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ECONOMIC DEVELOPMENT AND INCIDENCE OF FATAL OCCUPATIONAL ACCIDENTS: EVIDENCE FROM THE SELECTED OECD COUNTRIES

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Abstract: *Occupational accidents cause significant social and economic problems by the fatal and non-fatal injuries, and are parts of the individual and social costs of production. In this context, we explore the relationship between fatal occupational accidents and economic development for a selected 21 The Organization for Economic Co-operation and Development (OECD) countries over the period of 1995-2013 by performing panel cointegration techniques. The results indicate that cointegration relationship exists among the variables in consideration and by employing pooled mean group estimator method and the results reveal that as an indication of economic development GDP per capita is positively related with fatal occupational accidents in the short-run, however, in the long-run the relationship turns into be negative.*

Keywords*: Economic Development, Fatal Occupational Accidents, Panel Cointegration Tests.*

1. Introduction

Occupational accidents cause to significant social and economic problems by the fatal and non-fatal injuries, and are part of the individual and social costs of production. The number of occupational accidents and work-related diseases calculated by the International Labor organization (ILO) creates worldwide awareness, with 2.3 million fatalities annually, of which over 350,000 are caused by occupational accidents and close to 2 million by work-related diseases. It is also estimated that about 4 percent of the world's gross domestic product (GDP), or circa US $2.8 trillion, is lost annually in direct and indirect costs owing to occupational accidents and work-related diseases (ILO, 2016a). The

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high frequency and severity of these events represent a serious problem to society and require cause for concern to improve working conditions of workers.

Recently prevention of fatal and non-fatal occupational accidents is a high priority on the occupational health agenda in all over the world. The rapid pace of technological change, combined with the persistence of unsafe threatening working conditions, has served to focus attention on the need to create a safe and healthy working environment (ILO, 2016b). However, some evidences indicate that the total number of fatalities have decreased since the late 1960s in developed countries. Benavides et al., (2005) claim that fatal occupational injuries clearly declined over the period 1975-2000 in five selected European Union countries. For instance, in United Kingdom, fatal injuries fell by 82 percent (from 2.9 per 100 000 employees to 0.5) between 1974 and 2011. In Spain, the incidence of fatal occupational injuries declined from a rate of 9.8 per 100 000 workers in 1992 to 6.1 in 2002, and in Austria, rates decreased from 8.5 percent in 1955 to 4.08 percent in 2004. Moreover, in a recent study for Turkey, Unsar and Sut (2009) point out a remarkable decline in occupational fatality rate from 23.4 per 100 000 employees to 15.5 over the period 2000-2005.

1.1. Debates on the interplay between economic development and incidence of fatal occupational accidents

The declining pattern in rates of occupational fatalities especially in the developed countries could be reason of the change from an industrial society to a service society. Based on the experience in the early years of industrialization of the developed countries occupational accidents seemed to increase at first but with economic growth and investment in training and development and also improved awareness of precaution which lead to decrease work related accidents (Saloniemi and Oksanan, 1998).

According to the several studies economic development seems to have an impact on the incidence of occupational accidents. The early studies on relationship between the business cycle and occupational accidents support that the nature of occupational accidents is related to the business cycles; the number of accident tends to increase during economic upswings and decrease during economic downturns (Robinson 1988; Nichols 1991). After the 1970s, this so called pro-cyclical relationship has changed with the transition from the industrial sector to services sector especially declining the share of employed people in manufacturing and construction industries (Saloniemi and Oksanan, 1998). Recently the studies carried out for highly industrialized countries indicate the presence of an inverse relationship between economic development and the incidence of work-related accidents. However, for the United States, Asfaw et al., (2011) find the net impact of the GDP as a business cycle indicator on workplace injuries is positive and unemployment rate is negative over the three decades. Furthermore, they indicate that this relationship varies by industry sector and the relative influence of labor and physical capital utilization in those sectors. The finding of this study reveals that the firms in the construction, manufacturing, and mining industries should take additional precautionary safety measures during economic upturns.

On the other hand, Barth et al., (2007) examined the nexus between GDP and the occupational accidents rate between 1955 and 2004 in Austria. The scholars argue that a growing economy follows a path in which is associated with declining fatal and non-fatal injury rates. This could be the reason of rising GDP is accompanied by increase in occupational health and safety measures due to the scientific and technological developments that create new opportunities for the prevention of these hazards and preventive security reduce work-related accidents. On the other hand, during downturn periods because of decrease in investments and the fear of job losses and increased unemployment rate cause increased frequency of accidents.

Bear in mind that international comparison of the frequency of occupational accidents are difficult due to figures reported by each country are influenced by factors other than differences in the occurrence of actual accidents (Nishikitani and Yano, 2008). But prevention of occupational accidents requires the availability of consistent, comparable information on the intensity and incidence of occupational accidents occurring within countries (OECD).

2. Data Set and Methodology

2.1. Data set

Although the international comparison of the frequency of occupational accidents which are related to human, occupational and economic factors is a very important issue there has been little research on it. However, in this terrain most of the studies have been mainly focused on the nexus between economic development and occupational accidents on micro level (industry level, etc.) to our knowledge, there have been no studies attempting to investigate the impact of macro level factors over a long time period at international level. The present study aims to analyze the long-term links between GDP, working hours and fatal occupational accidents in selected 21 OECD countries. As is known occupational injury statistics cover the workers whom are insured by any social insurance institution and therefore most of the fatal or nonfatal occupational injuries are above the official estimates. Therefore, in this study considering the fact that nonfatal occupational accidents are less reported than fatal occupational accidents and data accessibility concerning fatal occupational accidents channelize us to examine the nexus between fatal occupational accidents and economic development for 21 OECD countries over the period of 1995-2013. Our choice of these twenty-one countries is purely due to the availability of consistent and without interruption time series data for only these countries.

In this study, as our main variable of interest, we compiled the data regarding the harmonized fatal occupational accidents statistics from the ILOSTAT database of ILO on annual basis in absolute values. As an indication for the scale of economy GDP per capita (with constant US $, 2005) is utilized and the data concerning this variable is collected on annual basis from the World Development Indicator database of World Bank. Finally, the effect of working hour of employees whom are engaged in regular jobs on fatal occupational accidents is examined by which using the data of average working hours in annual context is obtained by Penn World Table version 8.0 by Feenstra et al. (2013) and OECD Stat database of OECD. All the variables in empirical analysis are converted into natural logarithmic form.

Given the descriptions and data sources of variables above, descriptive statistics regarding these variables are displayed in Table 1. Maximum values of GDP, fatal occupational accidents (FAT) and average working hours (AVH) belong to Norway (in 2007), the USA (in 1995) and Mexico (in 2013) while minimum values of both GDP and fatal occupational accidents are observed for Estonia (in 1995 and 2012) and average working hours are observed for Germany (in 2013) respectively.

Table 1. Descriptive Statistics

Variables	# of obs.	Mean	Minimum	Maximum	Standard Deviation
$FAT_{i,t}$	399	627.25	14	6,275	1,188.25
$AVH_{i,t}$	399	1,764.78	1,363	2,237	187.99
$GDP_{i,t}$	399	28,431.17	5,150.232	69,094.74	16,563.77

Source: author's calculations.

2.2. Model and methodology

The nexus between fatal occupational accidents and economic development would be examined by panel cointegration techniques proposed by Pedroni (1999, 2004) and Kao (1999). In this context following equation is the main model that depicts the nexus between fatal occupational accidents and economic development:

$$LFAT_{i,t} = \alpha_i + \delta_{i,t} + \beta_1 LGDP_{i,t} + \beta_2 LAVH_{i,t} + \varepsilon_{i,t} \tag{1}$$

where α_i represents country specific fixed effects while $\delta_{i,t}$ represents the dynamic effects. Dependent variable is the fatal occupational accidents expressed in terms of natural logarithmic form while $LGDP_{i,t}$ and $LAVH_{i,t}$ represents GDP per capita (constant US $, 2005) and average working hour respectively which are expressed in natural logarithmic form as well.

Stationary check of the series is examined by performing unit root tests proposed by Maddala and Wu (1999) and Pesaran (2007) respectively. In Maddala and Wu (1999) type test, probability values of augmented Dickey-Fuller test statistics which is applied to each cross-sectional unit are used. In this context cumulative and deterministic trend models are estimated and the null of panels contain unit root ($\delta_i = 0$) tested over the alternative that panels do not contain unit root ($\delta_i < 0$). On the other hand, Pesaran (2007) proposes a simple alternative test over its counterparts such as Phillips and Sul (2003), Moon and Perron (2004), and Bai and Ng (2004). In this setting, standard DF (or ADF) regressions are augmented with the cross-section averages of lagged levels and first differences of the individual series. This is called "cross-sectionally augmented Dickey-Fuller (CADF)" and by estimating the CADF regression, averages of the t-statistics of lagged variables are taken to obtain cross-sectionally augmented IPS (CIPS) statistics.

By checking the stationarity of the series in the next step long-run relationship would be investigated by the panel cointegration methods proposed by Pedroni (1999, 2004) and Kao (1999) respectively. Pedroni (1999, 2004) offers tests that are based on the null of no cointegration among panel data series which allows for considerable heterogeneity. In this context, he develops seven test statistics, four of which are within group, while three of which are between groups to examine the long-run relationship among the series. The main difference between these two statistics arises from autoregressive coefficient (ρ_i) for which common value is estimated at within group statistics while no common value is estimated at between group statistics. For the first group statistics Pedroni (1999, 2004) proposes the following test statistics: variance ratio statistics, Phillips-Perron type ρ-statistics, Phillips-Perron type t-statistics, ADF type t-statistics. Based on group mean approach, for the second group statistics he proposes the following test statistics: Phillips-Perron type ρ-statistics, Phillips-Perron type t-statistics, and ADF type t-statistics. For both groups the null of no cointegration among series ($\rho_i = 1$) is tested over its alternative ($\rho_i < 1$). Based on Dickey-Fuller and augmented Dickey-Fuller tests, Kao developed a panel cointegration method to test the null of no cointegration among series ($H_0 : \rho = 1$) over the alternative of existence of cointegration among series ($H_0 : \rho < 1$).

Finally, by deciding that the series are cointegrated, both short-run and long-run relationship would be investigated by implementing pooled mean group estimator (PMGE) proposed by Pesaran, Shin and Smith (1999) which consists of mean group estimator which allows for either slope or drift parameter to vary by units and fixed effects estimator which allows for intercept to vary but slope parameter is fixed. Hence, PMGE holds long-run parameters to be fixed while allowing for short-run parameters and error variance to vary by panels.

3. Empirical Results

Before proceeding to the results of main analysis, cross-sectional dependence and the stationary of the series examined respectively. In the first step, proposed by Pesaran (2007) cross-sectional dependence test is performed and the results are displayed in Table 2.

Table 2. Cross-Sectional Dependence Test

Variables	Symbol	CD-Test (p-value)
Fatal Occupational Accidents, thousands (in natural logarithm)	$LFAT_{i,t}$	27.71 (0.0000)*
Average Working Hours (in natural logarithm)	$LAVH_{i,t}$	31.11 (0.0000)*
GDP, constant prices, 2005, US$ (in natural logarithm)	$LGDP_{i,t}$	57.23 (0.0000)*

Note: * indicates the significance level at 1 %.

Source: author's estimations.

The results indicate that each series exhibit strong cross-sectional dependence by which rejecting the null of no cross-sectional dependence at 1 % significance level. These results also disclose that by examining the stationarity of the series, one should consider the cross-sectional dependence and perform the unit root test which also considers this fact. Accordingly, two types of unit root tests are used in checking the stationarity of the series; one of them is proposed by Maddala and Wu (1999) which does not consider the cross-sectional dependence and while the other is proposed by Pesaran (2007) which considers the cross-sectional dependence. Estimation results of both types of unit root tests are presented in Table 3. Since the corresponding test statistics are significant, results do indicate that all series become stationary by which first differencing in Maddala and Wu (1999) type test by rejecting the null hypothesis of non-stationarity either including trend or without trend assumptions. Furthermore, by considering the cross-sectional dependence, Pesaran's (2007) test is performed and the results disclose that all series are not stationary in level since the calculated test statistics are insignificant. Nonetheless, by first differencing, all series become stationary by including trend or even without trend rejecting the null hypothesis of non- stationarity.

Table 3. Unit Root Tests

Maddala-Wu Unit Root Test	Level χ^2 -stat. (Prob.)		1st Difference χ^2 -stat. (Prob.)	
Variables	Without Trend	With Trend	Without Trend	With Trend
$LFAT_{i,t}$	40.82 (0.52)	63.682 (0.07)**	278.04 (0.00)*	225.96 (0.00)*
$LAVH_{i,t}$	31.20 (0.88)	67.791 (0.07)*	202.44 (0.00)*	173.33 (0.00)*
$LGDP_{i,t}$	60.07 (0.03)**	31.161 (0.89)	97.48 (0.00)*	120.25 (0.00)*
Pesaran's Unit Root Test	Level χ^2 -stat. (Prob.)		1st Difference χ^2 -stat. (Prob.)	
Variables	Without Trend	With Trend	Without Trend	With Trend
$LFAT_{i,t}$	-1.19 (0.11)	1.12 (0.87)	-5.71 (0.00)*	-4.02 (0.00)*
$LAVH_{i,t}$	-0.12 (0.45)	1.86 (0.96)	-3.98 (0.00)*	-3.53 (0.00)*
$LGDP_{i,t}$	-0.19 (0.42)	1.07 (0.85)	-1.40 (0.07)***	-2.01 (0.02)**

Note: ***,**,* indicates the significance level at 10 %, 5 % and 1 % respectively. Optimal lag length is selected to be 1 for both types of tests.

Source: author's estimations.

Having decided that the series are I (1), in the next step we investigate whether series are cointegrated or not. In this context, panel cointegration tests proposed by Pedroni (1999, 2004) and Kao (1999) are performed and results are shown in Table 4 and Table 5 respectively. According to Pedroni's (1999, 2004) cointegration tests results, four of seven tests reveal the existence of cointegration by rejecting the null hypothesis of no cointegration since the corresponding test statistics are significant at various significance levels under the assumptions of with and without deterministic trend. On the other hand, same implication is driven by performing Kao's (1999) panel cointegration test, since the t-statistics is significant at 5 % significance level which in turn causes to reject the null hypothesis of no cointegration.

Table 4. Pedroni Cointegration Test

Statistics	Without Trend	With Trend
Panel ν-statistic (p-value)	-0.9002 (0.816)	-0.1157 (0.546)
Panel ρ-statistic (p-value)	0.3611 (0.641)	-0.4757 (0.317)
Panel PP-statistic (p-value)	-1.9183 (0.027)**	-8.2595 (0.000)*
Panel ADF-statistic (p-value)	-2.2096 (0.013)**	-8.6459 (0.000)*
Group ρ-statistic (p-value)	2.6859 (0.996)	1.3457 (0.910)
Group PP-statistic (p-value)	-1.7905 (0.036)**	-10.7385 (0.000)*
Group ADF-statistic (p-value)	-1.8458 (0.032)**	-8.1463 (0.000)*

Note: **,* indicates the significance level at 5 % and 1 % respectively. The panel statistics are the within-dimension statistics while group statistics are between-dimension. These are one-sided standard normal test with critical values of 1%, 5% and 10% given by -2.326, -1.645 and -1.282. The critical values for the mean and variance of each statistic are obtained from Pedroni (1999). Lag length is chosen by Akaike Information Criterion.

Source: author's estimations.

Table 5. Kao Cointegration Test

	t-statistics	Probability
ADF	-2.1588	0.0154**

Note: ** indicates the significance level at 5 %. Lag length is selected by Akaike Information Criterion.

Source: author's estimations.

Since the series are cointegrated, in the following step, both long-run and short-run relationships among the variables are examined by performing PMGE and corresponding results are exhibited in Table 6. According to Table 6, either dependent or independent variables enter into the error correction form through pooled mean group estimation (PMGE) method by their corresponding differentiated forms revealed by unit root tests. In this context, $DLFAT_{i,t}$ denotes the first difference of fatal occupational accidents while $DLGDP_{i,t}$ and $DLAVH_{i,t}$ denotes the first differences of GDP per capita and average working hour respectively. Based on error correction form, estimation by PMGE yields the presence of positive relationship between GDP and fatal occupational accidents in the short-run while in the long-run it turns into negative. Results of PMGE reveal that 1 % increase in GDP decreases fatal occupational accidents by 0.87 % while in the short-run a 1 % increase in GDP increases fatal occupational accidents almost by 1.29. However, a 1 %

increase in average working hours causes fatal occupational accidents to rise by 0.98 % in the long-run; in the short-run it has no significant impact. The speed of adjustment to the long-run captured by the error correction term which is negative and significant through the expectations indicating that shocks to the fatal occupational accidents adjusted in one year by 47 %.

Table 6. Pooled Mean Group Estimation Results

Long-Run Relationship	
Dependent Variable: $LFAT_{i,t}$	
Variables	Coefficient (Standard Error)
$LGDP_{i,t}$	-0.8716 (0.108)*
$LAVH_{i,t}$	0.9875 (0.515)**
Error Correction Form	
Dependent Variable: $DLFAT_{i,t}$	
Variables	Coefficient (Standard Error)
C	2.9105 (0.401)*
$EC_{i,t}$	-0.4729 (0.062)*
$DLGDP_{i,t}$	1.2876 (0.539)**
$DLAVH_{i,t}$	0.9106 (1.142)

Note: ** indicates the significance level at 5 %. Lag length is selected by Akaike Information Criterion.

Source: author's estimations.

4. Conclusion

In this study, the correlations between economic development and fatal occupational accidents were tested on the basis of selected OECD countries for the period of 1995 to 2013. Our results indicate that GDP as general macroeconomic indicators has a positive impact on fatal occupational accidents as fatality rates increase during economic booms and decrease during recessions. This is consistent with the findings by Asfaw et al. (2011) that in the United States workplace injuries were positively related to the business cycle from 1976 to 2007. Moreover, Song et al. (2011) in a study for China found that economic scale was associated with decline of occupational death rate, and economic cycle was an indicator of work safety during 1979-2008.

On the other hand, our long term analysis shows that there is a negative interdependence between fatal occupational accidents and GDP between 1995 and 2012 as is observed in developed countries (Nichols 1991; Barth et al, 2007; Hamalainen, 2009). It seems that over a long time period, economic booming with high level of GDP, as a measure of welfare, increasing investment in new technologies and improving working conditions would make occupational accidents decrease, and economic depression would make occupational accidents increase. In addition, it is found that average working hours have positive effect on fatal occupational accidents in the long term period. This finding is consistent with other studies that long working hours adversely affect the health and wellbeing of workers (Van der Hulst, 2001; Dembe et al, 2005). Furthermore, Benavides et al, (2005) studied occupational injury rates in five selected European Union countries, in order to identify patterns in rate trends and found that fatal occupational injury crude rates have clearly declined. These results are accordant with those from the EUROSTAT (2003), confirming that there is a common downward trend in fatal occupational injury rates in developed countries (Benavides et al, 2005).

This present study has at least two policy implications. First, the results suggest that special attention needs to be paid to establish protective measures for people working overtime. Second, an inverse long-term parallelism between the economic development and the trend of fatal occupational accidents point out that the government should give importance to awareness about occupational health and safety and increasing working conditions of workers specifically during economic downturns. In future research, fatal and non-fatal occupational accidents could be examined in specific industries, sectors or economic activities to find out their sensitivity to the economic development and physical capital and labor utilization within industries over the long term.

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EKONOMSKI RAZVOJ I INCIDENTI FATALNIH NESREĆA NA RADU: DOKAZI IZ ODABRANIH ZEMALJA OECD-A

Apstrakt: Nesreće na radu izazivaju značajne društvene i ekonomske probleme usled fatalnih i nefatalnih povreda, i predstavljaju delove individualnih i društvenih troškova proizvodnje. U ovom kontekstu istražujemo odnos između fatalnih nesreća na radu i ekonomskog razvoja za odabrane zemlje u periodu od 1995. do 2013. godine, kroz tehnike panela za *kointegraciju. Rezultati ukazuju na to da postoji kointegracioni odnos među varijablama koje se razmatraju i upotrebom metode procene skupne srednje grupe i rezultati otkrivaju da je, kao pokazatelj ekonomskog razvoja, BDP per capita pozitivno povezan sa fatalnim nesrećama na radu u kratkom roku, međutim, na dugi rok postaje negativan.*

Ključne reči: ekonomski razvoj, fatalne nesreće na radu, ispitivanja panelnih kointegracija.