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► **To cite this version:**

Nathalie Greenan, Majda Seghir. Vulnerability to Adverse Working Conditions in EU-15 Countries: Empirical Evidence over two Decades. *Revue d'économie politique*, 2022, 132 (5), pp.751-791. 10.3917/redp.325.0751 . hal-03844470

HAL Id: hal-03844470

<https://hal.science/hal-03844470v1>

Submitted on 30 Jan 2023

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VULNERABILITY TO ADVERSE WORKING CONDITIONS IN EU-15 COUNTRIES: EMPIRICAL EVIDENCE OVER TWO DECADES

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February 2021

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We acknowledge financial support from European Union's Horizon 2020 research and innovation programme under Grant Agreement No 312691 (InGRID-1 project).

ABSTRACT

Workforce vulnerability has recently come to the forefront in European policy debate as countries searched for the potential engine of inclusive growth 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 the identification of workers who 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 cohort level and at the aggregate one, allowing comparisons across European countries.

Keywords: *vulnerability, adverse working conditions, pseudo-panel, European countries.*

JEL: *C23, I31, J81*

ANALYSE EMPIRIQUE DE LA VULNERABILITE DES TRAVAILLEURS EUROPEENS FACE AUX CONDITIONS DE TRAVAIL DEGRADEES

RESUME

Conformément aux objectifs européens d'une croissance et d'un marché du travail plus inclusifs, la question de la vulnérabilité des travailleurs occupe un pan essentiel de la politique économique et sociale européenne.

Ce travail s'insère ainsi dans une réflexion visant à définir et à mesurer les différentes formes de vulnérabilité qui peuvent survenir et se développer dans le travail en Europe. Nous proposons un cadre conceptuel et méthodologique où la vulnérabilité est définie comme le degré d'exposition des travailleurs à des risques cumulés sur le lieu de travail, ayant des effets néfastes pour le bien-être et la santé. À cette fin, un indicateur de conditions de travail défavorables est proposé : il agrège des facteurs relatifs aussi bien à l'environnement – qu'il soit physique ou social – qu'au contenu et à l'organisation du travail (forte intensité du travail, faible complexité, horaires atypiques). Cet indicateur synthétique est ensuite utilisé pour calculer la probabilité pour un travailleur d'être exposé à une dégradation de ses conditions de travail. C'est cette probabilité qui mesure la vulnérabilité aux conditions de travail dégradées. Notre mesure est construite à partir des données provenant des cinq dernières éditions de l'enquête européenne sur les conditions de travail (EWCS). S'appuyant sur les techniques d'estimation en pseudo-panel, nos résultats montrent de grandes disparités de la vulnérabilité des travailleurs occupés au sein des quinze pays fondateurs de l'Union européenne

Mots-clefs : *vulnérabilité, mauvaises conditions de travail, pseudo-panel, pays européens.*

JEL : *C23, I31, J81*

INTRODUCTION

The purpose of this paper is to identify and measure a new concept useful to monitor the quality of the work environment across European countries, the concept of vulnerability to adverse working conditions. We define it as the existence and the extent of risks at the workplace, i.e., the danger of adverse working conditions that may threaten workers' well-being.

This concept targets the low end of the job quality scale, where the need for public intervention is the most straightforward. An adverse working condition is a disamenity that has an established potential to jeopardise the health and well-being of workers. We chose to focus on cumulative risk exposure that is the joint exposure to a combination of disamenities. Indeed, risks may emanate from different work components and their accumulation further exacerbates workers' vulnerability. This concept also includes a notion of uncertainty in the risk exposition, drawing on research on poverty from the economic development literature.

In labour economics, vulnerability is somehow a loose concept, often used interchangeably with precariousness (Burgess et al., 2013; Pollert & 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 & 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. 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 worker in all types of jobs.

In times where inequalities have been growing within and between European countries and where workers *left behind* in the processes of globalisation, technological transformation or economic downturns express their dissatisfaction through social unrest, tools to monitor the poor quality of jobs are called for by governments (Warhurst and Knox, 2020). Measuring vulnerability to adverse working conditions allows to compare countries, sectors, occupations or employer types according to their ability to protect their workforce from the negative outcomes of ongoing changes. There are certainly lessons to be learned from work environments where workers appear sheltered and policies to be devised for those where economic restructuring is resulting in increasing threats to their well-being.

As the concept of vulnerability focuses on downside risks, the first step of our work comprises listing the different risks that may put workers' health and well-being at risk. Accordingly, and using the last five editions of the European Working Condition Survey (EWCS), five work-related dimensions are selected relying on previous findings in the literature (Green et al., 2013; Greenan et al., 2014): 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 (AWC) which is our measure of threatening risks at the workplace.

Finally, the vulnerability assessment raises a certain number of methodological issues that this paper endeavours to solve as follows. 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 likelihood that a worker has a level of cumulative adverse working conditions above a predefined threshold. As the European Working Condition Survey (EWCS) does not observe employees over time, we create a pseudo-panel that tracks a group of relatively homogeneous employees over time. This methodology allows identifying employees at risks – vulnerable –, which is a prerequisite for taking actions to mitigate the risk-generated loss. However, we need to keep in mind that its objective is mainly to assess vulnerability, not to explain it.

The remainder of this paper is structured as follows. The first section sets out the conceptualisation of vulnerability at the workplace. The following section presents the empirical strategy to measure vulnerability to adverse working conditions, which begins by the introduction of the data used and then the design of the cumulative adverse working conditions indicator and ends with the presentation of our measure of vulnerability. The third section presents the results before concluding in the last section.

1. WIDENING THE CONCEPT OF VULNERABILITY TO ADVERSE 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 (World bank, 2000) 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 TUC¹ 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” (TUC, 2008). The concept of vulnerability is then used by different practitioners with definitions and assessment methodologies which depend on the overarching conceptual framework which is 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 analysis is mainly done from the perspective of poverty and applied to developing countries (Hoddinott & Quisumbing, 2010; Ligon & 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 while 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

¹ In 2007, the Trade Union Congress in the United Kingdom (TUC) set up a Commission on Vulnerable employment.

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, particularly 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 inequality, the last decades come with new risks at the workplace such as work intensification, job insecurity or mental strain, leading 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 (International Labour Organization) 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 programmes and are more at risk in economic downturns. This definition suffers from many limitations: some salaried workers might also carry high economic risk, and some self-employed workers might be quite well off and not vulnerable at all. It is relevant however in assessing employment vulnerability in developing countries. In line with this definition but considering other aspects of the work contract, another literature characterises some subpopulations as vulnerable when they are more likely to have precarious employment arrangements such as migrants or women (Costello & Freedland, 2014; Sargeant & Giovannone, 2011). A serious shortcoming of this definition 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 workers' well-being. The downside risk workers face is thus poverty and lack of protection rights. 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 & 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 years 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 the number of vulnerable workers. However, all workers are not equally vulnerable, and in particular, non-unionised workers are more exposed. Indeed, unions can protect from employment vulnerability by raising their members' awareness of employment rights and providing them with the resources to claim them (Pollert & Charlwood, 2009).

Concurrently to these arguments, Bewley & Forth (2010) highlight the distribution of power between employers and employees as a determinant of employment vulnerability. Patterns of dependence that increase the bargaining power of employers are thus expected to increase both the risk of adverse treatment and employees' vulnerability, whilst the opposite effect is expected with patterns of dependence that increase the bargaining power of employees. The hypothesis of power lacks 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 employment contract characteristics, the working conditions or the work itself.

While there are some attempts to conceptualise vulnerable employment, empirical evidence concentrates on a small number of risks with an *ex post* approach of vulnerability assessment. To the best of our knowledge, Bazillier et al. (2016) are the first to construct an employment vulnerability index relying on employer and job characteristics. Using the European Social Survey (2008), the employer dimension of the index is approached at the individual level with five variables, namely, type of organisation, establishment size, type of employment contract, type of employment relation and influence on organisational level policy decisions, when the job dimension encompasses the following three variables: occupation, supervising responsibilities and capacity to decide how the daily work is performed. Nonetheless, this index remains an *ex post* assessment of employees' vulnerability with limited coverage of adverse working conditions.

Overall, several employment vulnerability measures coexist in the literature, stressing different and relevant risks related with the characteristics of the employment relationship. We will depart from this literature from two main standpoints. First, our focus is on the work rather than the employment relationship, that is, on what occurs at the workplace in terms of adverse working conditions once a worker has signed his or her employment contract. Second, borrowing from the development literature, this paper relies on an *ex ante* approach to anticipate workers that are likely to face adverse working conditions in the future, conditional on individual-, employer- and job-related characteristics. The *ex ante* vulnerability assessment allows identifying employees at risk in advance and thus is an information source for policies targeting.

2. DATA AND EMPIRICAL FRAMEWORK

2.1. Data source

We rely on the five latest editions of EWCS²: 1995, 2000, 2005, 2010 and 2015 to identify workers facing adverse working conditions in 15 European countries. This survey is conducted at home (i.e., outside the workplace) and is questionnaire based. The population target is the working population, aged 15 years 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 samples per edition have the following sizes: 12,539 workers for 1995, 17,998 for 2000, 12,266 for 2005, 17,776 and 17,798 for 2010 and 2015 respectively.

In this paper, and to allow for time comparison, we include only countries that were surveyed on a regular basis since 1995, namely, Austria, Belgium, Denmark, Germany, Greece, Italy, Luxembourg, Spain, France, Ireland, the Netherlands, Portugal, the United Kingdom, Finland and Sweden. For issues of sample size in the development of our methodology, we have

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

³ Detail on the methodology and characteristics of the EWCS can be found at the Eurofound's website: <https://www.eurofound.europa.eu/>

aggregated Belgium with Luxembourg. As a result, EU-15 is decomposed into 14 national entities, and the acronym “BLu” refers to Belgium & Luxembourg⁴.

2.2. Designing an Adverse Working Conditions Index (AWCI)

Up to now Job quality measure initiatives by European policy-related institutes (Eurofound, 2012; Leschke & Watt, 2014) have focused on composite indicators based on the aggregation of a set of sub dimensions identified as those positive job features that “meet workers needs from work” (Eurofound 2012, p. 10). There has been some debate about whether a single overall index could synthesise all relevant information about job quality (Muños de Bustillo et al., 2011), but a consensus has emerged regarding the importance of jointly analysing an overall indicator along with its sub-dimensions. The common idea in these initiatives is that the quality dimension of the more and better jobs political agenda could be monitored thanks to such indexes. If we agree with the fact that a single employment measure is not sufficient and that quality also needs to be monitored, we argue that it is better to target the low end of the quality scale rather an average quality level. Indeed, policy action should be taken primarily at the low end, where individual and collective costs are the highest. This is why, we are first going to identify the work related disamenities that can be considered as risk exposures for individuals. Second, we further argue that when targeting the low end, it is of great importance to monitor the cumulative risk exposure. Indeed, if an average overall job quality index could be an inefficient policy guide because of its difficult interpretation, we know without ambiguity that cumulative risk exposure requires public intervention. Of course, this argument does not mean that it is of no interest to follow up in detail every type of risk exposure. This is certainly useful to analyse mechanisms by which a given individual could come to face a combination of work-related risk.

Two additional reasons strengthen the relevance of a focus on cumulative risk exposure. First, it is very likely that the outcome of cumulative risk exposure is not the sum of the exposure to each individual risk. The literature provides evidence of the harmful impact of the cumulative exposure over time to a given risk (Fletcher et al., 2011). However, when the same risk occurs over time, individuals can develop coping strategies, which act as a shelter and play a mediating or moderating role. When the risks happen all at once, it is much more difficult to develop individual strategies to alleviate it. From a theoretical standpoint, such a mechanism is at the heart of the famous job demand and job control model (Karasek, 1979). The model points to a *relative excess* interaction between high job demand and low job control, which is empirically identified through interaction terms introduced in regressions. Furthermore, research on job types (Holman, 2013; Széker et al., 2017) highlight many job configurations where a negative amenity is partly balanced by a positive one. The compensation mechanism between wages and job disamenities has been widely discussed in the economic literature, but compensation effects between non-wage features of jobs are lesser known. In this respect also, cumulative risk exposure is a clear-cut situation as compared to the exposure to any single type of risk.

Second, the joint impact of technological progress, globalisation and migrations in the EU could exacerbate work-related cumulative risk exposures, calling for particular attention from public authorities. Indeed, these three major transformations are sources of contradictions and paradoxes between old and new processes and blur the boundaries among work, home

⁴ Belgium and Luxembourg present a very high level of similarity regarding working conditions as highlighted by Green (2006) relying on the same data source. The two countries have been merged to form a single entity mainly because of the small sample size of Luxembourg.

and communities. This may translate into uncontrolled hybrid forms or work organisations and tensions at the individual level like push-pull dilemmas or clashes of principles and actions (Mazmanian et al., 2013; Putnam et al., 2016) that are sources of cumulative risk exposure. Such a surge in occupational risks and hazards has been put in relation with the diffusion of high performance work practices in the US (Askenazy, 2001) and in France (Askenazy & Caroli, 2010).

2.2.1. The AWCI sub-components

In designing our *AWCI*, we retain the components that reflect the main risks that could occur at the workplace and that are measured in the same way throughout the five editions of the EWCS. The *AWCI* compiles five sub-indices that capture different threats to employees' well-being, health and skills development, 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 of the working environment are identified by the empirical literature as affecting workers' welfare (Green et al., 2013; Greenan et al., 2014). 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 another. Therefore, purpose of time and country comparison limits 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 follows⁵:

- 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 includes 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. They also generate occupational health and safety risks. The wage-risk trade-off has been used to compute the statistical value of risks to life and health (Viscusi, 1993). Cottini and Lucifora (2013) also provide evidence using the EWCS over the 1995-2005 period that adverse physical work environments go with a higher probability of workers reporting mental health problems at the workplace.

- Adverse social climate or workplace violence indicator (6 questions): It is represented by perceived cases of discrimination such as those related to age, sexual orientations, ethnicity, disability, nationality or exposition to unwanted sexual attention. The meta-analysis by Pascoe & Smart Richman (2009) show that perceived discrimination has a significant negative effect on mental and physical health as it both produces significantly higher stress responses and interacts with either the participation in unhealthy behaviours or the non-participation in healthy ones.

- 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 shown 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:

⁵ A detailed description of the questions used is provided in the Appendix A1.

disturbed body clock, shortened and disturbed sleep and disturbed family and social life (Tucker & Folkard, 2012).

- 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 workers to perform their tasks. 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. Cottini and Lucifora (2013) find that job demands are more strongly associated with workers' mental health problems than adverse physical work environments. Green et al. (2016) find that high work intensity is associated with low job-related well-being in Britain using data covering 2001, 2006 and 2012. Furthermore, they show that 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 diseases 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.

2.2.2. 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 issues⁶. There is no single way of composition and each method has its pros and cons, as summarised by Nardo et al. (2008). The structuring steps are nevertheless the same and can be grouped in three stages: normalisation, weighting and aggregation.

First, and to construct a composite indicator of adverse working conditions, the multiple response items from the EWCS are recoded to respect the following rule: the higher is the

⁶ Two limitations have to be considered when interpreting the results of any composite indicator: (i) they may vary according to the dimensions included in the indicator and (ii) the dimensions that are the most impactful in each circumstance are not assessed.

value, the more adverse are the working conditions. The lower grade corresponds therefore to the best working conditions while the higher grade is synonymous with 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 (see Decancq & 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 depend 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 summed. 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 backgrounds. The second strategy is data-driven. We use a principal component analysis to capture each type of risk, considering that it is a latent variable that 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 42%, 34%, 49% and 42% 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 14% of total variance. The first factor represents high intensity driven by technical constraints when the second factor represents high intensity driven by market forces⁷. The high intensity index totals the two factors once standardised. We use this second composite indicator in robustness checks. It is referred to as (*AWCI_{pca}*) throughout the paper.

2.3. Measuring vulnerability to adverse working conditions

⁷ This result on the two independent sources of work intensity is also found by Greenan et al. (2014).

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 workers' well-being. Although complementary to previous works on employment vulnerability, our approach is different. It is an attempt to encompass the multidimensional aspects of quality of working life 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, vulnerability is quantified by considering the probability for workers to face adverse working conditions in the future - that is, having predicted adverse working conditions above a predefined threshold - conditional on their individual characteristics and on that of their employers and of their jobs. The probability can be stated as follows:

$$v_{it} = \Pr (AWCI_{i,t+1} > z_t) \quad (1)$$

where $AWCI_{i,t+1}$ is the value of adverse working conditions at time $t + 1$ for worker i and z_t is the threshold of a socially acceptable level of exposure to adverse working conditions. Because $AWCI_{i,t+1}$ is not directly observable, this approach requires making predictions about the employees' future exposure. Therefore, this estimation of vulnerability requires the estimation of the underlying distribution of adverse working conditions, not just the expected (i.e., mean) exposure looking forward but also its variability (i.e., variance, from an inter-temporal perspective).

In the present work, this probability is modelled using pseudo-panel data. Indeed, when genuine panel data are not available, repeated cross-sectional surveys may offer an alternative that allows for unbiased estimates by using pseudo-panel techniques, as pioneered by Deaton (1985). Pseudo-panel comprises grouping individuals into cohorts⁸, which we are able to follow over time making use of all the cross-sectional information available at a point in time. In this paper, the used grouping variables⁹ are sex, age group (5 groups of 10 years span) and country (14 in our sample). The grouping leads to 140 cohorts¹⁰ (2x5x14), which we track over the five used editions of the EWCS (700 observations in total). The individual observations of the selected variables are averaged over cohorts leading to an equation expressed in terms of cohort-weighted means (i.e., taking into account survey weights), which then becomes the units of observation in the pseudo-panel. To obtain an estimate of the future state of adverse working conditions, we begin by specifying their determinants as their changes condition the future expectations of adverse working conditions. Accordingly, the first step comprises modelling the adverse working conditions in logarithm¹¹ as follows:

$$\ln AWCI_{c,t} = X_{c,t}\beta + \alpha_c + \delta_t + \varepsilon_{c,t} \quad (2)$$

where $AWCI_{c,t}$ is the averaged adverse working conditions index of cohort c at time t . α_c represents the cohort fixed effects. δ_t captures the time effect. $X_{c,t}$ are the means¹² of the

⁸ To obtain consistent estimators from a pseudo-panel, grouping variables should not present missing values for any individual in the sample and should be time invariant and exogenous (Verbeek, 2008).

⁹ 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 do Duval-Hernandez & Orraca (2009) who use birth year, sex and educational attainment or Arestoff & Djemai (2016) who use birth year and country.

¹⁰ Table 1 in Appendix A.2 reports the number of individuals per country-cohort.

¹¹ The indicator of adverse working conditions is normally distributed as illustrated by Figure 1 in Appendix A.2.

¹² A weighting adjustment is made in the computation of each cohort mean.

individual characteristics in each cohort, including socio-demographic background¹³ (a quadratic form of age, living with a partner, number of children, contribution to the household income), jobs' features (occupation, employment status and employment contract nature) and employers' attributes (company ownership, workplace size and sector of activity)¹⁴. $\varepsilon_{c,t}$ is a time-varying idiosyncratic disturbance, which captures unobservable shocks.

This econometric model allows to correct for potential biases. Indeed, averaging variables over the cohorts allows eliminating the unobserved individual heterogeneity within each cohort such as the differing abilities or motivations across individual when year and cohort fixed effects allows correcting respectively for differing economic situation over time and for invariant unobserved cohort heterogeneity. One potential source of bias that may be reduced this way is the one related to the fact that the people in employment who are targeted by the survey have unobserved characteristics that may differentiate them from the unemployed while being related with vulnerability to adverse working conditions¹⁵.

In estimating this equation, we are not interested in the assessment of the marginal effects *per se*, but using this assessment, we want to create an estimate of the expected level of exposure to adverse working conditions. 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 $\varepsilon_{c,t}$ is a zero mean disturbance term. The expected exposure to adverse working conditions are thus given by $E[\ln AWCI_{c,t}] = \hat{\beta}X_{ct} + \hat{\alpha}_c + \hat{\delta}_t$.

From (Equation 1), employees' vulnerability to adverse working conditions depends, not just on their expected (i.e., mean) exposure looking forward but also on their variability (i.e., variance, from an inter-temporal perspective). Therefore, to go from an estimate of adverse working conditions to a measure of employees' vulnerability, we need to estimate the variance of their future exposure to adverse working conditions. Within the context of cross-sectional data, the disturbance term is interpreted as the intertemporal variance of exposure to adverse working conditions. Viewed from this perspective, the assumption that the variance of exposure to adverse working conditions is the same for all employees (i.e., the underlying assumption of homoscedasticity) appears quite restrictive. Further, unlike in other settings 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. A biased estimate of this parameter will lead to a biased estimate of vulnerability (Chaudhuri, 2003). With pseudo-panel data, we are able to obtain empirical estimates of the adverse working conditions variance, computed as the average squared deviation of observed working conditions from expected ones: $Var[\ln AWCI_{c,t} | X_{c,t}\hat{\beta}, \hat{\alpha}_c, \hat{\delta}_t] = \hat{\sigma}_c^2$. The variance estimated through this procedure takes into consideration the average of both individual and job characteristics since it conditions expected adverse working conditions.

Once the moments of the distribution of exposure to cumulative adverse working conditions are estimated, the next step is to determine the exposure threshold above which a cohort is considered vulnerable. An absolute reference would be of great interest to policy makers and

¹³ An important variable is missing from the set of socio-demographic variable, namely the immigrant status as this information is only available in the two last editions of the EWCS. This variable is strongly related to adverse working conditions, especially to work-related discriminations and harassments.

¹⁴ Table 2 in the Appendix A.2 presents some descriptive statistics of the main variables used for the entire sample and by country.

¹⁵ We thank one of our referees for pointing this argument.

different stakeholders as it would facilitate the implementation of targeted policy actions to protect workers. While defining such benchmark for monetary outcomes or for tangibles assets is quite straightforward, the task is more challenging for working conditions because of the multidimensionality of the concept. Furthermore, the regulation of employment relationships and working conditions is continuously evolving both at the EU and the national levels. Social partners (including unions and their representatives, employers and management) must build consensus to gain commitment from all involved to reach an agreement on an acceptable level of working conditions' disamenities. The benchmark may hence be constructed in accordance with these minimum standards. In the absence of such consensus, we opt in this research for a relative and time-varying threshold, determined for each cohort and each year as the European median of the adverse working conditions index. Such a choice puts the focus on the distance of each cohort to a common European benchmark for each time period. This approach has the advantage of defining vulnerable groups with respect to the prevailing regulation of working conditions in each time period at the EU level. As a robustness check, we also use a time-invariant threshold provided for each cohort by the EU-15 median over the five survey editions of our index¹⁶.

Once the two moments of the distribution of the adverse working conditions index are estimated, we can provide a measure of vulnerability, approximated by the probability to have a level of cumulative adverse working conditions above the threshold z_t :

$$\phi \left[\frac{\ln z_t - E[\ln AWCI_{c,t} | X_{c,t}, \hat{\beta}, \hat{\alpha}_c, \hat{\delta}_c]}{\sqrt{Var[\ln AWCI_{c,t} | X_{c,t}, \hat{\beta}, \hat{\alpha}_c, \hat{\delta}_c]}} \right] \quad (3)$$

where ϕ is the normal cumulative distribution function.

3. ESTIMATION AND ANALYSIS OF VULNERABILITY

3.1. Descriptive statistics for AWCI

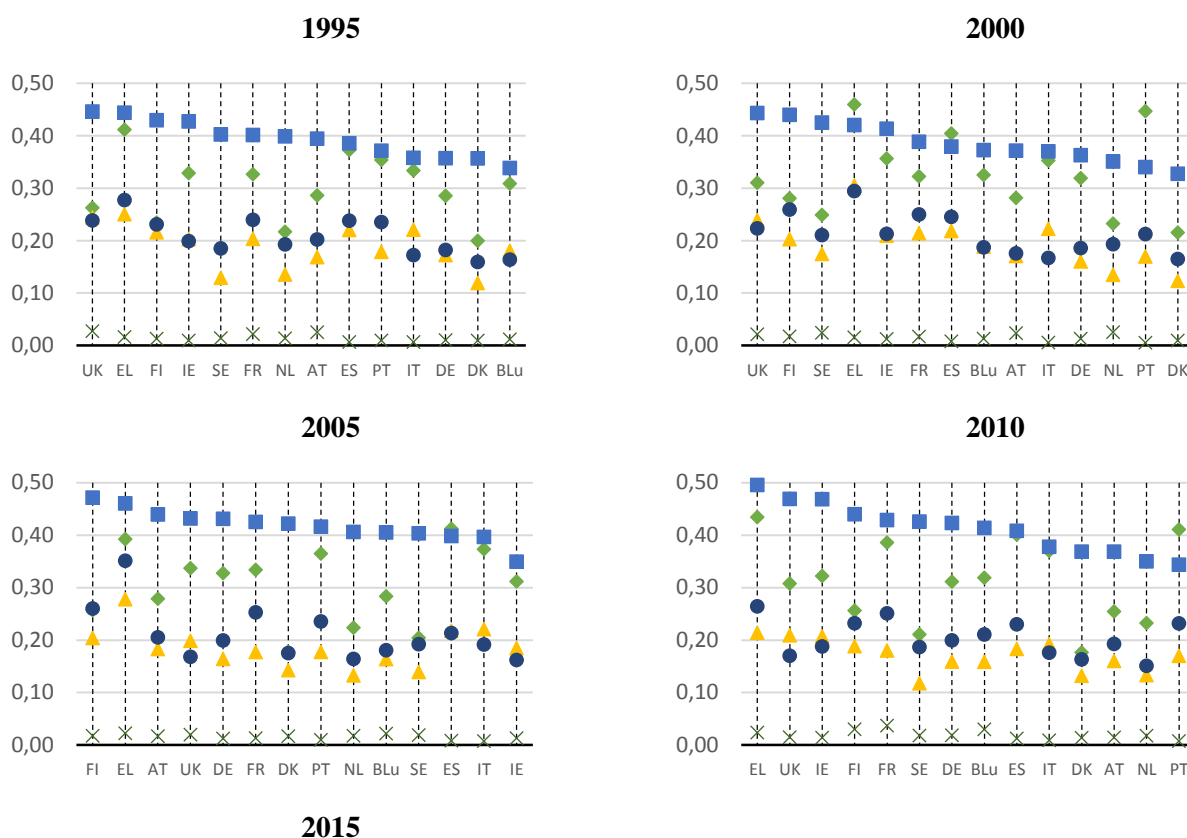
Figure 1 displays the average value of each sub-indicator used in computing the adverse working conditions indicator by survey edition and by country. At first sight, we can note that a common threatening risk in almost all the countries is high work intensity. While the time trend is upward since the 1990s with the highest value recorded in both 2010 and 2015 for Greece and in 2005 for Finland, we observe a cyclical pattern for some countries with rises and falls in the level of work intensity. Such pattern is clearly observed in Denmark, France, Ireland, the Netherlands, Portugal or Austria. Along with high work intensity, the second major workplace risk is low work complexity. Regarding this component, two groups of countries stand out: countries with high incidence of low work complexity on the one side such as Spain, Greece and Italy and on the other side the Nordic countries and the Netherlands where low work complexity is not prevalent. Germany, France, the United Kingdom and Portugal stand in between with relatively high but time varying levels of low work complexity. The distribution of the remaining risks appears more homogeneous across countries and over time. For instance, and surprisingly, the quality of the physical working environment has not improved much since 1995. Similarly, the prevalence of atypical

¹⁶ We thank one of our referees for valuable comments regarding the benchmark definition of adverse working conditions.

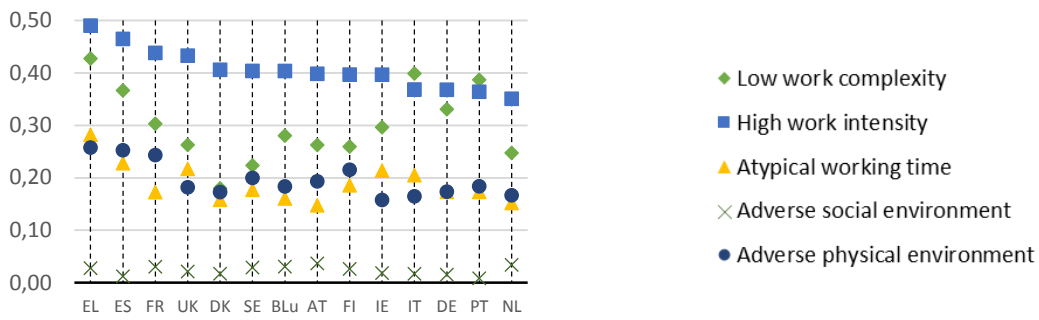
working hours among workers is somehow identical across European countries and from one year to another. Finally, and even if the adverse social climate represents a very marginal risk in comparison with the other risks, Figure 1 shows an increasing perception of social discrimination in some countries such as France, Finland, Sweden, Austria, the Netherlands, Belgium, Luxembourg and Greece.

Turning to the adverse working conditions index, Table 1 reports some descriptive statistics per survey year and country¹⁷. The global trend shows an increase in 2000 compared with 1995 and a smaller increase in 2010 compared with 2005. This suggests that working conditions worsen in economic booms as well as in recessions. However, if we look at country averages, we find a rise in adverse working conditions in almost all countries in 2000, but this is not the case in 2010, as working conditions get worse in only four national entities: Belgium & Luxembourg, France, Ireland and the United Kingdom. In every country, the composite indicator shows a normal distribution, more or less skewed to the right depending on the year and the country considered (see Figure 1 in Appendix A.2).

Figure 1. Average sub-indices per country and per survey edition



¹⁷ Table 3 in the Appendix A.2 reports descriptive statistics of the $AWCI_{pca}$ per survey year and country.



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

Table 1. Descriptive statistics of adverse working conditions per survey edition and country

	1995		2000		2005		2010		2015	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
BLu	1.003	0.475	1.086	0.471	1.053	0.477	1.131	0.484	1.057	0.464
DK	0.844	0.421	0.840	0.396	0.933	0.425	0.853	0.420	0.932	0.400
DE	1.007	0.498	1.041	0.484	1.133	0.495	1.110	0.484	1.059	0.474
EL	1.399	0.531	1.494	0.493	1.503	0.558	1.431	0.553	1.483	0.478
IT	1.091	0.442	1.118	0.448	1.188	0.463	1.124	0.436	1.152	0.468
ES	1.223	0.492	1.255	0.480	1.249	0.486	1.234	0.475	1.323	0.514
FR	1.192	0.515	1.192	0.502	1.201	0.497	1.281	0.564	1.186	0.514
IE	1.167	0.475	1.204	0.488	1.020	0.459	1.199	0.490	1.081	0.481
NL	0.957	0.458	0.936	0.446	0.943	0.431	0.883	0.410	0.949	0.451
PT	1.148	0.480	1.174	0.458	1.202	0.460	1.163	0.465	1.115	0.422
UK	1.219	0.505	1.237	0.519	1.154	0.479	1.170	0.502	1.114	0.481
FI	1.123	0.473	1.200	0.473	1.209	0.471	1.145	0.466	1.082	0.458
SE	0.914	0.453	1.083	0.448	0.957	0.403	0.958	0.402	1.032	0.461
AT	1.076	0.487	1.023	0.510	1.122	0.531	0.989	0.481	1.037	0.514
All	1.083	0.497	1.136	0.497	1.128	0.495	1.134	0.502	1.126	0.494

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

3.2. Vulnerability measure

Our measure of vulnerability to adverse working conditions follows the different steps recalled in section 2.3. Accordingly, we begin by estimating the expected mean and variance of adverse working conditions relying on Equation (2). Then, in a second step, the vulnerability measure is obtained by computing the likelihood of an expected level of the adverse working conditions index being above a predefined threshold (Equation (3)).

3.2.1 Predicting exposure to adverse working conditions

Table 2 presents the results from the weighted least-squares estimation using the pseudo-panel¹⁸. Columns 2-5 display the result of the estimation of Equation (2) where the dependent variable is the logarithm of our adverse working conditions index. To check the result sensitivity to the methodology used to construct this indicator, we report in column 2-3 the results obtained from the *AWCI* indicator and in column 4-5 the results from the *AWCI_{pca}* indicator. Overall, the results are convergent regardless of how the indicator is designed. The remainder of the paper is based on the use of the *AWCI* indicator.

¹⁸ Table 4 in Appendix A.2 displays the pseudo panel regression without fixed (*i.e.* cohort and time) effects and without the correction of measurement errors in variables allowed by the modified within estimator of Verbeek & Nijman (1993).

Table 2. Fixed effect model of the Adverse Working Conditions Index

Variables	AWCI (1)		AWCI _{pca} (2)		
	(1)	(2)	(3)	(4)	(5)
Age	-0.0231	(0.019)	0.0010	(0.019)	
Age-squared	0.0127	(0.018)	-0.0074	(0.018)	
Living with a partner	-0.0081	(0.046)	-0.0319	(0.045)	
Main breadwinner	0.1149***	(0.040)	0.1132***	(0.039)	
Number of children under 15, reference None					
One child	-0.0272	(0.054)	-0.0708	(0.053)	
2 children	0.1308*	(0.076)	0.1267*	(0.074)	
3 children	-0.3423**	(0.160)	-0.3436**	(0.158)	
4 or more children	-0.0864	(0.277)	-0.0596	(0.272)	
Employment status, reference Employed					
Self-employed	-0.1521	(0.156)	-0.1296	(0.153)	
Other	-0.0986	(0.118)	-0.1367	(0.116)	
Employment contract, reference Unlimited employment contract					
Fixed-term contract	0.1680***	(0.054)	0.1005*	(0.053)	
Temporary employment agency contract	-0.0084	(0.102)	-0.0859	(0.101)	
Apprenticeship or other training	-0.3969***	(0.144)	-0.3142**	(0.142)	
Other	-0.2026***	(0.051)	-0.1240**	(0.050)	
Tenure	0.0024	(0.002)	0.0013	(0.002)	
Occupation, reference Legislators, senior officials and managers					
Professionals	-0.3001***	(0.082)	-0.3133***	(0.081)	
Technicians and associate professionals	-0.2584***	(0.082)	-0.2594***	(0.081)	
Clerks	-0.1327	(0.091)	-0.2034**	(0.089)	
Service workers/shop and market sellers	0.0406	(0.080)	0.0010	(0.078)	
Skilled agricultural and fishery worker	0.1530	(0.116)	0.1612	(0.114)	
Craft and related trade workers	0.2228**	(0.089)	0.1565*	(0.087)	
Plant and machine operators and assembly workers	0.3058***	(0.098)	0.1990**	(0.096)	
Elementary occupations	0.0256	(0.084)	-0.0058	(0.083)	
Armed forces	0.9424***	(0.247)	0.7829***	(0.243)	
Company ownership, reference Private					
Public	-0.1625***	(0.049)	-0.1369***	(0.048)	
Other	0.1408**	(0.064)	0.0609	(0.063)	
Workplace size, reference 50-499 employees					
1 employee	0.0532	(0.070)	0.0370	(0.068)	
2-9 employees	-0.0346	(0.050)	-0.0357	(0.049)	
50-499 employees	0.0107	(0.047)	0.0243	(0.046)	
500 or more employees	0.0827	(0.053)	0.0906*	(0.052)	
Sector, reference Industry					
Agriculture, hunting, forestry and fishing	0.0230	(0.063)	0.0463	(0.062)	
Services (excluding public administration)	0.0917**	(0.042)	0.1450***	(0.041)	
Public administration and defence; compulsory social sector	0.1033*	(0.057)	0.1295**	(0.056)	
Other services	0.1213**	(0.049)	0.1634***	(0.049)	
Year fixed effect	YES		YES		
Cohort fixed effect	YES		YES		
R2(Within)	0.34		0.31		
Number of cohorts	700		700		

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

First, being the main contributor to the household's income increases the risk of adverse working conditions. Being more reliant on their jobs, the main breadwinners could bear more risks than workers without such responsibility. Having two children also increases risk exposure compared with workers who are not parents. However, the relationship of *AWCI* with the number of children is non-linear. Exposure to adverse working conditions is the lowest for workers with three children and the highest for workers with two children. Risk exposure is comparable when workers have no children, one child or four or more children. When these variables are taken into account, marital status has no influence on the *AWCI*. If we now turn to the employment contract characteristics, we see that self-employed are less exposed to adverse working conditions compared with employees, but the estimated coefficient is non-significant. Furthermore, employees under fixed-term contracts are more exposed to adverse working conditions than employees under permanent contract, and individuals in apprenticeship or training situation bear the lowest risks. We do not find any significant relationship between tenure and exposure to adverse working conditions. As far as the occupational status is concerned, armed forces bear the highest risk of exposure to cumulative workplace risk, followed by skilled blue-collar workers (craft and related trade workers and plant and machine operators and assembly workers). Elementary occupations and service workers and sellers have the same level of exposure as legislator, senior officials and managers, while clerks, technicians and professionals are less exposed. Finally, company ownership and sector have an influence on *AWCI*, but the relationship with workplace size is non-significant. More precisely, workers from service activities in the business sector are more exposed than public sector employees or employees in the manufacturing industry.

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. Pseudo-panels allow addressing some shortcomings linked to repeated cross sectional, notably by allowing for fixed effects and for unbiased estimates of the variance-covariance matrix. However, it also yields a number of econometric issues that we overcome as follows. First, since five observations are available for each cohort (corresponding to the five used editions of EWCS), the cohort aggregates are considered as error-ridden measurements of the true cohort population. Verbeek & Nijman (1993) propose an estimator¹⁹ that does not suffer from inconsistency due to a small number of time periods and which is based on a parametric specification of the measurement error and its correlation with the variable of interest. Second, the average of individual observations per cohort used in pseudo-panel estimations has the drawback of depending on a varying number of individuals from one cohort to another as well as on 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 of weighting each cohort with the number of observations in each cohort (Warunsiri & Mcnown, 2010; Arestoff & Djemai, 2016)

¹⁹ 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. Verbeek & Nijman (1993) propose a modified estimator of Deaton to achieve consistency when the number of individuals per cohort is small and/or the number of time periods is small.

3.2.2 Cohort vulnerability to adverse working conditions

Based on the methodology outlined above, we construct estimates of cohort vulnerability to adverse working conditions. Accordingly, observed cumulative exposure to adverse working conditions for each cohort is compared to the EU-15 median in the corresponding year²⁰. Alternatively, and in order to test the sensitivity of our vulnerability measure to the threshold definition, we also use a time invariant threshold represented, for each cohort, by the European median of our index over the five editions of the survey²¹. The results are convergent and the differences, on average, are not significant²². Table 3 reports the average vulnerability as well as its standard deviations per country and per survey edition while Figure 2 ranks the average vulnerability of European countries per survey edition.

Table 3. Average vulnerability per country and per survey edition

	1995		2000		2005		2010		2015	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
BLu	0.36	0.04	0.38	0.04	0.39	0.06	0.39	0.02	0.40	0.04
DK	0.16	0.11	0.17	0.11	0.24	0.09	0.19	0.10	0.27	0.08
DE	0.31	0.06	0.32	0.06	0.38	0.05	0.34	0.06	0.36	0.08
EL	0.58	0.02	0.60	0.04	0.59	0.03	0.55	0.03	0.60	0.02
IT	0.45	0.02	0.45	0.03	0.48	0.01	0.46	0.02	0.48	0.03
ES	0.51	0.03	0.53	0.03	0.53	0.03	0.50	0.03	0.54	0.02
FR	0.48	0.02	0.48	0.02	0.49	0.03	0.50	0.03	0.50	0.02
IE	0.42	0.03	0.45	0.04	0.40	0.04	0.42	0.04	0.43	0.03
NL	0.21	0.08	0.20	0.07	0.24	0.07	0.18	0.08	0.26	0.08
PT	0.44	0.04	0.47	0.05	0.48	0.06	0.45	0.05	0.46	0.07
UK	0.45	0.02	0.47	0.04	0.45	0.02	0.45	0.03	0.46	0.04
FI	0.45	0.04	0.45	0.03	0.47	0.05	0.47	0.06	0.45	0.08
SE	0.34	0.11	0.39	0.06	0.39	0.05	0.38	0.07	0.40	0.07
AT	0.36	0.08	0.31	0.09	0.36	0.09	0.29	0.09	0.33	0.06
All	0.40	0.12	0.41	0.13	0.42	0.11	0.40	0.12	0.42	0.11

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

These results denote a great heterogeneity in the level of work-related risks across European countries. Overall, several general trends can be detected. First, for almost all countries, vulnerability increased from 1995 to 2005 before declining until 2010. This trend can be explained by the destruction, in the early stage of a recession, of the jobs most heavily exposed to work-related risks. This may have happened during the crisis of the early 1990s and again in the end of the first decade of the millennium. In 2015, we observe a general increase of the level of vulnerability except in countries such as Finland where the average vulnerability has in contrast

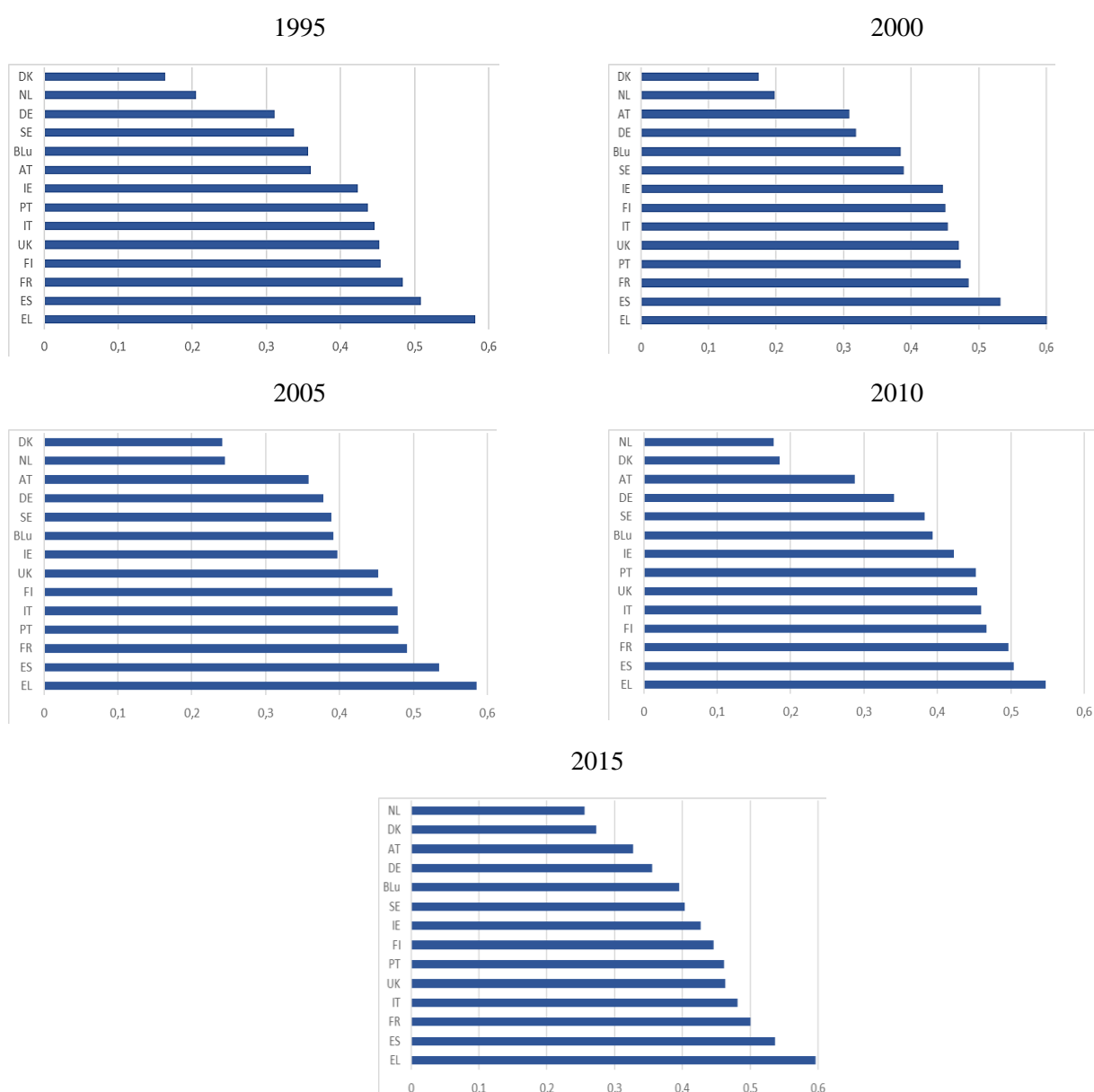
²⁰ Table 5 in Appendix A.2 reports the thresholds used to calculate the vulnerability measure for each cohort.

²¹ Figure 2 in Appendix A.2 provides the distribution of the vulnerability measure calculated respectively with a time variant threshold (i.e. for each cohort yearly EU-15 median of observed adverse working conditions) and a time-invariant one (i.e. for each cohort EU-15 median of observed adverse working conditions over the five survey editions).

²² Table 6 in Appendix A.2 compares the average vulnerability by country and year using the time varying and the time invariant thresholds.

decreased. Second, we find that Greece has the highest average level of vulnerability in all the survey editions, denoting a great divergence from the European median. Denmark and the Netherlands, in contrast have the lowest level of vulnerability denoting a working environment, on average, less risky than the European median level. Finally, we identify a class of countries with higher and constant average level of vulnerability in comparison with overall average value of vulnerability in each survey edition. For instance, the average vulnerability in 1995 is 0.40. Three countries are far above this average, namely, Greece (0.58), Spain (0.51) and France (0.48). The most striking observation when considering this set of countries is the high and constant level of vulnerability both in comparison with the average vulnerability of each survey edition and in comparison with the average vulnerability in other countries. Portugal, Italy, the UK and Finland are the next closest group of countries, the UK and Finland being characterised, similar to Spain in the first group, by larger time variations.

Figure 2. Average vulnerability per country and per survey edition

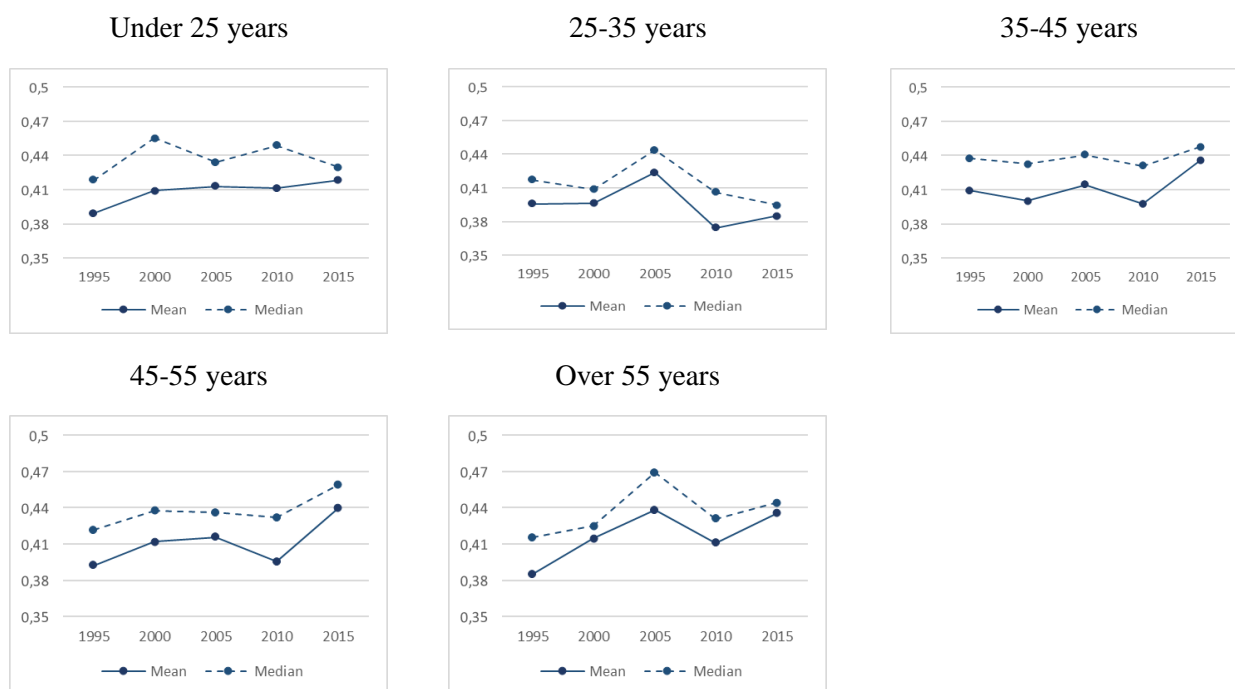


Note: Country abbreviation: Greece (EL), Spain (ES), United Kingdom (UK), France (Fr), Ireland (IE), Portugal (PT), Finland (FI), Italy (IT), Austria (AT), Germany (DE), Belgium & Luxembourg (BLu), Netherland (NL), Sweden (SE), Denmark (DK)

These differences could reflect the disparities between countries in terms of sectoral structuring as well as in terms of work and employment practices of employers. Indeed, such factors could contribute to reducing or widening differences in working environments and work-related risks across European countries. Institutional differences are also often noted as potential drivers of working conditions divergence across European States (Esping-Andersen, 1990; Gallie, 2007). Nonetheless, the traditional grouping of countries in this literature does not fully work out in the context of our study. If it applies for countries such as Denmark, Sweden, Greece or Spain, specific patterns are found for other countries such as Finland, Italy or Portugal. In terms of vulnerability to adverse working conditions, Finland appears to be an exception in the social democratic regime known for protecting the quality of jobs. Compared to other Southern European countries, Italy and Portugal record a lower average vulnerability to adverse working conditions than Spain, Greece or France.

Two employee characteristics that have been extensively investigated as enhancing risks at the workplace are sex and age. Beginning with the age effect, Figure 3²³ depicts the mean and the median value of vulnerability per age category in each survey edition.

Figure 3. Average vulnerability per age category



²³ Figure 3 in the Appendix A.2 plots the average vulnerability by age-group and by survey edition for each country.

Figure 4. Average vulnerability by sex



Our results highlight that for the youngest age group, average vulnerability has been steadily increasing over the years. Except for this age group, a decline in average vulnerability is observed between 2005 and 2010, which can be related to the destruction of the most precarious jobs in the early stage of the crisis. Vulnerability is globally increasing between 1995 and 2015 for cohorts over 35 years of age that reach a similar level of vulnerability in 2015. Workers over 55 had the lowest average vulnerability compared with other age groups in 1995. Vulnerability then increased steeply until 2005 and increased again between 2010 and 2015. The vulnerability increase is more moderate for 45-55 until 2005, but it is much steeper after 2010. A similar profile holds for 35-45, except between 1995 and 2000 when average vulnerability decreases. Finally, average vulnerability decreases slightly overall between 1995 and 2015 for the cohorts aged 25-35 with an increase until 2005 followed by a sharp decrease between 2005 and 2010.

Turning to the distribution of vulnerability by sex, Figure 4²⁴ compares time evolution between men and women. On average, women are more vulnerable to adverse working conditions than men in all survey editions. However, the median probabilities of vulnerability are almost identical for men and women, varying between 0.42 and 0.44. The time trends are also similar with a surge of vulnerability from 1995 to 2005 and from 2010 to 2015. Nonetheless, the overall increase is much greater for men than for women.

3.4. Who is vulnerable to adverse working conditions?

Stakeholders and public authorities may wish to specifically target vulnerable groups, so it is important to be able to identify the characteristics that condition or are symptomatic of vulnerability. We distinguish occupations, employer type and sectors as these categories are associated with actors that have an influence on setting minimum standards of employee protection or directly contribute to shaping organisation and work designs. We also consider the characteristics of employment relationships as they are affected by employment policies.

3.4.1 Characteristics of vulnerable and non-vulnerable cohorts

To this end, we provide in Table 4 the sample characteristics of cohorts that are classified as vulnerable versus those that are not classified as such. A cohort is considered as vulnerable when its likelihood of exceeding the EU-15 average is greater than 0.50, which corresponds to an equal chance of facing adverse working conditions.

²⁴ Figure 4 in the Appendix A.2 graphs the average vulnerability for male and female by survey edition for each country.

Table 4. Share and characteristics of vulnerable groups versus non-vulnerable groups, threshold of 0.50

	Non-vulnerable	Vulnerable	Pmean
1995	85.7	14.3	-
2000	78.6	21.4	-
2005	77.9	22.1	-
2010	80.0	20.0	-
2015	75.7	24.3	-
<i>Living with a partner</i>	0.64	0.60	0.17
<i>Main breadwinner</i>	0.61	0.59	0.35
<i>Employment status</i>			
Self-employed	0.12	0.20	0.00
Employed	0.86	0.79	0.00
<i>Employment contract</i>			
Unlimited employment contract	0.67	0.52	0.00
Fixed-term contract	0.10	0.13	0.00
Temporary employment agency contract	0.02	0.02	0.37
Apprenticeship or other training	0.02	0.01	0.17
<i>Tenure</i>	10.16	10.75	0.41
<i>Occupation</i>			
Legislators, senior officials and manager	0.08	0.07	0.02
Professionals	0.16	0.12	0.00
Technicians and associate professionals	0.15	0.10	0.00
Clerks	0.13	0.11	0.04
Service workers/shop and market sellers	0.16	0.19	0.02
Skilled agricultural and fishery worker	0.02	0.07	0.00
Craft and related trade workers	0.12	0.14	0.03
Plant and machine operators and assembly workers	0.07	0.08	0.34
Elementary occupations	0.10	0.12	0.02
Armed forces	0.01	0.01	0.19
<i>Company ownership</i>			
Public	0.26	0.20	0.00
Private	0.72	0.75	0.03
<i>Workplace size</i>			
1 employee	0.07	0.13	0.00
2-9 employees	0.24	0.33	0.00
10-49 employees	0.28	0.25	0.02
50-499 employees	0.26	0.21	0.00
500 or more employees	0.15	0.09	0.00
<i>Sector</i>			
Agriculture, hunting, forestry and fishing	0.09	0.12	0.08
Industry	0.24	0.22	0.15
Services (excluding public administration)	0.39	0.41	0.27
Public administration and defence; compulsory social sector	0.10	0.08	0.05

The first part of Table 4 gives the resulting share of vulnerable and non-vulnerable cohorts in each survey edition. We observe that this share has increased from 14.3% in 1995 to 24.3% in 2015. This growth has been rapid between 1995 and 2000 and again between 2010 and 2015. Relying on an independent samples *t-test*²⁵, we compare the means and medians of vulnerability determinants for both vulnerable and non-vulnerable groups assuming an unequal variance between the two groups.

Employment contract conditions make a clear difference in terms of vulnerability. For instance, on average, 67% of employees have a permanent contract in the non-vulnerable group, while this figure reaches 52% only in the vulnerable group. Conversely, and unsurprisingly, fixed-term contract is more often associated with vulnerability as the significant mean difference between the two groups of cohorts illustrates it: on average, 13% of workers in vulnerable cohorts work on a fixed contract versus 10% in non-vulnerable ones. These first results are in line with the results we found when analysing the determinants of our adverse working conditions indicator. We had also found that self-employed were less exposed to adverse working conditions than employees, although the result was not statistically significant. Vulnerable cohorts are however more often self-employed (20%) than non-vulnerable cohorts (12%). An interpretation for this difference is that if the working conditions of self-employed are less adverse on average, they are also more uncertain, and the likelihood that exposure to adverse working conditions will fall below the European average is not negligible.

Occupation is another critical determinant of both the type of working conditions and vulnerability. Non-vulnerable cohorts have significantly higher shares of higher occupational status groups such as managers, professionals and technicians and lower shares of lower occupational status groups than vulnerable cohorts. However, within the middling and unskilled occupations, the groups that are the most exposed to adverse working conditions are not the most vulnerable except for craft and trade related workers. Armed forces, plant and machine operators and assembly workers are evenly distributed between the vulnerable and non-vulnerable cohorts. Skilled agriculture and fishery workers, service and sales workers and elementary occupation, whose exposure to adverse working conditions is intermediate, are more represented in vulnerable cohorts (respectively 7%, 19% and 12%) than in non-vulnerable ones (respectively 2%, 16% and 10%).

Finally, employer characteristics play a clear role. Exposure to adverse working conditions and vulnerability relate in a similar way to company ownership: public sector employees are less exposed than private sector ones to adverse working conditions, and they are less vulnerable on average. Sector is a strong determinant of exposure to adverse working conditions while workplace size has no significant impact. We find the opposite result in terms of vulnerability. Small size workplaces represent a significantly higher share of vulnerable cohorts: on average, 46% of workers in vulnerable cohorts are affiliated to workplaces with less than 10 employees, whereas this figure amounts to 31% in non-vulnerable cohorts. In contrast, on average, 15% of workers in non-vulnerable cohorts belong to workplaces with 500 and more employees while this is the case for only 9% of workers in vulnerable cohorts. This indicates an uncertain evolution of working conditions in small workplaces with a significant likelihood of facing more adverse working conditions in the future.

²⁵ 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.

3.4.2 Varying the threshold of vulnerability

Setting the threshold of vulnerability at 0.50 to determine vulnerable groups implies a very low level of security: individuals in vulnerable cohorts are as likely to experience as not to experience adverse working conditions. In this section, we instead set this threshold at 0.33, implying that vulnerable cohorts are those that have one-in-three chances of facing adverse working conditions, which exceeds the European average. This allows us to apprehend changes in the proportion of vulnerable cohorts as well as in the vulnerable group characteristics' according to the choice of threshold.

Table 5 shows that the percentage of vulnerable cohorts with a threshold of 0.33 is more than twice the proportion of vulnerable cohorts with a threshold of 0.50. In 1995, 77.1% of cohorts have a one-in-three chances to face risky working environments while they were 14.3% when considering a vulnerability threshold of 0.50. The same pattern can be observed for each survey year. However, the share of the vulnerable cohort is more stable and has a different pattern of evolution than when the 0.50 vulnerability threshold is chosen: the main increase is between 2000 and 2005 when it reaches 80.7%, and then it decreases to 78.6% in 2010 and 77.9% in 2015.

The interest of changing the vulnerability threshold also lies in assessing the profile of vulnerable cohorts. To this end, we report in Table 5 as in the previous section the mean characteristics of vulnerable cohorts versus non-vulnerable cohorts when the threshold of vulnerability is set at 0.33. Overall the vulnerable cohorts' characteristics are similar when considering both vulnerability thresholds. Nonetheless, some features turn insignificant when the threshold is set at 0.33. While holding an unlimited employment contract is always synonymous to less vulnerability, holding instead a fixed-term contract denotes further vulnerability only when the threshold is set at 0.50.

In contrast, average tenure of employees in vulnerable cohorts turns significantly higher than in non-vulnerable ones, when this difference was non-significant in Table 4. Differences are also worth noting regarding the occupational status of employees when the threshold of vulnerability is set at 0.33. First, the differences between vulnerable and non-vulnerable cohorts is no more significant for both service and craft workers. Second, regarding the higher occupations and with respect to our one in three chances to be vulnerable, the mean percentage of legislators and managers is now significantly higher in the vulnerable group: 8% instead of the 7% obtained when the threshold is set at 0.5. Turning to the employer characteristics, the results are convergent with Table 4.

Table 5. Share and characteristics of vulnerable groups versus non-vulnerable groups, threshold of 0.33

	Non-vulnerable	Vulnerable	Pmean
1995	22.9	77.1	-
2000	22.9	77.1	-
2005	19.3	80.7	-
2010	21.4	78.6	-
2015	22.1	77.9	-
<i>Living with a partner</i>	0,63	0,63	0,98
<i>Main breadwinner</i>	0,59	0,61	0,42
<i>Employment status</i>			
Self-employed	0,07	0,15	0,00
Employed	0,91	0,83	0,00
<i>Employment contract</i>			
Unlimited employment contract	0,72	0,62	0,00
Fixed-term contract	0,11	0,11	0,74
Temporary employment agency contract	0,02	0,02	0,07
Apprenticeship or other training	0,03	0,01	0,00
<i>Tenure</i>	8,90	10,66	0,00
<i>Occupation</i>			
Legislators, senior officials and manager	0,07	0,08	0,01
Professionals	0,18	0,14	0,00
Technicians and associate professionals	0,18	0,13	0,00
Clerks	0,13	0,12	0,62
Service workers/shop and market sellers	0,16	0,17	0,52
Skilled agricultural and fishery worker	0,01	0,04	0,00
Craft and related trade workers	0,11	0,13	0,21
Plant and machine operators and assembly workers	0,06	0,07	0,03
Elementary occupations	0,09	0,11	0,01
Armed forces	0,00	0,01	0,38
<i>Company ownership</i>			
Public	0,25	0,25	0,89
Private	0,73	0,72	0,44
<i>Workplace size</i>			
1 employee	0,04	0,09	0,00
2-9 employees	0,22	0,27	0,00
10-49 employees	0,28	0,27	0,18
50-499 employees	0,29	0,23	0,00
500 or more employees	0,16	0,13	0,00
<i>Sector</i>			
Agriculture, hunting, forestry and fishing	0,08	0,10	0,07
Industry	0,23	0,24	0,58
Services (excluding public administration)	0,40	0,39	0,82
Public administration and defence; compulsory social sector	0,11	0,09	0,22

CONCLUSION

This paper has used the five last editions of the EWCS to identify and to analyse vulnerability to cumulative adverse working conditions at the workplace. 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, the Netherlands, Portugal, the United Kingdom, Finland and Sweden) that were surveyed on a regular basis since 1995. Relying on pseudo-panel techniques, we estimate the vulnerability of cohorts of employees grouped by sex, age group and country. Our results highlight disparities of vulnerability levels across European countries. Three classes of countries are identified: countries with very low levels of vulnerability, countries with varying levels of vulnerability over time and finally countries with persistently high levels of vulnerability. This classification is somehow surprising as it does not completely fit with the usual categorisation set by employment regimes theory with respect to similarities and dissimilarities of job quality and worker protection between European countries.

Indeed, Nordic countries tend to have strict employment protection laws, more influential trade unions and high union membership, thus ensuring very low levels of workforce vulnerability (Eurofound, 2015; Gallie, 2007). This assertion is convergent with our results except for Finland, which records very high levels of vulnerability. Similarly, Ireland and the United Kingdom, which are known for having a liberal regime with less employment protection have on average a close as well as high levels of vulnerability in comparison with the European average. 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 levels of trade union power. Instead, our results highlight great divergences between these countries, with Greece and Spain recording the highest levels of vulnerability, while the average vulnerability in Italy and Portugal is closer to the average in Ireland than in Spain. Finally, the level of vulnerability in France is close to the highest ones registered in Greece and Spain. However, the relationship between employment regimes and vulnerability to adverse working conditions should be interpreted cautiously as the indicator of working conditions takes into account aspects such as work-related discriminations that can hardly be attributed to employment regimes types.

At the individual level, our results suggest differences of vulnerability levels according to jobs' and employers' characteristics'. Skilled manual, service and sales workers and elementary occupations entail a higher concentration of vulnerable employees. Furthermore; employees with fixed-term contracts in private-owned small-sized establishment or self-employed are more likely to be vulnerable. It is precisely these jobs that are developing with the growth of services and of the platform economy as well as with labour market flexibility policies. Non-standard forms of employment would therefore be likely to impose a double sentence on employees: to the uncertainty linked to the employment relationship is added that associated with work related risks. It is therefore all the more important to follow up vulnerability to adverse working conditions.

The EWCS has the advantage of allowing comparisons between European countries. Sample sizes within countries limit however the scope for the precise identification of targets for policy intervention. The reach of the proposed indicator for policy intervention could be extended in two different directions. First, it would be useful to collect more information on the characteristics of employers and on their policies and practices to promote the health and well-being of their employees. Second, in many European countries collective bargaining at

the industry level plays a role in setting the minimum standards of employee protection. Monitoring the proposed indicator at this level of analysis could be particularly useful for negotiators and could help progress towards the definition of an absolute benchmark of exposure to cumulative workplace risk.

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APPENDIX

A.1 Variables included in the *AWCI*

a1.1 Adverse physical environment (9 questions):

- Are you exposed at work to?
 - Vibrations from hand tools, machinery, etc. (**multiple response items-7 items**)
 - Noise so loud that you would have to raise your voice to talk to people (**multiple response items-7 items**)
 - High temperatures that make you perspire even when not working (**multiple response items-7 items**)
 - Low temperatures whether indoors or outdoors (**multiple response items-7 items**)
 - Breathing in smoke, fumes, powder or dust, etc. (**multiple response items-7 items**)
 - Handling or being in direct contact with dangerous substances such as chemical, infectious materials, etc. (**multiple response items-7 items**)
- Does your main job involve?
 - Painful or tiring positions (**multiple response items-7 items**)
 - Carrying or moving heavy loads (**multiple response items-7 items**)
 - Repetitive or arm movements (**multiple response items-7 items**)

a1.2 Adverse social climate (6 questions):

- Over the past 12 months, have you or have you not, subject to?
 - Sexual discrimination (**yes/no answer**)
 - Unwanted sexual attention (**yes/no answer**)
 - Age discrimination (**yes/no answer**)
 - Ethnic discrimination (**yes/no answer**)
 - Disability discrimination (**yes/no answer**)
 - Nationality discrimination (**yes/no answer**)

a1.3 Atypical working time (4 questions):

- 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? (**yes/no answer**)

a1.4 High work intensity (8 questions):

- Does your job involve?
 - Short repetitive tasks of less than 10 min? (**yes/no answer**)
 - Working at very high speed (**multiple response items-7 items**)
 - Working at tight deadlines (**multiple response items-7 items**)

- On the whole, is your pace of work dependent, or not on?
 - The work done by the colleagues **(yes/no answer)**
 - Direct demands from people such as customers, passengers, pupils, patients, etc. **(yes/no answer)**
 - Numerical production target **(yes/no answer)**
 - Automatic speed of machine or movement of a product **(yes/no answer)**
 - The direct control of your boss **(yes/no answer)**

a1.5 Low work complexity (9 questions):

- Generally, does your main paid job involve?
 - Meeting precise quality standard **(yes/no answer)**
 - Assessing yourself the quality of your own work **(yes/no answer)**
 - Solving unforeseen problems **(yes/no answer)**
 - Complex tasks **(yes/no answer)**
 - Rotating tasks between you and your colleagues **(yes/no answer)**
 - Learning new things **(yes/no answer)**
- Are you able to choose or change?
 - Order of tasks **(yes/no answer)**
 - Methods of work **(yes/no answer)**
- You can get assistance from your colleagues if you ask for it? **(yes/no answer)**

A.2 Appendix tables

**Table 1. Structure of the pseudo-panel:
number of individual per country-cohort**

Country	Number of observation	Mean	Min	Max
BLu	50	225	24	671
DK	50	93	28	182
DE	50	141	43	260
EL	50	81	15	234
IT	50	99	14	220
ES	50	129	32	424
FR	50	139	21	421
IE	50	91	18	218
NL	50	97	19	213
PT	50	91	16	168
UK	50	112	39	193
FI	50	91	10	168
SE	50	91	8	169
AT	50	84	27	195
All	700	167	8	671

Note: in each country, there are 10 cohorts followed up during 5 years. The table gives the average, the minimum and the maximum number of individuals computed over the 50 available groups per country.

Table 2. Descriptive statistics of adverse working conditions determinants

In %	BLu	DK	DE	EL	IT	ES	FR	IE	NL	PT	UK	FI	SE	AT	ALL
Living with a partner:															
Yes	68.1	73.8	64.5	64.9	63.2	62.2	63.6	63.1	69.0	69.7	67.4	65.5	66.9	62.5	66.0
Main breadwinner:															
Yes	67.8	65.1	71.1	64.9	60.4	68.7	69.4	68.0	64.2	63.8	65.6	72.3	69.6	68.5	67.3
Number of children under 15:															
None	59.4	58.8	71.7	64.0	69.2	68.3	58.6	57.7	63.2	61	62.3	60.4	64.2	65	63.1
One child	19.2	18.9	16.8	18	18.3	19.0	20.3	16.4	14.1	25.1	17.1	18.9	16	18.2	18.4
2 children	16.0	17.6	9.7	14.7	10.8	10.9	15.8	15.3	16.6	11.5	15.7	14.2	14.9	13.5	14.0
3 children	4.21	4.4	1.6	2.5	1.5	1.5	4.2	7.7	4.9	1.9	1.7	5.1	4	2.8	3.5
4 or more children	1.1	0.6	0.2	0.7	0.2	0.2	1.0	3.0	1.2	0.5	1.1	1.3	1.0	0.5	0.9
Employment status:															
Self-employed	11.3	5.5	8.3	29.8	25.2	17.5	10.1	16.8	9.5	21.1	10.3	12.3	6.7	11.7	13.5
Employees	87.0	93.2	90.7	69.5	73.0	81.5	87.7	82.1	89.2	77.5	89.0	86.1	92.5	86.6	85.2
Other	1.7	1.3	1.0	0.7	1.8	1.1	2.2	1.0	1.4	1.4	0.7	1.5	0.7	1.7	1.3
Employment contract:															
Unlimited permanent contract	75.8	78.1	77.3	41.4	59.0	53.0	71.6	58.9	72.4	57.5	73.2	69.3	80.0	74.6	68.3
Fixed-term contract	6.4	7.3	8.9	6.1	7.0	20.3	10.6	7.4	11.8	10.8	6.9	12.3	7.6	5.1	9.3
Temporary employment agency contract	2.3	1.4	0.9	1.9	1.6	2.2	2.2	2.8	2.1	1.6	1.9	0.6	2.4	0.8	1.8
Apprenticeship or other training scheme	0.6	1.7	1.7	0.6	1.6	0.7	0.8	1.1	0.5	0.9	0.5	0.7	0.2	1.2	0.9
Other	1.8	5.2	2.4	19.6	4.6	6.1	2.7	11.5	2.6	6.5	5.9	2.7	2.1	4.2	5.0
Occupation:															
Legislators, senior officials & managers	7.9	7.6	4.8	9.1	4.9	6.1	5.9	9.9	10.1	7.5	11.4	6.5	8.8	7.7	7.6
Professionals	19.1	21.3	7.4	13.8	12.4	11.3	11.7	16.3	18.3	9.1	15.5	14.6	21.5	6.9	14.3
Technicians & associate professionals	14.4	20.6	17.2	6.2	17.2	9.9	17.3	10.4	17.0	6.1	11.7	17.8	19.9	16.2	14.5
Clerks	15.5	9.9	15.4	11.5	17.1	15.1	12.8	11.1	14.8	11.4	11.5	10.5	11.5	15.1	13.4
Service workers and shop, market sales workers	14.8	14.6	19.8	17.0	15.0	17.8	18.5	17.6	14.2	15.7	19.0	15.6	15.3	20.1	16.8
Skilled agricultural & fishery workers	1.0	0.6	1.5	9.4	1.5	2.8	2.3	5.1	0.9	4.8	1.2	4.2	0.8	2.3	2.5
Craft & related trades workers	10.4	11.7	17.1	16.7	14.8	14.8	12.4	10.8	9.6	17.8	10.6	13.4	8.5	14.3	12.9
Plant and machine operators & assemblers	5.3	5.5	6.9	7.0	6.1	5.4	5.7	8.1	5.8	10.1	7.6	8.2	7.0	5.6	6.6
Elementary occupations	11.1	7.7	9.5	8.1	10.4	16.4	13.0	10.1	8.7	16.5	11.2	8.6	6.1	11.3	10.9
Armed forces	0.5	0.5	0.4	1.2	0.5	0.3	0.5	0.6	0.4	1.0	0.2	0.6	0.7	0.5	0.5
Company ownership:															
Public sector	28.3	38.5	17.5	18.8	23.9	17.2	24.9	28.0	21.1	19.8	31.6	36.1	41.6	21.1	26.1
Business sector	70.0	60.8	81.5	65.8	74.4	80.8	73.0	65.7	75.9	77.0	65.9	62.5	57.3	76.9	71.1
Other	1.7	0.7	1.0	15.4	1.6	2.1	2.1	6.3	3.0	3.2	2.5	1.4	1.0	2.0	2.8
Workplace size:															
1 employee	7.1	3.6	3.5	17.3	15.6	14.5	11.4	10.9	5.7	15.9	6.7	8.4	4.5	7.6	9.1
2-9 employees	22.3	15.6	28.3	39.2	31.6	33.3	27.0	27.0	16.2	32.0	17.0	27.2	17.6	29.5	25.4
10-49 employees	26.9	31.3	29.9	23.4	21.4	23.5	22.8	26.8	25.6	23.8	26.8	30.5	32.0	26.5	26.6
50-499 employees	29.1	31.2	25.1	14.2	18.7	18.8	25.7	23.1	33.7	20.8	28.4	22.1	28.2	23.0	25.1
500 or more employees	14.6	18.3	13.2	5.9	12.7	10.0	13.2	12.3	18.7	7.5	21.1	11.8	17.8	13.3	13.9
Sector:															
Agriculture, hunting, forestry and fishing	3.6	6.5	10.0	13.5	8.3	8.4	5.5	10.4	7.9	11.1	4.7	9.9	6.1	8.4	7.7
Industry	16.9	20.8	23.1	21.6	22.1	19.5	18.3	21.5	19.8	26.9	19.0	29.4	18.7	24.1	21.0
Services (excluding public administration)	49.2	36.0	40.7	43.6	43.4	44.2	45.8	42.5	38.7	36.0	43.6	35.4	35.5	42.1	42.1
Public administration and defence	9.5	11.1	9.4	7.8	9.9	6.9	9.2	7.5	9.6	9.5	11.3	5.9	13.1	7.8	9.2
Other services	20.7	25.6	16.8	13.5	16.3	21.0	21.1	18.1	24.0	16.4	21.3	19.4	26.7	17.5	20.0

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

Table 3. Descriptive statistics of $AWCI_{pca}$ per survey edition and country

	1995		2000		2005		2010		2015	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
BLu	1.033	0.452	1.112	0.466	1.083	0.474	1.135	0.480	1.075	0.457
DK	0.936	0.403	0.931	0.395	1.029	0.405	0.941	0.404	1.012	0.377
DE	1.088	0.477	1.113	0.468	1.203	0.480	1.178	0.471	1.121	0.465
EL	1.382	0.529	1.510	0.511	1.548	0.570	1.438	0.563	1.514	0.478
IT	1.077	0.412	1.149	0.430	1.211	0.452	1.142	0.434	1.168	0.464
ES	1.181	0.483	1.199	0.477	1.255	0.491	1.214	0.474	1.297	0.508
FR	1.172	0.515	1.202	0.494	1.185	0.497	1.277	0.544	1.159	0.513
IE	1.157	0.453	1.215	0.465	1.068	0.447	1.214	0.484	1.116	0.476
NL	1.016	0.436	1.036	0.429	1.010	0.418	0.967	0.397	1.021	0.445
PT	1.157	0.480	1.167	0.451	1.141	0.450	1.115	0.456	1.111	0.423
UK	1.232	0.486	1.248	0.499	1.157	0.483	1.147	0.479	1.144	0.471
FI	1.179	0.455	1.244	0.457	1.250	0.455	1.178	0.445	1.111	0.434
SE	1.011	0.436	1.183	0.438	1.073	0.398	1.031	0.391	1.122	0.442
AT	1.191	0.458	1.113	0.490	1.189	0.504	1.062	0.469	1.076	0.486
All	1.119	0.473	1.173	0.480	1.165	0.484	1.154	0.486	1.150	0.480

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

Table 4. Regression model of the Adverse Working Conditions Index without fixed effects and without correction for measurement errors in variables

	AWCI	
Age	0.0115**	(0.005)
Age-squared	-0.0216***	(0.006)
Living with a partner	-0.1642***	(0.050)
Main breadwinner	0.1219***	(0.033)
<i>Number of children under 15, reference None</i>		
One child	-0.1049	(0.079)
2 children	0.1327*	(0.076)
3 children	-0.4320**	(0.196)
4 or more children	-0.3190	(0.380)
<i>Employment status, reference Employed</i>		
Self-employed	0.3928*	(0.209)
Other	0.0582	(0.166)
<i>Employment contract, reference Unlimited employment contract</i>		
Fixed-term contract	0.2526***	(0.054)
Temporary employment agency contract	0.2857**	(0.131)
Apprenticeship or other training	-0.4586***	(0.162)
Other	0.2400***	(0.062)
<i>Tenure</i>	0.0009	(0.002)
<i>Occupation, reference Legislators, senior officials and managers</i>		
Professionals	-0.1504	(0.121)
Technicians and associate professionals	-0.2035*	(0.110)
Clerks	0.2596**	(0.127)
Service workers/shop and market sellers	0.3167***	(0.109)

Skilled agricultural and fishery worker	0.8244***	(0.141)
Craft and related trade workers	0.4665***	(0.117)
Plant and machine operators and assembly workers	0.6227***	(0.128)
Elementary occupations	0.3102**	(0.123)
Armed forces	1.0241***	(0.288)
Company ownership, reference Private		
Public	0.1619***	(0.049)
Other	0.0777	(0.075)
Workplace size, reference 50-499 employees		
1 employee	0.1856*	(0.096)
2-9 employees	0.1457**	(0.064)
50-499 employees	0.0523	(0.063)
500 or more employees	-0.0177	(0.089)
Sector, reference Industry		
Agriculture, hunting, forestry and fishing	-0.0195	(0.060)
Services (excluding public administration)	0.1312***	(0.042)
Public administration and defence; compulsory social sector	0.1381*	(0.078)
Other services	0.2005***	(0.055)
Year fixed effect		NO
Cohort fixed effect		NO
R2(Within)		0.62
Number of cohorts		700

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 5. Thresholds of adverse working conditions

	1995		2000		2005		2010		2015		Overall	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Under 25 years	1.190	1.300	1.232	1.294	1.287	1.374	1.254	1.363	1.275	1.332	1.250	1.325
25-35 years	1.046	1.164	1.092	1.165	1.064	1.171	1.118	1.229	1.154	1.243	1.088	1.172
35-45 years	1.021	1.093	1.072	1.160	1.050	1.200	1.059	1.195	1.014	1.115	1.037	1.140
45-55 years	1.038	1.089	1.025	1.112	1.069	1.129	1.079	1.164	1.009	1.086	1.041	1.101
Over 55 years	1.029	1.115	1.059	1.043	1.012	1.015	1.012	1.057	0.979	1.013	1.009	1.044

Note: The reported thresholds correspond to the EU-15 median of the adverse working conditions index calculated for each age group, gender and survey edition. These thresholds are used in equation (3) to provide the vulnerability measure for each cohort.

Table 6. Comparison of average vulnerability based on a varying and time invariant thresholds

	1995		2000		2005		2010		2015	
	z_t	z	z_t	z	z_t	z	z_t	z	z_t	z
Blu	0.36	0,35	0,38	0,39	0,39	0,40	0,39	0,41	0,40	0,40
DK	0.16	0,16	0,17	0,18	0,24	0,25	0,19	0,20	0,27	0,27
DE	0.31	0,30	0,32	0,32	0,38	0,39	0,34	0,36	0,36	0,36
EL	0.58	0,58	0,60	0,61	0,59	0,59	0,55	0,56	0,60	0,60
IT	0.45	0,44	0,45	0,46	0,48	0,49	0,46	0,48	0,48	0,48
ES	0.51	0,50	0,53	0,53	0,53	0,54	0,50	0,52	0,54	0,54
FR	0.48	0,48	0,48	0,49	0,49	0,50	0,50	0,51	0,50	0,50

IE	0.42	0,41	0,45	0,45	0,40	0,41	0,42	0,44	0,43	0,43
NL	0.21	0,20	0,20	0,20	0,24	0,26	0,18	0,20	0,26	0,26
PT	0.44	0,43	0,47	0,48	0,48	0,49	0,45	0,47	0,46	0,46
UK	0.45	0,44	0,47	0,47	0,45	0,46	0,45	0,47	0,46	0,47
FI	0.45	0,44	0,45	0,45	0,47	0,48	0,47	0,49	0,45	0,45
SE	0.34	0,33	0,39	0,39	0,39	0,40	0,38	0,40	0,40	0,40
AT	0.36	0,35	0,31	0,31	0,36	0,37	0,29	0,31	0,33	0,33
ALL	0.40	0,40	0,41	0,41	0,42	0,43	0,40	0,42	0,42	0,42

Note: z_t is the time varying threshold used in eq.(3) and is given by the EU-15 median of adverse working conditions for each age group, gender and survey edition. z refers to the time invariant threshold which is the EU-15 median of adverse working conditions by age group and gender.

Figure 1. Kernel density of AWCI using EWCS 1995, 2000, 2005, 2010, 2015



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

Figure 2. Kernel density of the vulnerability measures with time-variant and time-invariant thresholds

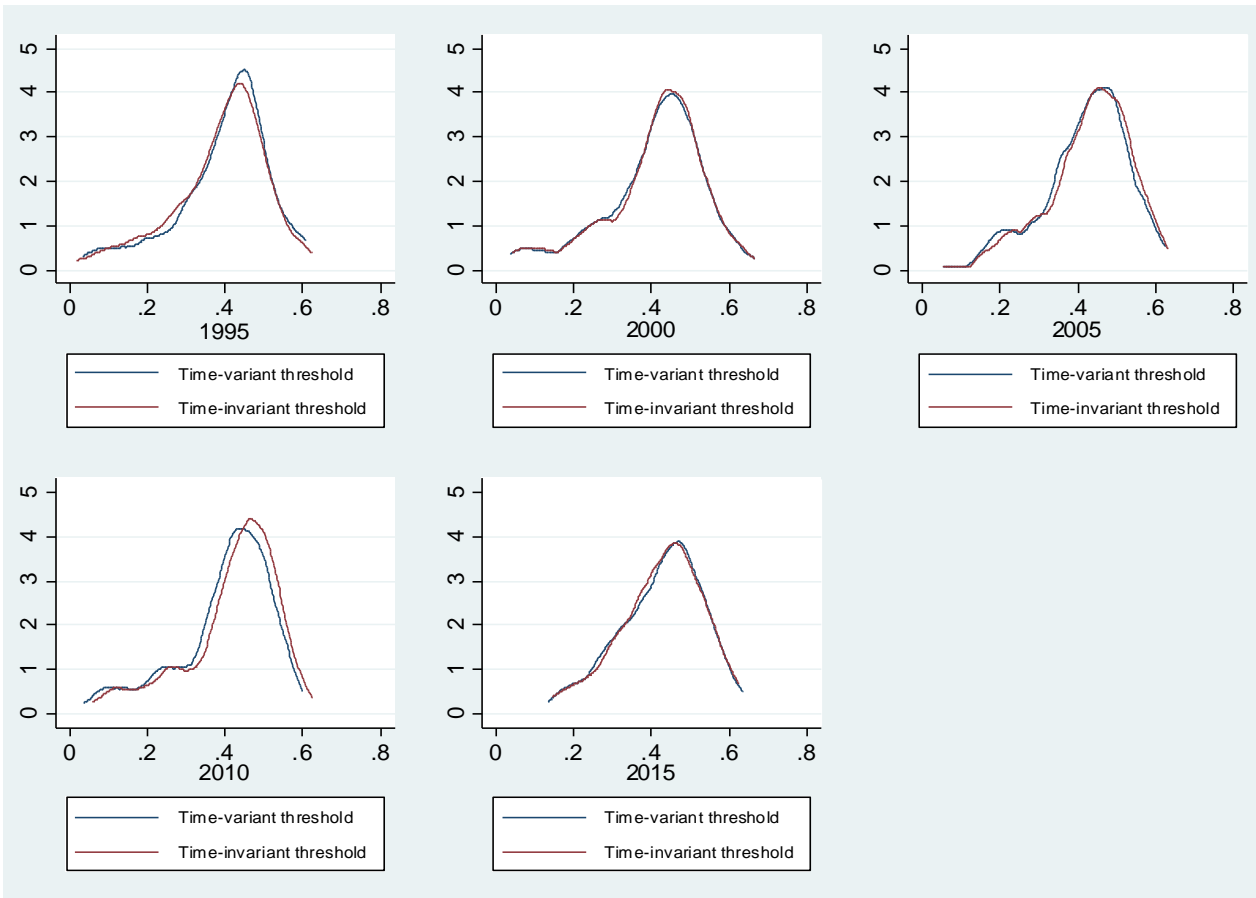
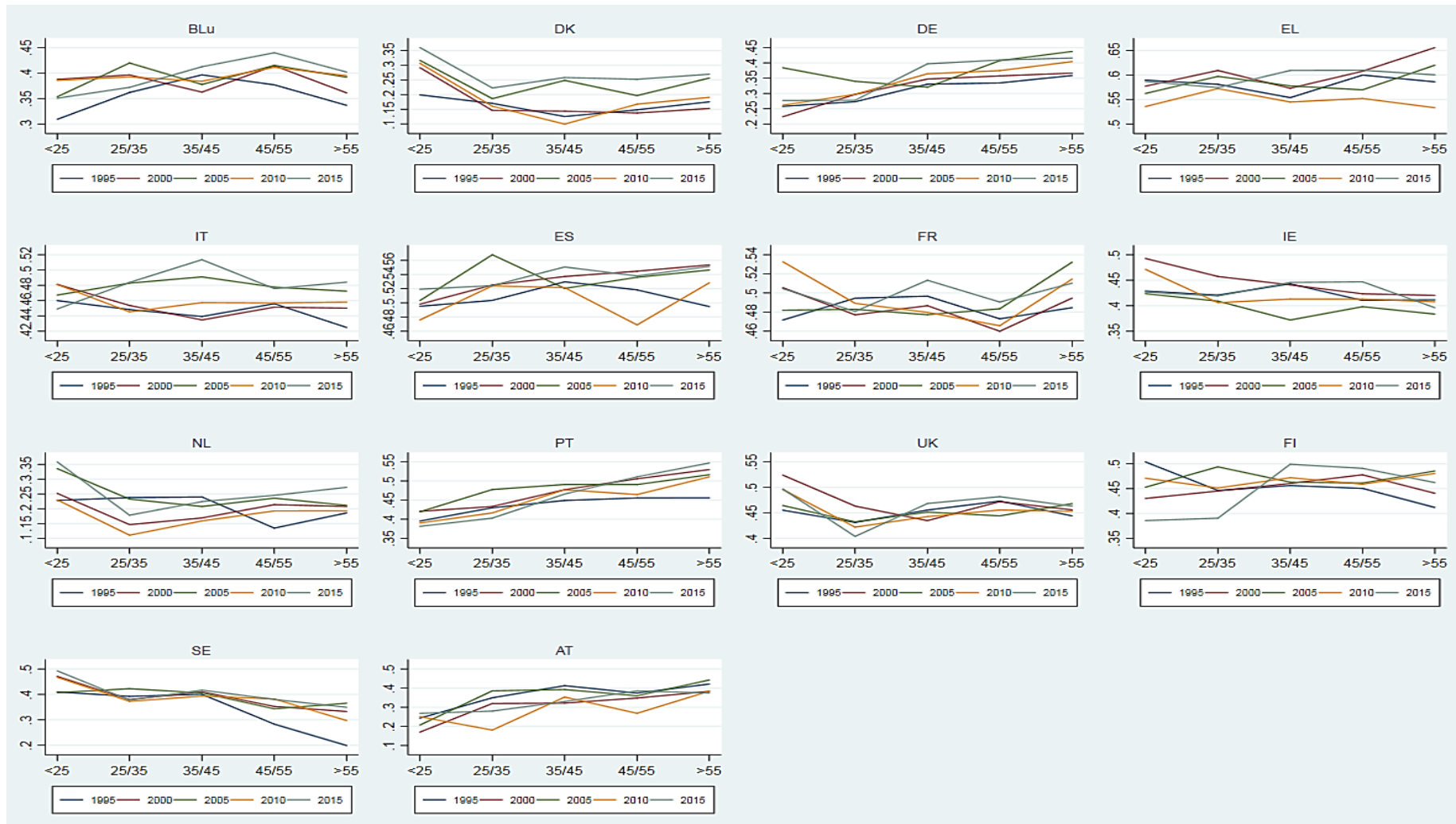
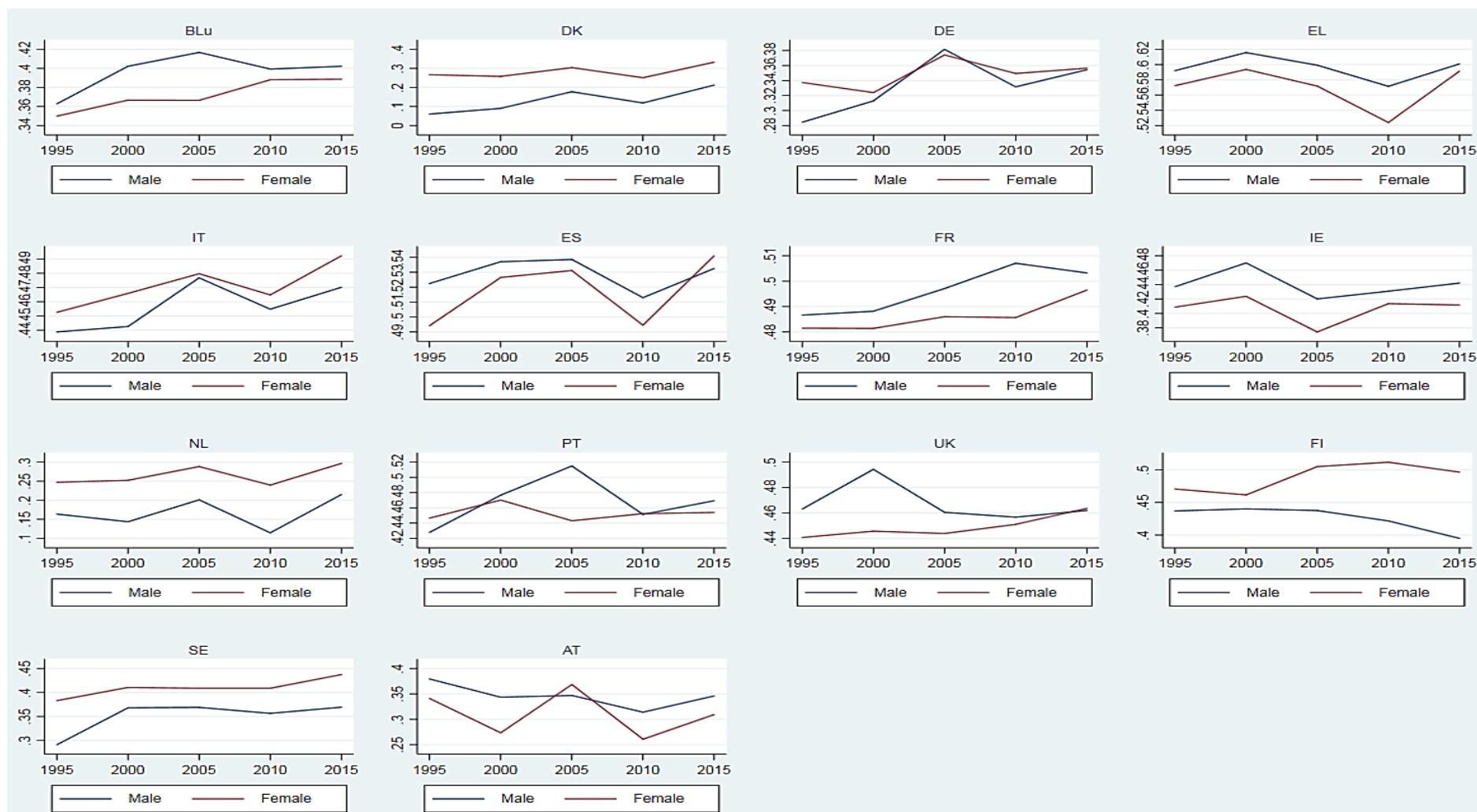


Figure 3. Average vulnerability per age-group and by survey year for each country



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

Figure 4. Average vulnerability per gender and by survey year for each country



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