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ISTITUTO NAZIONALE PER L'ASSICURAZIONE
CONTRO GLI INFORTUNI SUL LAVORO

SCIENCE-BASED POLICY MAKING IN OCCUPATIONAL SAFETY AND HEALTH

Scientific workshop

Parlamentino Inail

via Quattro Novembre, 144 – Roma

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Dipartimento di Studi Giuridici ed Economici
Sapienza Università di Roma

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Drivers and Frictions of Workplace Accidents: an Empirical Investigation of Cross-Country European Heterogeneity

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Drivers and Frictions of Workplace Accidents: an Empirical Investigation of Cross-Country European Heterogeneity

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Outline

- Background
- Research hypothesis and related literature
- Dataset
- Identification strategy
- Estimation results
- Key findings and policy implications

Background

- Workplace safety is a relevant issue that has been increasingly attracting the attention of institutions, labor organizations, researchers and policy makers

- In Europe, even though the number of occupational injuries shows a decreasing trend, cross-country differences in workplace accident rates show a heterogeneous dynamic mainly related to differences in definitions and measurement (Boone and van Ours, 2006; Anyfantis *et al*., 2018; Ivascu and Cioca, 2019; Lafuente and Daza, 2019; Verra *et al*., 2019)

Background

- Traditionally, occupational accidents have been investigated in relation to a combination of multifaceted determinants stemming from individual, sectoral and workplace-related factors

- Based on a model specification that combines productive system characteristics and socio-economic controls, our work aims to investigate, at a macro level of analysis, the main determinants of the occupational accident rates, disentangling cross-territorial heterogeneity within the business cycle theoretical framework

Main research questions

Hypothesis 1:

Territorial heterogeneity of workplace accidents, at European level, can be explained by recurring to a macro level of analysis, within the business cycle theoretical framework

Hypothesis 2:

Does it exist a non-linear (and non-monotonic) relationship between the occupational accident rate and the GDP level, while controlling for production-system, institutional and macroeconomic characteristics?

Main related literature – Hp. 1 Cross-country OA

The frequency of workplace accidents has been extensively studied in the literature which has identified four main groups of factors affecting injuries (Khanzode *et al.*, 2012):

i) individual factors related to workers characteristics (age, gender) and experience (Fotta and Bockosh, 2000; Jeong, 1999; Kletz, 1993; de la Fuente et al., 2014, Cioni and Savioli, 2016)

ii) job-related and sectoral factors (Ferguson *et al.*, 1985; Rasmussen, 1987; Vredenburgh, 2002; de la Fuente et al., 2014), technological change (Blank *et al.*, 1996b; Sari *et al.*, 2004)

iii) organization-related factors (Shannon et al., 1996) which include also environmental conditions (Fabiano *et al.*, 2001)

iv) business cycle and macroeconomic integrated approach (Kossoris, 1938; Bowers, 1981; Brooker et al., 1997; Hartwig et al., 1997; Anderson, 2002; Ussif, 2004; Davies et al., 2009; Aswaf et al. 2011)

Main related literature – Hp. 2 non-linearity OA-GDP

While the literature that investigates the relationship between OA and business cycle is well documented (Kossoris, 1938; Bowers, 1981; Robinson, 1988; Nichols, 1991; Fabiano *et al.*, 1995; Brooker et al., 1997; Hartwig et al., 1997; Anderson, 2002; Ussif, 2004; Davies *et al.*, 2009; Aswaf *et al.* 2011), we aim to investigate the existence of an inverted U-shaped relationship between the rate of occupational accidents and GDP, testing whether, as income increases, the accidents' rate might first grow and then fall

Main justification:

- ✓ Advances in technology (*i.e.*, Industry 4.0) can provide solutions able to enhance workers' health, safety and wellbeing → labor shifts from low- to high- productivity sectors → countries that have exploited new technologies displace, with respect to the others, higher levels of GDP → cross-country inverted-U shaped relationship between OA and GDP

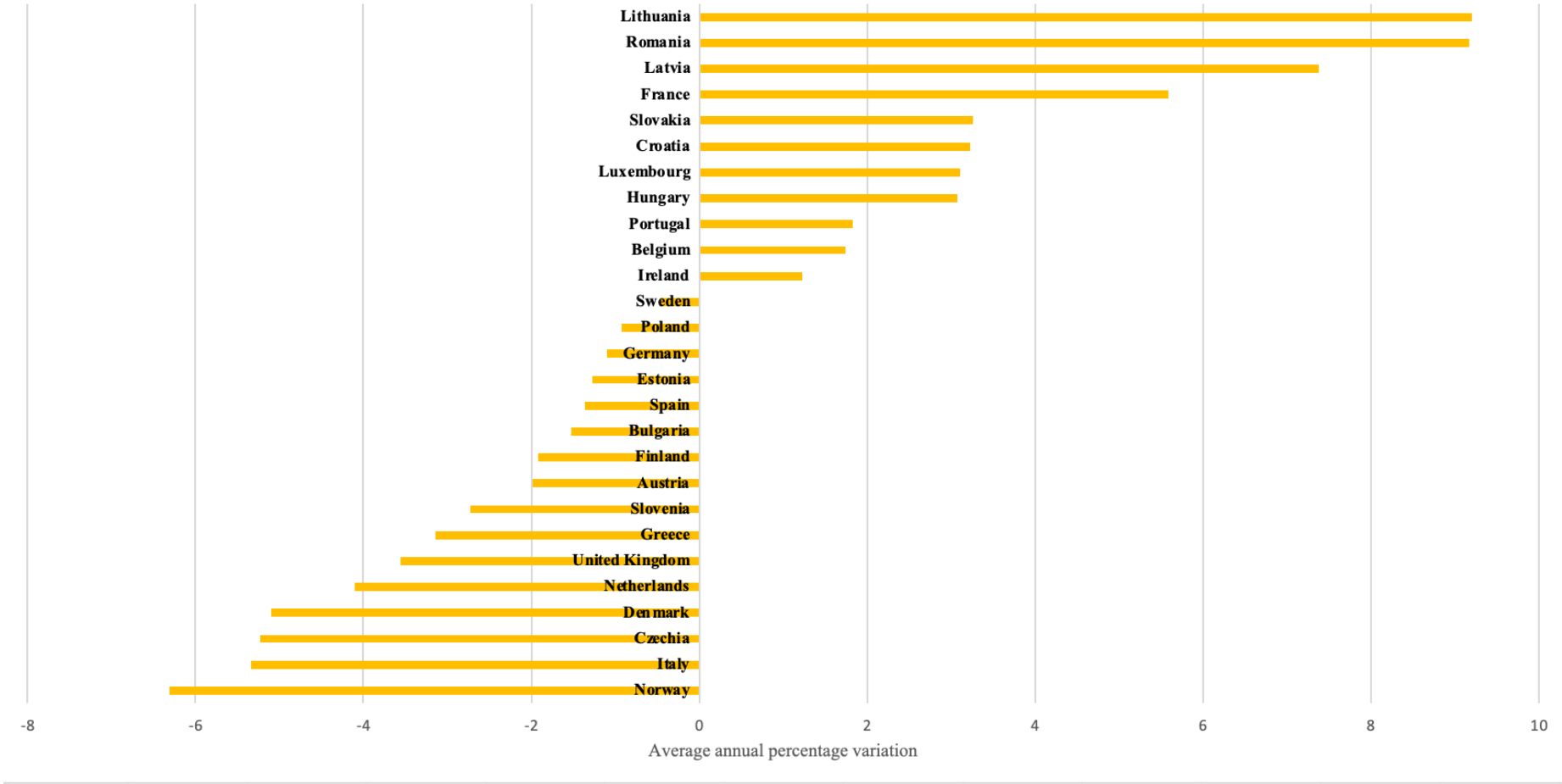
Variables and Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
OA Rate (non-fatal)	243	1226.776	887.779	47.97	3458.28
Total OA Rate	243	1229.107	887.657	52.88	3461.02
Employment Risk	243	0.351	0.073	0.192	0.497
Large Firms	243	0.002	0.001	0.001	0.005
Temporary Contracts	243	15.093	9.788	1.8	46.9
Per capita GDP	243	27166.46	18113.98	5050	83470
Secondary Education	243	48.021	11.38	18.8	71.1
Fixed Investments/GDP	242	20.707	3.502	10.77	35.81
Unemployment	243	9.335	4.909	2.2	27.5
Crime Index	243	1490.213	1055.366	220.99	5282.09

Our panel is composed by 27 European countries for 9 years (2010-2018): Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

Descriptive Statistics

Occupational Accidents rate
average annual variation (2010-2018)



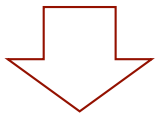
Source: Eurostat

Estimation model (I) – Pooled and P-FE

The investigation on the determinants of occupational accidents territorial heterogeneity (**Hp. 1**) in our panel moves from the following log-log specification (eq.1):

$$OA_{it} = \beta_0 + \beta_1 Xpsc_{it} + \beta_2 Zbc_{it} + \beta_2 Utv_{it} + T_t + FE_i + \varepsilon_{it} \quad (1)$$

We start by using pooled OLS and panel random and fixed effects (P-RE and P-FE) models



The Breusch-Pagan Lagrange Multiplier Test (1980) and the Hausman Test (1978) reveal that the fixed effects estimation model is the most appropriate one

Estimation model (II) – System GMM

However, OLS coefficients might be inconsistent also due to the correlation between OA_rate_{t-1} and the error term (omitted variable bias to the persistency in the dynamics of the dep. variable) …

… as a further robustness check, we also rely on the system-GMM estimator (Arellano and Bover, 1995; Blundell and Bond, 1998) and consider the following alternative model (eq. 2):

$$OA_{it} = \beta_0 + \beta_1 OA_{it-1} + \beta_2 Xpsc_{it} + \beta_3 Zbc_{it} + \beta_4 Utv_{it} + \eta_i + \xi_t + \varepsilon_{it} \qquad (2)$$

Estimation model (III) – testing for non-linearity

The trade-offs between safety at the workplace and production changes to income have been studied in the literature (de la Fuente *et al.*, 2014 and Asfaw et *al.*, 2011). However, the existence of a possible quadratic relationship between occupational accidents and real per-capita GDP has not been tested (**Hp. 2**). In this perspective, we recur to the following specification (eq. 3) :

$$OA_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP_{it}^2 + T_t + \varepsilon_{it} \quad (3)$$

The existence of non-linearity requires that $\beta_1 > 0$ and $\beta_2 < 0$

To ascertain the robustness this possible quadratic specification, we also consider the alternative (eq. 4) semiparametric fixed effects model (Baltagi and Li, 2002):

$$OA_{it} = \beta_0 + \beta_1 Xpsc_{it} + \beta_2 T_{it} + g(GDP_{it}) + \nu_{it} \quad (4)$$

Estimation Results: Pooled OLS

Variables	Model 1	Model 2	Model 3
Empl. Risk	1.583*** (0.337)	2.321*** (0.310)	2.537*** (0.292)
Large Firms	-0.565*** (0.125)	-0.183 (0.116)	-0.242** (0.109)
Temp. Contracts	1.225*** (0.105)	0.532*** (0.136)	0.531*** (0.127)
GDP_PC		0.905*** (0.125)	0.724*** (0.121)
Secondary Edu.		-0.892*** (0.227)	-0.532** (0.221)
Fixed Investments/GDP		-0.531 (0.326)	-0.598* (0.304)
Unemployment		0.469*** (0.145)	0.500*** (0.136)
Crime Index			0.414*** (0.075)
Year	Yes	Yes	Yes
Cons.	1.903** (0.852)	1.798 (2.273)	-0.731 (2.161)
F-stat	14.42***	23.72***	27.20***
R^2	0.41	0.62	0.67
Countries	27	27	27
Obs.	210	210	210

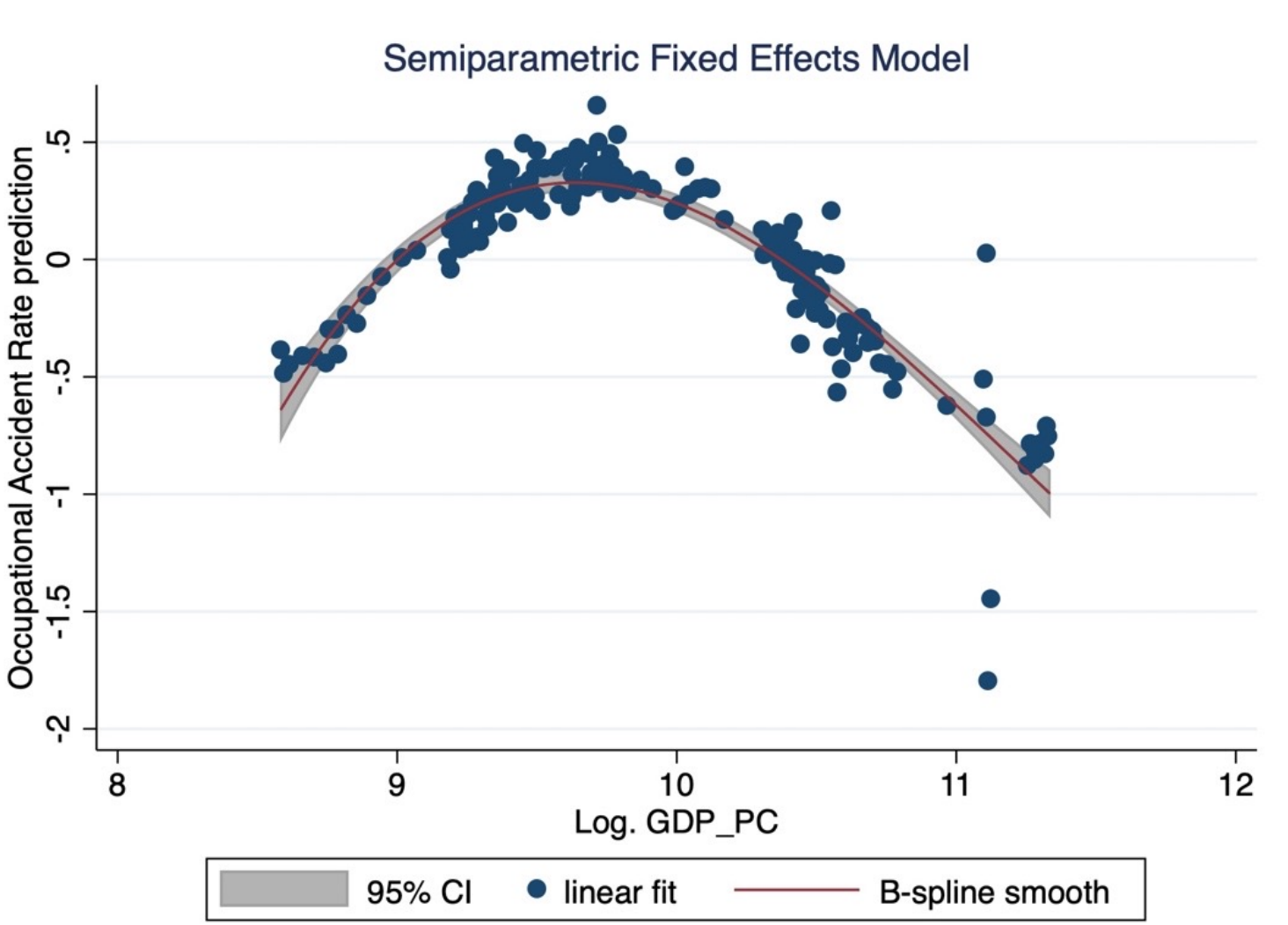
Estimation Results: Panel Fixed/Random effects model and system-GMM (dependent variable: OA rate)

Variables	Model 1 FE	Model 2 RE	Model 3 SYS-GMM
OA_Rate (t-1)			0.799*** (0.037)
Large Firms	-0.397** (0.194)	-0.307** (0.136)	-0.197*** (0.073)
Temporary Contracts	0.276** (0.110)	0.401*** (0.085)	0.008 (0.057)
Per capita GDP	1.016** (0.462)	0.810*** (0.162)	0.089 (0.349)
Secondary Education	0.145 (0.321)	-0.236 (0.256)	-0.244** (0.113)
Fixed Investments/GDP	-0.555*** (0.187)	-0.534*** (0.185)	-0.513*** (0.143)
Unemployment	-0.201* (0.111)	-0.250*** (0.093)	-0.145** (0.065)
Crime Index	0.157** (0.069)	0.215*** (0.066)	0.107** (0.050)
Year	Yes	Yes	Yes
Cons.	1.903** (0.852)	2.651 (1.936)	1.798 (2.273)
F-stat or Wald χ^2	4.38***	151.67***	168.69***
R^2	0.65	0.72	
AR(1) Pr > z			0.1036
AR(2) Pr > z			0.2780
Sargan test			19.60
Countries	27	27	27
Obs.	210	210	210

Estimation Results: testing for non-linearity

Variables	Model 1 OLS	Model 2 FE	Model 3 RE	Model 4 SYS-GMM
GDP_PC	19.707*** (1.678)	12.468*** (2.050)	10.663*** (2.238)	6.370*** (1.230)
GDP_PC^2	-0.939*** (0.084)	-0.569*** (0.104)	-0.464*** (0.115)	-0.334*** (0.061)
OA_Rate (t-1)				0.426*** (0.005)
Year	Yes	Yes	Yes	Yes
Const.	-95.840*** (8.340)	-60.609*** (10.146)	-53.090*** (10.992)	-26.330*** (6.146)
F-stat or Wald χ^2	38.77***	9.07***	127.23***	6803.97***
R^2	0.61	0.54	0.59	-
Countries	27	27	27	27
Obs.	210	210	210	210

Estimation Results: semiparametric FE model



Key-findings: cross-country analysis

a. **Hp. 1**: overall findings of cross-country analysis reveal that the heterogeneity of OA rates is significantly correlated to productive systems characteristics and to the business cycle

Production system controls:

- higher is the share of large firms, lower the OA rates (confirming previous empirical literature)
- feeble positive correlation between temporary contracts and OA (in line with Cioni and Savioli, 2016)
- higher the employment risk attached to the productive sector, higher OA rate (Ferguson *et al.*, 1985; Rasmussen, 1987; Vredenburgh, 2002; de la Fuente et al., 2014)

Business cycle controls:

- OA rate increases with real per capita GDP (confirming previous empirical literature)
- higher is the level of education, lower is OA rate (Fotta and Bockosh, 2000; Jeong, 1999; Kletz, 1993; de la Fuente *et al.*, 2014, Cioni and Savioli, 2016)
- higher is the propensity to the invest in fixed assets, lower is OA rate (Blank *et al.*, 1996b; Sari *et al.*, 2004; Aswaf *et al.*, 2011)

Key findings: non-linearity

b. Hp. 2:

- we find evidence of an inverted U-shaped relationship between the rate of OA and the real per capita GDP in a time of transition towards a new technological paradigm in Europe

- the results are robust to endogeneity linked to the transitional dynamics and persistency of the OA rate over time

- the transition towards the new Industry 4.0 paradigm, if exploited, could provide solutions able to enhance workers' health, safety and wellbeing, reducing OA rates

Policy implications

Fixed capital investments, hazardous and labour-intensive workplaces, and firms' size, represent the main determinants of OA rates

→ Risk of underinvestment in OSH of SMEs, especially during economic and financial downturns, becomes higher and socially concerning

Especially in recession periods, it becomes urgent to implement carrots policies (i.e., direct and indirect public aid schemes) to support OSH investments


work safety
work environment
workplace hazards
health
employee
protection
safety procedures
safety regulations
occupational stress
accident
injury
hardhat
electrocution
safety glasses
biological agents
occupational hearing loss
burns
helmet
lawsuit
allergens
machinery
inspector
chemicals
heavy metals
long working hours
construction
working conditions
gloves
fumes
workplace violence
hardhat
allergens
protection
safety regulations
heavy metals
biological agents
working conditions
accident
lawsuit
work safety
employee
workplace hazards
workplace violence
electrocution
helmet
health
safety glasses
fumes
workplace hazards
accident
inspector
safety procedures
safety regulations
workplace violence
biological agents
electrocution
machinery
gloves