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The Effect of Macroeconomic Conditions on Occupational Health and Safety; the European Experience

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Abstract: This paper investigates the effect of recessions as mirrored in the national unemployment rates on fatal and non-fatal work accidents in a panel sample of 13 European Union countries, for the period 1980-2006. The study takes into account cross-panel correlations and the fixed effect evidence suggest that recessions decrease the incidence of work accidents. However, once the temporary and permanent effects of unemployment on both fatal and non-fatal work accidents are examined separately and the effects of cross panel correlation is taken into account, the evidence suggests that although recessions have a negative transitory effect on the incidence of work accidents, the permanent effect of recessions is to increase the incidence of work accidents. This is remarkably consistent across the industrial sectors.

Keywords: Work accidents, Unemployment, Feasible GLS

JEL: J60, J81, C33

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The Effect of Macroeconomic Conditions on Occupational Health and Safety; the European Experience

1. Introduction

The stated long term aim of the European Commission is that Europe should become "the most competitive and dynamic knowledge-based economy in the world, capable of sustained growth with more and better jobs and greater social cohesion"[1]. Among key actions towards this aim is the modernisation of the social protection. After all, the health and well-being of people of working age are of fundamental importance. To this end a coherent and effective policy on health and safety in the workplace plays a key role. Around 4 million accidents at work resulting in more than 3 days of absence from work occurred in the EU-15 in 2005. This corresponds to an incidence rate of 3,100 non-fatal and 3.5 fatal accidents per 100,000 workers, exhibiting a significant downward trend in the last decade. According to the European Agency for Safety and Health at Work (2001), in most member states of the EU the estimates of costs due to work related injuries amount to between 2.6% and 3.8% of their gross national product (GNP).

On average, approximately 5,500 of fatal work-related accidents are reported in the European Union member countries cases annually and about 75,000 individuals are estimated each year to lose ability to work due to work-related accidents. The social and emotional costs of work-related accidents to the individuals concerned and their families should not be underestimated.

Over and above the individual suffering, the economic costs of illness or accidents at work are substantial. For the period 1998-1999, it is estimated that the economic cost of work-related accidents is approximately 150 million working days annually, and work-related health problems is about 350 million working days per year (European Agency for Health and Safety at Work 2001). In addition, about 5% of employees suffering a working accident are forced to change jobs, job tasks or reduce working hours. Estimates indicate that for the European Union countries the net effect of costs due to work related accidents is about 1% - 3% of GNP at the country level (European Agency for Health and Safety at Work 2001).

Recent literature suggests that work-place illness and accidents are related to the macroeconomic conditions. Overall, the majority of the empirical studies indicate the procyclical character of work accidents in relation to economic recessions (approximated by the country's unemployment rates). Boone and van Ours (2002) argue that non-fatal work accidents are procyclical. They approximate macroeconomic conditions with national unemployment rates. Their theoretical framework shows that there is a negative relationship between national unemployment rates and non-fatal work accidents during economic recessions, since employees who suffer a working accident avoid reporting it, because they are reluctant to take sick leave from their jobs as they face an increased risk of becoming redundant. Indeed, during periods of high unemployment employers are able to more readily lay off workers who fail to report for work compared to periods of economic upturns. The observed procyclicality of work accidents in the empirical literature is attributed mainly on: *i) Working conditions*, namely the higher level of effort and the amount of inexperienced workers during economic expansions increases the risk of work accidents. In line with the above, the pool of employees is higher during economic booms, therefore the number of work accidents is expected to be higher (Boone and van Ours 2006; Catalano 1979), *ii) Underreporting of work accidents*, that is, due to the economic incentive, during economic downturns employees who suffer a working accident are less inclined to report it due to their perceived higher probability of been dismissed from work (Boone and van Ours 2002; Davies *et al*. 2009; Leigh 1985).

Boone and van Ours (2002) examine empirically whether the procyclicality of work accidents can be explained by the "working conditions" or the "under-reporting" hypothesis in a panel sample of 17 OECD countries. They argue that the evidence is in favor of the "underreporting" hypothesis, since a negative relationship between unemployment and work accidents is detected only for non-fatal accidents.

The effect of macroeconomic conditions on accidents at work appears to vary with respect to the severity of the accident. Davies *et al*. (2009) argue that although there is evidence on pro-cyclicality in the relationship between unemployment rate and minor injuries for the UK, their findings do not support a similar relationship in the case of serious accidents at work. The procyclical behaviour of work accidents can be attributed to variations in employment conditions, changes in the composition of the workforce in terms of tenure and the incentives which cause workers to underreport

minor injuries. Similarly, Catalano (1979) uses time series data for California to show that during economic expansions work accidents increase and in particular, the relationship becomes even more profound as the flow of new workers to the employed population is increased during economic expansions.

Saloniemi and Oksanen (1998) examine the effect of macroeconomic conditions on fatal work accidents in Finland for the period 1977 - 1991. Although they did not find evidence that macroeconomic conditions affect overall fatal work accidents, their results show that there are differential effects on fatal accidents across occupational sectors. In particular, fatal accidents are higher for sectors such as mining and construction and for male employees in the lowest hierarchy employment positions. In the construction sector, both the incidence of fatal and non-fatal work accidents is higher in occupational groups of low occupational status, low wage and high job insecurity compared to other employees.

Corroborative evidence to the above findings is the procyclical nature of absenteeism rates (Askildsen *et al*. 1995) and the negative effects of the cost of absence on absence rates (Johansson and Palme 1996). Overall, it appears that accident reporting behaviour is an important factor which is needed to taken into account in order to disentangle the complex relationship between macroeconomic conditions and work accidents (Davies *et al*., 2009).

In contrast a number of studies suggest that recessions increase work accidents. Steele (1974) finds a negative relationship between unemployment and accident rates for the UK. Similarly, Brooker *et al*. (1997) show that in the US back pain claim rates increase during recessions, implying that the work-related back pain incidence increases during the cyclical upturn.

Furthermore, the relationship of interest between recession and accidents at work appears to vary from country to country. Sasaki (2009) used time series data to unearth a negative relationship between unemployment and work accidents for the US but a positive relationship for Japan. The positive relationship found for Japan is attributed to productivity improvements by firms which, on one hand caused unemployment rates to increase, and on the other, raised the incidence of work-related accidents. Ussif (2004), using time series data for the US, for Canada, Finland, France and Sweden during 1970-1999, shows that during economic expansions (approximated with the employment rate) there is an upward pressure on work-related injuries. On the contrary, Davies *et al*. (2009) has identified that during economic

expansions work accidents in specific occupational sectors decrease, but only for minor work injuries.

In the light of this conflicting evidence, the present study revisits the issue of the work accidents/unemployment rate relationship using a panel of thirteen European Union countries during the period 1980-2006. Furthermore, it investigates the transitory and permanent effects of unemployment on fatal and non fatal work accidents. Disaggregated study by industry is also carried out. The results show that for both fatal and non-fatal work accidents, the transitory effect of unemployment on work accidents is negative. However, the permanent effect is positive. This finding suggests that the impact of economic recessions on work accidents is far less straightforward than is assumed in the literature.

2. The Dataset

The data used in this study is a panel of 13 European Union countries (Austria, Belgium, Cyprus, Denmark, Finland, France, Greece, Ireland, Italy, Portugal, Spain, Sweden, UK) for the time period 1980-2006. Data on fatal and non-fatal work accidents are drawn from the International Labour Organization database (LABORSTA). In order to construct injury rates per 100,000 population, data on annual country population were drawn from the European Database 'Health for All' of the World Health Organization (WHO)[2].

However, the sample and the time period for the disaggregated by industrial sectors empirical models varies due to data limitations.

The definitions of the variables to be explained are detailed below[3]:

- *Total fatal and non-fatal injury rates per 100,000 population*
- *Fatal and non-fatal injury rates per 100,000 population for sector 1: agriculture, hunting, forestry and fishing*
- *Fatal and non-fatal injury rates per 100,000 population for sector 2: mining and quarrying*
- *Fatal and non-fatal injury rates per 100,000 population for sector 3: manufacturing*
- *Fatal and non-fatal injury rates per 100,000 population for sector 4: electricity, gas and water supply*

- *Fatal and non-fatal injury rates per 100,000 population for sector 5: construction*
- *Fatal and non-fatal injury rates per 100,000 population for sector 6: wholesale and retail trade, repair of motor vehicles and motorcycles, and personal and household goods, hotels and restaurants*
- *Fatal and non-fatal injury rates per 100,000 population for sector 7: transport, storage and communication*
- *Fatal and non-fatal injury rates per 100,000 population for sector 8: financial intermediation, real estate, rending and business services*
- *Fatal and non-fatal injury rates per 100,000 population for sector 9: public administration and defence, compulsory social security, education, health and social work, other community, social and personal service activities*

The data on GDP per capita are derived from the European Database 'Health for All' of the World Health Organization (WHO). The economic fluctuations are approximated by the country unemployment rate. Data on country unemployment rates are drawn from the Annual Labour Force Statistics of the OECD database, but when the country information is not available the WHO database is utilised. The summary statistics of the variables included in the regressions are shown in Table 1.

3. The Effect of Recessions on Work Accidents: Econometric Methodology

The first step in investigating the unemployment rate/accidents at work relationship is the estimation of the fixed effects specification model for the fatal and non-fatal work accidents. Thus the following model is estimated.

$$\ln Fatal\ \ Work\ Accidents_{it} = a_i + b_1 \cdot \ln UR_{it} + b_2 \cdot GDP_{it} + S_t + \varepsilon_{it} \qquad (1)$$

$$\ln Non-Fatal\ \ Work\ Accidents_{it} = a_i + b_1 \cdot \ln UR_{it} + b_2 \cdot GDP_{it} + S_t + \varepsilon_{it} \qquad (2)$$

The subscripts *i* and *t* denote the country and the year period respectively, a_i is the country-specific fixed-effects intercepts and S_t is the time effects, i.e. a year-specific dummy variable for 27 time periods (the omitted year is first year of each sample).

The results for overall fatal and non-fatal work accidents are reported in Table 2, Columns 1 and 2, respectively. In order to test for the robustness of the specification findings, the estimates of a Random Effects model are also reported (Table 2, second panel).

In line with the findings of Saloniemi and Oksanen (1998) the results show that after controlling for the country level of GNP per capita, a negative and statistically significant relationship between national unemployment rates and fatalities at work is observed (Column 1). Furthermore, in line with Boone and van Ours (2002), Catalano (1979) and Davies *et al*. (2009) a negative and significant relationship is also observed between country unemployment rates and non-fatal accidents at work (Column 2). In addition it is shown that the unemployment effect on non-fatal accidents is far stronger compared with its effect on fatal accidents.

Importantly, the estimation results are robust to the estimation method. Using random effects rather than fixed effects in estimating the relationship does not significantly affect the size or the significance of the variable of interest, the unemployment rate, on accidents at work.

4. Temporary and Permanent Effect of Recessions on Accidents at Work

One should expect that the impact of the unemployment rate on work accidents may take a long time to manifest itself. If the impact of unemployment on the institutional setting and health and safety attitudes or regulatory framework and working conditions is significant, then the effects of a change in unemployment on health and safety may be felt for many years after the occurrence of an increased rate of unemployment. However, the studies reviewed above assume a contemporaneous effect of unemployment on work accidents. One way to address this issue is for the researcher to introduce to the regressions lagged values of unemployment rates. However, the length and the lag structure are determined in an arbitrary way, as there is no *a-priori* theoretical reasoning. Alternatively, one can address this issue by distinguishing between the permanent and transitory components of unemployment rates upon work accidents.

The Mundlak (1978) decomposition methodology offers an easily implementable methodology which distinguishes between permanent and temporary effects. It is a hybrid specification where the potential correlation between unobservable

characteristics and the variable of interest, the unemployment rate, is accounted for (Greene 2000). In addition, following the transformation proposed by Van Praag *et al*. (2002), the Mundlak approach also introduces some dynamics in the model since differences across individuals in the averages measure the permanent effect of income inequality on health and the individual deviations from the averages per individual will measure the shock or transitory effects. This methodology is similar to Gottschalk *et al*. (1994). This approach is as follows:

$$\ln Fatal\ \ Work\ Accidents_{it} = \tilde{a}_i + b_1 \cdot \left(\ln UR_{it} - \ln \overline{UR}_i\right) + b_2 \cdot \ln \overline{UR}_i + b_3 \cdot GDP_{it} + S_t + \varepsilon_{it} \quad (3)$$

$$\ln Non-Fatal\ \ Work\ Accidents_{it} = \tilde{a}_i + b_1 \cdot \left(\ln UR_{it} - \ln \overline{UR}_i\right) + b_2 \cdot \ln \overline{UR}_i + b_3 \cdot GDP_{it} + S_t + \varepsilon_{it} \quad (4)$$

Where $\overline{UR}_i$ is the mean unemployment level for each country *i*, $\tilde{a}_i = \alpha_i - \overline{UR}_i \hat{\beta}_2$, a_i: the country effect, assumed to be the random effect disturbance term, which is correlated with at least one of the independent variables, and $E(\alpha_i UR_i) = 0$. The term $\left[b_1(UR_{it} - \overline{UR}_i)\right]$ expresses deviations from the country average unemployment rate and measures the *temporary* effects. The term $\left[b_2 \cdot \ln \overline{UR}_i\right]$ expresses the difference in the country average unemployment rates and measures the *permanent* effects.

In addition, since fixed and random effects are shown to generate similar estimates in size and magnitude any change in the estimated coefficients by using the above transformation reveals differences due to permanent / temporary specification. The findings are reported in Table 2 (second panel, first and second columns for fatal and non fatal work accidents respectively). The results show that only for non fatal accidents the temporary effect of unemployment turns out to be negative and significant.

5. The Effect of Cross Panel Correlations

A requirement in panel estimation for efficient estimates is controlling for cross-panel correlations (Beck and Katz 1995; Reed and Webb 2009; Podesta 2002). If this

condition is violated then, even if heteroskedasticity (or clustering) is controlled for (that is, if one corrects for differences in the variance of the error terms), one might still obtain inefficient estimates. Correlations between panels are highly probable to occur in the dataset of the European Union countries used in this study. One should expect that the European Commission directives and European-wide occupational health and safety legislation or regulation and labour market policies should affect working conditions across member countries. To investigate this issue a number of relevant tests are used in this study. For assessing the existence of groupwise heteroskedasticity the modified Wald statistics are used (Baum 2001; Greene 2000). For the existence of contemporaneous correlations of errors across cross-sectional units the Lagrange Multiplier statistic is also used (Baum 2001; Breusch and Pagan 1980). The results for both tests are reported at the end of the upper panel of Tables 2 for fatal and non-fatal Fixed Effects regressions. The results indicate that the errors from the fixed effect estimations suffer from both groupwise heteroskedasticity and contemporaneous correlation.

To remedy this shortcoming Feasible Generalized Least Squares (FGLS) can be used to control for cross-panel correlations. Wooldridge (2002) indicates that if there is cross-panel correlation, FGLS is more efficient than any other estimator that assumes no correlation (also echoed in Greene 2000). However, Beck and Katz (1995) argue that the use of FGLS estimator is problematic if the number of time periods is relatively small in comparison to the number of panels, causing biased findings.

In view of the size of the dataset used in this study, the above issue is not a cause for concern. The dataset used includes 26 years for total fatal work accidents and 21 years for total non-fatal work accidents. Hence the time dimension is large relative to the number of panels (12 countries for the fatal and 10 countries for the non-fatal work accidents). FGLS results are reported in the last two columns of Table 2 for fatal and non fatal accidents.

The FGLS estimates reported in Table 2 (second panel, third and fourth columns for fatal and non fatal work accidents respectively) reveal that the size and sign of the coefficients on the unemployment variable are similar to the earlier estimated models. However, the significance is affected, evidently due to the fact that cross panel correlation is accounted for. The results show that there is a transitory negative relationship between the unemployment rate and the fatal work accidents. There

appears to be a significant positive permanent effect. The pattern is similar when the effect of recession on non-fatal work accident rates is examined. The transitory effect of recessions on non fatal work accidents is negative and the permanent effect of recessions on non fatal work accidents is strongly positive. The above results do not support the 'underreporting' hypothesis since unemployment rates appear to affect both fatal and non fatal work accidents in similar fashion. The results may imply that at the initial stages of the economic downturn work accidents tend to decrease as the slowdown of production reduces the number of job shifts, ease the work intensity and the proportion of newly hired and less inexperienced workers decrease as last-in-first-out dismissal practices are implemented by employers who are keen to retain their most experienced workers. Furthermore, the job creation rate greatly declines and this further reduces the proportion of the inexperienced workforce. This entails a reduction in the incidence of work accidents and injuries. Hence, the transitory effect of the unemployment rate on the incidence of fatal and non-fatal work accidents is negative.

However, at later stages of the recession, cost cutting practices by employers may affect the OHS investments as firms reduce their expenditure on training and safety equipment (WorkCoverWA 2009; Sasaki 2009) and/or workers in employment, facing an increased risk of job loss, tend to undertake far riskier job tasks in a world of scarce employment opportunities. Furthermore, high unemployment severely weakens the ability of the trade unions to protect their rank and file from the degradation of the health and safety standards or succeed in improving the OHS procedures. Hence, the permanent effect of unemployment on work accidents becomes positive.

Conversely, at the initial stages of economic expansions, an increase in work intensity occurs as firms react to the pressure of increasing aggregate demand. This effect is reinforced by the reluctance of employers to hire new personnel before they are confident that the increasing demand is long lasting. Hence, there is an increase to hours of work and an increase to the pressure for increased productivity of the workers which might induce them to be less careful with safety procedures (Davies *et al*. 2009; Davies and Jones 2005; Catalano 1979). Robinson (1988) also notes that during economic booms there might be a tradeoff between increased productivity and workers' safety and this might be responsible for the negative relationship between unemployment and work injuries. This is also echoed in Sasaki (2009). This pertains to increased shift work, incidence of accidents at work and high work stress.

However, with the passage of time as the economy adapts to the improved state of affairs, productivity improvements during economic expansions encourage firms to invest in occupational health and safety capital. As the bargaining power of labour unions improves during economic expansions, their increased concerns and pressures towards employers to increase workplace safety (Robinson 1988) contributes to the decrease of workplace injuries. Thus the permanent effect of unemployment rate on work accidents turns out to be positive.

6. The Effects of Unemployment Rate on Work Accidents; An Analysis by Industry

The literature suggests that work accidents are not randomly distributed among industries. Davies *et al*. (2009) reports that economic booms are associated with an increased risk of workplace injuries and Davies *et al*. (2009) and Personick (1997) show that the construction and manufacturing sectors are more prone to the incidence of such injuries. The number of lost workdays and the incidence of restricted activity due to work injuries are far higher for these two sectors in comparison to all other sectors. Personick (1997) and Catalano (1979) also show that the manufacturing sector is one of the industries suffering from substantial economic losses due to work injuries. In view of the above findings, this study now turns to investigating the permanent and temporary effects of country unemployment rates disaggregated by fatal and non-fatal work accidents and by industry.

Hence, Table 3 and 4 report the findings regarding the impact of national unemployment rates on fatal and non fatal work accidents disaggregated by industrial sector. Only the estimated coefficients from the preferred specification obtained above are reported that is the FGLS specification with Mundlak transformation[4]. The industrial sectors used are *"agriculture, hunting, forestry and fishing", "mining and quarrying", "manufacturing", "construction", "wholesale and retail trade, repair of motor vehicles and motorcycles, and personal and household goods, hotels and restaurants", "transport, storage and communication", "financial intermediation, real estate, rending and business services"* and *"public administration and defence, compulsory social security, education, health and social work, other community, social and personal service activities"*.

Davies *et al*. (2009) found a cyclical behaviour for minor injuries in agriculture. The present study shows that for fatal work accidents both the transitory and permanent effects of the unemployment rate are positive. On the contrary, the transitory effect of recessions for non fatal work accidents is negative although the permanent effect of recessions on non fatal work accidents remains positive. This may imply that for this sector a transitory underreporting of work accidents and injuries may take place (Boone and van Ours 2002).

Studies on work accidents in manufacturing suggest that during economic expansions work injuries increase (Catalano 1979). Schmid (2009) finds evidence in favour the procyclical character of work injuries in relation to unemployment rates for the US manufacturing industry. He argues that the observed relationship is attributed to the job growth rate. Thus, during economic recessions the slowdown of the job creation rate reduces the number of newly hired and less inexperienced workers in the industry causing a negative relationship between unemployment and work injuries. Robinson (1988) suggests a positive relationship between unemployment rates, the rate of new hires and output per hour with work injuries in manufacture for the US. The present study shows that for non-fatal work accidents there is a transitory negative effect of unemployment rate on these accidents and a positive permanent effect consistent with the findings for the whole economy. Yet, for the fatal injuries both the transitory and permanent effects are positive. This implies that, in line with the study of Boone and van Ours (2002), there may be a transitory underreporting of work accidents and injuries in manufacturing.

Davies *et al*. (2009) found that for the *"mining"* sector economic booms are associated with an increase in the minor work injuries and that there is a positive relationship between GDP and minor injuries in the construction industry for the UK. In addition, Davies and Jones (2005) provided evidence that moving from a recession to an economic upturn is associated with a substantial increase in work injury rates in the construction industry for both male and female workers. Finally, Davies *et al*. (2009) found that during economic recessions (approximated by GDP) minor work injuries increase for the industry *financial intermediation*, while the work injuries decrease for the *public sector and defence* and *health and social work* industries. To the knowledge of the authors there are no other specific studies investigating the effects of the business cycle on work accidents and injuries for the remaining sectors. The present study shows that all other sectors investigated exhibit the same patterns as

those highlighted for the overall sample[5], namely the temporary unemployment effect on work injuries is negative, and the permanent unemployment effect is positive for both fatal and non fatal work accidents and injuries. Hence, this implies that underreporting of work injuries and accidents is not an issue for these sectors.

7. Discussion and Conclusions

The research on the effect of economic cycles on work accidents focuses on the effects of non-fatal work accidents on individual countries or occupational sectors. The literature provides ambiguous conclusions; a part of the literature suggests that high unemployment rates are negatively associated with work accidents, although these findings are sensitive to the choices of countries or occupational sectors. Yet, several studies report that recessions cause an increase in accidents and injuries at work. Furthermore, other research shows that high unemployment results in a high incidence of fatal accidents and injuries at work but for non-fatal accidents the effect of unemployment becomes negative. It is suggested that this is an outcome of the underreporting of non fatal work accidents and injuries.

This study attempts to provide further evidence of the effects of economic fluctuations on fatal and non fatal work accidents for thirteen European Union countries. The study also investigates the unemployment rate/workplace accidents relationship by disaggregating into nine industrial sectors. A novel feature of this study is that it distinguishes between the permanent and transitory effect of the unemployment rates on work accidents and controls for cross-panel correlation and heteroskedasticity, by using the FGLS methodology.

Overall, the results imply that cross panel correlation is important. Furthermore, when the decomposition of the effect of unemployment rates on accidents at work into the permanent and the transitory effects are introduced into the regressions, it is shown that recessions exert a differential effect upon both fatal and non-fatal working accident rates. In particular, although the transitory effect of an increase of unemployment rate is associated with a decrease in work accidents rates, the results also strongly suggest that an increase in unemployment rates has a permanent effect in rising work accidents.

The results suggest that the effect of recessions on the incidence of work accidents and injuries are more complicated than the patters detailed in the literature. It appears

that at the initial stages of the economic downturn, work accidents tend to decrease as the slowdown of production reduces the number of job shifts, ease the work intensity and decrease the proportion of newly hired and less experienced workers in the workforce as the rate of job creation declines. However, at later stages of the recession, cost cutting practices by employers may affect the OHS investments as firms reduce their expenditure on training and safety equipment and workers in employment tend to undertake far riskier job tasks in a world of scarce employment opportunities. Hence, the permanent effect of unemployment on work accidents becomes positive. Conversely, at the initial stages of economic expansions, an increase in work intensity occurs as firms react to the pressure of increasing aggregate demand. There is an increase to hours of work and an increase to the pressure for increased productivity of the workers which might induce them to be less careful with safety procedures. This implies a negative transitory unemployment rate/workplace accidents relationship. However, with the passage of time as the economy adapts to the improved state of affairs firms are encouraged to invest in occupational health and safety capital. Thus, the permanent effect of unemployment rate on work accidents turns out to be positive.

The present study shows that the above results are uniformly consistent with the results obtained after the industrial disaggregation, with two exceptions namely the *manufacturing* and *agriculture* sectors where there is evidence of a transitory underreporting of non fatal work accidents and injuries. In view of the evidence provided by this study, policy at the national and the European Union level which aims to improve working conditions and the decrease work accidents should be designed in combination with the macroeconomic policies aimed at evening out the macroeconomic fluctuations.

Notes

1. Council of Ministers, Nice Council meeting, December 2000.
2. The data are available at: European Health for All database (HFA-DB), Copenhagen, WHO Regional Office for Europe, (2009), (http://www.euro.who.int/hfadb).
3. More information on the construction of the injury rates indices is provided in Appendix A.

4. Results using the random effects regressions with Mundlak transformation by industry are reported in Appendix B to ease the comparability with the FGLS estimators. The sign and size of the estimated coefficients from the above estimations are mostly similar to those from the FGLS models in terms of sign and size, indicating that in the presence of error correlation, the FGLS method should be preferred for efficient estimates.
5. With the exception of the *electricity gas and water supply* industry where the transitory effect of unemployment on fatal injuries and accidents turns out to be insignificant.

References

Askildsen, J. A., Bratberga, E. and Nilsenb, O. A. (2005). Unemployment, labor force composition and sickness absence: a panel data study. *Health Economics*, 14(11): 1087-1101.

Baum, C. F. (2001). Residual diagnostics for cross-section time series regression models. *The STATA Journal*, 1(1): 101-104.

Beck, N. and Katz, J. N. (1995). What To Do (and Not To Do) with Time-Series Cross-Section Data. *American Political Science Review*, 89(3): 634-47.

Boone, J. and van Ours, J. C. (2006). Are recessions good for workplace safety? *Journal of Health Economics*, 25(6): 1069-1093.

Breusch, T. and Pagan, A. (1980). The LM test and its application to model specification in econometrics. *Review of Economic Studies*, 47(1): 239-253.

Brooker, A.-S., Frank, J. W. and Tarasuk, V. S. (1997). Back pain claim rates and the business cycle. *Social Science and Medicine*, 45(3): 429-439.

Catalano, R. (1979). Health Costs of Economic Expansion: The Case of Manufacturing Accident Injuries. *American Journal of Public Health*, 69(8): 798-794.

Davies, R. A., Jones, P. and Nunez, I. C. (2009). The impact of the business cycle on occupational injuries in the UK. *Social Science and Medicine*, 69(2): 178–182.

Davies, R. and Jones, P. (2005). *Trends and context to rates of workplace injury*. Warwick Institute for Employment Research University of Warwick for the Health and Safety Executive, Research Report No. 386.

European Agency for Safety and Health at Work (2001). *Preventing Accidents at work*, Belgium.

Gottschalk, P., Moffitt, R., Katz, L. F. and Dickens, W. T. (1994). The Growth of Earnings Instability in the U.S. Labor Market. *Brookings Papers on Economic Activity*, 25(2): 217-72.

Greene, W. (2000). *Econometric Analysis*. Upper Saddle River, NJ: Prentice–Hall.

Johansson, A. and Palme, M. (1996). Do economic incentives affect work absence? Empirical evidence using Swedish micro data. *Journal of Public Economics*, 59(2): 195-218.

Leigh, J. P. (1985). The effects of unemployment and the business cycle on absenteeism. *Journal of Economics and Business*, 37(2): 159–170.

Mundlak, Y. (1978). On the Pooling of Time Series and Cross Section Data. *Econometrica*, 46(1): 69-85.

Personick, M. E. (1997). *Three Measures of Nonfatal Injuries at Work*. Office of Safety, Health and Working Conditions, Bureau of Labor Statistics Report, USA.

Podesta, F. (2002). *Recent Developments in Quantitative Comparative Methodology: The Case of Pooled Time Series Cross-Section Analysis*. DSS Papers - SOC 3-02, p. 44.

Reed, W. R. and Webb, R. S. (2009). *Estimating standard errors for the Parks model: Can jackknifing help?* University of Canterbury, Department of Economics and Finance, New Zealand, Working Paper No. 18/2009.

Robinson, J. C. (1988). The Rising Long-Term Trend in Occupational Injury Rates. *American Journal of Public Health*, 78(8): 276-281.

Saloniemi, A. and Oksanen, H. (1998). Accidents and fatal accidents: Some paradoxes. *Safety Science*, 29(1): 59-66.

Sasaki, M. (2009). *Unemployment and workplace safety in a search and matching model*. Presented in the European Association of Labour Economists Conference (EALE) 2009, Talin, Estonia.

Schmid, F. A. (2009). *Workplace injuries and job flows*. SSRN Working Paper.

Steele, G. R. (1974). Industrial accidents: an economic interpretation. *Applied Economics*, 6(2): 143-155.

Van Praag, B. M. S., Frijters, P. and Ferrer-i-Carbonell, A. (2002). The Anatomy of Subjective Well-Being. *Journal of Economic Behavior and Organization*, 51(1): 29-49.

Ussif, A. A. (2004). An international analysis of workplace injuries. *Monthly Labor Review*, 127(3): 41-51.

Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

WorkCover WA (2009). *Impact of the Economic cycle of WorkCover Operations*. New South Wales Government, Australia, Research Report.

Table 1. Descriptive Statistics

Variables	*Mean*	*Standard Deviation*
DependentVariables		
Fatal work accidents per 100,000 population		
Total sample	1.607	1.057
Sector 1 agriculture, hunting, forestry and fishing	0.178	0.181
Sector 2 mining and quarrying	0.084	0.102
Sector 3 manufacturing	0.365	0.320
Sector 4 electricity, gas and water supply	0.051	0.066
Sector 5 construction	0.438	0.331
Sector 6 wholesale and retail trade, repair of motor vehicles and motorcycles, and personal and household goods, hotels and restaurants	0.182	0.127
Sector 7 transport, storage and communication	0.213	0.159
Sector 8 financial intermediation, real estate, rending and business services	0.072	0.086
Sector 9 public administration and defence, compulsory social security, education, health and social work, other community, social and personal service activities	0.122	0.108
Non-fatal work accidents per 100,000 population		
Total sample	1,022.105	703.432
Sector 1 agriculture, hunting, forestry and fishing	61.767	85.506
Sector 2 mining and quarring	15.640	22.650
Sector 3 manufacturing	407.580	305.940
Sector 4 electricity, gas and water supply	8.327	5.829
Sector 5 construction	192.713	157.513
Sector 6 wholesale and retail trade, repair of motor vehicles and motorcycles, and personal and household goods, hotels and restaurants	138.529	104.264
Sector 7 transport, storage and communication	77.808	38.709
Sector 8 financial intermediation, real estate, rending and business services	51.114	42.305
Sector 9 public administration and defence, compulsory social security, education, health and social work, other community, social and personal service activities	144.713	87.469
Independent Variables		
Country unemployment rate	8.433	4.574
Real GDP per capita (in PPP)	17,009.20	7,345.349

The data on work accidents are drawn from the ILO database (LABORSTA). Data on economic variables are drawn from the World Health Organization "Health for All database" and the Annual Labor Force Statistics, OECD.

Table 2. The effect of unemployment on fatal work accidents per 100,000 population

	Fatal	*Non Fatal*	*Fatal*	*Non Fatal*
	Fixed Effects		***Random Effects***	
CountryUR	-0.057*	-0.963*	-0.054	-0.951*
GDP	0.027*	-0.001**	0.026*	0.0001
Year Effects	Yes	Yes	Yes	Yes
Obs.	312	220	312	220
Breuch-Pagan LM test of independence	281.743 (0.000)	152.593 (0.000)		
Modified Wald test for groupwise heteroskedasticity	1,259.77 (0.000)	957.02 (0.000)		

	RE with Mundlak Transformation		***FGLS with Mundlak Transformation***	
	Fatal	***Non Fatal***	***Fatal***	***Non Fatal***
Temporary UR	-0.052	-0.401*	-0.123*	-0.371*
Permanent UR	0.635	1.964	0.643*	1.864*
GDP	0.022*	0.00001	0.024*	0.0001
Year Effects	Yes	Yes	Yes	Yes
Obs.	312	220	312	220

Work accidents and country UR are expressed in logarithms. * indicates statistical significance for $p<0.05$ and ** indicates significance for $p<0.10$.

Table 3. Short-run and Long-run Effects of unemployment on fatal work accidents; FGLS with Mundlak Transformation

	Sector 1	*Sector 2*	*Sector 3*	*Sector 4*	*Sector 5*	*Sector 6*	*Sector 7*	*Sector 8*	*Sector 9*
					Fatal Work Accidents, FGLS				
Temporary UR	0.067*	-0.020*	0.074*	0.006	-0.177*	-0.035*	-0.051*	-0.037*	-0.040*
Permanent UR	0.305*	-0.036*	0.254*	-0.055*	0.049*	0.015	0.193*	0.042*	0.136*
GDP	-0.014*	-0.002*	-0.030*	0.005*	-0.033*	-0.012*	-0.005*	-0.003*	-0.006*
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	208	200	208	210	210	200	225	192	176

Table 4. Short-run and Long-run Effects of unemployment on non-fatal work accidents; FGLS with Mundlak Transformation

	Sector 1	*Sector 2*	*Sector 3*	*Sector 4*	*Sector 5*	*Sector 6*	*Sector 7*	*Sector 8*	*Sector 9*
					Non-Fatal Work Accidents, FGLS				
Temporary UR	-0.555*	-0.086*	-21.190*	-0.115*	-0.713*	-0.469*	-0.263*	-0.275*	-0.501*
Permanent UR	1.894*	2.666*	22.221*	1.564*	1.715*	2.289*	2.107*	2.626*	1.663*
GDP	0.0004*	-0.00002	-0.002	0.00003*	0.0001	-0.00003*	0.000001	0.0001*	-0.0001*
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	198	153	198	198	198	198	198	198	153

Notes for Tables 3 and 4:

Work accidents and country UR are expressed in logarithms. * indicates statistical significance for $p<0.05$ and ** indicates significance for $p<0.10$.

Sector 1: agriculture, hunting, forestry and fishing; Sector 2: mining and quarrying; Sector 3: manufacturing; Sector 4: electricity, gas and water supply; Sector 5: construction; Sector 6: wholesale and retail trade, repair of motor vehicles and motorcycles, and personal and household goods, hotels and restaurants; Sector 7: transport, storage and communication; Sector 8: financial intermediation, real estate, rending and business services; Sector 9: public administration and defense, compulsory social security, education, health and social work, other community, social and personal service activities.

Appendix A. Construction of the injury rates indices by economic sector.

1980-1994	*1995-2006*	*Rearranged 1995-06 as following:*
1: agriculture, hunting, forestry and fishing	A: agriculture, hunting, forestry B: fishing	A+B=1
2: mining and quarring	C: mining and quarring	C=2
3: manufacturing	D: manufacturing	D=3
4: electricity, gas and water	E: electricity, gas and water supply	E=4
5: construction	F: construction	F=5
6: wholesale and retail trade and restaurants and hotels	G: wholesale and retail trade, repair of motor vehicles and motorcycles and personal and household goods H: hotels and restaurants	G+H=6
7: transport, storage and communication	I: transport, storage and communication	I=7
8: financing, insurance, real estate and business services	J: financial intermediation K: real estate, rending and business services	J+K=8
9: community, social and personal services	L: public administration and defense, compulsory social security M: education N: health and social work O: other community, social and personal service activities	L+M+N+O=9
0: activities not adequately defined	P: households with employed persons Q: extra-territorial organizations and bodies X: not classified by economic activity	P+Q+X=0

Injury rates by economic activity are provided with different categorisation before and after 1995 from ILO database. Therefore, we merged the economic sectors categories for the period 1995-2006 as shown above, in line with the categorisation for the period 1980-1994 in order to have comparable data for a longer time span. The last category "0: activities not adequately defined" was omitted from the analysis.

Appendix B. Short-run and Long-run Effects of unemployment on fatal and non-fatal work accidents; RE estimations

	Sector 1	*Sector 2*	*Sector 3*	*Sector 4*	*Sector 5*	*Sector 6*	*Sector 7*	*Sector 8*	*Sector 9*
					Fatal Work Accidents, Random Effects				
Short-term UR	0.056*	-0.026	0.022	-0.069**	-0.044**	-0.039*	-0.039*	-0.050*	-0.008
Long-term UR	0.328*	-0.026	-0.047	0.012	0.013	0.197	0.197	0.011	0.120
GDP	0.005	-0.021*	0.009*	0.018*	-0.012*	0.004	0.004	-0.009*	0.001
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	208	200	208	210	210	200	225	192	176
					Non-Fatal Work Accidents, Random Effects				
Short-term UR	-0.444*	0.039	-0.389*	-0.180**	-0.696*	-0.514*	-0.037*	-0.485*	-0.395*
Long-term UR	2.079	2.622	2.083	1.583	1.758	2.322**	2.038**	2.588**	1.654
GDP	0.0003	-0.00001	0.000004	0.00003	0.00002	-0.0001	0.00003	0.0001	-0.0001
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	198	153	198	198	198	198	198	198	153

Work accidents and country UR are expressed in logarithms. * indicates statistical significance for $p<0.05$ and ** indicates significance for $p<0.10$.

Sector 1: agriculture, hunting, forestry and fishing; Sector 2: mining and quarrying; Sector 3: manufacturing; Sector 4: electricity, gas and water supply; Sector 5: construction; Sector 6: wholesale and retail trade, repair of motor vehicles and motorcycles, and personal and household goods, hotels and restaurants; Sector 7: transport, storage and communication; Sector 8: financial intermediation, real estate, rending and business services; Sector 9: public administration and defense, compulsory social security, education, health and social work, other community, social and personal service activities.