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ECONOMIC SITUATION AND OCCUPATIONAL ACCIDENTS IN POLAND: 2002–2014 PANEL DATA REGIONAL STUDY

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Abstract
Objectives: Occupational accidents constitute a substantial health and economic burden for societies around the world and a variety of factors determine the frequency of accidents at work. The aim of this paper is to investigate the relationship between the economic situation and the rate of occupational accidents in Poland. **Material and Methods:** The analysis comprised data for 66 Polish sub-regions taken from the Central Statistical Office's Local Data Bank. The regression analysis with panel data for period 2002–2014 was applied to identify the relationships involved. Four measures of accidents were used: the rates of total occupational accidents, accidents among men and women separately as well as days of incapacity to work due to accidents at work per employee. Four alternative measures assessed the economic situation: gross domestic product (GDP) *per capita*, average remuneration, the unemployment rate and number of dwelling permits. The confounding variables included were: employment in hazardous conditions and the size of enterprises. **Results:** The results of the regression estimates show that the number of occupational accidents in Poland exhibits procyclical behavior, which means that more accidents are observed during the times of economic expansion. Stronger relationships were observed in the equations explaining men's accident rates as well as total rates. A weaker and not always statistically significant impact of economic situation was identified for women's accident rates and days of incapacity to work. **Conclusions:** The results have important implications for occupational health and safety actions. In the periods of higher work intensity employers should focus on appropriate training and supervision of inexperienced workers as well as on ensuring enough time for already experienced employees to recuperate. In terms of public health actions, policy makers should focus on scrutinizing working conditions, educating employers and counteracting possible discrimination of injured employees. Int J Occup Med Environ Health 2018;31(2):151–164

Key words:
Occupational hazards, Occupational health and safety, Gender differences, Accident at work, Business cycle, Panel data model

INTRODUCTION

Despite dynamic technological changes leading to a rapid improvement of occupational safety, the number of occupational accidents in Poland in 2014 amounted to nearly 90 000 (10.3 accidents per 1000 employees), resulting in 3.4 million days of work incapacity [1]. Such accidents give rise to considerable health losses and adversely affect labor supply and corporate productivity, which result in a slowdown of economic growth [2]. The consequences of accidents not only affect the whole economy or society

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but also individual companies and employees. The average cost of a single accident at work in Poland incurred by a company in 2011 was estimated at 33 610 PLN, an equivalent of 11 342 USD [3]. The total economic loss due to occupational accidents in Poland has not been estimated recently. Combined costs of accidents at work and occupational diseases in 2004 amounted to 8.2–9.2 billion PLN (0.93–1.04% of gross national product); these estimates, however, did not account for several costs categories, i.e., indirect costs and transfer payments [4].

Accidents at work are determined by a variety of behavioral, organizational, technical and economic factors [5]. Contemporary research concerning the reasons behind these accidents is conducted from 3 perspectives: business cycle, labor market and structural characteristics including for instance the size of a company or capital use intensity. The first approach allows for explaining how the rate of accidents changes in response to the course of a business cycle (economy fluctuations). These economy fluctuations affect many factors which may both directly or indirectly influence occupational safety, i.e., also the number of accidents. There has been some research making use of domestic or international data confirming that the frequency of accidents rises in the times of dynamic economic growth [6–13]. These results, however, have been obtained only with regard to a group of highly developed countries, while there are no analyses of analogous relationships in the countries of economic transition. The business cycle perspective constitutes the analytical basis for this study and its empirical part is based on Polish regional data.

Using aggregated data from Poland, this study focuses on the economic determinants of occupational accidents. In particular, the study aims to identify the relationship between economic situation and frequency of accidents at work by applying panel data regression for Polish regional data in the period 2002–2014. This approach continues the research agenda begun by Kossoris who almost 80 years ago examined the relationship between the economic situation and occupational accidents during the Great Crisis (1929–1933) in the United States [14]. In the following decades the topic was not subject to researchers' great interest. A considerable rise in the attention paid to the issue was seen at the beginning of the 21st century; however, we still lack sufficient scientific evidence on the nature of the relationship between economic situation and the rate of occupational accidents.

In Poland research in this area has never been conducted and the economic research preceding this study focused rather on institutional and financial aspects of occupational health and safety [15,16]. Thus, it seems that the unusual development of the economic situation in Poland in recent years (relatively fast economic growth, sizeable drop in the unemployment rate as well as considerable rise of flexible employment forms) provides original research context for the empirical analysis on the relationship between the business cycle and accidents at work. Also, by focusing on Poland, this research deals with a country of economic transition, where both production processes and labor market factors differ in comparison to highly developed economies that were subject to interest in the previous studies.

Poland is characterized by distinctively high percentage shares of industry employment (30.2% compared to 21.9% on average in the European Union (EU) in 2014) and agricultural employment (12% compared to 5.1% on average in the EU in 2013) suggesting that occupational risks and patterns of accidents may differ there from those in more service-oriented economies. Moreover, the labor market in Poland in the last 15 years has been characterized by dynamic and extreme changes including a high unemployment rate (exceeding 20% in 2002) and the highest percentage share of people working under temporary contracts in the European Union (28.3% of employees compared to the average of 14% in the UE in 2014).

All these factors seem to have considerable impact on working conditions as well as workers' behavior in the

labor market, including their inclinations to report accidents. This specificity makes Poland an interesting case allowing for verifying the relationships identified in highly developed economies.

MATERIAL AND METHODS

To identify the relationship between economic situation and the rate of occupational accidents we used data from 66 Polish sub-regions and for the period 2002–2014 (in the case of one variable, gross domestic product, data is only available for 2002–2012 period). The data used is taken from the Local Data Bank [1], which is an internet database of the Central Statistical Office that stores information on the socio-economic and health situation in Polish regions.

We used panel data regression to examine the causal relationships between economic situation and accidents. The term "panel data" refers to a structure of data used in model building. A set of panel data contains cyclical observations of the same entities (individuals, business companies, regions or countries) collected for multiple periods. The use of panel data allows for estimating more realistic models comparing to single-period cross-sectional data and time-series of a single entity [17].

The major advantages of panel models are [18,19]: controlling for individual heterogeneity of the objects; more informative data, more variability and less collinearity among the covariates; more degrees of freedom and higher efficiency; ability to model the dynamics of adjustment; identifying and quantifying the effects that are non-observable in cross-section or time-series data; ability to test more complex and realistic behavioral models; and accounting for omitted variables bias.

The variables selection for the models was based on literature as well as on the availability of data. Four measures of occupational accidents were used as dependent variables. Three of them use the annual number of occupational accidents in a sub-region per 1000 workers; the first refers to the total population of workers, while the other 2 to accidents among men and women. The fourth measure is an average number of days of incapacity to work due to occupational accidents per worker.

The independent variables used in the study are those describing the economic situation, exposure to occupational hazards and size-based structure of companies in sub-regions. Four alternative measures of the economic situation were used. The first is real gross domestic product (GDP) *per capita*; the second is the unemployment rate; the third is average real remuneration; the fourth is the number of dwellings for which construction permits were granted per 1000 population. All 4 measures are among the most commonly used in describing economic situation; their advantage is high availability, they are easily interpretable as well as they have been used in similar contexts [6,7,20].

The remaining 2 independent variables (the percentage share of those working in accident-prone conditions and size-based enterprises structure) are control variables and are not the major focus of the study. They are included in the models because leaving potential accident determinants out of the models would result in omitted variables bias. The first of these variables proxies employees' exposure to work-related hazards caused by environmental and mechanical factors. A higher percentage share of employees working in hazardous conditions is expected to be related to a higher accident rate; hence, the inclusion of this variable in the models seems essential.

The other control variable, i.e., the percentage share of medium-sized enterprises, has been included to test whether enterprise size is associated with the rate of occupational accidents as indicated in one study [21]. The percentage share of medium enterprises (50–249 employees) in a sub-region has been selected as it is the only variable used for assessing size-based structure of companies that has desirable properties in terms of distribution. The percentage shares of micro (up to 9 employees), small (10–49 employees) and large enterprises (over 250 employees)

were characterized by too little territorial variability, which has prevented us from using them as explanatory variables.

The definitions of the variables, their time span and descriptive statistics are shown in the Table 1.

Statistical analysis

The associations between a business cycle and the frequency of accidents have been identified using panel data regression. All the variables in the models estimated have been expressed in natural logarithms, allowing to interpret the regression coefficients as constant elasticities (if y is a dependent variable and x is an explanatory variable, the elasticity of y with respect to x shows a percentage change in y for a given percentage change in x).

Before estimating the regression models, the stationarity of the variables was tested to avoid possible incidence of spurious regression when using non-stationary time series. The stationarity was examined with the Im-Pesaran-Shin test [22] and Harris-Tzavalis test [23] which allow to identify a unit root in variables. In 3 of the explanatory variables, i.e., GDP, remuneration and the percentage share of employees working in hazardous conditions, non-stationarity were identified, thus, in the models the estimated variables were expressed as first differences, which proved to be stationary:

Table 1. Accidents measurement in the investigation of the relationship between the economic situation and rate of occupational accidents in Poland, 2002–2014[a]

Variable	Timespan	Definition (measurement unit)	M±SD	Min.–max
Accidents [n of persons]				
total	2002–2014	injured in occupational accidents per 1 000 employees	11.10±2.80	5.00–21.60
men	2002–2014	men injured in occupational accidents per 1 000 employees	15.20±3.90	7.40–28.20
women	2002–2014	women injured in occupational accidents per 1 000 employees	6.80±1.90	2.60–16.40
Days of incapacity to work [n]	2002–2014	days of incapacity to work due to occupational accidents per 1 employee	0.48±0.10	0.23–0.84
Gross domestic product (GDP) [PLN]	2002–2012	real* gross domestic product *per capita*	30 559.00±13 130.00	15 460.00–112 801.00
Remuneration [PLN]	2002–2014	real* average monthly gross salary	2 884.00±494.00	2 064.00–4 935.00
Unemployment [%]	2004–2014	registered unemployment rate	14.50±5.90	1.80–34.90
Permits granted for construction [n]	2005–2014	dwelling construction permits per 1 000 persons	4.30±2.70	1.00–17.90
Employment in hazardous conditions [n of persons]	2002–2014	individuals working in hazardous conditions per 1 000 employees	68.20±33.30	9.80–267.00
Medium enterprises [%]	2002–2014	share of medium enterprises** in total entities but microenterprises	15.90±1.60	12.20–21.50

[a] Based on: Central Statistical Office's Local Data Bank [1].
M – mean; SD – standard deviation; min. – minimal value; max – maximal value.
* Year 2010 is the baseline year.
** 50–249 employees.

$$\Delta x_t = x_t - x_{t-1} \quad (1)$$

where:

Δx_t – variable x change,

x_t – variable x value in the period t,

x_{t-1} – variable x value in the period t-1.

The results of the unit root tests for non-stationary variables are shown in the Table 2.

The specification of the models estimated is given by the following equation:

$$\Delta \ln Acc_{it} = \alpha + \alpha_i + \beta \Delta \ln Econ_{it} + \gamma \Delta \ln Haz_{it} + \delta \Delta \ln Size_{it} + \varepsilon_{it} \quad (2)$$

where:

Δ – a change from period t-1 to t,

Acc_{it} – a measure of occupational accidents in year t in a sub-region i,

α – a constant term, interpreted as a time trend,

α_i – a fixed effect for a sub-region i (only in fixed effects models),

$Econ_{it}$ – a measure of economic situation in a sub-region i in year t,

Haz_{it} – a variable describing the occupational hazards in a sub-region i in year t,

$Size_{it}$ – a variable illustrating the size-based enterprise structure in a sub-region i in year t,

ε_{it} – an error term,

β, γ – regression coefficients to be estimated.

Three alternative methods of estimation were tested in order to model the relationship between the accident rate and economic situation, and these were: pooled ordinary least squares (OLS); random effects model; and fixed effects model. The F test, Breusch-Pagan test and Hausman test were used for choosing between one of these 3 methods [18].

To check for possible collinearity among the explanatory variables, correlation coefficients among them were examined. In none of the covariates pairs the value of the Pearson correlation coefficient exceeded $r_{xy} = 0.2$, implying that collinearity was not a problem in this case.

RESULTS

Before estimating the regression models, we compared the dynamics of total occupational accidents and 2 commonly used measures of economic situation. The Figure 1 shows the dynamics of accidents and real GDP *per capita* change in the period under consideration.

From the path of 2 trend lines we can see that both time-series change in the same direction. The years of higher GDP increases (2004, 2006, 2010 and 2011) were accompanied by a growing rate of injures at work, while decreasing dynamics of production output corresponded

Table 2. Unit root tests statistics for levels and first differences of variables used in estimating determinants of occupational accidents in the sub-regions of Poland, 2002–2014[a]

Variable	Harris-Tzavalis test H_0: Panels contain unit roots H_A: Panels are stationary		Im-Pesaran-Shin test H_0: All panels contain unit roots H_A: Some panels are stationary	
	levels	first differences	levels	first differences
Gross domestic product (GDP) *per capita*	0.881 (p = 1.000)	−0.012 (p < 0.001)	0.418 (p = 0.662)	−6.815 (p < 0.001)
Remuneration	0.947 (p = 1.000)	0.226 (p < 0.001)	7.488 (p = 1.000)	−7.263 (p < 0.001)
Employment in hazardous conditions	0.752 (p = 0.106)	−0.344 (p < 0.001)	0.934 (p = 0.825)	−12.941 (p < 0.001)

[a] Table contains test statistics only for variables characterized by non-stationarity in levels.
H_0 – null hypothesis; H_A – alternative hypothesis.

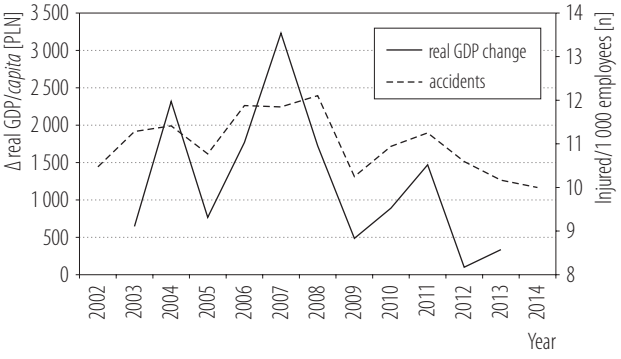

Fig. 1. Dynamics of real gross domestic product (GDP) *per capita* and total occupational accidents in Poland, 2002–2014

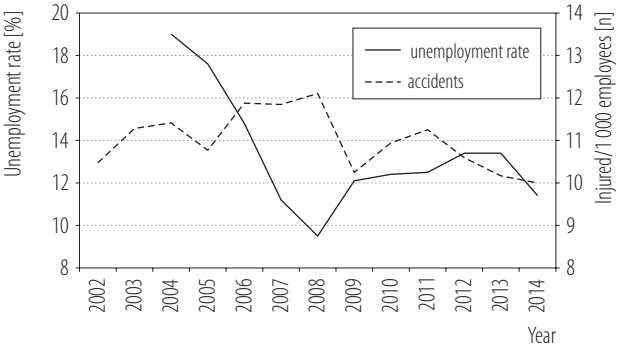

Fig. 2. Dynamics of unemployment rate and total occupational accidents in Poland, 2002–2014

with a lower frequency of accidents (years 2005, 2009, 2012). We observe similar patterns when the unemployment rate is used as an economic variable (Figure 2). The period 2004–2008 was characterized by a drop of the unemployment rate and a rising trend in the accident rate, while for the years 2009–2013 we observed reverse trends in both variables.

The data in both figures suggests that a considerable association exists between economic situation and the rate of accidents at work. To quantify these relationships, we estimated several regression models. Tables 3–6 present the results of models for 4 following variables illustrating accidents in sub-regions of Poland in the years 2002–2014:

– total accidents,
– accidents among men,
– accidents among women,
– days of incapacity to work due to occupational accidents.

For each of these variables, we used 4 alternative indicators of economic situation:

– real GDP *per capita*,
– average real remuneration,
– unemployment rate,
– dwelling construction permits.

Thus, 16 regression models were estimated altogether. In the first step, we estimated the models using pooled OLS, assuming that both time and individual effects were not significant. In every model estimated the F test value suggests that the pooled OLS is an appropriate estimation method. For the purpose of comparing all equations, we have also estimated them using fixed effects and random effects approaches. The values of the Hausman test indicate that out of the 2 approaches the random effects results are superior over fixed effects. The estimates yielded using random effects have proven to be virtually the same as the ones from pooled OLS, thus, they are not shown here.

The results suggest that the economic situation in the period 2002–2014 was significantly associated with the frequency of total accidents in the sub-regions of Poland. One percent growth of the GDP *per capita* or the average wage corresponded to a slightly over 0.4% rise in the rate of occupational accidents. A weaker relationship, though statistically significant, linked accidents and the housing situation variable. There was also a negative relationship between accidents and the unemployment rate – 1% growth in the unemployment rate was associated with 0.22% decline in the frequency of total accidents (Table 3).

A relatively stronger relationship between economic situation and occupational accidents was identified for men in comparison with the general population. One percent growth in the GDP and an average remuneration cor-

Table 3. Regression estimates for determinants of total occupational accidents in the sub-regions of Poland, 2002–2014[a]

Variable	Dependent variable: total occupational accidents			
	model 1.1 gross domestic product (GDP)	model 1.2 remuneration	model 1.3 unemployment	model 1.4 dwellings
Constant term	−0.013*** (0.004)	−0.012** (0.003)	−0.020*** (0.003)	−0.002 (0.002)
Economic situation	0.418*** (0.089)	0.433*** (0.104)	−0.222*** (0.022)	0.083*** (0.014)
Employment in hazardous conditions	0.056* (0.030)	0.055** (0.026)	0.056* (0.030)	0.113*** (0.035)
Medium enterprises	−0.222*** (0.053)	−0.268*** (0.051)	−0.000 (0.063)	−0.140* (0.074)
Observations [n]	660	792	660	594
F test for pooled ordinary least squares (OLS)	0.22 (p = 1.000)	0.22 (p = 1.000)	0.26 (p = 1.000)	0.24 (p = 1.000)
Adjusted R^2	0.042	0.031	0.135	0.067
F test	18.67 (p < 0.001)	15.21 (p < 0.001)	40.08 (p < 0.001)	22.85 (p < 0.001)

[a] Equations estimated with pooled OLS; all the variables expressed in natural logarithms. White's heteroscedasticity and autocorrelation robust standard errors with applied degrees-of-freedom correction shown in parentheses next to parameters estimates [24].
*** Parameter significant at 0.01 level.
** Parameter significant at 0.05 level.
* Parameter significant at 0.1 level.

Table 4. Regression estimates for determinants of men's occupational accidents in the sub-regions of Poland, 2002–2014[a]

Variable	Dependent variable: men's occupational accidents			
	model 2.1 gross domestic product (GDP)	model 2.2 remuneration	model 2.3 unemployment	model 2.4 dwellings
Constant term	−0.026*** (0.004)	−0.026*** (0.003)	−0.033*** (0.004)	−0.013*** (0.003)
Economic situation	0.558*** (0.094)	0.595*** (0.114)	−0.263*** (0.024)	0.101*** (0.014)
Employment in hazardous conditions	0.069** (0.033)	0.061** (0.028)	0.056* (0.029)	0.121*** (0.039)
Medium enterprises	−0.168* (0.057)	−0.241*** (0.054)	0.051 (0.092)	−0.095 (0.081)
Observations [n]	660	792	660	594
F test for pooled ordinary least squares (OLS)	0.23 (p = 1.000)	0.22 (p = 1.000)	0.26 (p = 1.000)	0.25 (p = 1.000)
Adjusted R^2	0.055	0.038	0.167	0.080
F test	21.77 (p < 0.001)	16.59 (p < 0.001)	48.17 (p < 0.001)	26.38 (p < 0.001)

Explanations as in Table 2.

responded to nearly 0.6% rise in accidents among men. A greater importance of economic situation for the rate of accidents among men was also confirmed by the coefficient values in models 2.3 and 2.4, which used the rate of unemployment and housing market situation as the estimates of economic situation (Table 4).

We identified markedly different estimates in the models describing the determinants of accidents among

Table 5. Regression estimates for determinants of women's occupational accidents in the sub-regions of Poland, 2002–2014[a]

Variable	Dependent variable: women's occupational accidents			
	model 3.1 gross domestic product (GDP)	model 3.2 remuneration	model 3.3 unemployment	model 3.4 dwellings
Constant term	0.020*** (0.005)	0.021*** (0.005)	0.012*** (0.003)	0.025*** (0.004)
Economic situation	0.027 (0.121)	0.048 (0.144)	−0.115*** (0.027)	0.038* (0.020)
Employment in hazardous conditions	0.019 (0.029)	0.033 (0.028)	0.053 (0.033)	0.093** (0.037)
Medium enterprises	−0.289*** (0.089)	−0.269*** (0.085)	−0.093 (0. 094)	−0.220** (0.112)
Observations [n]	660	792	660	594
F test for pooled ordinary least squares (OLS)	0.24 (p = 1.000)	0.20 (p = 1.000)	0.24 (p = 1.000)	0.21 (p = 1.000)
Adjusted R^2	0.007	0.006	0.024	0.001
F test	3.96 (p = 0.010)	3.56 (p = 0.010)	9.64 (p < 0.001)	5.42 (p = 0.001)

Explanations as in Table 2.

Table 6. Regression estimates for determinants of days of incapacity to work due to occupational accidents in the sub-regions of Poland, 2002–2014[a]

Variable	Dependent variable: days of incapacity to work due to occupational accidents			
	model 4.1 gross domestic product (GDP)	model 4.2 remuneration	model 4.3 unemployment	model 4.4 dwellings
Constant term	−0.008* (0.005)	−0.012*** (0.033)	−0.029*** (0.002)	−0.016*** (0.033)
Economic situation	0.183 (0.113)	0.033 (0.140)	−0.138*** (0.027)	0.060*** (0.018)
Employment in hazardous conditions	0.027 (0.030)	0.037 (0.027)	0.044 (0.034)	0.085** (0.039)
Medium enterprises	−0.169** (0.066)	−0.212*** (0.064)	0.150** (0.068)	0.043 (0.064)
Observations [n]	660	792	660	594
F test for pooled ordinary least squares (OLS)	0.21 (p = 1.000)	0.16 (p = 1.000)	0.18 (p = 1.000)	0.19 (p = 1.000)
Adjusted R^2	0.006	0.005	0.041	0.023
F test	4.44 (p = 0.004)	4.29 (p = 0.005)	10.65 (p < 0.001)	5.48 (p = 0.001)

Explanations as in Table 2.

women. The coefficients of regression in the case of the GDP and remuneration were also positive, however, noticeably lower than in the case of men and not statistically significant. On the other hand, the associations between unemployment and accidents as well as between housing market situation and accidents were significant among women but considerably weaker than in the case of men (Table 5).

Similar results to those from the models explaining the relationships for women were obtained in the equations

where accidents were assessed by days lost due to incapacity to work. Also in this case, the GDP and remuneration appeared not to be significantly associated to accidents, while in the case of the unemployment rate and housing situation an important relationship was confirmed (Table 6).

The estimates for 2 other determinants of accidents (the percentage share of employees working in hazardous conditions and the percentage share of medium-sized enterprises) are ambiguous to a certain extent. In all 16 equations, the coefficients of the variable concerning occupational hazard were positive, which was to be expected, however, they were significant in 10 models.

Generally, with lower coefficient values, the importance of this variable for determining the accident rate was lower than in the case of economic situation. A higher percentage share of medium-sized companies among the enterprises in the Polish sub-regions is related to a lower accident rate and this relationship is significant in a majority of the equations estimated. Interestingly, the importance of this variable is higher in the case of women than men; however, this result has not referred to the models with the unemployment rate.

Considering the quality of the models estimated, the values of 2 statistics should be pointed to, these are the F test and adjusted R^2. In all 16 models, the F statistic values have allowed for rejecting the hypothesis that all coefficients in the equations are equal to zero ($p = 0.01$). The estimated models have low values of adjusted R^2 amounting to 16.7% at the highest, though, the low values of this goodness-of-fit statistic are typical for the first differences models as indicated in the literature on the panel data regression [25].

In the models with first differences, the constant term of regression is also subject to interpretation and it represents a time trend, i.e., the dynamics of a dependent variable due to factors other than the ones included in the model. The values of the constant term here show a significant decrease in the frequency of accidents with regard to total accidents, accidents among men and days of incapacity to work. On the contrary, in the case of accidents among women, a positive value of the constant term indicates a rise in the frequency of accident, which is due to factors other than the ones included in the model.

DISCUSSION

This paper provides estimates of the relationship between economic situation and occupational accidents in sub-regions of Poland in the period 2002–2014. The results of the panel data models imply that accidents at work are procyclical, meaning that the number of accidents grows together with improving economic situation. This relationship is statistically significant for most of the models and is of considerable magnitude; however, a relatively stronger relationship has been observed in total accidents and accidents among men. In the case of accidents among women and days of incapacity to work due to accidents, the relationship is weaker and it is not statistically significant in all of the estimated models.

The stronger relationships identified in the case of men probably result from their higher exposure to occupational accidents. An average number of injured men is more than 2 times higher in comparison with the one for women (15.2±3.9 compared with 6.8±1.9 per 1000 employees) (Table 1), resulting from men's more frequent employment in hazardous work conditions. The 2013 data shows that 28% of men in Poland worked in hazardous conditions, while it was only 8% of women that were exposed to risky work environment [26].

The stronger relationship between economic situation and accidents among men is probably also due to their dominant role in industries which are more strongly exposed to economic fluctuations and, at the same time, are characterized by a higher accident risk, e.g., construction or industry. On the other hand, the percentage share of women is higher in the sectors relatively more resistant to economic downturns, like health care and education,

where also accidents occur more rarely. The other noticeable gender difference is reflected in the dynamics of the accidents rate. The coefficient for time trend (a constant term in regressions) is negative for men and positive for women, implying that the dynamics of accidents in time differs between genders in favor of men.

The direction and significance of the relationships identified for Poland are similar to those concerned with more developed economies, suggesting that neither high employment in industry and agriculture, nor the peculiarity of the Polish labor market are important for associations between business cycle and occupational safety. Thus, it seems that these associations do not depend on the economic transition process, they are rather universal instead.

The association between the unemployment rate and total accidents identified in this study is the same as in the research concerning the U.S. (1976–2007) [7]; in both cases one percent increase in the unemployment rate is associated with 0.22-percent decline in the accidents rate. Interestingly, we have observed the same estimates for Poland and the U.S. also for the equations in which economic situation has been assessed by the number of construction permits. The same results in the studies using different spatial and time settings make the conclusions on the relationships involved more credible.

On the other hand, though, when using the GDP as an explanatory variable we have identified considerably different results than in the American labor market. The estimates based on the U.S. data show that 1-percent growth in the GDP correspond to 1.65-percent rise in the accident rate [7] and this elasticity is 4 times higher than our result. This discrepancy may be due to relatively higher GDP fluctuations in the American economy. In the period investigated in this study, Poland did not experience recession in a strict sense (two successive quarters of the GDP decline), while in the U.S. the fluctuations of the economy were more intense, which has resulted in identifying stronger relationships between the GDP and accidents.

A considerably stronger relationship between economic situation (measured by the GDP changes) and accidents than identified here has been indicated in the analysis of the British labor market (1985–2005) [6]. In this research 1-percent GDP change is associated with 3.3-percent change in minor accidents in the whole economy, suggesting that occupational injuries are strongly procyclical. However, this result is statistically significant only at the 90% confidence level and is estimated with only 72 observations, which calls for caution in interpretation.

The study of the relationship between the unemployment and rate of occupational accidents in 16 Organizations for Economic Co-operation and Development (OECD) countries has also yielded similar results to ours. According to the estimates by Boone and van Ours, 1-percent rise in the unemployment rate in this group of countries is associated with 0.32-percent decline in the number of non-fatal accidents [13]. These authors claim that the procyclical fluctuations of occupational accidents result from employees' attitudes towards reporting accidents and not from changes in occupational safety related to economic situation. They argue that in the periods of higher unemployment employees do not report minor accidents because they are afraid of negative consequences for their employment security.

In the later research of Boone et al. [27], the same authors have made use of data on more than 200 000 Austrian employees and come to the conclusion that those who reported an occupational accident in a given period were exposed to a higher risk of being dismissed in the following periods. Moreover, in their research the employees who assessed the risk of losing job as higher, were less prone to report accidents [27].

The earlier research also indicates that employees more rarely report accidents during economic downturns be-

cause they are afraid of being reduced [8], and those absent from work due to accidents are sooner and more frequently dismissed [9]. The above conclusions on the employees' reporting behavior in the times of recession are undoubtedly interesting, but the investigation of this problem is beyond the scope of this research. The availability of data on the Polish regions does not allow to study this issue and further work is required to construct a conceptual model which would correspond to the statistical information in hand.

A procyclical character of occupational accidents is also identified by Fairris in his work on the labor market in the U.S. in the 1960's and 1970's [10] and Ussif, who analyzed the relationships between the economic situation and accidents in the U.S., Canada, Finland, France and Sweden [11]. The impact of the current economic crisis on occupational accidents has not yet been thoroughly examined; the first results show similar associations to those observed in earlier decades. A research analyzing the labor market in Spain pointed to a decline in the number of accidents due to the recent economic crisis, particularly in the sectors of high accident risk, i.e., construction and industry [12].

Before concluding the discussion of other papers on the topic, we should point that some studies did not identify any significant relationship between economic situation and accidents at work, e.g., the research on the industry and construction sectors in Finland (1977–1991) did not recognize any associations between the course of business cycle and number of occupational fatal accidents [20].

Strengths and limits of the study

This paper broadens the background knowledge on the relationship between accidents at work and economic situation in several aspects. To begin with, it is the first research that analyses the relationship separately for men and women, which is important due to differences between sexes in the frequency of accidents.

Secondly, in the models estimated here we control factors other than economic situation. The implicit assumption made in other studies [6,7,13] about the accidents being affected only by economic situation seems oversimplified as it disregards such important injury determinants as working conditions or the enterprise size. Here, both the company size and occupational conditions are taken into account, allowing to get more realistic estimates for the economic situation-accidents relationship.

Thirdly, we use a wide range of variables to describe the state of economy, which allows for reaching more credible conclusions through testing the stability of estimates in alternative specifications.

Fourthly, with the use of panel data, we apply a dataset with a higher number of observations in comparison with earlier research. For example, in the research by Davies et al. [6] and Asfaw et al. [7] there were 72 and 31 observations used respectively, which called for caution in interpreting the results. In this study, there are 594–792 observations used, making the estimates of the parameters more reliable.

A limitation of this study is the fact that the associations identified here do not provide enough evidence to draw conclusions on the mechanisms involved and only allow for speculating on the reasons behind the relationships between economic situation and occupational accidents. The procyclical behavior of accidents in Poland may result from increased work intensity and a higher demand for employees in the periods of economy expansion. As a consequence, those already employed experience more fatigue at work, also a higher percentage share of workers is less experienced, and both these factors contribute to increased exposure to injury risk. On the other hand though, the declining rate of accidents during an economic downturn may be due to reporting behavior, specifically, the fear of losing a job among those who experience injuries.

Such fears are particularly intense when the labor market collapses as was the case in Poland in the 2000s, when the unemployment rate reached 20% level. The job insecurity still affects the way employees in Poland perceive their position in the labor market and may affect their accident reporting behavior. Despite a dynamic decrease in the unemployment rate (from 14.4% in February 2013 to below 10% in April 2016), the self-perceived risk of job loss in Poland remains one of the highest in 19 countries surveyed in "Work Monitor" survey [28]. In June 2016, 37% of respondents in Poland reported a severe or moderate fear of losing a job and it was the second highest share in the group of European countries [28].

Directions for future research

The reasons behind the declining rate of injuries during recessions are certainly a research orientation to be pursued. It is also purposeful to explore the issue of occupational accidents in particular economy sectors accounting for an industry-specific economic situation. The studies that have attempted to make sectoral analyses used general economic indicators, while industry-specific measures (e.g., value added or remuneration in particular sectors) are more appropriate to disentangle relationships specific for various sectors of economy.

Some sectors – like construction or industry – are characterized by more accidents and, at the same time, they are relatively more susceptible to business cycle fluctuations, which suggests that the specificity of these sectors makes them different from the whole economy. It would also be interesting to pursue research on the importance of gender for the relationships between economic situation and injuries at work. Our results show that the association is stronger for men, which may result from many factors, e.g., their higher exposure to occupational risks, possibly heavier overtime workload in the periods of economy expansion, but also from behavioral gender-based differences.

CONCLUSIONS

The research results have important implications for occupational health and safety both for employers and the state's health policy.

Employers should account for the rising danger of accidents in the periods of higher work intensity in their companies and pay more attention to reduce occupational risks. In particular, if the percentage share of newly employed or temporary staff grows with increased production, employers ought to focus on appropriate training and supervision of the inexperienced workers. On the other hand, when a higher demand for work is met by overtime work done by already qualified employees, it becomes more important to take a proper care of enough time for the workers to recuperate.

These conclusions seem to be critical in industries susceptible to fluctuations of the economy and, at the same time, more prone to risks of occupational accidents. Investing in human capital through occupational safety trainings as well as avoiding excessive workloads become particularly important in the periods of increased order volume, when a potential loss of a worker due to an accident may be costly for a company.

The results of this study are also important for health policy, in particular in the area of occupational health and safety. Accounting for the relationships identified, it seems appropriate to intensify policy actions aimed at limiting occupational risks particularly in the periods of dynamic economic growth. These actions could focus both on scrutinizing working conditions and on educating employers.

On the other hand, if the reason for a lower number of accidents reported during economic downturns is employees' fear of job loss, the objective of the state should be to introduce actions designed to counteract the discrimination of injured workers who are dismissed for reporting accidents.

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