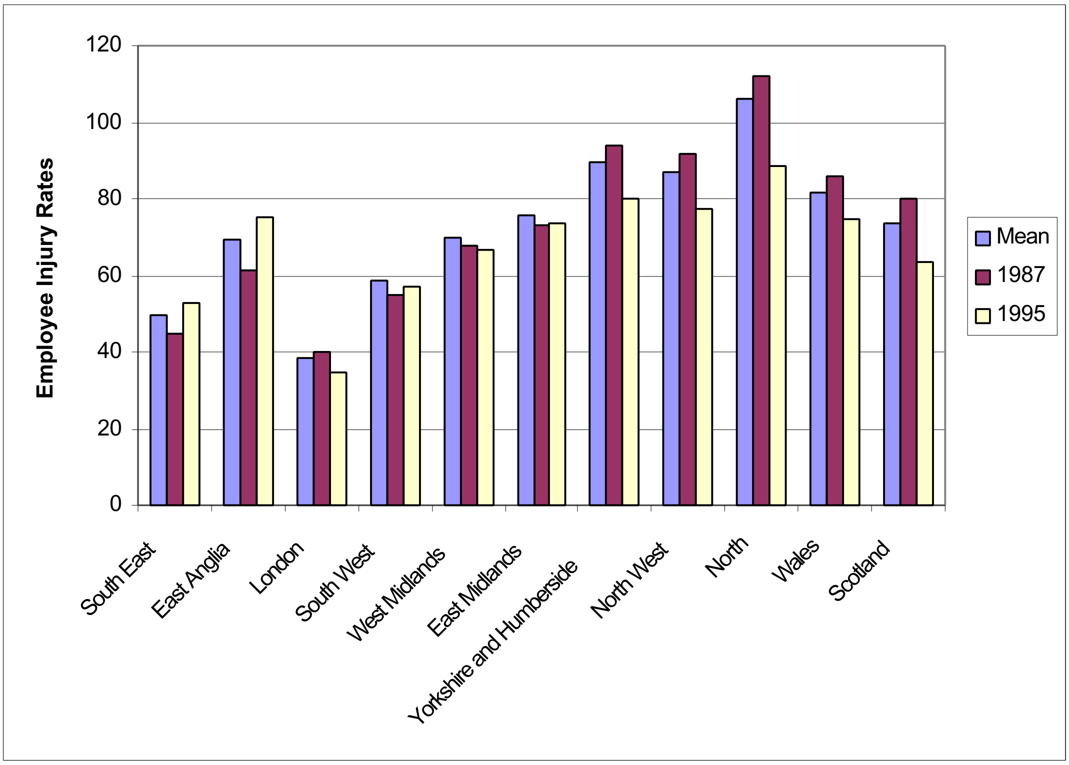
Figure 5.5: Employee Injury Incidence Rates – Females



Regional Variations in Employee Injury Rates

5.21 Figure 5.6 shows average adjusted monthly injury rates for the 11 standard regions over the period April 1986 to March 1997. Significant variations are shown to exist between the regions, although these variations appear to diminish over the duration of the study period. Over the period of analysis, average monthly injury rates are highest in the North (106.2 injuries per 100 thousand employees), Yorkshire and Humberside (89.8) and in the North West (86.9). Employee injury rates are lowest within London (38.6 injuries per 100 thousand employees), the South East (49.8) and the South West (58.54).

Figure 5.6: Average Monthly Employee Injury Rates (per 100,000 employees)



5.22 The introduction of RIDDOR 95 leads to difficulties in making consistent comparisons between the beginning and end of the sample period. Average monthly injury rates are provided for 1987 and 1995 (the first and last complete years of injury data collected under the RIDDOR 85 regulations). Simple comparisons between these two periods also fail to take into account the position of the economic cycle at these points. However, it is worth noting that the largest falls in employee injury rates have occurred within those regions that had amongst the highest injury rates during 1987 (i.e. the North, North West and Yorkshire and Humberside). This is likely to be indicative of the greater pace of structural change that has occurred within these regions and the associated decline of traditional industries.

C Concluding Comments

5.23 Analysis of aggregate injury data noted the presence of temporal and geographical variations in the incidence workplace injuries reported under RIDDOR. The construction of injury rates by deflating the aggregate injury data by an appropriately defined employment base points to cyclical, seasonal and geographical variations in the risk of a workplace injury. Analysis of the injury rate data point to the need for external factor variables which can be constructed and utilised to analyse the observed time-series and cross sectional variation in injury rates. The following chapter outlines the results of multivariate analyses to consider these issues.

6. STATISTICAL ANALYSIS OF WORKPLACE INJURIES REPORTED UNDER RIDDOR

Introduction

This chapter outlines the results of statistical analyses of temporal and geographical variations in reported injury rates within Great Britain. Multivariate statistical techniques were utilised to control for cyclical and structural influences that contribute to the observed patterns in industrial injury rates, both over time and between the regions. Due to the relative incompleteness in coverage of RIDDOR data in terms of the reporting of injuries incurred by the self-employed, the statistical analysis is restricted to employee injury rates. For technical reasons outlined in Chapter 4, employee injury rates are modelled as the logistic transformation of the employee injury rate.

The analysis was conducted in 2 stages. Firstly, monthly injury rate data from April 1986 to March 1997 for Great Britain was analysed to examine seasonal and cyclical variations in national injury rates. The second stage of the analysis utilised quarterly injury rate data for the 11 standard regions of Great Britain for the period Spring 1992 (March to May) to Winter 1996/97 (December to February). The shorter sample period corresponds to the availability of quarterly data from the Labour Force Survey. This information enabled a more detailed examination of both temporal variations in workplace injuries and the development of external factor variables to determine the causes of differential injury rates between the regions of Great Britain.

The results of the time series analysis conducted on monthly injury rate data for Great Britain from April 1986 to March 1997 are presented in Section A. Section B outlines the construction of external factor variables from the Labour Force Survey and presents the results of the analysis utilising the pooled time series regional injury rate data over the shorter sample period. The full results from these modelling procedures are presented in the appendices. Section C presents the results of statistical modelling undertaken to explore the factors that drive variations in employee injury rates between the regions of Great Britain. Section D provides regional commentaries for the results of the modelling exercise.

A Time Series Analysis of National Monthly Injury Rate Data

Estimation Techniques and Results

6.1 Previous empirical studies of workplace injuries have typically estimated a model where injury rates (or a logarithmic transformation thereof) are modelled as a function of a set of independent variables. These empirical studies however do not consider the stationarity of the injury rate time series utilised[5]. If a data generating process is non-stationary, a dynamic specification of the injury rate equation would be required. Statistical tests

[5] Stationarity assumes that the mean and variance of a time series process are independent of time. All observations come from the same probability distribution.

were conducted to establish the stationarity of the injury rate time series over the study period. A technical description of the tests undertaken and the results are provided in Appendix 2. These tests indicated that the injury rate time series for males and females are stationary, and could therefore be analysed in terms of levels.

6.2 The estimation results of the employee injury rate models are summarised in table 6.1. A description of the dependent and explanatory variables used within these models is provided in Appendix 3(a). Detailed estimation results of these models are provided in Appendix 3(b). Models of monthly employee injury rates were estimated for all employees, and then separately for males and females. Initial estimates using Ordinary Least Square estimation techniques suffered problems of autocorrelation in the residuals. The effect of autocorrelation is that it artificially deflates the standard errors associated with the estimated coefficients of these models, rendering tests of statistical significance unreliable. To overcome these problems, the models of monthly employee injury rates were estimated using auto-regressive least squares (RALS) techniques[6]. This non-linear estimation procedure provides a statistical treatment of the problems of autocorrelation, enabling an evaluation of the statistical significance of the explanatory variables in the monthly model.

The Economic Cycle

6.3 The discussion in Chapter 4 noted the importance of attempting to control separately for the effects of experience, work intensity and labour scarcity when modelling the impact of the economic cycle upon workplace injuries. The development of a monthly injury rate time series for Great Britain for the period April 1986 to March 1997 (132 monthly observations) provides a rich picture of cyclical and seasonal movements in workplace injuries. However, consistent monthly data regarding employment tenure and work intensity is not available for this period. The monthly analysis therefore utilises the unemployment rate as a single 'catch all' measure of the influence of the economic cycle[7]. Information on unemployment is taken from Employment Service estimates of the claimant unemployment rate. The data series has been adjusted to remove inconsistencies due to changes in the rules and procedures of payment in benefits.

6.4 Estimation results indicate that a negative relationship exists between employee injury rates and the claimant unemployment rate. Employee injury rates are therefore estimated to follow a pro-cyclical pattern. This relationship is estimated to be statistically significant at the 1% level for males and at the 5% level for females. The relationship within the combined model for males

[6] The RALS procedure is an iterative process that minimises the sum of the unexplained variation in the dependent variable. RALS jointly searches for estimates of the underlying model and of the auto-correlation process until convergence of these values is achieved.

[7] It is likely that the initial problems of autocorrelation were caused by the inability of the unemployment rate to perfectly capture all of the influences of economic cycle upon employee accident rates.

and females is estimated to be statistically significant at the 1% level. Considering the relative impact of the economic cycle upon male and female injury rates, the absolute value of the coefficient on the unemployment variable within the male injury rate model is greater than the value estimated within the female injury rate model. The female employee injury rate is therefore estimated to be less responsive to the effects of the economic cycle compared to the male employee injury rate.

Table 6.1: Time Series Models of Monthly Employee Injury Rates

Variable	All	Males	Females
Constant	-7.1595**	-6.9189**	-8.0377**
JAN	0.12528**	0.12092**	0.15399**
FEB	0.096946**	0.11325**	0.055493*
MAR	0.084009**	0.096363**	0.058012*
MAY	0.019601	0.01959	0.026219
JUN	0.10188**	0.10466**	0.10128**
JUL	0.081742**	0.092447**	0.057649*
AUG	0.004143	0.023932	-0.066438**
SEP	0.091314**	0.090275**	0.10015**
OCT	0.16405**	0.167**	0.15981**
NOV	0.12327**	0.12414**	0.13639**
DEC	-0.27619**	-0.29126**	-0.21583**
RIDDOR95	-0.00947	-0.00394	0.076915*
TREND	-0.00082**	-0.00117**	0.0085743**
TRENDSQR			-5.20 -05**
UERATE	-0.01456**	-0.01441**	-0.0090115*
Diagnostic Statistics			
Autocorrelation	1.58771	1.13385	1.42282
Heteroscedasticity	1.8793*	1.7889*	1.2906

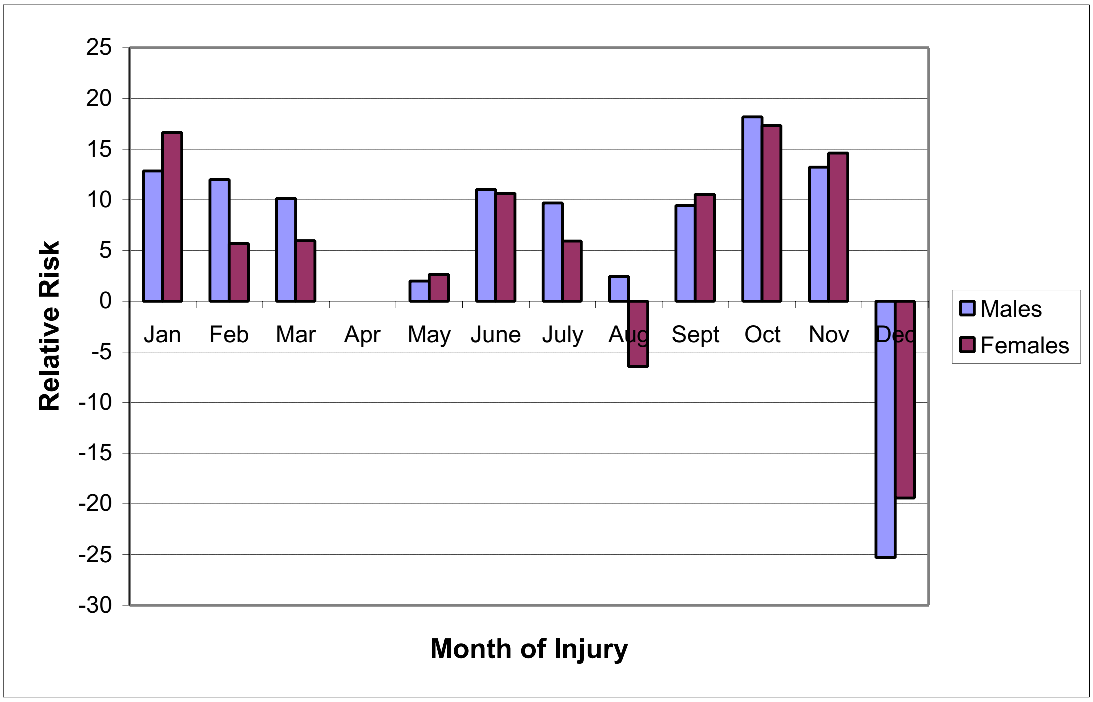
Notes:
**/* indicates statistical significance at the 1% and 5% levels respectively.

Seasonal Effects

6.5 The analysis of monthly employee injury rates points to the importance of seasonal influences upon employee injury rates. Compared to the reference month of April, all employee injury rates are estimated to be significantly higher in January, February, March, June, July, September, October and November. Employee injury rates are estimated to be significantly lower during December. All of these results are statistically significant at the 1% level. In terms of sign and statistical significance, identical seasonal effects are estimated within the model of male employee injury rates. Slight differences emerge between males and females in terms of seasonal influences upon employee injury rates. For female employees, seasonal effects for February, March and July are estimated to be statistically significant at the lower significance level of 5%. Female employee injury rates are also estimated to be significantly lower during August compared to April.

6.6 Using the estimation results presented in table 6.1, figure 6.1 provides estimates of the relative risk of an employee experiencing a workplace injury by month of occurrence. The risks are measured relative to the reference month of April. The seasonal differentials in relative risks are derived from the coefficients on the seasonal term within the logistic regressions[8]. For both male and female employees, the risk of a workplace injury is greatest during October. Male employees are 18% more likely to experience a workplace injury during the month of October relative to April. Similarly, female employees are 16% more likely to experience a workplace injury during October compared to April. Employee injury rates are found to be lowest during the month of December reflecting the reduced days worked in this month. Male employees are 25% less likely and female employees are 19% less likely to experience a workplace injury during December relative to April. With the exception of December, employee injury rates are generally higher during the Autumn and Winter months (September, October, November and January). Seasonal variations in employee injury rates are also estimated to be larger for males than females.

Figure 6.1: Seasonal Variations in Relative Risk of Workplace Injuries



Long Term Trends in Employee Injury Rates

6.7 To consider the existence of underlying trends in the incidence of workplace injuries, time trends were incorporated into the models of monthly employee injury rates. In the absence of external factor variables to control for structural

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8 Taking the exponential of the coefficients from the regression results, subtracting 1 and then multiplying by 100 gives the percentage difference in the risk of injury relative to the reference category.

influences directly (e.g. industrial composition of employment, occupational structure etc.), these terms are likely to capture the influence of structural changes that may lead to upward or downward trends in employee injury rates over the period of analysis. The inclusion of external factor variables within the analysis of pooled time series regional injury rate data will enable the identification of trends in workplace injury rates after controlling for effects of structural change (although only for a shorter sample period).

6.8 The all employee injury rate model estimates that employee injury rates are following a linear downward trend over the period of analysis. This trend is estimated to be statistically significant at the 1% level. However, the separate analysis of male and female employee injury rates indicates that this overall trend (for males and females combined) is a net effect masking quite different trends for men and women.

6.9 The analysis for males estimates the presence of a downward trend in employee injury rates over the period of analysis. This downward trend is estimated to be statistically significant at the 1% level. Incorporating the effects of the economic cycle, male employee injury rates are therefore estimated to be following a pro-cyclical pattern around a long-run downward trend between April 1986 to March 1997. In contrast, female employee injury rates are estimated to follow an upward quadratic trend over the period of analysis. The positive coefficient on the linear trend combined with the negative coefficient on the quadratic trend, indicate that female employee injury rates follow an upward trend, although the rate of increase diminishes over time. Both the elements of this quadratic trend are estimated to be statistically significant at the 1% level.

B Pooled Analysis of Quarterly Regional Injury Rate Data

Estimation Techniques and Results

6.10 Information from the Labour Force Survey is available quarterly from Spring 1992. Combined with injury rate data, this would only provide a sample of 20 observations for a purely time-series multivariate analysis of employee injury rates (Spring 1992 to Winter1996/7). To increase the number of sample observations available, multivariate analysis is conducted on employee injury rate data pooled across the 11 standard regions of Great Britain. This pooling of regional data increases the number of observations for analysis to 220. This sample size is comparable with previous pooled time series/cross sectional analyses of workplace injury rates (see discussion of pooled time series/cross sectional analyses in Chapter 2).

6.11 The analysis of national injury rates utilised the claimant unemployment rate as a single 'catch all' variable to control for the effects of the economic cycle. Information from the Labour Force Survey has enabled the replacement of the 'catch all' unemployment rate with explanatory variables that more closely reflect the hypothesised causal mechanisms behind temporal movements in injury rates. To consider these causal mechanisms in greater detail, the analysis of pooled regional employee injury rates will incorporate variables to control for work intensity (hours worked), experience (length of time in current employment) and labour scarcity (the ratio of unemployment to vacancies).

6.12 To consider geographical variations in employee injury rates between the 11 standard regions of Great Britain, external factor variables are constructed to control for structural differences in the populations at risk of a workplace injury between the regions. External factor variables were developed to control for variations in the following structural characteristics between the regions:

- industrial composition of employment;
- occupational structure;
- personal characteristics of those in employment (including educational attainment, age, gender, ethnicity);
- workplace characteristics (including size of workplace, provision of job related training);
- incidence of atypical employment (including part time employment, temporary employment).

6.13 Estimation results from the pooled time series employee injury rate model are summarised in table 6.2. A description of the dependent and explanatory variables used within this model is provided in Appendix 4(a). Detailed estimation results are provided in Appendix 4(b). The modelling strategy adopted involved sequentially introducing groups of variables as defined by the above categories. The development of the model considered how the inclusion of various explanatory variables effected the significance and stability of other explanatory variables included and the statistical performance of the overall model[9]. The inclusion of irrelevant explanatory variables in a multivariate model can lead to problems of misspecification and an associated loss of precision in the interpretation of significance tests. Explanatory variables of low statistical significance were therefore removed from the model to produce a final "best" model as presented in table 6.2.

Work Intensity, Labour Market Experience and Labour Scarcity

6.14 The average work experience of employees is not estimated to have a statistically significant effect upon the employee injury rate. The average number of hours worked by employees in their main job is estimated to have a positive effect upon the employee injury rate. This is estimated to be statistically significant at the 1% level. This intensity effect was however only found to be significant when seasonal variables reflecting the quarter of

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[9] Analysis of the correlation matrix of the final model yielded high correlation coefficients amongst some of the occupation and industry explanatory variables: sector2/scomaj6 = 0.86; sector2/socmaj8 = 0.85; socmaj4/socmaj8 = -0.81; socmaj5/socmaj8 = 0.82. Such correlation can lead to difficulties in quantifying the separate influences of explanatory variables. The correlation coefficients for sector2 may explain the lower statistical significance of this variable. However, the high statistical significance of the occupation variables indicates that correlation between explanatory variables is not a significant problem in the final model.

occurrence were excluded from the model. This suggests that variations in the number of hours worked by employees are the driving force behind seasonal variations in employee injury rates. Finally, the ratio of unemployment to vacancies is found to have a negative effect upon employee injury rates. This is estimated to be statistically significant at the lower 5% level. As the level of opportunity declines in the labour market (represented by an increase in the U/V ratio), employee injury rates decline. This may reflect safer behaviour on the part of employees who become more fearful of losing their jobs.

Table 6.2: Analysis of Pooled Regional Employee Injury Rates

Variable	Coefficient
Constant	-5.2152**
RIDDOR95	0.035796
TREND	-0.0071687
SECTOR2	0.011490*
SECTOR3	0.067628**
SECTOR4	0.036587**
SOCMAJ4	0.035225**
SOCMAJ5	0.042196**
SOCMAJ6	0.061139**
SOCMAJ8	0.035335**
SOCMAJ9	0.023659*
NVQ5	-0.061759**
NVQ4	-0.040571**
NVQ3	-0.029066**
NVQ1	-0.033489**
OTHER	-0.041049**
NONE	-0.035518**
AGE	-0.082935**
FEMALE	0.020362*
SMALL	-0.024927**
TEMP	0.017759*
HOURS	0.030765**
UVRATIO	-0.0026313*
Diagnostic Statistics	
R-squared (Explanatory Power)	93.59%
Autocorrelation	1.5749
Heteroscedasticity	1.3674
Functional form	2.1013

Notes:
**/* indicates statistical significance at the 1% and 5% levels respectively.

Industrial Composition of Employment

6.15 The proportion of employees in employment within the Manufacturing sector, the Construction sector, and within the Distribution and Transport sector are estimated to have a significant positive effect upon regional employee injury rates relative to the reference sector of Business and Miscellaneous Services.

Comparisons of the size of the estimated coefficients indicate that employment within Construction is estimated to have the largest effect upon the rate of workplace injuries. The effects of employment within the Construction and the Distribution and Transport sectors are both estimated to be statistically significant at the 1% level. The effect of employment within the Manufacturing sector is estimated to be statistically significant at the lower significance level of 5%.

Occupational Structure

6.16 There is a significant variation in the relative risk of a workplace injury between employment within different Major Groups of the Standard Occupational Classification. Employment within Clerical and Secretarial Occupations (Major Group 4), Craft and Related Occupations (Major Group 5), Personal and Protective Service Occupations (Major Group 6), Plant and Machine Operatives (Major Group 8) and Other Occupations (Major Group 9) are all estimated to have a positive effect upon regional employee injury rates relative to Sales Occupations (Major Group 7). Comparisons of the size of the estimated coefficients indicates that employment within Personal and Protective Service Occupations exerts the largest influence upon the regional employee injury rates. Employment within Major Groups 1: Managers and Administrators, Major Group 2: Professional Occupations and Major Group 3: Associate Professional and Technical Occupations are not estimated to have a statistically significant effect upon employee injury rates.

Educational Attainment

6.17 The attainment of both high and low level qualifications is estimated to have a significant negative effect upon employee injury rates relative to the attainment of qualifications at NVQ level 2 or equivalent. The size of this negative effect is also estimated to increase with the attainment of higher and lower level qualifications. The proportion of employees holding qualifications at NVQ level 5 or equivalent is estimated to exert the largest negative influence upon the regional employee injury rate. All educational attainment effects are estimated to be statistically significant at the 1% level. It should be noted that the inclusion of educational terms within the multivariate analyse is justified on the grounds that educational attainment is correlated with exposure to workplace hazards, rather than because workers of different educational attainment behave differently. Educational attainment therefore aims to control for other aspects of the working environment not captured through the inclusion of occupational and industry variables.

Personal Characteristics

6.18 The average age of employees in employment within a region is estimated to have a negative effect upon the regional employee injury rate. This relationship is estimated to be statistically significant at the 1% level. The proportion of employees in employment who are female is estimated to have a positive effect upon the employee injury rate relative to male employment. This is estimated to be statistically significant at the lower 5% level. Given that males are traditionally employed within occupations characterised by higher risks of workplace injury, this finding is not immediately intuitive. However, graphical analysis of employee injury rates in Chapter 5 indicated that female employee injury rates were increasing over the study period. This increase in female injury rates has coincided with increased female participation in employment. This association may be dominating the expected negative cross sectional relationship between female employment and regional injury rates. The proportion of employees within a region who are of an ethnic minority origin is not estimated to have a significant effect upon the employee injury rate.

Firm Characteristics

6.19 The incidence of employment in workplaces with fewer than 25 employees is estimated to have a negative effect upon the regional employee injury rate relative to employment within larger workplaces. This relationship is estimated to be statistically significant at the 1% level. This counter intuitive result may be due to under-reporting of workplace injuries by employers in small workplaces. However, Elias and McKnight (1999) also estimate a negative relationship between employment in small workplaces and the risk of workplace injuries based upon self-reporting. The proportion of employees in a region who have received some form of job related training in the previous 4 weeks is not estimated to have a significant effect upon the relative risk of workplace injury.

Atypical Employment

6.20 The incidence of temporary employment is found to have a positive effect upon the regional employee injury rate relative to employment based upon permanent contractual arrangements. This relationship is estimated to be statistically significant at the 5% level. This relationship may reflect the lower levels of employment tenure amongst those in temporary forms of employment. Alternatively, this positive relationship may reflect the greater vulnerability of those in atypical forms of employment. Part time employment is not estimated to have a significant effect upon employee injury rates.

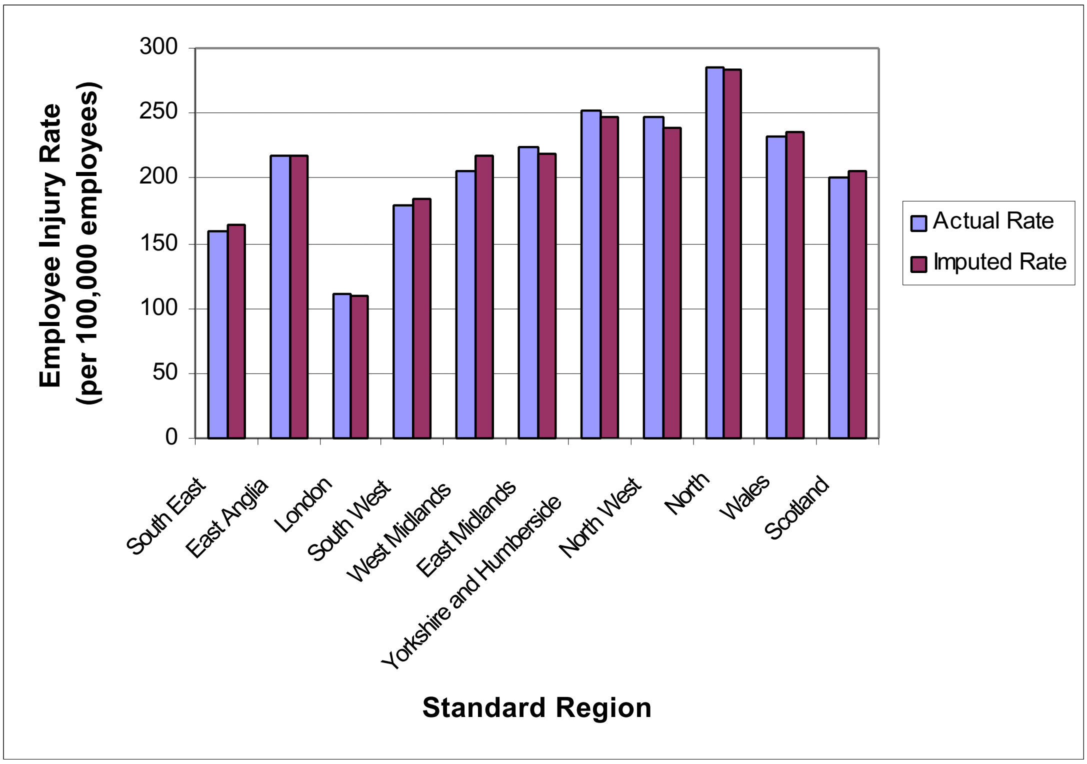
Long Term Trends

6.21 After controlling for a variety of structural influences, the estimation of a negative coefficient on the trend term indicates that employee injury rates are following a long run downward trend. However, this trend term is only estimated to be statistically significant at the 10% level (see Appendix 4). This statistical significance is lower than that estimated for the trend term in the monthly injury rate model for all employees. It is likely that the trend term in the monthly model is capturing the influence of structural changes that are now being captured directly by the inclusion of external factor variables. The estimated downward trend in the quarterly model may be due to the omission of unidentified structural factors that are exerting a downward influence upon employee injury rates. Alternatively, the low statistical significance of the trend term may provide some evidence of real improvements in employee injury rates that are attributable to structural changes.

Explanatory Power of Multivariate Analysis

6.22 The calibration of a model of regional employee injury rates that included control variables for the level of economic activity, industrial sector, occupation, education, personal characteristics, firm characteristics and atypical employment, was able to account for 94% of the temporal and geographical variations witnessed in employee injury rates for each quarter between Spring 1992 and Winter 1996/97. The ability of the pooled model to account for regional variations in employee injury rates is highlighted in Figure 6.2. This graph shows that the mean predicted quarterly injury rates generated using the econometric model, closely reflect the actual average quarterly injury rates over the period of analysis. After making allowance for identified external factor variables, the estimated model is able to account for a significant majority of the variation in employee injury rates, both over time and across the regions.

Figure 6.2: Average Quarterly Regional Employee Injury Rates: Actual and Predicted Values



C Factors Contributing to Regional Variations in Injury Rates

6.23 Whilst figure 6.2 shows that there is a strong correlation between observed actual and imputed employee injury rates between the standard regions, it is not clear which factors are driving these geographical variations. A modelling exercise was therefore undertaken to consider the relative impact of different external factor variables on regional injury rates. The results of this exercise are presented in terms of a breakdown of the reasons why reported employee injury rates in any particular regions are lower or higher than the national average.

6.24 The modelling procedure utilises the coefficients derived from the multivariate model to re-estimate regional injury rates. An average quarterly employee injury rate was calculated by inputting the mean values of the external factor variables across all regions between Spring 1992 and Winter 1996/7 into the final "best" model (as shown in table 6.2). This process generates an employee injury rate over the sample period for a hypothetical "average" region. The modelling procedure then replaces the mean values of the external factor variables with those actually observed within each of the 11 standard regions over the sample period. The "average" region therefore acts as a baseline case, against which the impact of variations in structural characteristics upon regional employee injury rates can be considered. This process considers the effects upon regional employee injury rates of the following regional characteristics:

- the industrial composition of employment (the industry effect);
- the occupational structure of employment (the occupation effect);
- the level of qualifications held by those in employment (the education effect);
- the age/sex profile of employees (personal characteristics);
- the proportion of employees in small workplaces and in temporary forms of employment (other workplace effects);
- the number of hours worked and labour scarcity (labour market).

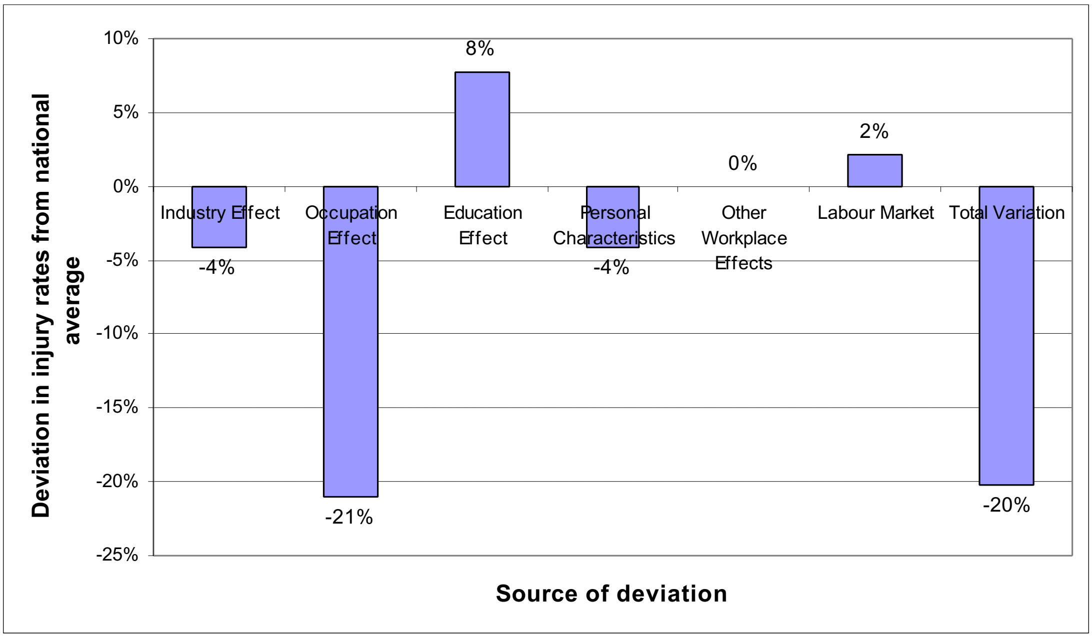
6.25 The results of the modelling exercise are presented in table 6.1, which shows the impact of each of the six categories of structural characteristics upon regional employee injury rates. This is expressed in terms of the percentage variation in regional injury rates from the average rate (estimated as 205 injuries per 100,000 employees). For example, between Spring 1992 and Winter 1996/7 the average quarterly employee injury rate within the North is estimated as 283 injuries per 100.000 employees, 38% higher than the average employee injury rate. Considering the relative influence of structural characteristics, it can be seen that a majority of this variation is attributable to the industrial and occupational composition of employment found within this region. Holding other influences constant, employee injury rates are approximately 13% higher than average due the industrial composition of employment and 14% higher than average due to occupational structure.

6.26 Table 6.1 points to the general importance of industrial structure and the occupational composition of employment in determining regional variations in reported employee injury rates. Finally, it is worth noting that the number of hours worked and the level of labour scarcity has a relatively small influence upon regional employee injury rates. This suggests that the measures of hours worked and labour scarcity are capturing temporal rather than structural influences. The following sections provide brief commentary of these results for each of the 11 standard regions. The commentaries identify the salient characteristics of regions that contribute to geographical variations in employee injury rates.

D Discussion of Regional Results

South East

Figure 6.3: South East



6.27 Average employee injury rates for the South East are estimated to be approximately 20% below the average employee injury rate across all regions over the sample period. The relatively low employee injury rate is seen to be largely attributable to the occupational composition of employment found within this region. In particular, a relatively low number of people are employed within Craft and Related Occupations (8.3% compared to an average of 11.1%), Plant and Machine Operatives (7.5% compared to an average of 10.7%) and Other Occupations (7.8% compared to an average of 9.2%). Industrial structure is estimated to reduce average injury rates in the South East by approximately 4%. In particular, relatively few people are employed within the Manufacturing sector (18.67% compared to an average of 22.41%). Finally, the personal characteristics of employees within the South East are also estimated to reduce the employee injury rate by approximately 4%. The average age of employees in employment is highest in this region (38.3 years compared to an average of 37.8 years).

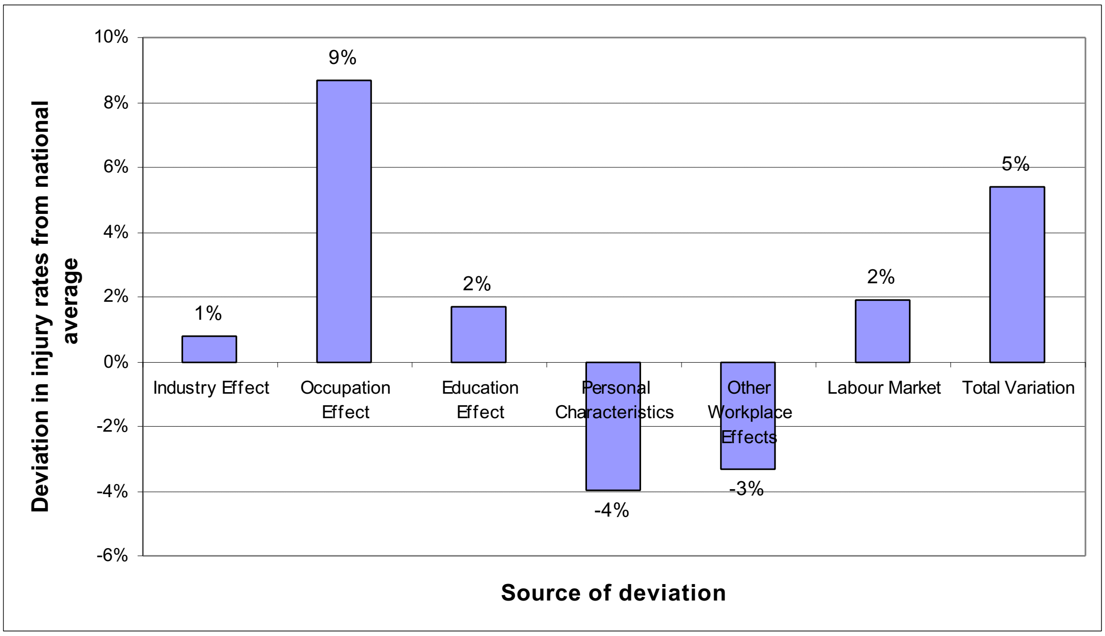
Table 6.1: Estimated Impact of Structural Characteristics on Regional Employee Injury Rates (%)[1]

Region	Average Injury Rate		Structural Characteristics						
	Actual	Estimated	Industry Effects	Occupation Effects	Education Effects	Personal Characteristics	Other Workplace Characteristics	Labour Market Effects	Total
South East	159	163	-4%	-21%	8%	-4%	0%	2%	-20%
East Anglia	218	216	1%	9%	2%	-4%	-3%	2%	5%
London	111	110	-15%	-32%	-20%	7%	9%	0%	-46%
South West	179	183	-6%	0%	8%	-2%	-9%	-1%	-10%
West Midlands	205	216	2%	7%	-2%	-4%	4%	-1%	6%
East Midlands	224	218	0%	6%	3%	-4%	0%	1%	6%
Yorks and Humber	253	247	7%	11%	4%	1%	-1%	-2%	21%
North West	247	238	2%	2%	6%	2%	3%	0%	16%
North	285	283	13%	14%	5%	2%	3%	-3%	38%
Wales	231	235	-2%	13%	6%	3%	-5%	0%	15%
Scotland	200	204	6%	4%	-14%	4%	-1%	2%	0%

Note:
The summation of the estimated structural effects may not sum to the total estimated variation in regional employee injury rates from the average. Due to the logistic transformation of the workplace injury rate outlined in chapter 4, the explanatory variables in the estimated model are not linearly related to the injury rate. However, as the logistic function is approximately linear, the summation of the individual structural effects provide a good approximation of the total variation in regional employee injury rates.

East Anglia

Figure 6.4: East Anglia



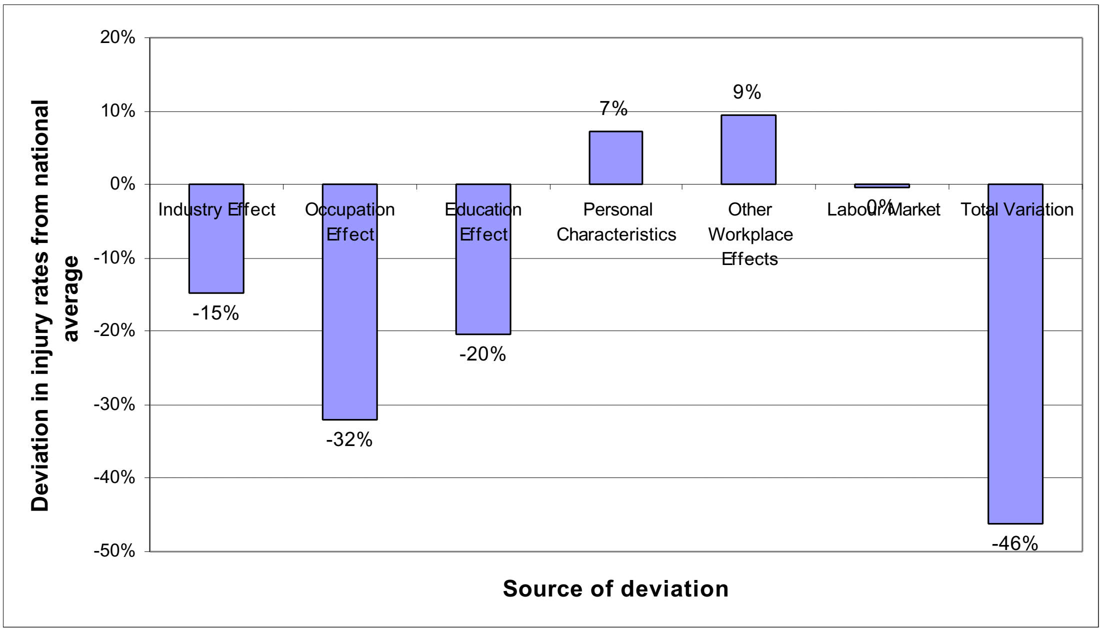
6.28 Average employee injury rates are estimated to be approximately 5% higher within East Anglia compared to the average employee injury rate across all regions over the sample period. The occupational composition of employment is estimated to underlie this regional variation. In particular, a relatively high proportion of people are employed within Personal and Protective Service Occupations (12.4% compared to an average of 11.5%), Plant and Machine Operatives (12.0% compared to an average of 10.7%) and Other Occupations (10.24% compared to an average of 9.23%). However, other workplace characteristics are estimated to reduce the reported employee injury rate by approximately 3%. This is attributable to the relatively high proportion of people employed within workplaces with less than 25 employees (35.3% compared to 33.7%).

London

6.29 Average employee injury rates within London are estimated to be approximately 46% below the average employee injury rate across all regions over the sample period. The relatively low employee injury rate is seen to be largely attributable to the occupational composition of employment found within this region. In particular, London contains the lowest proportion of people employed within Craft and Related Occupations (6.3% compared to an average of 11.1%), Plant and Machine Operatives (5.3% compared to an average of 10.7%) and Other Occupations (7.2% compared to an average of 9.2%). Educational attainment is estimated to reduce the employee injury rate in London by approximately 20%. In particular, a high proportion of employees possesses qualifications at an equivalent level to NVQ level 4 or higher (30.8% compared to an average of 22.4%). Industrial structure is also estimated to reduce average injury rates within London by approximately 15%. In particular, relatively few people are employed within the Manufacturing sector (11.6% compared to an average of 22.4%).

6.30 Whilst industrial and occupational influences contribute to a relatively low employee injury rate within London, a number of personal characteristics, other workplace characteristics and labour market influences are estimated to exert a positive effect upon the employee injury rate relative to the average rate over the sample period. Employees in London are estimated to have the lowest average age (37.1 years compared to an average of 37.8 years). The incidence of temporary employment is also relatively high in London (8.0% compared to an average of 7.0%). Although the net effect of labour market influences is estimated to be relatively small, this disguises the offsetting effects of both a relatively high number of hours worked by employees (33.07 hours compared to an average 31.92 hours) and a high ratio of unemployment to vacancies (32.54 compared to 17.39).

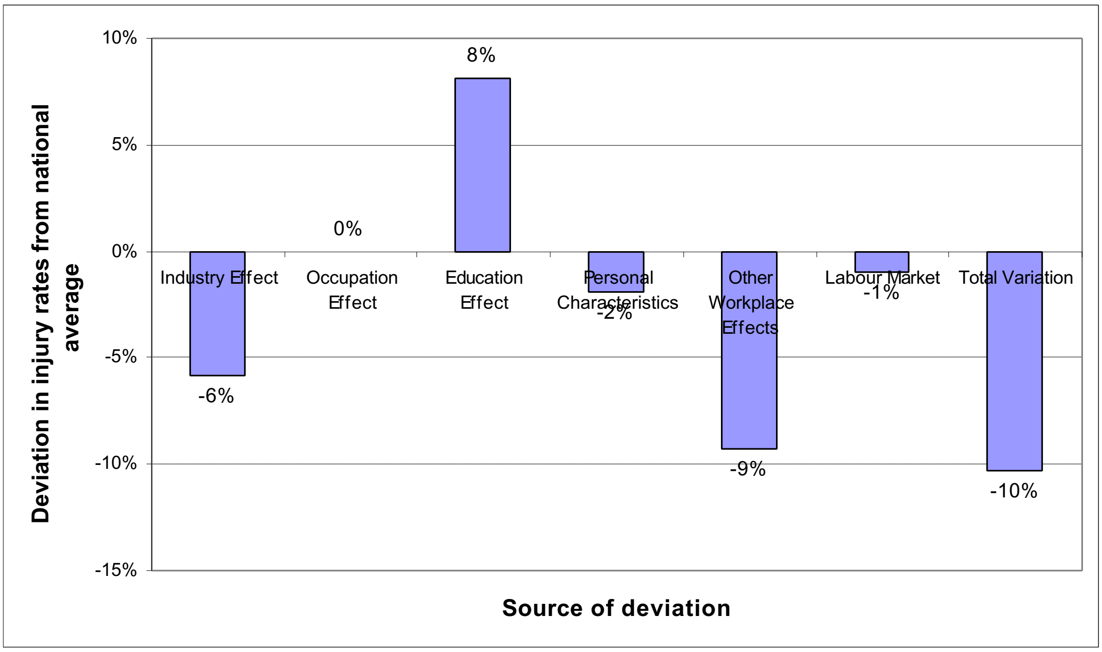
Figure 6.5: London



South West

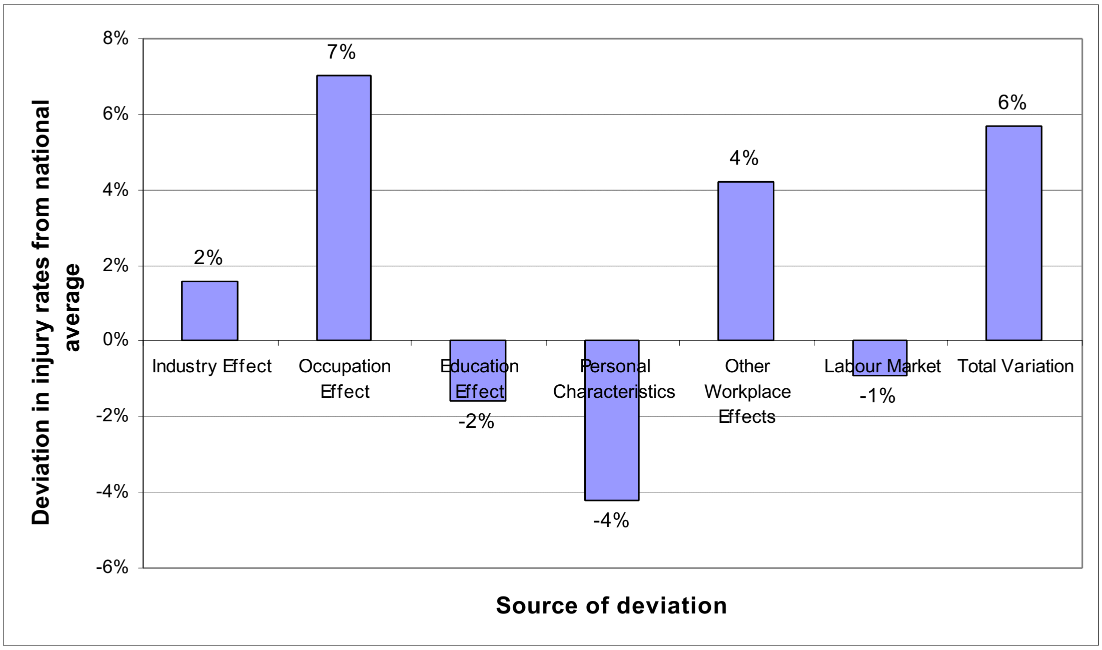
6.31 Average employee injury rates within South West are estimated to be approximately 10% below the average employee injury rate for all regions over the sample period. The relatively low employee injury rate is seen to be largely attributable to the industrial composition of employment and other workplace characteristics found within this region. Considering the industrial composition of employment, a relatively low proportion of people are estimated to be employed within Manufacturing (19.5% compared to an average of 22.4%) and Construction (3.8% compared to an average of 4.7%). Considering firm characteristics, a relatively high proportion of employees are employed in workplaces with less than 25 employees (37.5% compared to an average of 33.7%).

Figure 6.6: South West



West Midlands

Figure 6.7: West Midlands

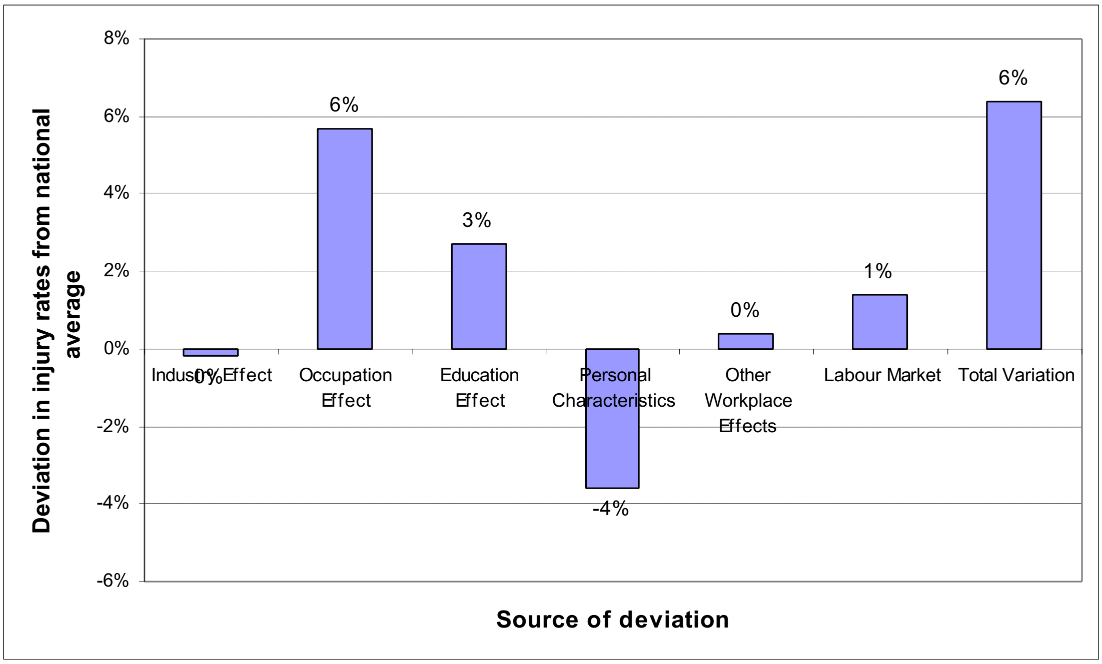


6.32 Average employee injury rates within West Midlands are estimated to be approximately 6% higher than the average employee injury rate across over the sample period. The relatively high employee injury rate is seen to be largely attributable to the occupational structure of employment and firm characteristics found within this region. Considering the occupational structure of employment, a relatively high proportion of people are estimated to be employed within Craft and Related Occupations (13.2% compared to an average of 11.1%) and as Plant and Machine Operatives (13.7% compared to an average of 10.7%). Considering other workplace characteristics, the lowest proportion of employees are employed in workplaces with less than 25 employees (31.4% compared to an average of 33.7%). However, the West Midlands has the lowest proportion of employees who are in non-permanent forms of employment over the sample period (6.1% compared to an average of 7.0%).

East Midlands

6.33 Average employee injury rates within the East Midlands are estimated to be approximately 6% higher than the average employee injury rate for all regions over the sample period. The relatively high employee injury rate is seen to be largely attributable to the occupational structure of employment found within this region. A relatively high proportion of people are employed within Craft and Related Occupations (14.0% compared to an average of 11.1%) and as Plant and Machine Operatives (12.2% compared to 10.7%).

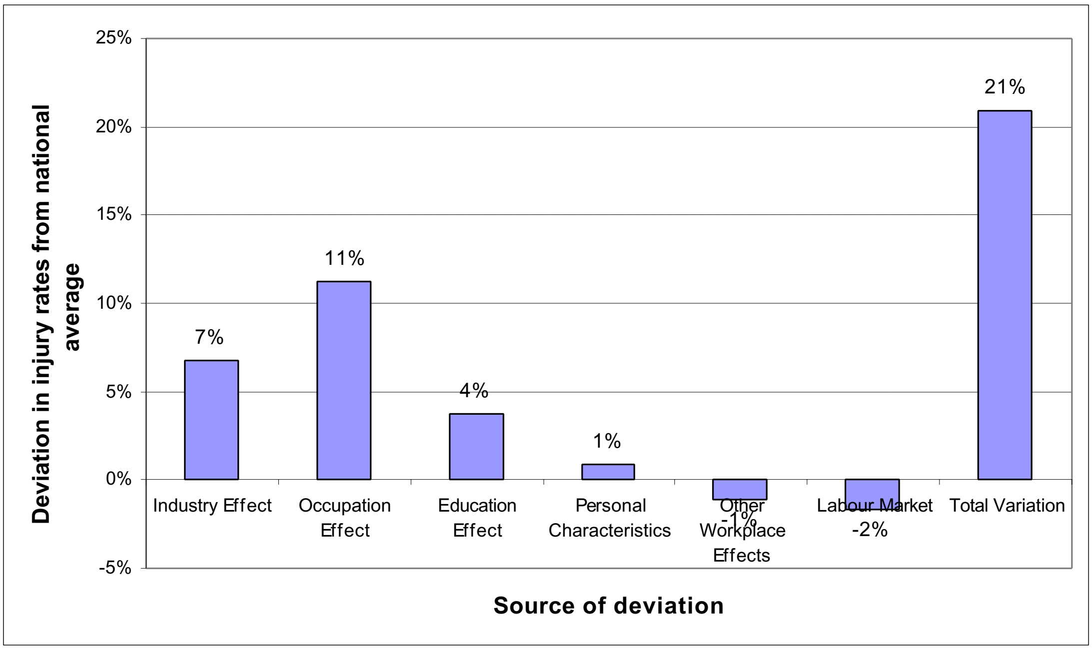
Figure 6.8: East Midlands



Yorkshire and Humberside

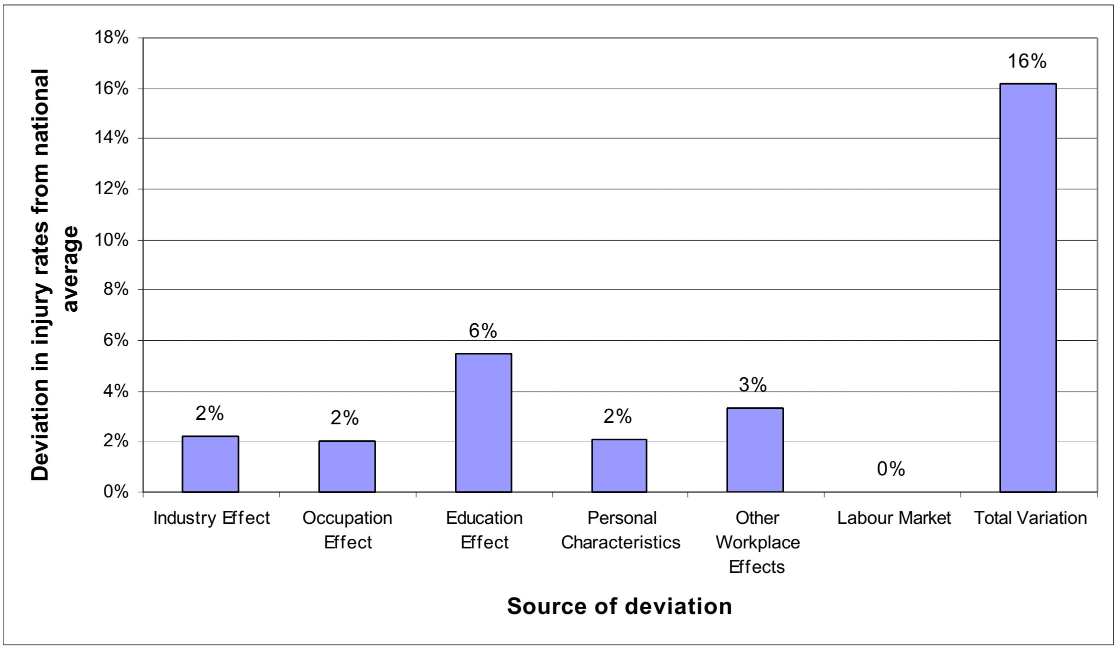
6.34 Average employee injury rates within Yorkshire and Humberside are estimated to be approximately 21% above the average employee injury rate for all regions over the sample period. The relatively high employee injury rate is seen to be largely attributable to the occupational composition of employment found within this region. In particular, a relatively high proportion of people are employed within Craft and Related Occupations (12.3% compared to an average of 11.1%) and as Plant and Machine Operatives (12.5% compared to an average of 10.7%). Industrial structure is also estimated to increase average injury rates within Yorkshire and Humberside by approximately 7%. In particular, a relatively high proportion of people are employed within the Manufacturing sector (24.9% compared to an average of 22.4%).

Figure 6.9: Yorkshire and Humberside



North West

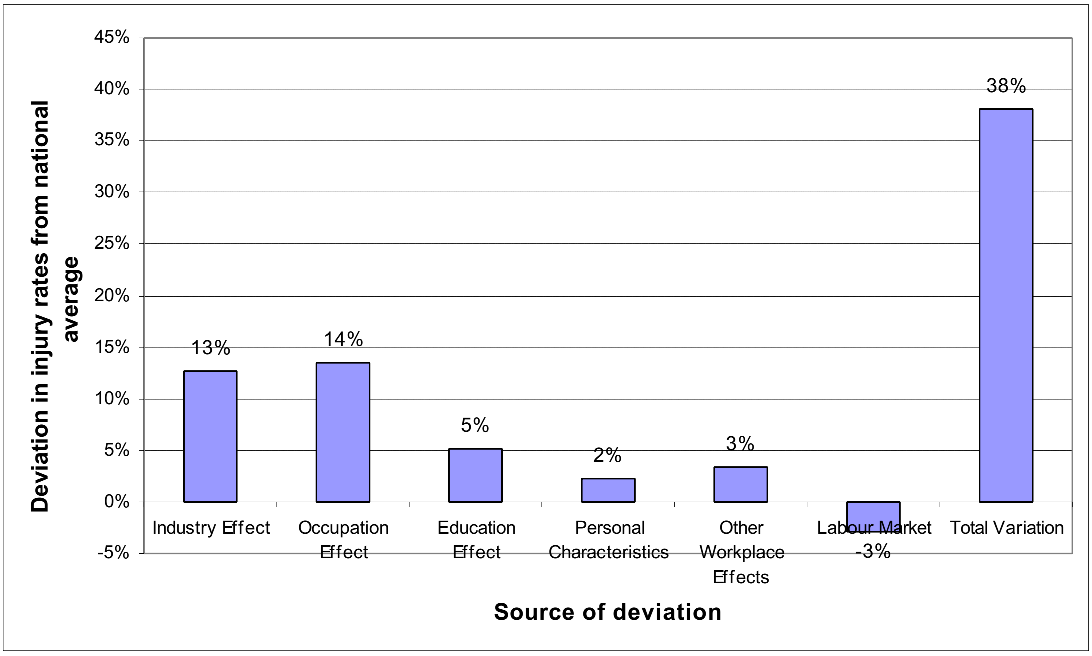
Figure 6.10: North West



6.35 Average employee injury rates within the North West are estimated to be approximately 16% above the average employee injury rate for all regions over the sample period. It can be seen that a variety of structural characteristics contribute to this relatively high injury rate. In terms of the occupational composition of employment, a relatively high proportion of people are employed within Clerical and Secretarial Occupations (17.3% compared to an average of 16.4%). Considering educational attainment, a relatively high proportion of employees have attained possess qualifications at the intermediate level of NVQ level 2 or equivalent (22.0% compared to an average of 21.0%). Considering the industrial structure of employment, a relatively high proportion of those in employment are employed within manufacturing (24.6% compared to 22.4%). Finally, a relatively small proportion of employees are employed in workplaces with less than 25 employees (31.8% compared to an average of 33.7%).

North

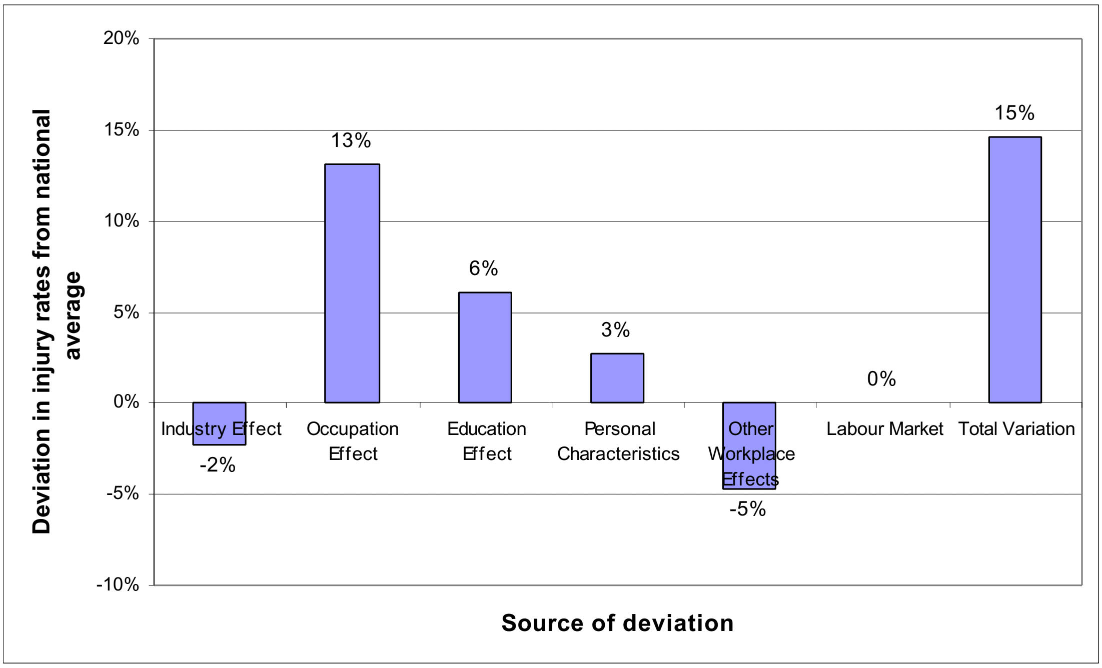
Figure 6.11: North



6.36 Average employee injury rates within the North are estimated to be approximately 38% above the average employee injury rate for all regions over the sample period. It can be seen that a majority of this variation is attributable to the industrial and occupational composition of employment. In terms of the industrial structure of employment, a relatively high proportion of people are employed within the Construction sector (6.4% compared to an average of 4.7%). Considering the occupational composition of employment, a relatively high proportion of employees are employed within Craft and Related Occupations (12.7% compared to an average of 11.1%) and within Other Occupations (10.3% compared to an average of 9.2%). Finally, the North contains the highest proportion of employees who are in non-permanent forms of employment (8.2% compared to an average of 7.0%).

Wales

Figure 6.12: Wales



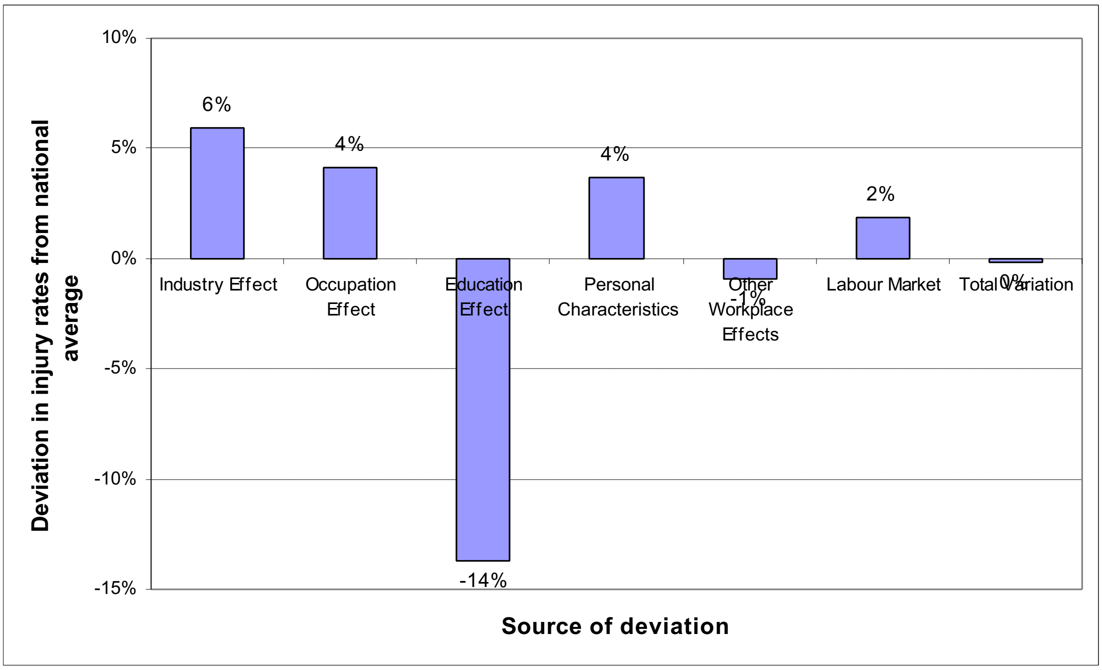
6.37 Average employee injury rates within Wales are estimated to be approximately 15% above the average employee injury rate for all regions over the sample period. The relatively high employee injury rate is seen to be largely attributable to the occupational composition of employment found within this region. In particular, Wales contains the highest proportion of people employed within Personal and Protective Service Occupations (12.6% compared to an average of 11.5%). A relatively high proportion of people are also employed as Plant and Machine Operatives (12.8% compared to an average of 10.7%) and in Other Occupations (10.3% compared to an average of 9.2%). Educational attainment is estimated to increase the employee injury rate in Wales by approximately 6%. In particular, a high proportion of employees possesses qualifications at NVQ level 2 or equivalent (22.6% compared to an average of 21.0%).

6.38 However, other workplace effects within Wales are estimated to have a negative effect upon the average employee injury rate. With the exception of the South West, Wales contains the highest proportion of people employed within establishments with less than 25 employees (36.4% compared to an average of 33.7%). However, Wales does contain a relatively high proportion of employees who are in non-permanent forms of employment (8.1% compared to an average of 7.0%).

Scotland

6.39 Average employee injury rates within Scotland are estimated to be approximately equal to the average employee injury rate across all regions over the sample period. However, the overall lack of variation disguises the influence of separate structural characteristics upon employee injury rates within Scotland. The industrial composition of employment is estimated to increase the employee injury rate by 6% over the sample period. This is attributable to a relatively high proportion of people employed within the Construction sector (6.7% compared to an average of 4.7%). Considering the occupational composition of employment, a relatively high proportion of employees are employed within Other Occupations (10.8% compared to an average of 9.2%). However, educational attainment is estimated to reduce the average employee injury rate in Scotland over the sample period by approximately 14%. This is due to the relatively high level of employees who possess qualifications at NQV level 3 or higher (58.2% compared to an average of 46.6%).

Figure 6.13: Scotland



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Appendix 1

Expansion of Injury Definitions Under RIDDOR 95

Fatalities:

Under RIDDOR 95, the fatalities arising from the following acts became reportable in addition to fatalities already reportable under RIDDOR 85.

- fatal injuries resulting from acts of suicide or trespass on railways or other relevant transport systems;
- fatal injuries resulting from acts of physical violence at work.

Major Injuries:

Under RIDDOR 95, the following injuries became reportable as major:

- any fracture (break, crack or chip) except to fingers, thumbs or toes including fractures to shoulders, shoulder blades, ribs, feet and hands; (such injuries may have led to over-three-day injuries under RIDDOR 85);
- any amputation (traumatic or surgical), not just those resulting in the joint or bone being completely severed;
- dislocations of shoulder, hip knee or spine;
- major injuries resulting from acts of violence at work;
- any injury to a member of the public which causes a person to be taken from the site of the accident to a hospital (previously injuries to the public were reportable if included in a list of specified major injuries).

Over-3-Day Injuries:

The only change in legislation for over-3-day injuries under RIDDOR 95 is that injuries resulting from acts of violence at the workplace become reportable.

Appendix 2

Stationarity of Injury Rate Time Series.

A2.1 The conventional test for stationarity is the Dickey Fuller test to determine whether a time series is a unit root process. If the time series has a unit root, it is an integrated process and hence non-stationary. Consider the following auto-regressive process:

$$1 \qquad Y_t = \beta Y_{t-1} + u_t$$

A2.2 If β equals 1 then Y_t is a unit root process. The basis of the Dickey Fuller test is to take the difference of this equation (subtract Y_{t-1} from both sides) and estimate the following equation using OLS:

$$2 \qquad dY_t = \delta Y_{t-1} + u_t$$

A2.3 Testing the hypothesis β =1 in equation 1 (i.e. a unit root) is equivalent to testing the hypothesis that $\delta = 0$ in equation 2. The Dickey Fuller test statistic does not have a standard t distribution since under the null hypothesis, the regressor Y_{t-1} is non stationary. T-statistics therefore have to be compared with values calculated by Dickey and Fuller (1979). Equation 2 can be estimated with the inclusion of a time trend and seasonal terms for which different critical values are considered. In different specifications of equation 2, the parameter of interest is always δ.

A2.4 The Dickey Fuller test does assume that the error term u_t is a white noise process. If the error term is not a white noise process, it is necessary to augment the Dickey Fuller regression with additional dY_{t-j} terms to allow for an ARMA process. The test statistics for the Augmented Dickey Fuller tests are the same as for the Dickey Fuller tests. After performing the Dickey Fuller test, it is therefore also necessary to analyse the residuals generated by the estimation of equation 2.

A2.5 Tests for stationarity were conducted on the time series of log odds ratios of full time equivalent male and female injury rates. The results of these tests are presented in sections A3(1) and A3(2). Section A3(1) provides results for Dickey Fuller tests. Section A3(2) provided results for Augmented Dickey Fuller tests where additional auto-regressive terms have been included in the test equation. Note that all Dickey Fuller tests incorporate time trends and seasonal terms.

A2.6 The results of Dickey Fuller tests suggest that we can reject the null hypothesis of a unit root process for both the male and female injury rate time series. However diagnostic tests indicate the presence of residual autocorrelation (LM test and Portmanteau statistics are both statistically significant for equations 1 and 2). It is therefore necessary to include additional autoregressive terms in the testing procedure. Five additional autoregressive terms were included in the augmented test. The ADF tests reject the null hypothesis of a unit root process for both the male and female injury time series. Tests for the presence residual autocorrelation are statistically insignificant (equations 3 and 4) indicating that the inclusion of the autoregressive terms was appropriate.

A2.7 Augmented Dickey Fuller tests indicate that the injury time series for males and females are stationary in the presence of seasonal and trend terms. It is therefore not necessary to difference the injury time series to achieve stationarity. The results are even more significant given that unit root tests have been shown to have low power against relevant alternatives and that in the presence of any structural breaks, Dickey Fuller tests are biased towards the non-rejection of a unit root hypothesis.

A2(1) Dickey Fuller Test of Male and Female Log Odds Ratios

```
Unit-root tests 86 (5) to 96 (3)
Critical values: 5%=-3.448 1%=-4.037; Constant and Trend and
Seasonals included

                 t-adf      beta Y_1    \sigma lag  t-DY_lag  t-prob
F-prob
ADJMODDS       -7.4895**     0.27197  0.059766   0
ADJFODDS       -4.5694**     0.64467  0.070034   0
```

Analysis of Residuals Generated by Dickey Fuller Tests

(a) Males

```
EQ(1) Modelling dadjm by OLS  (using pcgive.xls)
The present sample is:  86 (5) to 96 (3)

Variable     Coefficient    Std.Error  t-value  t-prob PartR^2
ADJMODDS_1      -0.72803     0.097207   -7.490  0.0000  0.3482
Seasonal       -0.049197     0.028302   -1.738  0.0851  0.0280
Seasonal_1      -0.10957     0.027644   -3.963  0.0001  0.1301
Seasonal_2     -0.022478     0.026739   -0.841  0.4025  0.0067
Seasonal_3      0.033930     0.027705    1.225  0.2234  0.0141
Seasonal_4     -0.029068     0.030448   -0.955  0.3419  0.0086
Seasonal_5      -0.43602     0.028704  -15.190  0.0000  0.6873
Seasonal_6      0.090964     0.040397    2.252  0.0264  0.0461
Seasonal_7     -0.021694     0.028527   -0.760  0.4487  0.0055
Seasonal_8     -0.033011     0.028523   -1.157  0.2497  0.0126
Seasonal_9      -0.14001     0.029404   -4.762  0.0000  0.1776
Seasonal_10    -0.093494     0.026741   -3.496  0.0007  0.1043
Constant         -5.0350      0.68559   -7.344  0.0000  0.3394
Trend        -0.00073078   0.00018452   -3.960  0.0001  0.1300

R^2 = 0.915451  F(13,105) = 87.452 [0.0000]  \sigma = 0.0597663  DW =
2.02
RSS = 0.3750605123 for 14 variables and 119 observations


AR 1- 7 F( 7, 98) =     8.2396 [0.0000] **
ARCH 7  F( 7, 91) =    0.60457 [0.7507]
Normality Chi^2(2)=     8.7512 [0.0126] *
Xi^2    F(15, 89) =     1.3195 [0.2077]
RESET   F( 1,104) = 0.00040282 [0.9840]
```

(b) Females

```
EQ(2) Modelling dadjf by OLS  (using pcgive.xls)
The present sample is:  86 (5) to 96 (3)

Variable     Coefficient    Std.Error  t-value  t-prob PartR^2
Seasonal_1      -0.19312     0.031420   -6.146  0.0000  0.2646
Seasonal_2      0.052601     0.032035    1.642  0.1036  0.0250
Seasonal_3    0.00047974     0.031990    0.015  0.9881  0.0000
Seasonal_4     -0.061578     0.033177   -1.856  0.0662  0.0318
Seasonal_5      -0.40071     0.032586  -12.297  0.0000  0.5902
Seasonal_6       0.20606     0.036519    5.643  0.0000  0.2327
Seasonal_7      -0.13077     0.033102   -3.951  0.0001  0.1294
Seasonal_8     -0.065195     0.031541   -2.067  0.0412  0.0391
```

Seasonal_9	-0.13500	0.032665	-4.133	0.0001	0.1399
Seasonal_10	-0.078952	0.031335	-2.520	0.0133	0.0570
Constant	-2.7384	0.62089	-4.410	0.0000	0.1563
Trend	0.00079090	0.00027508	2.875	0.0049	0.0730
Seasonal	-0.11039	0.032036	-3.446	0.0008	0.1016
ADJFODDS_1	-0.35533	0.077763	-4.569	0.0000	0.1659

```
R^2 = 0.87184  F(13,105) = 54.945 [0.0000]  \sigma = 0.0700337  DW =
2.46
RSS = 0.5149953253 for 14 variables and 119 observations


AR 1- 7 F( 7, 98) =     8.2801 [0.0000] **
ARCH 7  F( 7, 91) =    0.43704 [0.8765]
Normality Chi^2(2)=     10.394 [0.0055] **
Xi^2    F(15, 89) =     1.9436 [0.0288] *
RESET   F( 1,104) =    0.71496 [0.3997]
```

A2(2) Augmented Dickey Fuller Test of Male and Female Log Odds Ratios

Unit-root tests 86 (10) to 96 (3)
Critical values: 5%=-3.449 1%=-4.041; Constant and Trend and Seasonals included

	t-adf	beta Y_1	\sigma	lag	t-DY_lag	t-prob	F-prob
ADJMODDS	-1.3654	0.83224	0.046803	5	-2.4403	0.0165	
ADJMODDS	-2.0554	0.75076	0.047995	4	-1.1686	0.2455	0.0165
ADJMODDS	-2.4242	0.71502	0.048086	3	-0.41086	0.6821	0.0285
ADJMODDS	-2.6037	0.70370	0.047881	2	-5.4623	0.0000	0.0623
ADJMODDS	-4.5940**	0.45538	0.054410	1	-3.0087	0.0033	0.0000
ADJMODDS	-7.4876**	0.24846	0.056558	0			0.0000

Unit-root tests 86 (10) to 96 (3)
Critical values: 5%=-3.449 1%=-4.041; Constant and Trend and Seasonals included

	t-adf	beta Y_1	\sigma	lag	t-DY_lag	t-prob	F-prob
ADJFODDS	-2.5683	0.78975	0.054194	5	-2.1310	0.0357	
ADJFODDS	-2.8594	0.76422	0.055184	4	-0.54778	0.5851	0.0357
ADJFODDS	-2.9355	0.75991	0.054985	3	-1.4768	0.1430	0.0938
ADJFODDS	-3.1591	0.74272	0.055315	2	-2.8228	0.0058	0.0758
ADJFODDS	-3.5992*	0.70162	0.057229	1	-4.9076	0.0000	0.0061
ADJFODDS	-5.3520**	0.54546	0.063492	0			0.0000

Analysis of Residuals Generated by Dickey Fuller Tests

(a) Males

EQ(3) Modelling dadjm by OLS (using pcgive.xls)
The present sample is: 86 (10) to 96 (3)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
Constant	-1.0453	0.86943	-1.202	0.2323	0.0150
adjml1	-0.16776	0.12287	-1.365	0.1754	0.0192
Seasonal	-0.075364	0.051727	-1.457	0.1484	0.0219
Seasonal_1	-0.14617	0.054649	-2.675	0.0088	0.0700
Seasonal_2	-0.10871	0.051684	-2.103	0.0381	0.0445
Seasonal_3	0.0036854	0.039373	0.094	0.9256	0.0001
Seasonal_4	-0.036824	0.044997	-0.818	0.4152	0.0070
Seasonal_5	-0.50898	0.052691	-9.660	0.0000	0.4955

Seasonal_6	-0.10468	0.058066	-1.803	0.0746	0.0331
Seasonal_7	-0.022235	0.045051	-0.494	0.6228	0.0026
Seasonal_8	0.030127	0.071225	0.423	0.6733	0.0019
Seasonal_9	-0.23656	0.071330	-3.316	0.0013	0.1038
Seasonal_10	-0.15920	0.067384	-2.363	0.0202	0.0555
Trend	-0.00047365	0.00017541	-2.700	0.0082	0.0713
dadjml1	-0.83429	0.13968	-5.973	0.0000	0.2730
dadjml2	-0.69290	0.15081	-4.595	0.0000	0.1818
dadjml3	-0.34544	0.15516	-2.226	0.0284	0.0496
dadjml4	-0.33715	0.13255	-2.544	0.0126	0.0638
dadjml5	-0.23221	0.095155	-2.440	0.0165	0.0590

R^2 = 0.951596 F(18,95) = 103.76 [0.0000] \sigma = 0.0468028 DW =
1.93
RSS = 0.2080973325 for 19 variables and 114 observations

```
AR 1- 7 F( 7, 88) =    0.74809 [0.6320]
ARCH 7  F( 7, 81) =    0.46013 [0.8605]
Normality Chi^2(2)=     3.5933 [0.1659]
Xi^2    F(25, 69) =      1.123 [0.3431]
RESET   F( 1, 94) =  0.0047589 [0.9451]
```

(b) Females

EQ(4) Modelling dadjf by OLS (using pcgive.xls)
The present sample is: 86 (10) to 96 (3)

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
Constant	-1.5108	0.65411	-2.310	0.0231	0.0532
adjfl1	-0.21025	0.081861	-2.568	0.0118	0.0649
dadjfl1	-0.68392	0.10881	-6.286	0.0000	0.2937
dadjfl2	-0.43673	0.12522	-3.488	0.0007	0.1135
dadjfl3	-0.28243	0.12803	-2.206	0.0298	0.0487
dadjfl4	-0.21394	0.12035	-1.778	0.0786	0.0322
dadjfl5	-0.19615	0.092049	-2.131	0.0357	0.0456
Seasonal	-0.12340	0.047744	-2.585	0.0113	0.0657
Seasonal_1	-0.22160	0.041851	-5.295	0.0000	0.2279
Seasonal_2	-0.064484	0.043721	-1.475	0.1436	0.0224
Seasonal_3	0.018116	0.037745	0.480	0.6324	0.0024
Seasonal_4	-0.036636	0.043266	-0.847	0.3993	0.0075
Seasonal_5	-0.43722	0.049530	-8.827	0.0000	0.4506
Seasonal_6	-0.022952	0.054568	-0.421	0.6750	0.0019
Seasonal_7	-0.047940	0.040279	-1.190	0.2369	0.0147
Seasonal_8	-0.10334	0.055643	-1.857	0.0664	0.0350
Seasonal_9	-0.18883	0.057171	-3.303	0.0013	0.1030
Seasonal_10	-0.15664	0.060129	-2.605	0.0107	0.0667
Trend	-5.4406e-007	0.00025726	-0.002	0.9983	0.0000

R^2 = 0.925881 F(18,95) = 65.929 [0.0000] \sigma = 0.0541939 DW =
1.93
RSS = 0.2790134179 for 19 variables and 114 observations

```
AR 1- 7 F( 7, 88) =     1.0316 [0.4150]
ARCH 7  F( 7, 81) =    0.56491 [0.7823]
Normality Chi^2(2)=     2.9686 [0.2267]
Xi^2    F(25, 69) =      0.947 [0.5444]
RESET   F( 1, 94) =   0.066945 [0.7964]
```

Appendix 3

A3(a) Description of Dependent and Explanatory Variables for Analysis of National Injury Rate Time Series:

Sample Period:
April 1986 to March 1997 – 132 months

Dependent Variables:
Model 1: ADJODDS.
Logarithmic transformation of full time equivalent monthly employee injury rate.

Model 2: ADJMODDS.
Logarithmic transformation of male full time equivalent monthly employee injury rate.

Model 3: ADJFODDS.
Logarithmic transformation of female full time equivalent monthly employee injury rate.

Explanatory Variables:
JAN-DEC.
11 seasonal 0/1 dummy variables
Reference month = April

RIDDOR95.
Step dummy variable to reflect introduction of RIDDOR95 reporting regulations – equals 0 prior to introduction of RIDDOR 95 and 1 thereafter.

TREND: Deterministic linear trend.

UERATE: Monthly claimant unemployment rate.

A3(b) Estimation Results

Model 1: Monthly Employee Injury Rates – All Employees

Modelling ADJODDS by RALS
The present sample is: 86 (7) to 97 (3)

Variable	Coefficient	Std.Error	t-value	t-prob
Constant	-7.1595	0.043850	-163.272	0.0000
JAN	0.12528	0.018799	6.664	0.0000
FEB	0.096946	0.024817	3.906	0.0002
MAR	0.084009	0.024826	3.384	0.0010
MAY	0.019601	0.025263	0.776	0.4394
JUN	0.10188	0.025283	4.030	0.0001
JUL	0.081742	0.018430	4.435	0.0000
AUG	0.0041429	0.024850	0.167	0.8679
SEP	0.091314	0.024851	3.674	0.0004
OCT	0.16405	0.020779	7.895	0.0000
NOV	0.12327	0.024798	4.971	0.0000
DEC	-0.27619	0.024796	-11.138	0.0000
RIDDOR95	-0.0094695	0.025720	-0.368	0.7134
TREND	-0.00082144	0.00023098	-3.556	0.0006
UERATE	-0.014562	0.0046046	-3.163	0.0020
Uhat_3	0.39027	0.089452	4.363	0.0000

Diagnostic Statistics:
Autocorrelation = 1.58771 [0.1568]
Heteroscedasticity = 1.8793 [0.0315] *
ARCH effects = 0.11328 [0.7371]

Model 2: Monthly Employee Injury Rates – Male Employees

Modelling ADJMODDS by RALS
The present sample is: 86 (7) to 97 (3)

Variable	Coefficient	Std.Error	t-value	t-prob
TREND	-0.0011679	0.00022174	-5.267	0.0000
Constant	-6.9189	0.042433	-163.055	0.0000
JAN	0.12092	0.018463	6.549	0.0000
FEB	0.11325	0.024149	4.690	0.0000
MAR	0.096363	0.024161	3.988	0.0001
MAY	0.019590	0.024594	0.797	0.4274
JUN	0.10466	0.024616	4.252	0.0000
JUL	0.092447	0.018114	5.104	0.0000
AUG	0.023932	0.024180	0.990	0.3244
SEP	0.090275	0.024192	3.732	0.0003
OCT	0.16700	0.020393	8.189	0.0000
NOV	0.12414	0.024130	5.145	0.0000
DEC	-0.29126	0.024135	-12.068	0.0000
UERATE	-0.014410	0.0044420	-3.244	0.0016
RIDDOR95	-0.0039448	0.024867	-0.159	0.8742
Uhat_3	0.38223	0.089042	4.293	0.0000

Diagnostic Statistics:
Autocorrelation = 1.13385 [0.3471]
Heteroscedasticity = 1.7889 [0.0435] *
ARCH effects = 0.030009 [0.8628]

Model 3.
Monthly Employee Injury Rates – Female Employees

```
Modelling ADJFODDS by RALS
The present sample is:  86 (6) to 97 (3)
```

Variable	Coefficient	Std.Error	t-value	t-prob
Constant	-8.0377	0.053236	-150.983	0.0000
JAN	0.15399	0.025764	5.977	0.0000
FEB	0.055493	0.022421	2.475	0.0148
MAR	0.058012	0.025821	2.247	0.0266
MAY	0.026219	0.026196	1.001	0.3190
JUN	0.10128	0.021984	4.607	0.0000
JUL	0.057649	0.025725	2.241	0.0270
AUG	-0.066438	0.024730	-2.687	0.0083
SEP	0.10015	0.025705	3.896	0.0002
OCT	0.15981	0.025261	6.327	0.0000
NOV	0.13639	0.025721	5.303	0.0000
DEC	-0.21583	0.024849	-8.685	0.0000
UERATE	-0.0090115	0.0044832	-2.010	0.0468
RIDDOR95	0.076915	0.034166	2.251	0.0263
TREND	0.0085743	0.00090660	9.458	0.0000
TRENDSQR	-5.2001e-005	7.0922e-006	-7.332	0.0000
Uhat_2	0.25759	0.091103	2.827	0.0056

Diagnostic Statistics:

```
Autocorrelation         = 1.42282 [0.2116]
Heteroscedasticity      =  1.2906 [0.2152]
ARCH effects            = 0.02424 [0.8766]
```

Appendix 4

A4(a) Description of Dependent and Explanatory Variables for Analysis of Pooled Regional Injury Rate Time Series:

Sample Period:
Spring 1992 to Winter 1996/7 for 11 regions - 220 quarters.

Dependent Variables:
REJODDS: Logarithmic transformation of quarterly full time equivalent regional employee injury rate.

Explanatory Variables:

Seasonal Variables:
LFS1-LFS4: 3 seasonal 0/1 dummy variables relating to LFS quarters (dropped variable = LFS2).

LFS1 = December to February
LFS3 = June to August
LFS4 = September to November

Cyclical Variables:
UVRATIO: Regional unemployment/vacancy ratios.

HOURS: Average hours worked per week by employees in main job.

EMPMON: Average length of time continuously employed (months).

TREND: Deterministic linear trend.

Industrial Composition of Employment:
SECTOR1–SECTOR6: Percentage of employees employed in following industrial sectors:

SECTOR1 = Primary sector and utilities.
SECTOR2 = Manufacturing.
SECTOR3 = Construction.
SECTOR4 = Distribution, transport.
SECTOR5 = Business and miscellaneous (reference)
SECTOR6 = Non-marketed services.

Occupational Composition of Employment
SOCMAJ1-SOCMAJ9: Percentage of employees employed in Major Groups 1-9 of the Standard Occupational:

SOCMAJ1 = Managers and administrators.
SOCMAJ2 = Professional occupations.
SOCMAJ3 = Associate professional and technical occupations.
SOCMAJ4 = Clerical and secretarial occupations.
SOCMAJ5 = Craft and related occupations.
SOCMAJ6 = Personal and protective services occupations.

SOCMAJ7 = Sales occupations (reference).
SOCMAJ8 = Plant and machine operatives.
SOCMAJ9 = Other occupations.

Educational Attainment:
NVQ1-NVQ5, OTHER, NONE: Percentage of employees possessing highest qualifications at NVQ levels 1 to 5 (or qualifications of an equivalent standard), other qualifications not elsewhere classified or no qualifications.

NVQ5 - Higher degree, NVQ level 5.
NVQ4 - First degree, other degree, HNC/HND, BTEC higher, teaching qualification, nursing qualification, RSA higher diploma, NVQ level 4.
NVQ3 – A level, Advanced GNVQ, RSA advanced diploma, OND/ONC, BTEC/SCOTVEC national, SCE higher, AS level, trade apprenticeship, NVQ level 3.
NVQ2 – GNVQ intermediate, RSA diploma, City and Guilds, BTEC/SCOTVEC first or general diploma, O level, GCSE grade A-C, NVQ level 2. (reference).
NVQ1 – GNVQ/GSVQ foundation level, CSE below grade 1, GCSE below grade C, BTEC/SCOTVEC first or general certificate, RSA other, City and Guilds other, YT/YTP certificate, NVQ level 1.

Personal Characteristics:

FEMALE: Percentage of employees who are female.

BLACK: Percentage of employees of non-white descent.

AGE: Average age of employees in employment.

Workplace Characteristics:

SMALL: Percentage of employees in workplaces with less than 25 employees.

TRAIN: Percentage of employees who have received job related education or training in the previous 4 weeks.

Atypical Employment:

TEMP: Percentage of employees who are in non-permanent employment.

PTIME: Percentage of employees who are in part-time employment.

A4(b) Estimation Results

Quarterly Regional Employee Injury Rates

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
Constant	-5.2152	1.3927	-3.745	0.0002	0.0664
RIDDOR95	0.035796	0.033449	1.070	0.2859	0.0058
TREND	-0.0071687	0.0043078	-1.664	0.0977	0.0139
SECTOR2	0.011490	0.0055622	2.066	0.0402	0.0212
SECTOR3	0.067628	0.013376	5.056	0.0000	0.1148
SECTOR4	0.036587	0.0073295	4.992	0.0000	0.1123
SOCMAJ4	0.035225	0.0096000	3.669	0.0003	0.0640
SOCMAJ5	0.042196	0.0090988	4.638	0.0000	0.0984
SOCMAJ6	0.061139	0.0089211	6.853	0.0000	0.1925
SOCMAJ8	0.035335	0.0090520	3.904	0.0001	0.0718
SOCMAJ9	0.023659	0.010350	2.286	0.0233	0.0258
NVQ5	-0.061759	0.014442	-4.276	0.0000	0.0849
NVQ4	-0.040571	0.0069205	-5.862	0.0000	0.1485
NVQ3	-0.029066	0.0050591	-5.745	0.0000	0.1435
NVQ1	-0.033489	0.010541	-3.177	0.0017	0.0487
OTHER	-0.041049	0.0085885	-4.779	0.0000	0.1039
NONE	-0.035518	0.0074597	-4.761	0.0000	0.1032
AGE	-0.082935	0.022612	-3.668	0.0003	0.0639
FEMALE	0.020362	0.0094394	2.157	0.0322	0.0231
SMALL	-0.024927	0.0047872	-5.207	0.0000	0.1210
TEMP	0.017759	0.0082883	2.143	0.0334	0.0228
HOURS	0.030765	0.0053379	5.764	0.0000	0.1443
UVRATIO	-0.0026313	0.0011728	-2.244	0.0260	0.0249

Diagnostic Statistics:

```
Autocorrelation        = 1.5749 [0.1564]
Heteroscedasticity     = 1.3674 [0.0869]
ARCH effects           = 1.5625 [0.1603]
Functional form        = 2.1013 [0.1488]
```