Measuring vulnerability to adverse working conditions: evidence from European countries*

Nathalie GREENAN† and Majda SEGHIR‡

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Abstract

Workforce vulnerability has recently come to the forefront in European policy debate as countries searched for the potential engine of inclusive growth and with an aim of protecting workers against adverse working conditions. This paper presents a methodology to measure vulnerability at the workplace relying on a definition of vulnerable workers as carrying the burden of working under the threat of adverse physical and psychosocial working conditions. Vulnerability is thus a forward-looking concept that allows identifying workers that are the most exposed to work resource deprivations and more generally to ill-being at the workplace. Using a pseudo panel derived from repeated cross-sectional data, second-order moments can be used to identify and estimate the variance of shocks on working conditions and, therefore, the probability of being exposed to adverse working conditions in the future. Estimates from the last editions of the European Working Conditions Survey (EWCS) provide a vulnerability measure both at the cohortl level and at the aggregate one allowing for country comparison across European countries.

Keywords: Vulnerability, adverse working conditions, pseudo-panel, European countries

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†CNAM, Lirsa, CEET and TEPP

‡CNAM, Lirsa and CEET

1 Introduction

The issue of vulnerability has gained prominence among social scientists and policy-makers because of its potential impact on individual well-being and economic performance especially after the global financial crisis. Notwithstanding this surge of interest, the concept of vulnerability in labour economics is somehow vague and often used interchangeably with precariousness (Burgess et al., 2013; Pollert and Charlwood, 2009). Even if the two concepts are linked, they are not identical. Precarious work implies work features that are already established as risky for employees. Non-standard work arrangements or atypical contracts and jobs with risk of redundancy are examples of precarious work (Fudge and Owens, 2006). The welfare loss resulting from precariousness is therefore certain. Comparatively, vulnerability implies a risk that has not yet materialised and which is by extension not directly observable. The difference between the two concepts has many implications in terms of assessment methodologies, policy evaluation and implementation of preventive policies.

The purpose of this paper is to identify and to analyse the employees' vulnerability at the workplace across European countries. As a first contribution, this paper proposes a conceptual framework to analyse vulnerability at the workplace drawing on previous works from the economic development literature. We define vulnerability as the existence and the extent of risks at the workplace; the danger of adverse working conditions that may threaten the worker's well-being. Risks may emanate from the different work components and their accumulation further exacerbates the employee vulnerability. We assume that vulnerability is not restricted to some category of employees (e.g. disabled workers, migrant workers, young or older workers, women) as it is usually the case in the literature. Nor is it limited to some work-related dimensions (e.g. work arrangement, wage) or job characteristics' (working in the formal or informal sector, industry versus services). It extends to every employee in all sorts of jobs. Filling thus our purpose of identifying vulnerable employees and knowing that vulnerability is not directly observable, we opt for an identification methodology that relies on prediction and probability computation to assess the risks facing employees and by extension the extent of their risk exposition.

As the concept of vulnerability focuses on downside risks, the first step of our work consists in listing the different risks that may jeopardise employees' well-being at the workplace. Accordingly and using the last four editions of the European Working Condition Survey, five objective and work-related dimensions are selected relying on previous findings in the literature (Green et al., 2013; Greenan et al., 2013): adverse physical environment, workplace violence or adverse social climate, atypical working schedules, high work intensity and low work complexity. Relying on these five components, we construct a composite indicator of cumulative adverse working conditions which will be our aggregate measure of threatening risks at the workplace and which represents the second contribution of this paper.

The third contribution of this paper is methodological. In fact the vulnerability assessment raises a certain number of methodological issues that this paper endeavours to solve as follows. First, the concept of vulnerability is related to risks that are characterised by an unknown probability of realisation. All employees face multiple risks and preventive actions are desirable before their materialisation. An ex-ante assessment of vulnerability is then crucial for risk management. Based on a probabilistic approach, our vulnerability measure at the workplace is provided by the probability that an employee has a level of cumulative adverse working conditions above a predefined threshold. This methodology allows thus identifying employees at risks -vulnerable- and taking actions to mitigate the risk-generated loss. An illustration of risk-mitigation action in the context of growing risks at the workplace is given by the demand-control model (Karasek, 1979) which emphasises high decision latitude when job demands are high. Nonetheless, identifying the risks that may threaten employees' well-being and make workers vulnerable is a pre-required step to implement preventive policies.

The remainder of this paper is structured as follows. The second section sets out the conceptualisation of vulnerability at the workplace. The following section presents the data used as well as the pseudo-panel approach followed to measure vulnerability. The fourth section presents the results before concluding in the last section.

2 Risk and vulnerability at the workplace: concept and measurement

Before looking at how to measure vulnerability to adverse working conditions, a worthwhile starting point is to examine how the concept is defined in the social sciences literature. This will help us to propose a conceptual framework for addressing vulnerability in the specific context of work.

2.1 Widening the concept of vulnerability to working conditions

A common thread to vulnerability definitions in social sciences appears to be that vulnerability relates to a "sense of insecurity, of potential harm people must feel wary of-something bad may happen and spell ruin"(Dercon, 2006). For instance, vulnerability as defined by Chambers (1989) refers "to exposure to contingencies and stress which is defencelessness, meaning a lack of means to cope without damaging loss" [p.1]. The World development report 2000/01 defines vulnerability as the likelihood that a shock will result in a decline in well-being. Along with these definitions and applied to the specific context of employment, the TUC[1] commission defines vulnerable employment as "precarious work that places people at risk of continuous poverty and injustices resulting in imbalance of power in the employer-worker relationship". The concept of vulnerability is then used by different practitioners and the definition used as well as its assessment methodology depends on the overarching conceptual framework chosen. However and regardless of the investigation area, the concept of vulnerability always refers to a risk chain comprising the following components: a) risk or risky events, b) options for managing risk, or the risk responses and, c) outcome in terms of welfare loss (Alwang et al., 2001).

A strong element in the literature on vulnerability comes from international economics and more precisely from development economics. This is mainly done from the perspective of poverty and applied to developing countries (Hoddinott and Quisumbing, 2008; Ligon and Schechter, 2003). Two perspectives are usually adopted: a forward looking approach and a backward looking one. The backward looking approach favours the ex-post assessment of the extent to which a negative shock caused a welfare loss when the forward looking approach focuses on the ex-ante assessment of a future welfare loss. Accordingly, an ex-ante measure requires the probability computation of a future welfare loss conventionally defined as a fall below a given benchmark. Usually, the vulnerability is assessed relying on metric money measures (e.g. income, wage or consumption) because such measures are easily compared both across individuals and across countries. However, the rising concern about multidimensional deprivations in the poverty literature widened the measure of vulnerability to other tangible and intangible assets in order to identify vulnerable households or individuals both in developed and developing areas.

Working life contributes strongly to most people's well-being. It takes a large part of their time and profoundly models their life experience. Despite great improvement in the quality of jobs during the last decades, especially in industrialised economies, new threats and risks have emerged and accompanied economic structural changes. Along with the question of earnings and its inherent risks of poverty and

[1]The Trade Union Congress in the United Kingdom (TUC) set up a Commission on Vulnerable employment. The definition provided of employment vulnerability is taken from the resulting report.

inequality, the last decades come with new risks at the workplace such as work intensification, job insecurity or mental strain, leading thus to the introduction of the concept of vulnerability in the labour studies literature. We can identify three strands within this literature that conceptualise vulnerability in terms of job-related risks.

First, the employment vulnerability definition and measure provided by the ILO which is work-contract centred. Vulnerable workers operate in relatively precarious circumstances, namely as family workers or self-employed. These two categories of workers are less likely to have formal work arrangements, access to benefits or social protection programs and are more at risk to economic cycles. This definition suffers from many limitations: some wage and salaried workers might also carry high economic risk and some self-employed workers might be quite well off and not vulnerable at all. It could be relevant however in assessing employment vulnerability in developing countries. In line with this definition but considering other aspects of work contract, another literature characterise some subpopulations as vulnerable when they are more likely to have precarious employment arrangements such as migrants or women (Costello and Freedland, 2014; Sargeant and Giovannone, 2011). A serious shortcoming of this definition of employment vulnerability is the tendency to treat vulnerability as a label fixed on a particular population and on particular employment contract characteristics.

Second and in a different vein, the employment vulnerability literature identifies low wages and non-unionism as threats to worker's well-being. The downside risk workers face is thus poverty and lack of rights protection. The poverty risk materialises, for instance, when the earned income is below some predefined threshold: one third of the median hourly wage (Hudson, 2006) or the median hourly earnings (Pollert and Charlwood, 2009). Hence low pay can be taken as an indicator of vulnerability. Goos et al. (2009) show that changes in the labour market in the last 25 year spurred a polarisation of jobs, with an increase in both the number and proportion of low paid jobs, which indicates by extension an increase in vulnerable workers. However, all workers are not equally vulnerable and especially non-unionised workers are more exposed. Indeed, unions can protect from employment vulnerability as it raise their members awareness of employment rights and provide them with the resources to claim them (Pollert and Charlwood, 2009).

Concurrently to these arguments, Bewley and Forth (2010) highlight the distribution of power between employers and employees as determinant of employment vulnerability. Patterns of dependence which increase the bargaining power of employers can thus be expected to increase the risk of adverse treatment and increase employees' vulnerability, whilst patterns of dependence which increase the bargaining power of employees is expected to reduce their vulnerability. The hypothesis of power lack as determinant of employment vulnerability contrasts with a more general framework based on risk and capacity, which constitutes a third approach of employment vulnerability. O'Regan et al. (2005) and Taylor (2008) define vulnerable workers as those with higher risk of exposure and lower protection capacities. The risk content can encompass all the dimensions related to job quality, namely the work contract characteristics, the working condition or the work itself.

While there are some attempts to conceptualise vulnerable employment, empirical evidences are mostly focused on a small number of risks with an ex-post approach of vulnerability assessment. To our best knowledge, Bazillier et al. (2014) are the first to construct an employment vulnerability index relying on several dimensions of work, eight in total, namely: type of employment contract, type of labour relations, establishment size, type of organisation, supervising responsibilities, capacity to decide how the daily work is performed, capacity to influence decisions about activities of the organisation and type of occupation. Nonetheless, this index suffers from being an ex-post assessment of employees vulnerability as well as from omitting several dimensions related to working conditions and to job content.

Overall, in the literature there are several employment vulnerability measures, all focused on different and relevant aspects of work-related risks. However, it is possible to assess employment vulnerability, looking at all the risks that workers may face. Borrowing from the development literature, this paper rely on an ex-ante approach to anticipate workers that are likely to face adverse working conditions in the future, conditional on individual information and work related characteristics. The ex-ante vulnerability assessment allows identifying employees at risk in advance and thus is an information source for policies targeting.

2.2 Measuring vulnerability to adverse working conditions

In this paper, we define vulnerability as the existence and the extent of risks at the workplace; the danger of adverse working conditions that may threaten the worker's well-being. Though complementary to previous works on employment vulnerability, our approach is different. It is an attempt to encompass the multidimensional aspects of job quality and the various associated risks that may jeopardise employees well-being.

Relying on a risk-based definition of vulnerability, the aim is to identify workers at risk of adverse working conditions in the future based on their current standing, so that it is an ex-ante, forward looking measure. Accordingly, employee vulnerability is quantified by considering the probability to face adverse working conditions in the future that is having predicted adverse working condition above a predefined threshold, conditional on both the jobs' and employees' characteristics.

The probability can be stated as follows:

$$v_{it} = Pr(I_{(it+1)} > z_{(t+1)}) \tag{1}$$

where $I_{(it+1)}$ is the value of adverse working conditions at time $t+1$ for employee i, $z_{(t+1)}$ is the threshold of a socially acceptable level of working conditions. The issue with this measure is that $I_{(it+1)}$ is not observable, so this approach requires making predictions about the employees' working conditions. To obtain an estimate of the future state of working conditions, we begin by specifying the determinants of adverse working conditions and allowing predicted changes in these various determinants to condition the future expectations of adverse working conditions. Accordingly, the first step consists of estimating the following equation:

$$I_{(it)} = \beta X_{it} + \alpha_i + \epsilon_{it} \tag{2}$$

where X_{it} represents a bundle of employee as well as job characteristics, α_i is unobservable individual-specific factors and ϵ_{it} is a time-varying idiosyncratic disturbance which captures unobservable shocks. The objective from the estimation of this equation is not the estimation of the marginal effects per she, but rather using the marginal effects to create an estimate of the expected level of working conditions at period $t+1$. If shocks are unanticipated perturbations, then it seems reasonable to assume that the mean of these shocks is zero leading thus to the underlying assumption that ϵ_{it} is a zero mean disturbance term. The expected working conditions are thus given by $E[I_{(it+1)}] = \hat{\beta} X_{it} + \hat{\alpha}_i$.

From (Equation1), an employee vulnerability to adverse working conditions depends, not just on its expected (i.e. mean) working conditions looking forward, but also on the variability (i.e. variance, from an inter-temporal perspective) of its working conditions. Therefore to go from an estimate of adverse working conditions to a measure of employees vulnerability to adverse working conditions, we need to estimate the variance of their future working conditions. Within the context of cross-sectional data, the

disturbance term is interpreted as the intertemporal variance of working conditions. Viewed from this perspective, the assumption that the variance of working conditions is the same for all employees (i.e. the underlying assumption of homoscedasticity) seems quite restrictive. Further and, unlike in other setting where failure to take into account heteroscedasticity results in a loss of efficiency but need not bias the main parameters of interest, here, the standard deviation of the disturbance term enters directly in generating an estimate of vulnerability. When data is longitudinal, we can use the estimate of expected working conditions to derive an estimate of the employee's variance of working conditions computed as the average squared deviation of observed working conditions from expected ones: $Var[I_{(it)} \mid X_{it}, \hat{\beta}, \hat{\alpha}_i] = \sigma_i^2$. The variance of working conditions thus takes into accounts both the employee and the job characteristics.

Once the moments of working conditions distribution are estimated, the following step consists in determining the threshold of adverse of working conditions above which an individual is considered as vulnerable. As it is difficult to establish an absolute reference or benchmark for working conditions, we opt in this study for a relative definition of vulnerability, meaning that the threshold of adverse working conditions is established as the mean or the median of the observed adverse working conditions per country and per survey edition.

With these two moments of the working conditions distribution estimated, we can provide a measure of vulnerability to adverse working conditions, approximated by the probability to have a level of adverse working conditions above some threshold:

$$\phi[\frac{lnz - E[I_{(it+1)} \mid X_{it}, \hat{\beta}, \hat{\alpha}_i]}{\sqrt{Var[I_{(it)} \mid X_{it}, \hat{\beta}, \hat{\alpha}_i]}}] \tag{3}$$

where ϕ is the normal cumulative distribution function.

3 Data and empirical framework

The assessment of vulnerability to adverse working conditions is a tree-stages procedure. The first stage identifies actual characteristics that are associated with adverse working conditions. In a second stage, a composite indicator of adverse working conditions is constructed. Then, the third stage computes probabilities of being exposed to adverse working conditions. The empirical methodology results in an estimate of a value of adverse working conditions threshold, used to construct the probabilities associated with vulnerability.

3.1 Data sources:

In these stages, we rely on the four latest editions of the European Working Conditions Survey (EWCS)[2], 1995, 2000, 2005 and 2010 to identify workers facing adverse working conditions in 15 European countries. This survey is carried at home (i.e. outside the workplace) and is questionnaire-based. The population target is active population, aged 15 year and over and living in each of the Member States. The target number of interviews is 1,000 in all countries, except for Luxembourg (target 500)[3]. After deleting missing or incomplete observations, the remaining sample per edition is of approximatively: 12 000 workers for both 1995 and 2005 editions, 18 000 for 2000 and 16 000 for 2010. In this paper and in order to allow

[2]The EWCS is performed by the European Foundation for the Improvement of Living and Working conditions (Eurofound) to gather information about working conditions, the quality of work and employment in order to contribute to the planning and design of policies aiming at improving the conditions of life and work of Europeans.

[3]Detail on the methodology and characteristics of the EWCS can be found at the Eurofound's website

for time comparison, we include only countries that were surveyed in regular basis since 1995, namely: Austria, Belgium, Denmark, Germany, Greece, Italy, Luxembourg, Spain, France, Ireland, Netherlands, Portugal, Kingdom, Finland and Sweden.

3.2 Designing an Adverse Working Conditions Index (AWCI):

Relying on the four editions of EWCS, the first step is to design an adverse working conditions index.

3.2.1 The AWCI sub-components:

Ideally, the adverse working conditions indicator measures the cumulative risk exposure at the workplace. In designing the AWCI, we retained the components that reflected the main risks that could occur at the workplace and that were measured in the same way throughout the four editions of the survey. The AWCI is compiles five sub-indices that capture different threats to employees' well-being and health, namely: adverse physical environment, workplace violence or adverse social climate, atypical working schedules, high work intensity and low work complexity. The choice of these structuring dimensions reflects a number of considerations. On the one hand, all these dimensions are identified by the empirical literature as central issues that affect workers' welfare (Green et al., 2013; Greenan et al., 2013). On the other hand data limitations inevitably curtailed the choice of sub-indices. The EWCS offers a broad coverage of risks related to working conditions; however the survey focus differs from one edition to the other. Therefore, filling our purpose of time and country comparison shorten the number of dimensions that could be considered in our composite indicator. Notwithstanding data constraints, the AWCI takes into account several aspects of adverse working conditions that are organised as follows[4]:

- Adverse physical working environment indicator: as workplace nuisances, environmental hazards and poor postures are well-identified sources of risk at the workplace and by extension of workers vulnerability, this indicator include the following 9 questions: exposition to vibrations from used tools, loud noise, low and high temperatures, breathing in smoke or fumes, exposition to dangerous substances, painful position, carrying or moving heavy loads and doing repetitive movement. In the economic literature these job disamenities have a negative impact on employees' welfare and thus they should be associated with a wage premium. These disamenities also generate occupational health and safety risks. The wage-risk trade-off has been used to compute the value of risks to life and health (Viscusi, 1993).
- Adverse social climate or workplace violence indicator (6 questions): it is represented by the different cases of discrimination against employees such as discriminations related to age, sexual orientations, ethnicity, disability, nationality or exposition to unwanted sexual attention. The meta-analysis by Pascoe and Richman (2009) show that perceived discrimination has a significant negative effect on both mental and physical health as it both produces significantly higher stress responses and interacts with the participation in unhealthy of the non-participation in healthy behaviours.
- Atypical working schedules indicator (4 questions): it is based on information about night work, Sunday or Saturday work and shift work. These atypical working schedules are showed to be detrimental to the well-being and work-life balance of workers and their families (Fagan et al., 2012). There is also evidence that they impair health through three channels: disturbed body clock shortened and disturbed sleep and disturbed family and social life (Tucker and Folkard, 2012).

[4]A detailed description of the questions used is provided in the annex.

- High work intensity indicator (8 questions): It may be conceptualised as comprising an intensive perspective (e.g. short repetitive tasks of less than 10 minutes, working at very high speed or to tight deadlines) combined with a work pressure component (e.g. pace of work dependent on the work done by the colleagues or by external people, pace of work dependent on numerical production targets or on machine, pace of work dependent on the direct control of boss). Work intensity is a measurement of the effort engaged by the worker to perform his task. From an economic standpoint, it generates a disutility which is compensated by the wage. If we refer to the psychosocial model developed by Karasek (1979) work intensity is a component of job demands, the other main component being role conflict. High job demands are sources of job stress, but their relationship with job satisfaction and well-being is ambiguous. Using nationally representative data for Britain in 2001, 2006 and 2012, Green et al. (2016) find however that high work intensity is associated with low job-related well-being. Furthermore, work intensification accounts significantly to the fall in job-related well-being observed through the great recession, and all the more so when it is not accompanied by rises in task discretion or organisational participation in decision-making.

- Low work-complexity indicator (10 questions): It includes items related to the characteristics of tasks, how they are performed and the associated learning process. Low work complexity entails low task discretion (no possibility to choose or change the order of tasks or the methods of work), low skill use (simple and monotonous tasks, no quality standards nor self-assessments of quality) and low skill development (no job rotation, no support from colleagues, no on the job learning). Low work-complexity limits job opportunities, skills development and may be detrimental to employee's cognitive and emotional functioning (Frese, 1982). Work complexity shares many common features with job control as defined in the Job Demand-Control model (Karasek, 1979). Combined with high job demands, low job control lead to high strain jobs associated with low job satisfaction and well-being and detrimental health effects. In a more recent paper, Karasek argues that absolute low control in social organisations can contribute to the development of chronic disease through the deregulation of highly integrated physiological systems (Karasek, 2008). Indeed, decision latitude is a major resource for developing strategies to maintain the stability of internal physiological processes in the turbulent context of globalised economies.

3.2.2 Methodological choices to aggregate the components of the AWCI:

Our composite indicator captures exposure to cumulative risks engendered by workplace organisation and practices. The construction of a composite indicator usually yields a number of methodological issues tackled by numerous researchers and organisation. There is no single way of composition and each method has his pros and cons as summarised in the OECD handbook (2008). The structuring steps are nevertheless the same and can be grouped in three stages: normalisation, weighting and aggregation.

First of all and in order to construct a composite indicator of adverse working conditions, the individual answers from the EWCS are recoded to respect the rule: the higher the value, the most adverse are the working conditions. The lower grade corresponds therefore to the best working conditions while the higher grade is synonym of adverse working conditions. The different elements (variables, indicators or dimensions) have then to be brought to a unified scale to allow for a meaningful summation and to permit composition. In this paper, normalisation to a 0-1 range is adopted with 0 corresponding to the most favourable working conditions while 1 refers to the most adverse working conditions.

Once the individual answers are normalised, a weighting scheme should be adopted to determine the relative importance of the different items in the sub-indices on the one hand and the weights of the sub-indices in the composite indicator on the other hand. The issue of weighting is arguably one of the most difficult aspects of constructing a composite indicator and the literature offers several weighting

procedures such as statistical methods, participatory methods or normative methods (Decancq and Lugo, 2013) for a detailed presentation of the different weighing approaches). However, there is no consensus regarding the reliability of one method over the others and the choice of the weighting methodology is often related to the purpose of the indicator. In our case, the objective of the AWCI indicator is to capture the cumulative risk exposure at the workplace. The issue then is what weight to attach to adverse physical environment vis-à-vis the adverse social climate or how much weight should be placed on atypical working schedules and on high work intensity. Weighting requires a system of valuation of the different risks threatening workers well-being that is difficult to define because the risk perception differs among workers and over time. Therefore, an unequal weighting of the different components of the composite indicator may bias results as the individual preferences and by extension the answers depends on the individual context (Tangian, 2007). Consequently, we choose an equal weighing procedure to aggregate the five sub-components in AWCI.

For the aggregation of the variables into each sub-index, two different strategies are used. The first strategy is again an equal weighing procedure where the variables are simply summed up. The advantage of this procedure is its simplicity, making it easily reproducible. The drawback is that the questions in the EWCS have not been designed in relation to a scientifically validated scale. Indeed, it would be very difficult to find a general agreement among the various users of the survey, coming from different institutional and academic background. We thus use a data-driven method, a principal component analysis to capture each type of risk, considering that it is a latent variable which cannot be directly observed but which can be approached through a set of partly redundant variables. Each sub-index results from the factors of a principal component analysis including the associated set of variables. We retain the first factor for adverse physical conditions, adverse social climate, atypical working schemes and low work complexity. It represents respectively 44%, 34%, 49% and 25% of total variance and it is built on the opposition between high and low levels of each variable entering the index, with a weight depending on the correlations between variables. For the high work intensity index, we use the first two factors, representing respectively 28% and 15% of total variance. The first factor represents high intensity driven by technical constraints when the second factor represents high intensity driven by market forces[5].The high intensity index sums up the two factors once standardised. We use this second composite indicator in robustness checks. It is referred to as (AWCIpca) throughout the paper.

Figure 1 illustrates the time evolution, per country, of the mean value of each of the five sub-indices used in computing the AWCI indicator namely: low-work complexity, atypical working schedules, adverse physical environment and social climate and high work intensity. At first sight, we can notice that a common threatening risk in almost all the countries is high work intensity. While the time trend is upward since the 90's with the highest value recorded in 2010 for countries such as Belgium, Italy, Spain and Germany, we can notice a cyclical pattern for some countries with rises and falls in the level of work intensity. Such pattern is clearly observed in Netherlands, Poland, Austria and Denmark. Along with high work intensity, the second major and acknowledged workplace risk is low work-complexity. Regarding this component, two groups of countries are noticeable: countries with very low level of work complexity such as Spain, Greece and Italy and countries with varying and relatively high levels of work complexity like Germany, France, United Kingdom and Poland. The distribution of the remaining risks seems more homogeneous across countries and over time. For instance and surprisingly the quality of the physical working environment has not improved that much since 1995. Similarly, the prevalence of atypical working hours among workers is somehow identical from one year to the other and across European countries. Finally and even if the adverse social climate represents a very marginal risk in comparison with the other risks , Figure 1 shows an increasing level of social discrimination in some countries such as France, Finland and Belgium in 2010.

[5]This result on the two independent sources of work intensity is also found by Greenan et al. (2013).

Turning to the country comparison of the AWCI, Figure 2 presents its density function for the four survey years and for each country. The AWCI distribution looks more or less skewed to the right depending on the year and the country considered. The AWCI distribution has lost mass at the lower end in some countries such as Poland and Austria, especially in 2010 in comparison with other years. Hence, the more exposed workers in these countries are not trapped in their relative precarious and adverse working conditions. Year-2010 density has, on the contrary, stretched out in comparison with previous years, particularly in Greece, France, Germany, Belgium and Denmark, denoting thus a deterioration of the working conditions in 2010. Further, the distribution presents signs of bimodality either when considering all the survey editions (for example Greece) or when looking to a particular survey edition (Denmark in 2005).

3.3 Determinants of adverse working conditions:

Relying on the set of employee information available in the European Working Conditions Survey, the included determinants of adverse working conditions are a combination of socio-demographic background (such as marital status and a binary variable capturing whether the interviewed employee is the main bread winner), firm (sector and size) and employment contract characteristics (the nature of the employment contract and the employee occupation). Table 1 presents some descriptive statistics of the main variables used for the whole sample and by country. Regarding the marital status, most of employees are married and are the main contributor to the household income. There are few disparities regarding these variables across European countries. Considering the type of employment contract, the unlimited contract is the most common employment arrangement with a proportion of 69% for the whole sample. However, some countries such as Greece, Ireland and Portugal record a share of indefinite contract which are far below the European average (41%, 59% and 60% respectively). The distribution of the economic sectors differs widely from one country to another except for the service sector which is the prevailing sector for the whole sample (41%) as well as for each country. The last covariate is the establishment size classified into five categories according to the number of employees. The share of employees working in establishments with one employee or in establishments with more than 500 employees is small in comparison with the other categories (8% and 14% respectively for the whole sample). Micro-companies (1-9 employees) and small companies (10-49 employees) represents nearly 63% of the sample of employees in Greece, while medium-sized companies (50-499 employees) is the most underrepresented size group comparatively to the other European countries. Large companies (more than 500 employees) are predominant in the United Kingdom (22%) and scarce in Greece (6%).

Other natural and well-identified determinants of working conditions in the literature include union representation. Adverse working conditions and vulnerabilities arise when the workers are not aware of their employment rights and when they lack the resources to defend them. Information on the presence of unions would be very useful to explain the levels of adverse working conditions but unfortunately, such data is not available in the four considered editions of the EWCS. Similarly, data on wages and education (even if the occupational status may be viewed as a good proxy of the educational attainment), though provided in some editions, suffer from a lot of missing values.

3.4 The pseudo-panel:

Tackling the issue of work-related vulnerabilities as well as their time evolution requires longitudinal data that are seldom available within the context of working conditions surveys. Although repeated cross-sectional data have the obvious drawback of not tracking the same individuals over time, they have

some advantages such as less attrition and non-response problems in comparison with panel data (Ridder & Moffitt, 2007). Nonetheless, repeated cross-sectional surveys may offer an alternative that allow exploring time variations by using pseudo-panel techniques, as pioneered by Deaton (1985). Pseudo-panel consists of grouping individuals into cohorts that we are able to follow over time making use of all the cross-sectional information available at a point in time. To obtain consistent estimators, from a pseudo-panel, grouping variables should not present missing values for any individual in the sample, should be time invariant and exogenous (Verbeek, 2008). The number of cohorts should be large enough to avoid measurement error problems and similarly the size of each cohort has to be large.

In this paper, the used grouping variables[6] consist of gender, country and birth year in ten year spans[7]. After grouping into cohorts, 140 cohorts were constituted and may be tracked over the four used editions of the EWCS. The size of each cohort is sufficiently large to avoid sample size problems with an average of 105 individuals per cohort. The individual observations of the selected variables are averaged over cohorts leading to an equation expressed in terms of cohort means, which then becomes the units of observation in the pseudo-panel. Equation (2) becomes:

$$\bar{I}_{(ct)} = \beta \bar{X}_{ct} + \alpha_c + \bar{\epsilon}_{ct} \tag{4}$$

where $\bar{I}_{(ct)}$ is the averaged adverse working conditions index of cohort c at time t, α_c represents the cohort fixed effects and $\bar{X}_{ct}$ are the mean[8] of both employee and job characteristics in each cohort. Hence, the pseudo-panel allows following cohorts over time through the mean of intra-cohort observations.

4 Estimation and analysis of vulnerability

4.1 Vulnerability estimates

Our estimates of the vulnerability to adverse working conditions follow the different steps recalled in the methodology section. Accordingly, we begin by estimating the expected mean and variance of adverse working conditions relying on Equation (4). Then in a second step the vulnerability measure is obtained by computing the probability of an expected level of the adverse working conditions index being above a predefined threshold (Equation (3)).

Table 2 presents the results from the weighted least-squares estimation in the pseudo-panel data. Columns 1-2 display the result of the estimation of Equation (4) where the dependent variable is our previously constructed AWCI indicator[9]. Overall, the results are convergent regardless of how the AWCI is designed. First, being the main contributor to the households income increases the risk of adverse working conditions since such workers are more reliant on their jobs and may bear more risks than workers without such responsibility. Second, being on apprenticeship or training reduces the level of adverse working conditions when taking unlimited contract as a reference to employment contract duration, whilst other employment contract identified as precarious (such as fixed term contract and temporary employment agency contract) do not increase significantly the level of adverse working conditions. Third,

[6] Further details about the pseudo-panel construction are provided in the Appendix A

[7] The grouping variable is often based on the date of birth (resulting in age cohorts), however defining cohorts over more than one dimensions is also possible as Duval-Hernandez and Orraca (2009) who use birth year, gender and educational attainment or Arestoff and Djemai (2016) who use birth year and country.

[8] A weighting adjustment is made in the computation of each cohort mean.

[9] In order to check the result sensitivity to the methodology used to construct the AWCI indicator, we also report the estimation results with the AWCIpca indicator.

working in the service sector increases the exposure to adverse working conditions in comparison with the industrial sector. Considering the occupational status impact on adverse working conditions, the results show that with respect to managers, other high-skilled clerical status (such as professional and technical occupations) are less exposed to cumulative workplace risks while both high and low manual status (except for elementary occupations) have instead a higher impact on risk exposure. As our interest lies in the measurement of vulnerability, the estimation of the conditional distribution of adverse working conditions is of primary importance since both the predicted value and the variance of working conditions enter in the vulnerability measure, we are not going to discuss more extensively the explanatory variables signs. Nonetheless, we can notice that using pseudo-panel allows dealing with some shortcomings linked to repeated cross section data such as not taking into account fixed effect and the difficulty to obtain unbiased estimates of the variance-covariance matrix. However it also yields a number of econometric issues that we overcome as follows. First, since four observations are available for each cohort (corresponding to the four used editions of EWCS), the cohort aggregates are considered as error-ridden measurements of the true cohort population. Verbeek and Nijman (1993) propose an estimator[10] which does not suffer from inconsistency due to a small number of time periods and which is based on parametric specification of the measurement error and its correlation with the variable of interest. Second, using the average of individual observations per cohort presents another caveat that is the varying number of individuals from one cohort to another as well as the varying size of cohorts from one edition to another. These size changes are likely to create heteroscedasticity, yielding biased standard errors. To overcome heteroscedasticity within the context of pseudo-panel, we follow the usual procedure that consists of weighting the observations with cohorts size.

Based on the methodology outlined above, we construct estimates of cohort vulnerability to adverse working conditions. As we are dealing with cohorts of employees created by birth-year, gender and country, our threshold of adverse working conditions, used to compute vulnerability probability in Equation (3), is given by the median of observed working conditions in the 15 European countries by gender and by birth date. Accordingly, the working conditions of each cohort are compared to the median of their counterparts in the corresponding year.

4.2 Vulnerability analysis across European countries:

Figure 3 plots the average probabilities of vulnerability, obtained from Equation (3) and delimited by country and by survey year. We can split the set of countries into three categories: those with very low level of vulnerability, those with varying levels of likelihood to be exposed to cumulative workplaces risks and those with very high levels of vulnerability. The first class comprises countries with probabilities ranging from 0 to 20% denoting thus a very low exposition to adverse working conditions such as Belgium, Denmark, Sweden or Netherlands. For the second set of countries, vulnerability differs over time but with different pattern. From 1995 to 2005, the vulnerability declined in Finland but increased in 2010. In the United Kingdom, the vulnerability increased from 1995 to 2000 but remained flat after. France alternated between period of high vulnerability (2005 and 2010) and period of low vulnerability (1995, and 2005). Finally, the third set of countries with high and constant level of vulnerability over the survey editions such as Greece.

In order to allow country comparison over time, Figure 4 presents the average vulnerability ranked

[10] In fact and as outlined by Deaton (1985), the sample-based averages of the cohort means are estimates of the unobserved population cohort means with measurement error. It is then necessary to correct the within estimator for measurement errors which tend to zero if the number of individual per cohorts tends to infinity. In cases where the cohorts are undersized, Verbeek and Nijman (1993) propose a modified estimator of Deaton to achieve consistency when the number of individuals per cohort is small and the time periods are small.

by country in each year. At the first sight, the average vulnerability for most of the European countries is below 50% except for Greece which has the higher average levels of vulnerability in all editions. This country is followed by Spain and France among countries with the highest and sustainable level of work-related vulnerabilities. Conversely, the lowest average level of vulnerability is recorded for Austria, Belgium, the Netherlands and Germany in 1995, 2000, 2005 and 2010 respectively. Though the concept of vulnerability is quite new in the literature on working conditions and no previous results are available for comparison, the trend of vulnerability highlighted in Figure 3 and the resulting ranking of European countries regarding workers' protection against adverse working condition is similar to previous findings related to job quality evolution in Europe. For instance, the Eurofound report on convergence and divergence of job quality in Europe (2015) suggests a general trend in the EU15 towards a low work complexity and high work intensity between 1995 and 2005. Such pattern is also identified by other authors such as Green et al. (2013) and Greenan et al. (2013).This downward trend is convergent with our results of increasing vulnerability in some countries.

4.3 Age and gender effects:

Two employee characteristics that have been extensively investigated as enhancing risks at the workplace are gender and age. Beginning with the age effect, Figure 5 depicts the average vulnerability per age category in each country and in each survey edition. At the first sight, two groups of countries can be identified: those with very close levels of vulnerability regardless of the age considered and countries with varying levels of vulnerability according to the age and to the survey edition. An illustration of the first set of countries is provided by Denmark, Belgium and the Netherlands where the vulnerability profile is almost the same both through age group and over time. Greece is another example of persistent levels of vulnerability but this time, the level of vulnerability is permanently high. At the opposite, the United Kingdom, Italy and France start exhibit very high levels of vulnerability at lower ages but follow different profiles when considering the other age groups: in the UK, the level of vulnerability is low and stable in the middle age categories (namely 25-45) but increase up to 45 years old except in 2005 where it goes down; in France and Spain similar patterns are observed, although more fluctuant over time.

Turning to the distribution of vulnerability by gender, Figure 6 compares time evolution between men and women. Surprisingly, men are more likely to be exposed to work-related risks than women in all European countries except in Finland where women record higher levels of vulnerability, especially after 1995. Though, the gender gap is closing in the remaining countries; there are also some differences worth noting. While the vulnerability levels tend to converge over time in some countries (such as Denmark, Belgium or Portugal), the gender gap seem to widen in some other countries. Indeed and since 2005, one can notice a divergence of the level of vulnerability between men and women in France, Sweden, Finland and Greece. The risks surrounding men are more important in comparison with women in the last decade in such countries.

4.4 Who is vulnerable?

Stakeholders and protection policies may wish to specifically target vulnerable employees, so it is important to be able to identify the characteristics that condition or are symptomatic of vulnerability. To this end, we provide in Table 3 the sample characteristics of cohorts that are classified as vulnerable versus those that are not vulnerable. Relying on an independent samples *t-test*[11], we compare the means and medians of vulnerability determinants for both vulnerable and non-vulnerable groups assuming an

[11]We perform parametric tests of significance to determine whether there is a statistically significant difference between the means of the two samples of vulnerable and non-vulnerable cohorts.

unequal variance between the two groups. The retained threshold to define vulnerable groups is 50% which corresponds to an equal chance to have adverse working conditions below or above the median value of adverse working conditions.

The comparison of statistics across groups indicates that vulnerable groups are significantly different from non-vulnerable groups in terms of their characteristics. Regarding the socioeconomic background, there is no significant difference between the two considered samples regarding the marital status and the contribution to the household income which means that being married or being the main breadwinner does not make a significant difference between the two groups. Turning to the employment contract features, overall there are significant differences between vulnerable and non-vulnerable groups. First, the mean of cohorts with an unlimited employment contract is higher in the non-vulnerable group (0.68) in comparison with the vulnerable group (0.50). Conversely and unsurprisingly, fixed term contract is more often associated with vulnerability as the significant mean difference between the two samples illustrates it: the mean of fixed term contract is higher (0.13) in the vulnerable group in comparison with the non-vulnerable group (0.10). This result contrasts with our finding in Table 2 where no significant impact of fixed term contract on adverse working conditions is reported. It comes from this result that fixed work contract has no specific impact on adverse working conditions but has a significant impact of the employee vulnerability.

Second, cohorts working in the industrial sector are more likely to be vulnerable when working in other sectors do not expose significantly to more vulnerability. Another important distinguishing feature of vulnerable group is the establishment size. Indeed, vulnerable cohorts are mainly self-employed or employed in micro-enterprises (size 1-9 employees). Conversely, non-vulnerable cohorts are more likely to be employed in middle, large and very large firms (10-49 employees, 50-499 employees and 500 or more employees respectively). Similarly, higher occupational status groups such as professionals and technicians are on average non-vulnerable in comparison with lower occupational status. More precisely, high skilled manual such as agricultural workers, craft and trade workers are more vulnerable.

To sum up and on average, vulnerable cohorts have employment contracts other than unlimited, work in the industrial sector within small-sized firms or are self-employed and are low-skilled.

4.5 Vulnerability dynamics with respect to different thresholds:

To further investigate the vulnerability dynamics across the survey editions, table 4 reports both the probability and the quartile transition matrices of cohorts over the period 1995-2010. Based on our measure of vulnerability, these transition matrices allow decomposing the vulnerable cohorts into those that are permanently vulnerable (i.e. those cohorts that are vulnerable in each survey edition) and those that are transitorily vulnerable (i.e. those cohorts that are not vulnerable at least one time). Assessing the vulnerability dynamics requires defining the probability threshold of vulnerability above which a cohort should be considered as vulnerable. The probability threshold could have an important role in the dynamic analysis of vulnerability because where the threshold is set could affect results of both the percentage of vulnerable cohorts as well as of transition. A threshold of 50% may be an obvious choice as in this case a cohort with a probability above 50% to be exposed to adverse working conditions is considered as highly vulnerable. However and as illustrated by Figure 3, the average probability of vulnerability across countries and over time is mostly below 50. Furthermore, setting the threshold of vulnerability at 50% means an equal likelihood to be vulnerable or to be not vulnerable which is highly unsecure and risky for employees. Alternatively to the threshold probability of 50%, we also examine transition between quartiles as well as between different thresholds in order to figure to some degree the extent to which this matters.

Taking then a step further in the vulnerability dynamics analysis, we consider in Table 4 three vulnerability cutoffs as well as quartile distribution to track the vulnerability status over time. The table reports probability transition from the initial time point in the rows, and the vulnerability status at the final time point in the columns, so that the proportional distributions across rows provide an assessment of the transition to vulnerability and the extent of vulnerability stability. The percentage of cohorts falling in the first and the fourth vulnerability distribution (corresponding to the less and most vulnerable respectively) is stable from one survey to the other. For instance, 49% of cohorts that were in the first quartile in 1995 remain in this quartile in 2000 and 43% that were in the 1st quartile in 2000 remain in this quartile in 2005. Similarly, the proportion of chronic vulnerable is approximatively the same from one survey edition to the other (71% of the cohorts in the fourth quartile in 1995 have remained in this quartile in 2000). However, we can notice that the fraction of cohorts moving from the 4th quartile distribution to the 2nd quartile is decreasing over time and reaches the level of 0% from 2005 to 2010 while the fraction of cohorts moving from the 4th to the 3rd quartile is increasing. Along with the quartile transition reported in table 4, probability transition matrix is also presented when considering the following probability thresholds: 0.25, 0.50 and 0.75. Since 2000, the proportion of chronic vulnerable with high probability occurrence (>75%) has declined from 80% in 2000 to 54% in 2010. Overall, most of the cohorts remain within their original probability interval, except for the period running from 2000 to 2005 where 52% of the cohorts move to the lower class (vulnerability below 0.25) while only 44% remain in their originate class. These results mean that the fraction of chronic vulnerable is higher in comparison with transitory vulnerable and the transition is often delimited to the neighbouring class.

5 Conclusion

This paper has used the four last editions of the European Working Condition Survey to identify and to analyse vulnerability at the workplace to cumulative adverse working conditions. Vulnerability is defined in this work as the likelihood that an employee has a level of adverse working conditions above some predefined threshold. We focus on 15 countries (Austria, Belgium, Denmark, Germany, Greece, Italy, Luxembourg, Spain, France, Ireland, Netherlands, Portugal, Kingdom, Finland and Sweden) that were surveyed on regular basis since 1995. Relying on pseudo-panel techniques, we estimate the vulnerability of cohorts of employees grouped by birth-year, gender and country. Our results highlight disparities of vulnerability levels across European countries. Three classes of countries are identified: countries with very low level of vulnerability, countries with varying level of vulnerability over time and finally countries with sustainable high level of vulnerability. This classification is somehow surprising as the composition does not fit the usual categorization sets by employment regimes theory with respect to similarities and dissimilarities of job quality and worker protection between European countries.

Indeed, Nordic countries[12] tend to have strict employment protection laws, more influential trade unions and high union membership ensuring thus very low levels of workforce vulnerability (Eurofund, 2015; Gallie, 2007). This assertion is convergent with our results except for Finland which record very high levels of vulnerability. Conversely, Ireland which is often assimilated to United Kingdom as having liberal regimes with less employment protection has on average a level of vulnerability very low and similar to Nordic countries. Further, vulnerability in southern countries, such as Spain, Italy and Greece, may be expected to be higher and alike as employment policies are weaker in these countries and they have lower level of trade union power. Instead, our results highlight great divergences between these countries with Greece recording the highest levels of vulnerability while the average vulnerability in Italy is close to the average in Ireland than in Spain. The relationship between employment regimes and vulnerability

[12]Denmark, Finland, Sweden

deserves then more attention to explain differences between European countries.

At the individual level, our results suggest differences of vulnerability levels according to job characteristics': employees with fixed work arrangement, low skilled and working in the industrial sector within small-sized firms are more likely to be vulnerable. Women seem to be less exposed to work-related vulnerabilities than men except in Finland. In fact the gender gap is tightening or widening depending on the year and the country considered but remains overall small. Regarding the age effect on vulnerability, our results highlight greater vulnerability for younger and older workers but only in some countries such as France and the United Kingdom.

6 Appendix

6.1 Variables included in the composite indicator of adverse working conditions (AWCI):

The AWCI results from the aggregation of 5 sub-indices and each sub-indice is based on the responses of a worker to the following questions:

1. Adverse physical environment (9 questions):

   -Are you exposed at work to?

   - Vibrations from hand tools, machinery, etc.
   - Noise so loud that you would have to raise your voice to talk to people
   - High temperatures that make you perspire even when not working
   - Low temperatures whether indoors or outdoors
   - Breathing in smoke, fumes, powder or dust, etc.
   - Handling or being in direct contact with dangerous substances such as chemical, infectious materials, etc.

   -Does your main job involve?

   - Painful or tiring positions
   - Carrying or moving heavy loads
   - Repetitive or arm movements

2. Adverse social climate (6 questions) :

   -Over the past 12 month, have you or have you not, subject to?

   - Sexual discrimination
   - Unwanted sexual attention
   - Age discrimination
   - Ethnic discrimination
   - Disability discrimination
   - Nationality discrimination

3. Atypical working time:

   -Normally, how many times a month do you work?

   - At night, for at least 2 hours between 10.00 pm and 05.00 am
   - On Sundays
   - On Saturdays

   -Do you work shifts?

4. High work intensity (8 question):

   -Does your job involve?

   - Short repetitive tasks of less than 10 min?

- Working at very high speed
- Working at tight deadlines

-On the whole, is your pace of work dependent, or not on?

- The work done by the colleagues
- Direct demands from people such as customers, passengers, pupils, patients, etc.
- Numerical production target
- Automatic speed of machine or movement of a product
- The direct control of your boss

5. Low work complexity (9 question):

   -Generally, does your main paid job involve?

   - Meeting precise quality standard?
   - Assessing yourself the quality of your own work?
   - Solving unforeseen problems?
   - Complex tasks?
   - Rotating tasks between you and your colleagues
   - Learning new things

   -Are you able to choose or change?

   - Order of tasks
   - Methods of work

   -You can get assistance form your colleagues if you ask for it?

6.2 Pseudo-panel construction

The grouping variables for cohort data are country, gender and year of birth. Considering the year of birth, instead of taking the declared age in each survey, we create a new variable, equal to the difference between the survey year and declared age. This solves the problems of interviewed employees in different year but reporting the same age: for instance, a 25 years-old employee interviewed in the last edition of 2010 would not have the same working conditions as a 25 years-old employee interviewed in 1995 (all other things being equal). With the pseudo panel and in order to allow for relevant comparison of working conditions over time, each cohort should be associated with only one birth year interval. The cohorts are defined then for the birth year from 1927 to 1994 using data surveys from 1995 through 2010. The averages for each birth year are generated by country and by gender.

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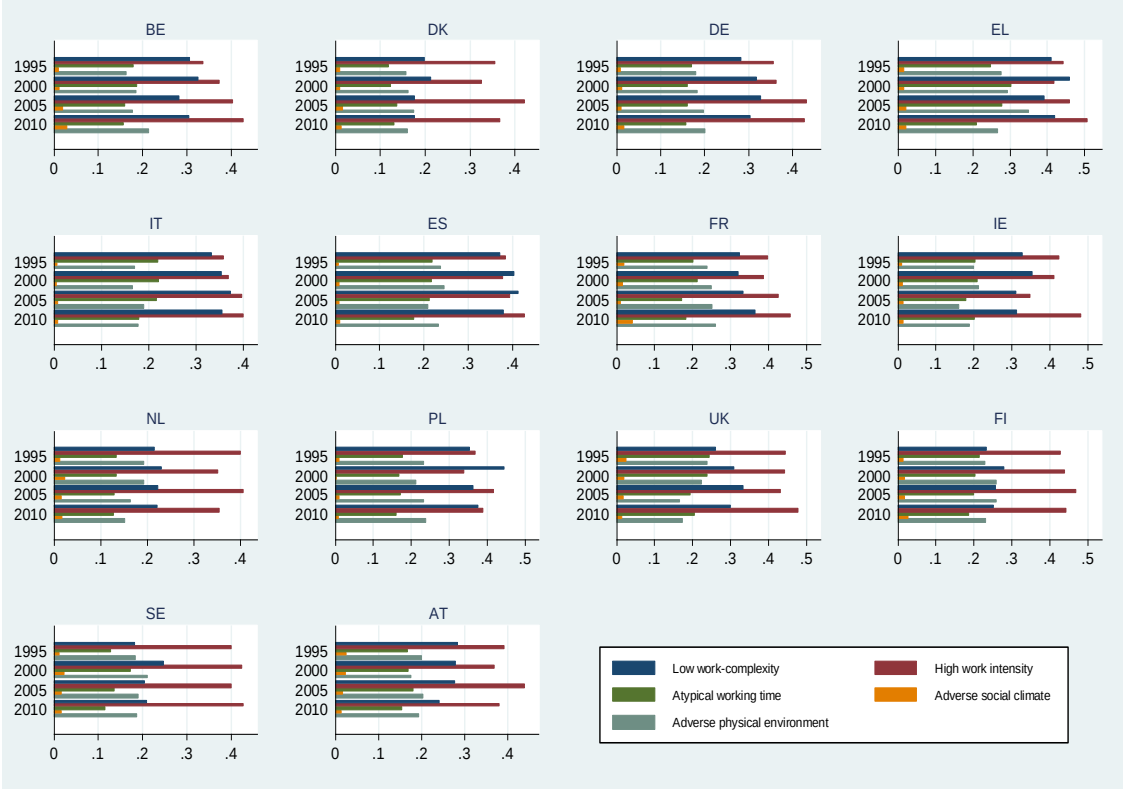
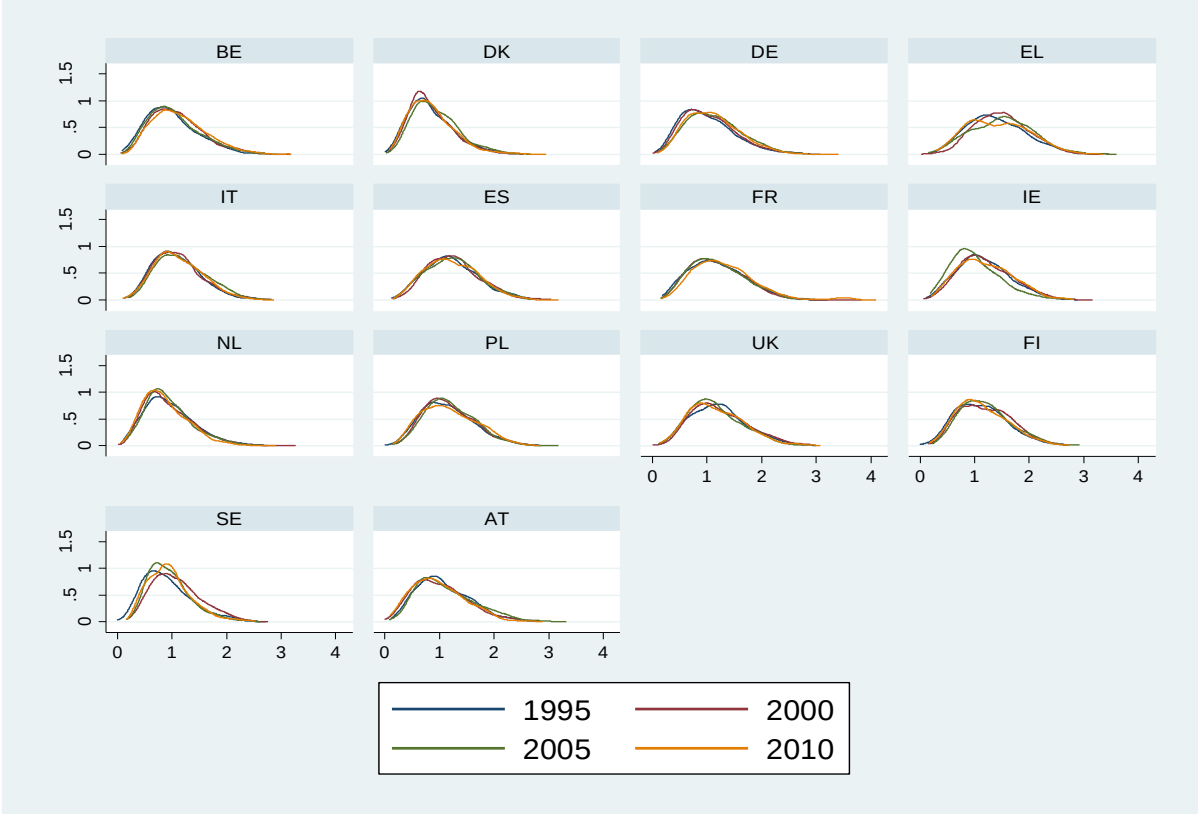
Figure 1: *Average sub-indices per country and per survey edition*



Note: Country abbreviation: Greece (EL), Spain (ES), United Kingdom (UK), France (Fr), Ireland (IE), Portugal (PL), Finland (FI), Italy (IT), Austria (AT), Germany (DE), Belgium (BE), Netherland (NL), Sweden (SE), Denmark (DK

Figure 2: *Kernel density of AWCI using the EWCS 1995, 2000, 2005 and 2010*

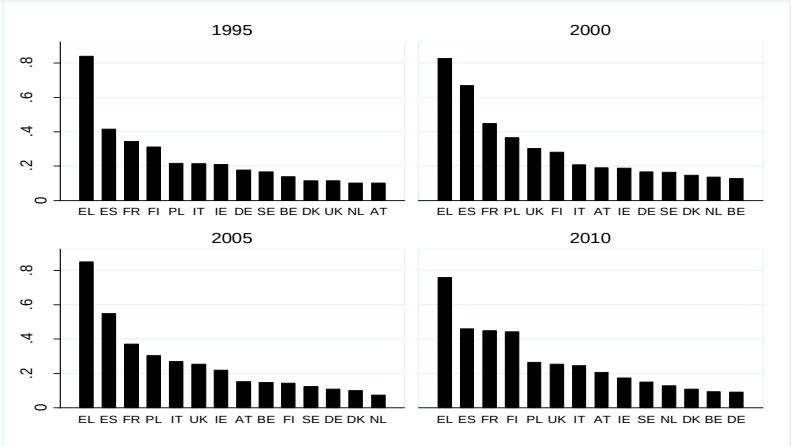


Note: Country abbreviation: Greece (EL), Spain (ES), United Kingdom (UK), France(Fr), Ireland (IE), Portugal (PL), Finland (FI), Italy (IT), Austria (AT), Germany (DE), Belgium (BE), Netherland (NL), Sweden (SE), Denmark (DK)

Figure 3: *Average vulnerability per survey edition and per country*

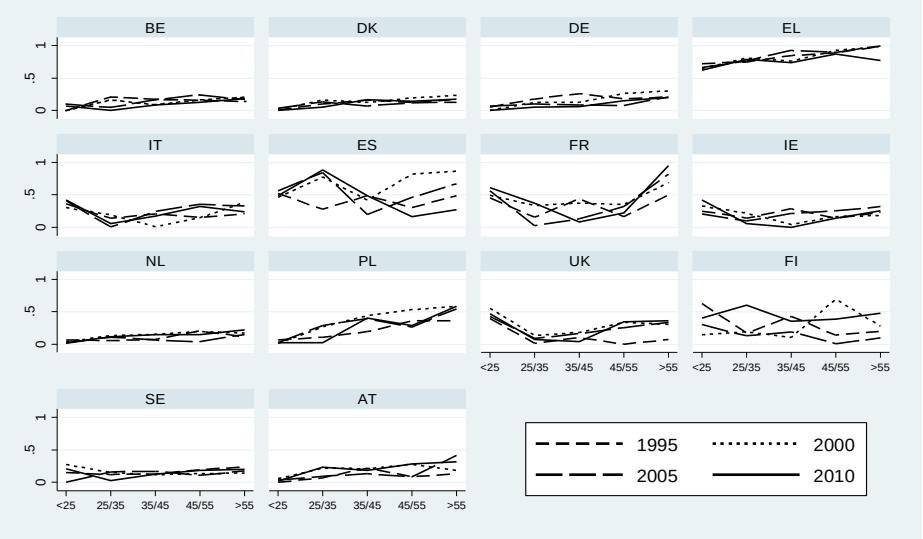
Note: Country abbreviation: Greece (EL), Spain (ES), United Kingdom (UK), France(Fr), Ireland (IE), Portugal (PL), Finland (FI), Italy (IT), Austria (AT), Germany (DE), Belgium (BE), Netherland (NL), Sweden (SE), Denmark (DK)

Figure 4: *Ranking of Average vulnerability per survey edition and per country*



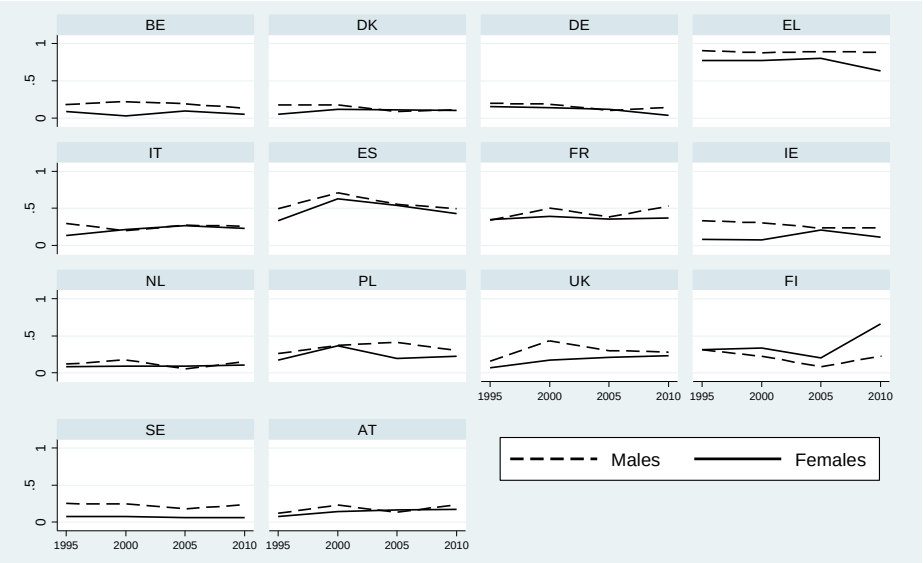
Note: Country abbreviation: Greece (EL), Spain (ES), United Kingdom (UK), France(Fr), Ireland (IE), Portugal (PL), Finland (FI), Italy (IT), Austria (AT), Germany (DE), Belgium (BE), Netherland (NL), Sweden (SE), Denmark (DK)

Figure 5: *Average vulnerability per age group*



Note: Country abbreviation: Greece (EL), Spain (ES), United Kingdom (UK), France(Fr), Ireland (IE), Portugal (PL), Finland (FI), Italy (IT), Austria (AT), Germany (DE), Belgium (BE), Netherland (NL), Sweden (SE), Denmark (DK)

Figure 6: *Average vulnerability by gender*



Note: Country abbreviation: Greece (EL), Spain (ES), United Kingdom (UK), France(Fr), Ireland (IE), Portugal (PL), Finland (FI), Italy (IT), Austria (AT), Germany (DE), Belgium (BE), Netherland (NL), Sweden (SE), Denmark (DK)

Table1: Descriptive statistics

	BE	DK	DE	EL	IT	ES	FR	IE	NL	PL	UK	FI	SE	AT	All
Marital Status															
Single	31	25	34	35	37	37	37	38	30	30	31	35	32	37	33
Married	69	75	66	66	63	63	63	62	70	70	69	65	68	63	67
Main breadwinner															
No	34	35	29	36	42	34	31	34	36	39	37	28	31	31	34
Yes	67	65	71	64	58	66	69	66	64	61	63	73	69	69	66
Employment Contract															
Unlimited	76	78	78	41	62	52	73	59	74	60	72	69	80	75	69
Fixed	7	7	9	6	6	19	11	8	11	12	8	13	7	5	9
Temporary	2	2	1	2	2	3	2	3	2	2	2	1	3	1	2
Training	1	2	2	1	2	1	1	1	1	1	1	1	0	1	1
Other	2	6	2	19	3	5	2	11	2	5	6	3	2	4	5
Sector															
Agriculture, hunting, forestry and fishing	5	8	13	15	10	11	7	11	9	11	6	10	7	10	9
Industry	19	23	25	24	24	24	21	24	22	31	22	33	20	27	24
Services (excluding public administration)	51	36	38	40	41	43	47	42	38	33	44	35	35	41	41
Public administration and defence	10	12	11	9	12	8	10	8	11	12	13	6	15	9	10
Other services	16	23	13	12	13	14	16	15	21	13	16	16	23	14	16
Occupation															
Legislators, senior officials & managers	8	8	6	11	5	8	6	10	10	9	10	7	9	8	8
Professionals	17	18	6	14	12	8	10	15	18	8	14	14	19	5	13
Technicians & associate professionals	15	22	18	6	19	11	18	10	17	7	12	18	20	16	15
Clerks	18	11	16	13	19	17	14	12	16	12	13	11	13	16	15
Service workers and shop , market sales workers	14	14	18	14	13	15	17	17	13	14	18	15	14	20	15
Skilled agricultural & fishery workers	1	1	2	10	1	2	2	5	1	3	1	4	1	3	2
Craft & related trade workers	11	12	19	18	15	17	14	12	10	19	12	14	9	15	14
Plant and machine operators & assemblers	5	6	6	7	6	6	6	8	6	11	8	9	7	6	7
Elementary occupations	11	8	9	7	10	15	13	11	9	17	12	9	7	12	11
Armed forces	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1
Firm size															
One employee	6	4	4	18	14	15	9	10	6	14	6	8	5	7	8
1-9 employees	24	16	30	40	33	36	29	28	17	33	18	28	18	31	27
10-49 employees	28	31	30	23	21	23	24	27	26	24	27	30	32	27	27
50-499 employees	28	31	24	14	19	16	25	22	33	21	27	22	27	22	24
500 or more employees	15	19	13	6	13	11	14	12	19	8	22	12	18	13	14

Note: Country abbreviation: Greece (EL), Spain (ES), United Kingdom (UK), France(Fr), Ireland (IE), Portugal (PL), Finland (FI), Italy (IT), Austria (AT), Germany (DE), Belgium (BE), Netherland (NL), Sweden (SE), Denmark (DK)

Table 2: *First-stage regression. Dependent variable: The AWCI composite indicator of adverse working conditions*

VARIABLES	(1)		(2)	
Married	-0.0157	(0.048)	-0.0098	(0.047)
Main breadwinner	0.1477***	(0.044)	0.1149***	(0.044)
Employment contract :Unlimited employment contract versus/				
Fixed term contract	0.0633	(0.065)	0.0191	(0.064)
Temporary employment agency contract	-0.0441	(0.120)	0.1189	(0.118)
Apprenticeship or other training	-0.4290**	(0.185)	-0.2568	(0.182)
other	-0.1461**	(0.058)	-0.0816	(0.057)
Sector: Industry versus /				
Agriculture, hunting, forestry and fishing	-0.0537	(0.043)	-0.0264	(0.042)
Services (excluding public administration)	0.1054***	(0.034)	0.1169***	(0.034)
Public administration and defence; compulsory social sector	0.0310	(0.060)	0.0568	(0.059)
Other services	0.1467***	(0.045)	0.1679***	(0.044)
Firm size: 50-499 employees versus/				
One employee	-0.0680	(0.094)	-0.0761	(0.092)
1-9 employees	-0.0742	(0.071)	-0.0631	(0.070)
10-49 employees	-0.0645	(0.071)	-0.0484	(0.070)
500 or more employees	-0.0008	(0.067)	0.0326	(0.066)
Occupation: Legislators, senior officials and manager versus /				
	-		-	
Professionals	0.3534***	(0.093)	0.3904***	(0.092)
Technicians and associate professionals	-0.2000**	(0.096)	-0.2167**	(0.094)
Clerks	-0.1078	(0.109)	-0.1675	(0.107)
Service workers/ shop and market sellers	0.1020	(0.097)	0.0483	(0.095)
Skilled agricultural and fishery worker	0.3620***	(0.120)	0.3113***	(0.118)
Craft and related trade workers	0.2403**	(0.103)	0.1496	(0.102)
Plant and machine operators and assembly workers	0.4187***	(0.118)	0.2948**	(0.116)
Elementary occupations	0.1132	(0.102)	0.0500	(0.101)
Armed forces	0.9568***	(0.278)	0.8208***	(0.274)
Observations	540		540	540

Note: the dependant variable in column 1 is the *AWCI* indicator performed with equal weighing in all the construction stages. In column 2 the dependent variable is the *AWCIpca* indicator obtained with our second weighting strategy (See section III.2. for details)
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: *Quartile and probability transition matrix 1995/2010*

Quintile Transition Matrix for cohorts, 1995-2000

		2000			
		1st quantile	2nd quantile	3rd quantile	4th quartile
1995	1st quantile	48.57	31.43	5.71	14.29
	2nd quantile	34.29	31.43	28.57	5.71
	3rd quantile	8.57	28.57	54.29	8.57
	4th quartile	8.57	8.57	11.43	71.43

Probability Transition Matrix for cohorts 1995-2000

		2000			
		<=25%	>25%& <=50%	>50%& <=75%	>75%
1995	<=25%	71.11	23.33	2.22	3.33
	>25%& <=50%	36.67	43.33	16.67	3.33
	>50%& <=75%	0.00	20.00	80.00	0.00
	>75%	10.00	0.00	10.00	80.00

Quintile Transition Matrix for cohorts, 2000-2005

		2005			
		1st quantile	2nd quantile	3rd quantile	4th quartile
2000	1st quantile	42.86	28.57	25.71	2.86
	2nd quantile	28.57	42.86	22.86	5.71
	3rd quantile	20.00	22.86	40.00	17.14
	4th quartile	8.57	5.71	11.43	74.29

Probability Transition Matrix for cohorts 2000-2005

		2005			
		<=25%	>25%& <=50%	>50%& <=75%	>75%
2000	<=25%	82.89	14.47	2.63	0.00
	>25%& <=50%	52.78	44.44	2.78	0.00
	>50%& <=75%	12.50	31.25	37.50	18.75
	>75%	16.67	8.33	8.33	66.67

Quintile Transition Matrix for cohorts, 2005-2010

		2010			
		1st quantile	2nd quantile	3rd quantile	4th quartile
2005	1st quantile	40.00	34.29	17.14	8.57
	2nd quantile	37.14	37.14	22.86	2.86
	3rd quantile	14.29	28.57	40.00	17.14
	4th quartile	8.57	0.00	20.00	71.43

Probability Transition Matrix for cohorts 2005-2010

		2010			
		<=25%	>25%& <=50%	>50%& <=75%	>75%
2005	<=25%	76.74	19.77	2.33	1.16
	>25%& <=50%	36.36	51.52	12.12	0.00
	>50%& <=75%	10.00	20.00	50.00	20.00
	>75%	0.00	0.00	45.45	54.55

Table 4: *Characteristics of vulnerable versus non-vulnerable*

	Mean			Median		
	Non-vulnerable	Vulneble	Pmean	Non-vulnerable	Vulnerable	Pmedian
Married	0,64	0,60	0,16	0,72	0,65	0,42
Main bread winner	0,61	0,60	0,80	0,55	0,56	0,91
Employment contract						
Unlimited employment contract	0,68	0,50	0,00	0,71	0,52	0,00
Fixed term contract	0,10	0,13	0,02	0,07	0,08	0,09
Temporary employment agency contract	0,02	0,03	0,10	0,01	0,01	0,21
Apprenticeship or other training	0,02	0,01	0,25	0,00	0,00	0,42
Other	0,05	0,11	0,00	0,03	0,07	0,00
Sector						
Industry	0,10	0,14	0,02	0,03	0,08	0,00
Agriculture, hunting, forestry and fishing	0,27	0,24	0,16	0,25	0,23	0,08
Services (excluding public administration)	0,38	0,40	0,48	0,37	0,38	0,46
Public administration and defense; compulsory social sector	0,11	0,10	0,66	0,07	0,08	0,90
Other services	0,14	0,11	0,03	0,08	0,07	0,30
Firm size						
One employee	0,07	0,13	0,00	0,06	0,11	0,00
1-9 employees	0,26	0,37	0,00	0,25	0,35	0,00
10-49 employees	0,27	0,24	0,02	0,27	0,25	0,02
50-499 employees	0,24	0,18	0,00	0,24	0,17	0,00
500 or more employees	0,15	0,08	0,00	0,11	0,05	0,00
Occupation						
Legislators, senior officials and manager	0,08	0,08	0,23	0,07	0,07	0,28
Professionals	0,15	0,11	0,00	0,14	0,10	0,00
Technicians and associate professionals	0,15	0,10	0,00	0,14	0,09	0,00
Clerks	0,14	0,12	0,19	0,12	0,11	0,20
Service workers/ shop and market salers	0,15	0,17	0,14	0,13	0,15	0,14
Skilled agricultural and fishery worker	0,02	0,08	0,00	0,01	0,05	0,00
Craft and related trade workers	0,13	0,16	0,01	0,11	0,18	0,00
Plant and machine operators and assembly workers	0,08	0,07	0,96	0,06	0,06	0,91
Elementary occupations	0,10	0,11	0,32	0,08	0,10	0,37
Armed forces	0,01	0,01	0,13	0,00	0,00	0,17