Do Longer Working Hours Lead to More Workplace Injuries? Evidence from Australian Industry-Level Panel Data

Roger Wilkins*
Melbourne Institute of Applied Economic and Social Research
The University of Melbourne

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Melbourne Institute of Applied Economic and Social Research
The University of Melbourne
Victoria 3010 Australia
***Telephone* (03) 8344 2100**
***Fax* (03) 8344 2111**
***Email* melb-inst@unimelb.edu.au**
***WWW Address* http://www.melbourneinstitute.com**

Abstract

Using Australian industry-level data on weekly hours of work and frequency of new workers' compensation claims for work-related accidents over the 1990s, the relationship between working time and work-related injuries is examined. Results using panel data techniques suggest there is no relationship between working time of full-time workers and workplace safety performance. This finding is in contrast to cross-sectional evidence presented by previous researchers showing significant effects of working time on safety performance. Evidence is found in this study, however, that increased working time of *part-time* employed persons is associated with a greater rate of workplace injuries.

1. Introduction

Understanding the determinants of work-related injuries is critical to the implementation of safe and productive work practices. One potentially important determinant is working time – that is, the length of time worked per shift, week, or indeed any other period of time. For example, fatigue associated with long hours of work may increase the likelihood of accidents, and exceptionally long hours may also result in injuries associated with breaching physical endurance limits. While it stands to reason that a relationship between working time and safety does exist, there is limited understanding of the extent and nature of the relationship. For example, it is not clear what effect working an additional hour per week has on the likelihood of injury.

This paper seeks to examine the relationship between working time and safety using industry-level data disaggregated at the Australia and New Zealand Standard Industrial Classification (ANZSIC) two-digit level over the period 1991-92 to 1999-2000. These data comprise industry-level information on weekly hours of work and the number of workers' compensation claims for work-related accidents. Two specific issues are examined. First, the relationship between mean weekly hours of work and work-related injuries, and whether this differs between part-time and full-time workers, is investigated. Second, the relationship between the incidence of extreme, and more specifically, very long, weekly hours of work and work-related injuries is examined.

Attention is restricted to these two dimensions of working time largely due to the limitations of available data. It is acknowledged that other dimensions to working time are potentially important for their effects on workplace safety, and these two measures may not capture these dimensions. For example, the length of time worked without breaks within a shift, the length of the shift, and the number of days worked in succession are all likely to be important, and are also likely to be imperfectly correlated with mean weekly hours of work and the proportion of workers in the industry working very long hours.

Data availability similarly dictates the decision to use *industry*-level data. Ideally, individual-level data on working hours and the occurrence of workplace injuries for a representative sample of workers would be used to investigate the issue, one advantage of which would be that examination of how the effects of working time on safety differ by industry, occupation, age, educational attainment, sex and other personal characteristics would be possible. However, suitable individual-level are not available in Australia.

Despite the limitations of the available data, the application of appropriate econometric techniques – in particular, panel data methods – to these data can deliver valuable insights into the relationship between working time and workplace safety. In fact, the application of panel data methods to the data represents the main contribution of this study. Previous studies of this issue, whether using individual-level or industry-level data, have employed cross-sectional regression methods (for example, Kriebel (1982), Leigh (1982, 1986), Curington (1986) and Wooden (1990, 1998)).[1] Such methods are susceptible to spurious inferences deriving from unobserved characteristics. Specifically, even when variables for observed characteristics that are likely to impact on safety are included in cross-sectional regression models, unobserved factors that affect safety and are also correlated with working time are likely to remain.

The panel data methods employed in this study control for unobserved characteristics, and are therefore not open to the criticism that unobserved characteristics are driving an apparent association between working time and workplace safety. The intuition for the approach is that the effect of working time on safety is identified by changes in measures of working time and safety from year to year *within* each industry. Put plainly, if there is a relationship between working time and safety, then a change in working time in an industry from one year to the next should, all else equal, cause a change in workplace safety performance.

As the preceding discussion suggests, an important motivation for the current study is doubt about the validity of findings by previous research using cross-sectional approaches. Previous studies using industry-level data have essentially used differences in working hours and safety performance across industries to identify the relationship, attempting to control for other sources of differences in safety outcomes by including variables for other observable characteristics of industries. While differences in focus, data and variable definitions make generalisations difficult, it is reasonable to characteristics these studies as finding a negative relationship between working time and safety performance: that is, increased working time leads to more workplace injuries.

The current study calls these findings into question. No evidence is found that increased working time of full-time workers is associated with an increased rate of workplace injuries, suggesting results of previous studies may derive from unobserved differences across industries that

[1] It should also be noted that there is a significant body of what might be characterised as ‘medically-based’ research, investigating the links between workplace safety and fatigue and sleep deprivation, both of which may be correlated with working time. See Dawson *et al.* (2001) for a review of this literature. Dawson et. al also document two studies (Haenecke et al. (1998) and Nachreiner et. al (2000)) that examine the closely related issue of the relationship between length of shift (an important dimension of working time) and *fatality* risk. Both studies find that working beyond the ninth hour increases the fatality risk.

happened to be correlated with working hours – for example, the extent of manual labour used in the industry and the inherent danger of the work. Evidence is found, however, that increased working time of part-time workers does increase the injury rate.

2. Data

Safety outcomes

Safety outcomes are measured using data on new workers' compensation claims in each financial year over the period 1991-92 to 1999-2000, produced by the National Occupational Health and Safety Commission (NOHSC).[2] These data are compiled from claims received from insurance companies, self-insurers and some government departments for workers' compensation made under the various Commonwealth, State and Territory workers' compensation Acts. Claims covered are those that resulted from a fatality, a permanent disability, or a temporary disability that involved an absence from work of at least 5 days. In addition to excluding claims for injuries resulting in absences from work of less than 5 days, the NOHSC data also exclude:

- claims for injuries or diseases occurring on a journey to or from work;
- cases compensated under legislation for specific groups of workers that is separate from the general Commonwealth, State and Territory workers' compensation legislation;
- injuries suffered by military personnel within the defence forces;
- cases not explicitly acknowledged as being work-related injuries;
- most occupational injuries to the self-employed.

The time frame 1991-92 to 1999-2000 is largely dictated by the available data on workers' compensation claims. National data on work-related injury claims do not exist prior to 1991-92, while the most recent year for which national data currently exist is 1999-2000.[3] Indeed, the data available over the period 1991-92 to 1999-2000 are not entirely complete, with claims for Victoria and the ACT excluded for all years in order to produce a consistent measure of claims over time. The reasons for these exclusions are that data for the ACT are not available in any year, while the Victorian claims data are not available in 1991-92 and 1993-94, and for other years exclude claims involving absences from work of between five and ten days. However, the

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[2] The sources for these data are Worksafe Australia (1993, 1994, 1995), the NOHSC website (http://www.nohsc.gov.au) and NOHSC (1998a, 1998b, 1999, 2000, 2002).

[3] The potential exists to utilise State-based data over longer time frames, but aggregation to produce national estimates is not viable due to significant gaps in the data and differences in the information collected across States.

available NOHSC data do not allow us to exclude Victoria in 1992-93. The analysis therefore excludes the 1992-93 financial year.

A further source of inconsistency over time is that changes to the system for classifying industries occurred in 1994-95. Industries were classified according to the Australian Standard Industrial Classification (ASIC) prior to 1994-95, but have since been classified according to the Australia and New Zealand Standard Industrial Classification (ANZSIC). Although most of the 53 industry subdivisions are the same for both classification systems, there are some important differences. Details on the attempts made to achieve concordance between the ASIC and ANZSIC categories are provided in an appendix.

In addition to the problems constructing the variable ‘new workers’ compensation claims’, it should also be acknowledged that the variable is itself not a perfect measure of workplace injuries. First, only injuries that give rise to the compensation claims described above are included, implying measured workplace injuries diverge from actual workplace injuries. Importantly, the degree of divergence between the number of claims and the number of actual workplace injuries is likely to vary across industries. This is because of both differences in the types of injury incurred across industries – that is, some industries will have a higher incidence of injuries that do not give rise to included workers’ compensation claims – and differences in the propensity to lodge a claim for a given injury. For example, more highly unionised industries probably have higher rates of claims, all else being equal, because workers are likely to be better informed about their rights.

A second important limitation of using data on the number of compensation claims is that no allowance is made for the severity of the injury. It is arguable that some adjustment for severity is important. For example, an injury leading to permanent work incapacity should perhaps be given more weight than an injury leading to a one-week absence from work and no long-term adverse effects. The available data do not, however, allow us to do this.

Rather than examine the number of claims, the focus is on the frequency of claims, defined as the number of claims per one million hours worked in the industry. This frequency variable is preferable to the actual number of claims, since it adjusts for the number of hours that workers are ‘at risk’ of injury in each industry (i.e., the number of hours worked in the industry). The effects of differences in industry sizes are therefore eliminated. Expressing claims as a proportion of (million) hours worked also has the advantage of reducing sensitivity to the exclusion of groups of workers. For example, as noted above, most claims for self-employed workers are excluded, so the hours worked by these self-employed workers are also excluded in estimating the claims frequency.

Working time

Data on hours of work in each 2-digit industry for each year come from unpublished ABS data. The data relate to the August quarter of each year, with the focus on mean weekly hours of work and the proportion of employees working long hours, defined as 50 or more hours per week. Managerial employees are excluded from all data used in the analysis on the grounds that managerial hours are unlikely to affect the frequency of workplace injuries.[4] The data also permit distinguishing between full-time and part-time workers, and therefore allow us to examine separate hours measures for these two groups, as well as condition on the proportion of employees who are part-time.

As indicated in Section 1, these measures may not capture dimensions of working time that may affect workplace safety. These include the length of time worked over different time frames, such as a single day, a month or a year, as well as other working time patterns, such as the extent and nature of shift work, the length of time between breaks on shifts, the number of days worked in succession and interactions between these dimensions (for example, the length of the shift combined with the time of day worked). Ideally, the effects on workplace safety of these other dimensions of working time would be examined, but this is not possible with the available ABS data on working hours in each industry.[5] The measures used do, however, provide important information on the length of working time of employees in each industry, and it is therefore legitimate to investigate their implications for the rate of occurrence of workplace injuries.

3. The relationship between working time and workplace safety

Methods

Previous research using industry-level data to investigate the relationship between working time and workplace safety has adopted a cross-section regression approach (for example, Kriebel (1982), Curington (1986), Wooden (1990, 1998)). Using this approach, the relationship between working time and claims is identified via variation in working time and claims across industries.

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[4] While managerial employees are typically at low risk of physical injury, they are arguably at greater risk of stress-related conditions. However, given our interest is in workplace *injuries*, and that less than 4% of workers' compensation claims are for mental disorders (see http://www.nohsc.gov.au for details on claims by injury type), the focus on working time of non-managerial employees appears justified.

[5] Heiler et. al. (2000) explore some of these dimensions of working time for a sample of 180 coal and metalliferous mines in Australia in 2000. Although the authors discuss the potential implications of working time patterns for workplace safety in the mining industry, they do not have data on safety outcomes to enable any conclusions to be drawn about the relationship between working time patterns and workplace safety.

The intuition is that if industries with higher claims frequencies tend to have higher (or lower) working times, then we would find a relationship between the two. The equations estimated are of the form:

$$E\left(c_i\right) = \alpha + \beta H_i \qquad (1)$$

where $E\left(c_i\right)$ is the expected frequency of claims of industry i, H_i is either mean weekly hours of work in industry i or the proportion of employees working long hours in industry i, and where estimation is over all I industries in one year.

This approach has the problem that differences between industries other than differences in working time may be responsible for differences in claims rates. For example, inherently dangerous industries may tend to have more persons employed on a full-time basis, perhaps because costs of required safety training are too prohibitive to warrant employment on only a part-time basis. In such industries, the higher average working hours do not cause the higher rate of claims; rather, a high claims frequency and long working hours *both* derive from the more dangerous nature of the work. Cross-sectional estimates of the effects of working hours on the frequency of claims may therefore reflect the effects of (unobserved) differences, such as the inherent danger of the work, rather than the effects of working hours differences themselves.

In principle, it is possible to control for other sources of inter-industry variation in claims frequency and thereby accurately identify the effect of working time using cross-sectional methods. That is, we can include variables capturing other characteristics of industries that affect the claims frequency. Indeed, previous studies of workplace safety have included in the models estimated variables for a number of characteristics other than working time. In practice, however, the problem of not controlling for other sources of variation in the claims frequency is unlikely to be completely resolved by the inclusion of additional variables. This is because some sources are likely to be unobservable (such as the use of technology to improve safety) and therefore variables for these sources of inter-industry variation in claims frequency will not be available from any data source.

This problem motivates the use of panel data regression methods – specifically, 'fixed effects' models, which control for (time-invariant) differences across industries in unobserved characteristics. These models essentially identify the relationship between working time and safety by comparing across industries the within-industry changes over time in working hours and safety. That is, to identify the effects of working time on the frequency of workers' compensation claims, industry-specific effects are assumed fixed over time – for example, holding constant working time, the extent to which coal mining is more dangerous than property services is constant over time.

The models estimated also control for 'year effects', which is achieved by allowing for differences in claims frequencies across years, under the assumption that these year-specific (time) effects are the same for all industries. For example, changes to government policy may change the claims frequency over time, and this effect is controlled for, to the extent that it is the same for all industries.[6]

The intuition for the fixed effects estimation method is that variations over time in each industry's claims frequency and working hours, controlling for economy-wide changes over time in the claims frequency, are used to identify the relationship between the two. That is, if working time affects claims, then changes in hours in an industry from year to year should be associated with changes in claims, *after controlling for changes in claims from year to year that derive from other sources* (which we necessarily assume are common to all industries).[7]

The fixed effects models estimated can thus be formally represented as:

$$E\left(c_{it}\right) = \alpha + \beta H_{it} + \upsilon_i + \eta_t \tag{2}$$

This shows that β measures the variation in c associated with variation in H (across I industries and T years), controlling for that variation in c associated with industry $\left(\upsilon_i\right)$ and time-period (year, η_t). Time-invariant industry effects are captured by υ_i (industry effects that are 'fixed' over time), and economy-wide year effects are captured by η_t (year effects that are 'fixed' over industries).

If unobserved characteristics of industries change over time in ways that affect working hours or claims, or economy-wide changes impact on the measured safety performance of industries differentially, these effects are not captured by the fixed effects model, and the relationship between working time and claims frequency may not be correctly identified. Reasons why

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[6] The models estimated are sometimes called 'two-way fixed effects' models, in reference to effects across both industries and years.

[7] The other main class of panel data models is the 'random effects' group of models. These models require stronger distributional assumptions than fixed effects models, in essence assuming that unobserved characteristics are not correlated with the dependent variable. These models are therefore liable to the same criticisms as cross-sectional models, and as such the current paper focuses on fixed effects models. The benefits of random effects models are that, compared with fixed effects models, the stronger assumptions 'buy' more precise estimates; while compared with cross-sectional models, they utilise more information – both the variation across and *within* industries (versus only variation across industries). All else equal, the preferred approach is the fixed effects panel data model. (Random effects models were in fact estimated in this study, and inferences found to not be sensitive to the imposition of the additional assumptions.)

effects may not be fixed include the potential for regulatory changes to impact differently across industries (for example, they may have a greater effect on more dangerous industries) and similarly, the potential for the safety effects of technological changes to differ across industries. Effects may also not be fixed because of changes to the composition of industries over time, in terms of characteristics such as occupational composition, unionisation rates, female employment shares, firm sizes, shift work patterns and work experience and educational attainment levels of workers. For example, the proportion working in high-hours occupations that are prone to injury may change over time (which is a change in the occupational composition of the industry).

Adding variables for industry characteristics other than working time could at least partially overcome the problem of time-varying industry effects. That is, the effects on claims of changes in other characteristics that affect claims could be captured by including variables for these characteristics. This is not attempted in this paper, however, since time series information on many industry characteristics is not available.[8]

Results

Characteristics of the data

Table 1 contains information on the characteristics of the data used in the analysis, presenting descriptive statistics in each year for each variable used. The top panel shows there is substantial variation across industries in safety performance, as measured by the workers' compensation claims frequency. In every year, the highest claims frequency is at least twenty times the lowest claims frequency. There is also significant variation over time, with an overall trend decline in the claims frequency evident: the mean claims frequency across the 53 industries declines from 21 claims per million hours worked in 1991-92 to 14 claims per million hours worked in 1999-2000.

The remaining panels of Table 1 present descriptive statistics to the measures of working time used in the estimated models. As with the claims frequency, substantial variation across industries is evident for all working time measures. Notable changes over time include increases in mean weekly hours of full-time employees, the proportion of employees working long hours

[8] Wooden (1998), who uses cross-sectional methods to examine the relationship between claims frequency and industry characteristics in Australia, draws on data sources (namely, the 1991 Census, the 1993 Survey of Education and Training, the 1989-90 Australian Workplace Industrial Relations Survey and the 1993 Working Arrangements Survey) that do not permit the time-series variation in the variables that is required for the addition of the variables to add value in panel data models.

and the proportion of employees employed part-time. Increased variation across industries in weekly hours of work and the proportion working long hours is also apparent.

Table 1: Characteristics of the data

	1991-92	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	All years
No. of obs.	53	53	53	53	53	53	53	53	424
					Safety				
Frequency of new workers' compensation claims per million hours worked									
Mean	20.9	18.4	20.4	16.7	14.5	14.9	13.1	13.9	16.6
Std deviation	16.4	10.3	15.8	9.3	8.0	9.5	7.3	10.2	11.6
Minimum	2.1	2.0	3.2	1.9	0.9	0.3	1.8	1.2	0.3
Maximum	85.9	47.7	105.2	41.0	34.7	54.1	36.7	72.1	105.2
					Working-time				
Mean weekly hours of all employees									
Mean	35.2	35.5	36.0	36.3	36.7	36.3	36.4	37.1	36.2
Std deviation	4.6	5.0	5.2	5.0	5.4	4.9	5.5	6.1	5.2
Minimum	17.7	19.6	18.5	19.1	20.5	20.3	16.4	18.2	16.4
Maximum	43.5	47.9	48.0	46.1	54.8	47.8	50.4	50.3	54.8
Proportion of all employees working more than 49 hours per week (%)									
Mean	13.2	14.5	17.0	17.5	18.1	17.3	17.3	19.3	16.8
Std deviation	7.4	7.3	9.1	9.5	10.3	8.6	8.5	10.5	9.1
Minimum	0.0	4.8	5.1	5.2	4.2	3.6	2.4	3.8	0.0
Maximum	34.5	39.0	40.6	43.5	57.7	43.3	43.7	50.6	57.7
Proportion of employees working part-time (%)									
Mean	16.5	18.1	18.5	18.4	18.0	17.9	18.3	18.4	18.0
Std deviation	16.20	16.32	16.75	16.68	15.58	16.39	17.59	15.68	16.42
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	72.6	74.7	71.0	71.2	64.2	74.7	84.3	65.7	84.3
Mean weekly hours of part-time employees									
Mean	16.5	16.6	17.0	17.1	16.2	17.0	16.4	16.9	16.7
Std deviation	4.7	4.6	4.4	4.8	4.5	4.8	5.5	5.6	4.9
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	32.0	24.0	28.6	26.9	26.9	32.0	32.0	30.7	32.0
Mean weekly hours of full-time employees									
Mean	39.3	40.1	40.6	40.9	41.1	40.6	40.9	41.5	40.6
Std deviation	2.7	3.2	3.2	2.6	3.5	3.0	2.9	4.3	3.3
Minimum	33.8	34.0	34.7	34.1	35.7	34.3	36.8	35.3	33.8
Maximum	47.4	49.9	52.4	48.4	54.8	48.7	53.0	57.6	57.6

Cross-sectional evidence

Cross-sectional evidence is presented to illustrate the value of the panel data methods used in this paper, and to also highlight the potential for other studies to make incorrect inferences on relationships of this kind because of the failure to take into account other (unobserved) sources of differences across industries. Table 2 presents coefficients estimates where each industry subdivision is assigned the mean value for each variable over the period 1991-2 to 1999-2000 (excluding 1992-3). They show a positive effect on claims of hours worked. The estimates imply each one-hour increase in mean hours increases the claims frequency by 0.65, or that a one percentage point increase in the proportion working long hours increases the claims frequency by 0.28. Although we do not control for other sources of differences in claims rates across industries (for example, the unionisation rate, the fatality rate and the age composition of employment), this is broadly consistent with other studies that do attempt to control for these differences. For example, Wooden (1998) found that each additional hour of paid overtime was associated with an increase in the claims frequency of 2.9.[9]

Table 2: Estimates of the effects of working time on the frequency of workers' compensation claims – Cross-sectional evidence (mean values of variables across all years)

	Specification (1)	Specification (2)
Constant	-6.923 (9.702)	11.893*** (3.092)
Mean hours	0.650** (0.266)	
Proportion working long hours (%)		0.280* (0.166)
Adjusted R squared	0.087	0.034

Notes: Number of observations is 53. The dependent variable is the frequency of new workers' compensation claims per one million hours worked. Standard errors are reported in parentheses. * indicates the coefficient estimate is statistically significantly different from zero at the 10% level, ** indicates significance at the 5% level and *** indicates significance at the 1% level.

The cross-sectional results therefore imply that, although safety performance improved (as evidenced by Table 1), greater improvements would have been achieved had working time not increased, because of the positive relationship between workplace injuries and hours of work apparent from the cross-sectional data. However, as mentioned, the critical concern is that there are other differences across industries that impact on claims frequency, and that are correlated with working time. Failure to control for these other differences may be leading to incorrect inferences.

[9] Wooden also includes a variable 'proportion of employees working in excess of 49 hours per week', but this is interpreted as primarily reflecting the effects of working unpaid overtime, given the inclusion of the variable 'number of hours of paid overtime'. Wooden actually finds a negative effect of this variable on the frequency of injuries, which he argues reflects a selection effect – workers only work long 'unpaid' hours if the work is relatively safe.

Panel data evidence

The fixed effects models estimated control for both other (unobserved) sources of differences in claims frequencies across industries that are stable over time, and other sources of change in claims frequencies over time that are the same across all industries.

Estimates from three specifications are reported in Table 3, the first two specifications analogous to the two specifications estimated using the cross-sectional approach. Considering these two specifications first, the estimates imply that, in contrast to the cross-sectional results, there are no statistically significant effects on the frequency of compensation claims of either mean hours or the incidence of long hours, although a weakly significant (at the 10% level) *negative* effect of the incidence of long hours on the claims frequency is evident. Thus, once controls are employed for unobserved differences across industries (that do not change over time) and for the effects of economy-wide changes over time, we find no significant role for working time.

Table 3 also present estimates for a third specification which allows for working time of part-time employees to impact on safety differentially to working time of full-time employees, by controlling for the proportion of the industry employed part-time and by distinguishing mean part-time hours from mean full-time hours. Specifically, the following four variables for working time are included:

- proportion of employees employed part-time;
- mean hours of part-time employees;
- mean hours of full-time employees; and
- proportion of all employees working more than 49 hours per week.

The results show no significant effects of the proportion employed part-time, mean hours of full-time workers, or the incidence of long hours of work. Interestingly, however, there does appear to be a role for part-time employment: increases in the average hours of part-time workers are associated with increases in the claims frequency. It is curious that it is not the rate of part-time employment itself that is associated with an increased claims frequency, but rather increased hours of work of those part-time employees that are in the industry. Explanations of the effects associated with part-time work therefore need to focus not on differences between part-time workers and full-time workers, but rather on differences between part-time workers by working time. For example, it may be that higher part-time working hours per week are associated with longer individual shifts and/or shift work. However, it must be acknowledged that no conclusions can be reached based on the evidence presented in this paper on the reasons for the association between mean hours of part-time workers and workplace safety. Nonetheless, this would seem to be a significant finding.

Table 3: Estimates of the effects of working time on the frequency of workers' compensation claims – Fixed effects models

	Specification (1)	Specification (2)	Specification (3)
Constant	22.217*** (5.639)	22.506*** (1.279)	21.028*** (7.998)
Mean hours	-0.039 (0.158)		
Proportion working long hours (%)		-0.125* (0.073)	-0.108 (0.105)
Proportion working part-time (%)			-0.115 (0.095)
Mean hours of part-time workers			0.235*** (0.086)
Mean hours of full-time workers			-0.018 (0.222)
R squared within	0.195	0.202	0.220
R squared between	0.105	0.053	0.028
R squared overall	0.049	0.028	0.083
Rho	0.724	0.735	0.721
Number of observations	424	424	424

Notes: The dependent variable is the frequency of new workers' compensation claims per one million hours worked. These results exclude data from the 1992-3 financial year. Standard errors are reported in parentheses. * indicates the coefficient estimate is statistically significantly different from zero at the 10% level, ** indicates significance at the 5% level and *** indicates significance at the 1% level. 'R squared within' is the proportion of the variation in claims frequency within industries (across years) 'explained' by variation (within industries) in the independent variables. 'R squared between' is the proportion of the variation in claims frequency across industries 'explained' by variation (across industries) in the independent variables. 'R squared overall' is the proportion of the variation in claims frequency 'explained' by the model. 'Rho' is the proportion of the variation in claims frequency 'explained' by variation in claims frequencies across industries.

The contrast of these findings with Wooden (1998) is particularly striking. Wooden, using the same data on compensation claims, but over the period 1991-92 to 1993-94, found significant effects on claims frequencies of both paid overtime and long hours of work. His analysis is cross-sectional, and although he controlled for other sources of variation in claims across industries, the panel data results presented in this paper suggest he was not able to control for all other sources of variation in claims (that are correlated with working hours). That is, the implication of the panel data results presented here is that the highly significant effects of paid overtime and long hours on claims that Wooden found is the result of differences across industries, other than working time, that are correlated with both claims frequency and working time.

Caveats

While fixed effects models overcome some of the problems of cross-sectional approaches, several caveats still need to be borne in mind when interpreting the panel data evidence. First, as noted, industry and year effects are unlikely to be completely 'fixed'. Other industry characteristics are likely to change over time, and year effects are likely to differ across industries. However, failure to control for these effects is very unlikely to cause insignificant estimates of the effects of working time if the true effect is non-zero.

Second, the variables used may not identify the effects of very high hours (either per shift or per week), because they do not measure the proportion working such hours, or capture the effects of working such hours in some other way. For example, there may be little correlation between the mean hours/proportion working long hours variables that are used and the rate of occurrence of extreme hours (such as 80-hour weeks, 12 hour days, and so on). This is a *measurement* problem, rather than a methodological problem. That is, the variables used may not be good measures of the dimensions of working time that are thought important for their safety implications.[10]

A third, related, point is that other dimensions of working time patterns may be important to safety, such as shift work incidence and patterns, number of days worked in succession, length of time between shift breaks, and so on. These dimensions have not been explored in this paper, which has focused on the relationship between *length* of working time *per week* and workplace safety.

Finally, as discussed in Section 2, the outcome measure used – frequency of workers' compensation claims – is not a perfect measure of workplace safety. It does not capture all workplace injuries, since many injuries will not give rise to workers' compensation claims (and indeed, a given injury may be more likely to give rise to a claim in some industries than in others), and no allowance is made for the severity of the injury. Furthermore, the data used exclude Victoria and the ACT.

Thus, although the evidence obtained from utilising the panel features of the data on industry working hours and compensation claims frequency strongly supports the contention of no

[10] This is a criticism that could, however, be levelled at many studies of this issue.

relationship between working time and safety among full-time workers, the degree of confidence in this conclusion depends on the view taken on the validity of the assumptions implied by the above four caveats.

4. Conclusion

The evidence from Australian industry-level panel data is that hours worked per week by full-time workers do not affect safety performance. This represents a contrast with results from cross-sectional studies of this issue. For example, Wooden (1998) finds that a one-hour increase in mean paid overtime (which necessarily applies only to full-time workers) increases the claims frequency by 2.9 per million hours worked. The implication of this study is, therefore, that it is other differences between industries, correlated with both safety and working hours, that are responsible for the observed association between hours and safety at the cross-sectional level. For example, industries that have high usage of physical labour may tend to have both more claims and higher average hours of work for full-time workers. Thus, it may be that, rather than longer hours causing higher claims, the physical nature of the work causes both higher claims and longer hours of work.

It is, on reflection, perhaps unsurprising that working time of full-time workers is found not to impact on safety outcomes. While it is almost certain that extremely long working hours are detrimental to safety, it is not clear why this effect should operate at less extreme hours – for example, working 40 hours versus 35 hours per week. Yet, this type of effect has indeed been asserted by the existing research, which has found an increase in working time increases the likelihood of injury per hour worked at all levels of working time.

The fixed effects model does identify an effect of working time on safety performance, which is that increased working time of part-time workers increases the injury rate per hour worked. While we could speculate that the reasons for this finding relate to differences in shift work patterns between part-time workers with different working times, there would seem to be value in future investigation of the reasons for this association. However, irrespective of these reasons, it would appear that policies with respect to working time that are aimed at reducing workplace injuries are best focused on part-time workers.

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6. Appendix

Table A1: Workers' compensation claims data: Matching the ASIC industry categories used up until 1993-4 with the ANZSIC industry categories used from 1994-5.

	ANZSIC (from 1994-95)	ASIC (up until 1993-94)
1	Agriculture	Agriculture
2	Services to Agriculture; Hunting & Trapping	Services to Agriculture
3	Forestry & Logging	Forestry & Logging
4	Commercial Fishing	Fishing & Hunting
5	Coal Mining	Coal mining
6	Oil & gas extraction	Oil & gas extraction
7	Metal Ore Mining	Metallic Minerals
8	Other Mining	Construction Materials; Other Non-Metallic Minerals
9	Services to Mining	Services to Mining
10	Food, Beverages & Tobacco	Food, Beverages & Tobacco
11	Textiles, Clothing, Footwear & Leather	Textiles; Clothing & Footwear
12	Wood & Paper Products	Wood, Wood Products & Furniture
13	Printing, Publishing & Recorded Media	Paper, Paper Products, Printing & Publishing
14	Petroleum, Coal, Chemical & Associated Products	Chemical, Petroleum & Coal Products
15	Non-Metallic Mineral Products	Non-Metallic Mineral Products
16	Metal Products	Basic Metal Products; Fabricated Metal Products
17	Machinery & Equipment	Transport Equipment; Other Machinery & Equipment
18	Other Manufacturing	Miscellaneous Manufacturing
19	Electricity & Gas Supply	Electricity & Gas
20	Water Supply, Sewerage & Drainage Services	Water, Sewerage & Drainage
21	General Construction	General Construction
22	Construction Trade Services	Special Trade Construction
23	Basic Material Wholesaling	Wholesale Trade
24	Machinery & Motor Vehicle Wholesaling	Wholesale Trade
25	Personal & Household Good Wholesaling	Wholesale Trade
26	Food Retailing	Retail Trade
27	Personal & Household Good Retailing	Retail Trade
28	Motor Vehicle Retailing & Services	Retail Trade
29	Accommodation, Cafes & Restaurants	Restaurants, Hotels & Clubs
30	Road Transport	Road Transport
31	Rail Transport	Rail Transport
32	Water Transport	Water Transport
33	Air & Space Transport	Air Transport
34	Other Transport	Other Transport
35	Services to Transport	Services to Transport
36	Storage	Storage
37	Communication Services	Communication
38	Finance	Finance & Investment
39	Insurance	Insurance & Services to Insurance
40	Services to Finance & Insurance	Insurance & Services to Insurance
41	Property Services	Property & Business Services
42	Business Services	Property & Business Services
43	Government Administration	Public Administration
44	Defence	Defence

Table A1 continued: Workers' compensation claims data: Matching the ASIC industry categories used up until 1993-4 with the ANZSIC industry categories used from 1994-5.

	ANZSIC (from 1994-95)	ASIC (up until 1993-94)
45	Education	Education, Museum & Library Services
46	Health Services	Health
47	Community Services	Welfare & Religious Institutions; Other Community Services
48	Motion Picture, Radio & Television	Entertainment & Recreational Services
49	Libraries, Museums & the Arts	Education, Museum & Library Services
50	Sport & Recreation	Entertainment & Recreational Services
51	Personal Services	Personal Services
52	Other Services	Other Community Services
53	Private Households Employing Staff	Private Households Employing Staff

Matches are not exact for industries 2, 4, 8, 11-13, 23-29, 39-42, 45, 47-50 and 52. Where more than one ASIC 2-digit industry is assigned to an ANZSIC 2-digit industry, the mean claims frequency of the assigned ASIC industries is used.