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An Inquiry into the Theory, Causes and Consequences of Monitoring Indicators of Health and Safety at Work

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ABSTRACT

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This paper engages in an interdisciplinary survey of the current state of knowledge related to the theory, determinants and consequences of *occupational safety and health* (OSH). First, it synthesizes the available theoretical frameworks used by economists and psychologists to understand the issues related to the optimal provision of OSH in the labour market. Second, it reviews the academic literature investigating the correlates of a comprehensive set of OSH indicators, which portray the state of OSH *infrastructure* (social security expenditure, prevention, regulations), *inputs* (chemical and physical agents, ergonomics, working time, violence) and *outcomes* (injuries, illnesses, absenteeism, job satisfaction) within workplaces. Third, it explores the implications of the lack of OSH in terms of the economic and social costs that are entailed. Finally, the survey identifies areas of future research interests and suggests priorities for policy initiatives that can improve the health and safety of workers.

JEL Classification: J17, J28, J81, K32

Keywords: health, safety, indicators, accidents, diseases, absenteeism

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1. Introduction

"All too often lives are shattered unnecessarily of poor working conditions and inadequate safety systems. Let me encourage everyone to join the ILO in promoting safety and health at work. It is not only sound economic policy; it is basic human right".

Mr. Kofi Annan, former Secretary General of the United Nations

The purpose of this survey is to review the current state of knowledge and issues related to the determinants and consequences of *occupational safety and health* (OSH) at work. The increasing competition related to the globalisation era, the predominance of service-oriented industries, the rising job insecurity associated with labour market flexibility (e.g. part-time/temporary contracts) and the shifting demographic composition of the workforce (towards more female, racially diverse and elderly employees), poses important challenges for the health and safety of workers in modern economies. Given the rapidly changing economic environment of recent decades health and safety has therefore gained new impetus, spurred primarily by the non-trivial costs it entails to both individual and national welfare.

An indication of the considerable economic costs associated with the lack of provision of OSH is given by the World Health Organization (WHO) and the World Bank. They attribute about 3% of lost life years to the factor '*work*' (Kreis and Bodeker, 2004). Furthermore, social insurance expenditure on OSH (e.g. statutory sick pay, disability allowances, industrial injuries disablement and incapacity benefits) accounts for approximately 2-3% of Gross Domestic Product (GDP) in most advanced Western economies (Adema and Ladaique, 2009). International Labour Organization (ILO) estimates also show that work-related diseases and accidents account for economic losses as high as 4% of world-wide GDP (ILO, 2003). Around 4 million accidents at work resulting in more than 3 days of absence occurred in the EU-15 in 2005 (European Commission, 2009, p. 19). This corresponds to an incidence rate of 3100 non-fatal and 3.5 fatal accidents per 100,000 workers, although the rate has exhibited a significant downward trend (of 27.4% and 42.4%, respectively) in the last decade. Furthermore, for each worker in the EU-15 an average of 1.3 working days is lost each year due to an accident at work and 2.1 days are lost because of other work-related health problems (European Communities, 2004). 2-4% of contracted work hours have also been estimated to be lost due to sickness absence (Lusinyan and Bonato, 2007). Some calculations suggest that the socio-economic costs of (sickness) absence in advanced Western economies account for between 2-3% of their total GDP (EUROFOUND, 1997), that is a typical year's growth. Similarly, the estimated direct and indirect costs of work-related injuries and illnesses in the US are approximately $170 billion annually (CSTE, 2005; CDC, 2007). All of the above figures neglect other major non-quantifiable costs, such as the insurance and health care costs that affected individuals face, the indirect costs that companies incur (e.g. the cost of training inexperienced replacement workers, administrative expenses, production bottlenecks, low employee morale), the impact on families and communities and the inefficiency of having a large proportion of a potentially active workforce being disabled, idle or prematurely retired.

The need for up-to-date information on OSH is of critical importance for the purposes of identifying areas of required action and for setting priorities for policy initiatives on improving health and safety at work. According to recent ILO (2008) estimates, the global number of work-related fatal and non-fatal accidents and diseases does not seem

to have changed significantly during the past 10 years. This is mainly driven by the globalization process and by rapid industrialization in relatively poor countries that are not capable of maintaining effective OSH systems. It has therefore been argued that the need to focus on health and safety is as paramount as ever, given that "the traditional hazard and risk prevention and control tools are still effective but need to be completed by strategies designed to address the consequences of a continuous adaptation to a rapidly changing world of work" (ibid, 2008, p. vii).

The purpose of this survey is, thus, to review current knowledge of the concepts of work-related hazards and risks, and to improve understanding regarding the policy options that can improve health and safety at the workplace. This is achieved via a comprehensive overview of the academic literature that investigates the correlates of various indicators of health and safety at work, such as injuries or illnesses, and the implications of the lack of OSH in terms of the economic and social costs that it entails. Although there is some pre-existing literature on individual indicators of OSH, such as employee absenteeism (Brown and Sessions, 1996), a wide-ranging review that encompasses many aspects and indicators of OSH simultaneously is missing from the academic discourse.

This survey takes a holistic approach that synthesises the available medical, psychological, sociological and economic literatures on the determinants and implications of OSH for individual workers, economies and societies. Thus this review provides a useful guide to researchers in investigating issues related to health and safety by employing an integrative analysis. In addition, it serves as a useful source for the interested reader who may be bewildered by the voluminous but disparate amount of publicly available information on the issue of OSH, in both academic journals and official reports commissioned by major public bodies (such as the WHO, the ILO and the EU).

A few points regarding the underlying structure of the survey are warranted. First, in view of the interdisciplinary approach adopted in this paper, studies from several disciplines, such as medicine, psychology, sociology and economics, are included. The topic of OSH constitutes an area of lively discourse across disciplines, but complementarities in the methodological or empirical findings have not yet been brought together. As Weil (2001) suggests, since the determinants of occupational health are multifaceted there is a great need for further collaboration among researchers of different disciplines on issues related to OSH. Second, although, there is a burgeoning literature examining aspects of the health situation of the population in general, such as the effect of various pathogenic behaviours (e.g. smoking, diet, lifestyle) on mortality, this survey focuses on issues related to the factor '*work*' and examines the implications of the latter for individual (and societal) health.

The structure of the paper is as follows. *Section 2* reviews some of the theoretical frameworks that are employed by researchers in order to analyse issues of health and safety and to inform public policy. The pioneering paradigm of Adam Smith's (1776) *compensating wage differences* is discussed in view of recent advances from the fields of psychology and behavioural economics. *Section 3* discusses the various measures or indicators of employee health and safety that are typically referred to in the literature. *Section 4* provides an extensive literature review of the determinants of measures of OSH. In *Section 5* studies on the economic (and social) implications of lack of health and safety at the workplace, such as the impact on GDP or labour market prospects, are discussed. Finally, *Section 6* concludes with a discussion of issues that remain unexplored in the current literature, as a means of stimulating future academic research.

2. Health and Safety at Work: Theoretical Underpinnings

2.1 Revealed preferences: Compensating wage differentials for job disamenities

The theory of *compensating wage differentials* (CWDs), rooted in the work of Adam Smith's (1776) *Wealth of Nations*, has been argued to constitute "the fundamental long-run market equilibrium construct" (Rosen, 1986) of labour economics. According to this theory, the existence of market forces ensures the payment of wage premiums by firms which are characterised by inferior working conditions, as a means of recruiting and retaining valuable labour. It is further postulated that in a perfectly competitive labour market an equilibrium wage distribution should arise whereby "matching" of the preferences of workers and firms occurs. Thus, risk-averse workers will take up jobs in firms which provide a safer working environment, whereas less risk-averse workers will be more willing to be employed in jobs in which the marginal cost of safety provision is dearer.[1] Such an assortative matching procedure predicts that jobs characterised by a higher risk of injuries/illnesses should, in equilibrium, offer compensating rents, offered over and above the market equilibrium rate of pay. Market forces will therefore ensure that CWDs will raise the cost of non-OSH provision to firms, providing them with an inherent incentive to provide an adequate level of safety to their employees.

A number of empirical studies (discussed below) confirm the existence of CWDs, thus raising the question about whether government intervention in the form of OSH policies and regulations is likely to distort the efficiency of the incentives provided by competitive markets. An extensive literature provides estimates for the presence and extent of CWDs in a large number of countries via estimation of the so-called *hedonic wage equations*. Predominant attention has been paid to the "value of life" approach (Thaler and Rosen, 1976), which attempts to detect the monetary value that employees themselves place on their lives, on the basis that they are willing to accept jobs of a higher likelihood of a fatal job accident occurring.

Acknowledging that employees who suffer from *non-fatal* accidents and illnesses can have debilitating and life-changing experiences, economists have widened the scope of the value of life approach by implementing a hedonic wage framework that considers non-fatal risks. Conventionally, a Mincer-type wage equation of the following form is estimated:

$$\ln w_i = \beta_0 + \beta_1 f_i + \beta_2 r_i + \mathbf{x}_i'\gamma + u_i \qquad (1)$$

where w_i (i = 1,..., N) are individual earnings, f_i and r_i are fatal and non-fatal job-related risks, respectively, while the vector $\boldsymbol{x}$ contains a number of confounding factors (such as gender, age, education) that are used as control variables. The regression estimates of the parameters β_1 and β_2 are hence believed to provide an unbiased measure of the wage premium required to induce workers to accept an extra marginal unit of (fatal or non-fatal) job risk.

A plethora of studies show that, *ceteris paribus*, jobs associated with a higher degree of fatal risk and unhealthy working conditions are coupled with a higher wage level than safer jobs (Smith, 1979; Marin and Psacharopoulos, 1982; McNabb, 1989; Viscusi, 1993; Arabsheibani and Marin, 2000). Interestingly, while many studies confirm that there exist positive and statistically significant CWDs for fatal injuries, others fail to find any significant CWDs for non-fatal injuries (Siebert and Wei, 1994; Sandy and Elliot, 2005; Wei, 2007).[2]

Sandy and Elliott (2005) and Wei (2007) investigate the existence of CWDs for job-related *illnesses*, highlighting the fact that employees face a far greater risk of illness related to work rather than fatal or non-fatal *injury*. Using data from a Health and Safety Executive (HSE) module in the UK's Labour Force Survey (LFS), Sandy and Elliott (2005) find evidence of significant CWDs for manual male workers only in response to their constructed broad measure of occupational long-term illness. Wei (2007) confirms this finding using data from the 1998 wave of the Workplace

Employee Relations Survey (WERS), which permits him to construct establishment-specific illness and accident rates. He finds that the estimated wage compensation for one job-related illness episode per year ranges from 27% to 140% of annual earnings depending on gender and the estimation methodology.

Notwithstanding the appeal of the aforementioned approach, a number of researchers argue that there are significant shortcomings associated with the estimation of hedonic wage functions. The most prominent of these are *measurement error in the risk variables* and the *endogeneity between job risk and earnings*. The former is said to arise due to "aggregation bias" (Lalive, 2003), given that broad industry or occupation level measures of job risk are typically used in the literature. However, this masks the important discrepancies in the level of job risk faced by people who perform different tasks, even if they are classified within the same industry or occupational category. Another source of measurement error may also be at work in studies that ignore the influence of non-fatal job risks on workers' compensation, since the latter are collinear with the respective fatal risks (Arabsheibani and Marin, 2000). Using a matched employer-employee dataset, Elliott and Sandy (1998) illustrate that overstatement of job disamenities by employees who are dissatisfied with their pay brings into question the validity of CWDs obtained on the basis of employee responses to questions of job risk. Following the above arguments, Viscussi (2004) confirms that measurement error bias tends to lead to underestimation of estimates of CWDs.

The heterogeneity in individual preferences for risk and income (Garen, 1988; Hwang *et al*., 1992; Hintermann *et al*., 2008) is likely to compromise estimates of CWDs too, by masking important unobserved factors that can simultaneously affect both individuals' taste for earnings and their preferences for job risk. For instance, it is often argued that since safety can be considered to be a normal good (Biddle and Zarkin, 1988), people in non-manual jobs or those who enjoy a higher level of human capital can "afford" to select jobs with better working conditions. Proposed ways to circumvent this problem are either to use panel data methods that control for unobserved individual heterogeneity or to utilise appropriate instrumental variable (IV) techniques (Arabsheibani and Marin, 2000; Johansson and Palme, 2001; Hintermann *et al*., 2008; Wei, 2007). However, the latter approach tends to suffer from the fact that the choice of instruments typically appears to be *ad hoc*.

Finally, a more technical point regarding the inefficiency of the revealed preferences approach sis that existing data sources contain insufficient information on specific non-fatal risks (Karnon *et al*., 2005).

2.2 Revealed preferences: Sub-optimal allocation of job market risk

In addition to the above problems, a number of further issues have been raised that cast doubt on the theoretical predictions of the CWD theory and its usefulness for the policy discourse on OSH. The existence of CWDs that are conducive to the attainment of an efficient degree of OSH provision on behalf of firms hinges critically on the strong requirement that competitive markets forces are at work. Nevertheless, convincing arguments exist on both *equity* and *efficiency* grounds regarding the necessity for OSH policies. These arguments are based on the reasoning that the equilibrium level of OSH provision, as determined in the theoretical realm of the free market, is likely to be suboptimal.

On the equity front, it is often pointed out that the social class distribution of occupational accidents and illnesses is skewed, with job risk affecting a relatively vulnerable portion of the workforce (e.g. lower educated/lower income individuals) to a far greater extent than individuals in higher rungs of the social strata (Henderson, 1983). Crucially, this may justify public provision of compensation or regulation of OSH levels even among employees who receive the same

risk premium on their wage within a given occupational group, since there may still be inequity in the incidence of occupational accidents and diseases.

Furthermore, the efficiency of market forces is also likely to be diluted due to the fact that not all of the (opportunity) costs of OSH provision are borne by employers. Henderson (1983) provides a convenient formalisation by arguing that, in the absence of regulation, a sufficient condition for profit-maximising firms selecting the optimal safety level, *S**, is that their OSH decisions should reflect all of the '*prevention costs*' and '*damage costs*' (Figure 1). The former include *ante-factum* outlays of preventive practices and equipment, which are likely to face rising marginal costs as the levels of health and safety within a firm increase. This is reflected in the convexity of the cost curve in Figure 1. The latter, are *post-factum* costs following a serious incident, such as medical expenses, forgone output and the suffering of the affected individual or of his/her immediate family. These are likely to fall at a diminishing rate as health and safety levels increase, since the severity of incidents at higher levels of safety is likely to be subdued. As shown in Figure 1, only at *S** is the cost of extra safety through more prevention equalised with the value of the reduced damage costs that an additional unit of job safety entails.

[INSERT FIGURE 1 ABOUT HERE]

It is nevertheless the case that firms do not typically bear all of the damage costs of a workplace injury or disease. As the negative externalities of such adverse occurrences, such as the social costs on families/communities/national welfare systems, are typically not internalized in the decisions of firms, economic theory predicts that a less than optimal degree of OSH is provided to workers.

Inefficiencies are also likely to arise since competitive markets require the existence of symmetric information between the two sides of an employment relationship regarding workplace risks. However, it is often the case that individual employees suffer from an informational disadvantage relative to their employers, particularly with respect to the probability of incidents occurring within particular occupations and the likely severity of accidents/illnesses. "Accidents that occur relatively rarely, or industrial diseases that take years or even decades to manifest themselves after initial exposure to the hazardous agent causing them, are unlikely to be known with any degree of precision" (Henderson, 1983, p. 79).

Evidence from cognitive psychology research also highlights that individual workers consistently underestimate the probability of an accident/illness at work happening. According to the predictions of *prospect theory* (Kahneman and Tversky, 1979), people do not always respond in a 'rational' manner to messages about risk (Kahneman *et al*., 1982; Slovic, 2000; Kahneman and Tversky, 2000). Several explanations are offered to explain this "paradoxical" phenomenon. There is considerable evidence that people employ simplifying *heuristics* in judgement and decision making i.e. simple rules of thumb which enable individuals to handle the enormous amount of information at hand and arrive at assessment of the risk entailed (Tversky and Kahneman, 1974; Gilovich *et al*., 2002). However, these heuristics are shown to lead to biases in peoples' interpretation of risk and in their subsequent choices. Research in psychology shows that the reason is that human beings have an *inbuilt resistance to unwelcome information* and that they suffer from *cognitive limitations* (Denscombe, 1993). Gilbert (2006, p.109) has summarized the evidence from numerous psychological experiments that point to the fact that people make systematic errors in their perception of the future. One prominent reason is that they fail to account for the fact that current emotions intrude on assessments of the future ('*presentism*'), thereby consistently underestimating how differently they will feel after an event has occurred.

Slovic *et al* (1982) found that survey respondents overestimated the frequency of dramatic or sensational causes of death (homicide) and underestimated the frequency of less well-publicised causes (such as stroke and asthma). Bernstein (1996) also reports some interesting results from an experiment that the prominent psychologist Amos Tversky carried out on 120 Stanford graduates, who were asked to estimate the probability of dying from various causes. A significant discrepancy was found between the subjects' estimates and the actual statistical figures, with subjects consistently underestimating some risks (e.g. natural causes) and vastly overestimating the probabilities of others (e.g. unnatural causes). For instance, the estimate given by the group regarding the probability of an accident occurring was 0.32, which differed significantly from the 'true' statistical estimate of 0.05. The perception of risk has also been shown to be affected by factors such as the immediacy and framing of the effect, people's perception of controllability over risks, anchoring and the novelty or magnitude of an incident (Furnham, 1988; Thaler and Sunstein, 2008). Weinstein (1989) has emphasized that *optimism bias* is a pervasive feature of human life, since people are commonly found to overestimate their personal immunity from harm, believing, instead, that certain hazards are more risky for other individuals than for themselves. Moreover, while much of the literature has focussed on whether people understand and recall the probabilities of events, there is also evidence suggesting that individuals tend to underestimate the qualitative nature and severity of outcomes in terms of their current and future impact on their health and functional status/quality of life (Rogers *et al*., 2000; Lloyd, 2001).

The evidence from above would therefore suggest that employees tend to underestimate the level, nature and severity of hazards associated with the execution of certain occupations, as they perceive the chance of an accident/illness happening to them as being less probable than what would be predicted on the basis of statistical analysis and expert advice. This is, in turn, associated with miscalculation on their behalf of the magnitude of the risk premium required to compensate them for undertaking a hazardous occupation, which mutes the incentives faced by employers to provide the efficient level of health and safety.

Finally, CWDs are only likely to arise in a free market when alternative employment opportunities are open to employees, as the mobility of labour will, in theory, spur competition by employers in terms of providing an attractive [wage, safety] bundle. However, in industries where accident or illness risk is most prevalent (e.g. manufacturing, construction, transportation) there is a high incidence of workers suffering from a low pay-no pay vicious cycle (Asplund *et al*., 1998; Stewart and Swaffield, 1999; European Commission, 2004). Jobs are normally offered on a take-it-or-leave- it basis and refusal of the job offer from the part of the worker may imply unemployment or another dead-end job as the only outside options available. Under such circumstances, employees are expected to be reluctant to quit their current job.

As shown in Figure 2, the above arguments imply that the market level of safety provision turns out to be less than the efficient level ($S' < S^*$). A discrepancy therefore arises between the workers' willingness to pay for risk reduction in the workplace through diminished wages and market valuations of the cost of such a reduction when measured at current levels of risk exposure (Biddle and Zarkin, 1988; Herzog and Schlottmann, 1990). Hence, government intervention, in the form of the provision of adequate information, the setting of standards or the imposition of financial penalties or prosecution, is necessary not only to achieve equitable levels of OSH but also to facilitate the attainment of efficient levels.

[INSERT FIGURE 2 ABOUT HERE]

2.3 Stated preferences: Willingness to pay for job safety

In view of the above deficiencies of the revealed preferences approach and of the theory of CWDs, research has recently favoured the "willingness-to-pay" (WTP) methodology of valuing the risk of accidents or illnesses. The WTP estimates provide useful information regarding the cost and benefits of alternative health and safety interventions, which allows the relative efficiency of different policies to be assessed (Rosen, 1986; Arabsheibani and Marin, 2000; Hintermann *et al*., 2008).

WTP estimates typically seek to elicit the magnitude of the rate at which individuals are willing to forgo income in exchange for additional safety, which would nevertheless keep their utility unchanged i.e.

$$WTP = \frac{\partial w_i}{\partial r_i} \qquad (2)$$

In a perfectly competitive labour market in long-run equilibrium, it is expected that $WTP = W'(R) = \beta_2$, where β_2 is the estimated coefficient of the hedonic wage equation (1). Economists have attempted to measure the WTP of individuals using "job switching" regression estimates, exploiting the fact that workers "vote with their feet" among jobs in various industries that differ with respect to working conditions and compensations (Viscusi and Moore, 1990; Herzog and Schlottmann, 1990). Nevertheless, such estimates suffer from the shortcomings discussed in the last section and, in addition, are open to the criticism of selectivity bias, since unobserved characteristics may underlie the decisions of individuals who decide to quit their jobs.

In recent years, the *stated preferences methodology* is utilised more often. This is an implication of research by psychologists and behavioural economists who have paid greater attention to observable human traits, such as misperceptions of probabilities, information asymmetries and impulsive short-sighted behaviour (Kahneman *et al*., 1997). The traditional ordinal choice-based utility concept of economics has also been argued to be inadequate for the purposes of public policy evaluation as it essentially *assumes* the optimally of individual behaviour, rather than attempting to evaluate it. Furthermore, a significant number of studies over the last thirty years indicate that "practically speaking, stated and revealed preferences seem to match up surprising well in different choice contexts, cultures and time periods" (Louviere *et al*., 2000, p. 12).

Stated preferences research was originally carried out by using the so-called *contingent valuation* approach. This approach relies on asking respondents to provide direct monetary valuations of alternative preventative measures (Gerking *et al*., 1988; Miller *et al*., 2002). To overcome the inconsistency of simple open-ended questions, which are subject to response bias and the so-called embedding effect (whereby respondents typically ignore income constraints in their evaluations) (Diamond and Hausman, 1994) economists have strived to provide more pragmatic contingent markets. This is achieved via the design of a realistic payment vehicle (such as the specification of sensible income-taxation trade-offs) and by providing sufficient information for individuals to make informed choices.

In a similar spirit, the complementary approaches of *conjoint analysis* and of *relative valuations* have been employed in recent years as a means of imitating the actual choices of individuals in quasi-market settings. Both of these methods ask respondents to make a series of deliberate hypothetical choices between pair wise comparisons describing alternative events in the context of the same set of attributes. In the conjoint analysis approach, the WTP of

individuals is obtained directly by including an income variable within the set of attributes describing a realistic job scenario (or '*vignette*'). Van Beek *et al*. (1997), for instance, use such a method to detect employers' preferences for desirable characteristics of job applicants, while Pouliakas and Theodossiou (2010[b]) have recently utilised such a method to report estimates associated with workers' WTP to avoid insecure contracts and physically demanding jobs.

In the relative valuations approach, instead, indirect monetary valuations are obtained against a suitable peg event for which a reliable valuation exists. Karnon *et al*. (2005), for instance, evaluate the benefits of the prevention of non-fatal work-related accidents and ill health pegged against monetary valuations for the prevention of road deaths.

Though such methodologies constitute a welcome contribution to informing policymakers about the effectiveness of OSH interventions, caution is nonetheless warranted on the grounds that choices elicited in hypothetical settings are likely to be affected by the degree of 'contextual realism' that the researcher establishes for the respondents (Dolan and Kahneman, 2008, p. 225).

3. Indicators of Health and Safety at Work

The focus of public policy has shifted considerably in the past two decades. From a strict definition of OSH that is concerned merely with the prevention of occupational injuries and illnesses, it is now moving towards a more encompassing concept geared towards the overall protection of workers' health, the maintenance of their working capacity and the improvement of the working environment in a manner that promotes safer and healthier workplaces.

It is hence important that public policy is informed via appropriate measures and ***indicators*** of health and safety, which paint a picture of the state of the *workplace infrastructure, inputs* and *outputs* of individual economies.[3] A way to conceptualise OSH indicators is depicted in Figure 3. As Rantanen *et al*. (2001, p. 17) suggests, the socio-economic structure of the economy, including demographic conditions, the industrial or service-oriented nature of markets and the technological frontier, are crucial factors for determining the state of *workplace inputs* and the exposure of different risk groups of employees to them. Exposure to work-related risk factors is, in turn, one of the main determinants of *health and safety outcomes*, such as the absence behaviour of employees (partly mediated by their job satisfaction), the incidence of work accidents and the occurrence of occupational diseases. These negative OSH outcomes are important as they entail significant direct and indirect economic costs at both an individual and national level (discussed in Section 5 below).

[INSERT FIGURE 3 ABOUT HERE]

A number of important research projects on OSH have been undertaken under the auspices of major international organizations such as the WHO, ILO and the EU. These projects have identified a plethora of generic and specific indices of OSH, covering a wide range of OSH contingencies. Primary examples of these projects include the *European Community Health Indicators Project* (ECHI) (Kramers, 2003), the assessment of the state of OSH throughout the EU Member States by the EASHW (2000), or the European Commission's emphasis on the creation of '***good work***' (EC Communication, 2001; EUROFOUND, 2007). The above echoes the ILO's preoccupation with the attainment of '***Decent Work***' (ILO, 2005). Other important contributions include those of the Finish Institute of Occupational Health (FIOH) (Rantanen *et al*., 2001), the US National Occupational Research Agenda (NORA) project (CSTE, 2005; CDC, 2007) and the EU WORKHEALTH project (Kreis and Bodeker, 2004), which develop a comprehensive set of OSH

indicators that become operational by separating them into clear-cut policy domains. The three major domains usually referred to include (1) **"*OSH policy and infrastructure*"**; (2) **"*OSH hazards/work conditions*"** and (3) **"*OSH outcomes*",** as summarised in Table 1.

[INSERT TABLE 1 ABOUT HERE]

4. Determinants of Indicators of Health and Safety at Work

The remainder of the paper presents a comprehensive overview of the empirical literature on the determinants of selected indicators of OSH and their economic and social consequences. Overall, significant differences in the level of OSH risks are observed between workers of different demographic and job-related factors, such as sex, age, sectors of economic activity, occupational groups, firm size and other characteristics as identified below.

4.1 OSH Infrastructure

The underlying OSH infrastructure of firms and the economy as a whole is an important means of enhancing the health and safety of employees. To devise indicators able to capture all of the individual elements of OSH infrastructure within a country is difficult, although various suggestions in the literature include the following components: (*i*) the amount of national *OSH expenditure costs* as a proportion of GDP (or within enterprises, the proportion of total costs of the firm devoted to OSH); (*ii*) The extent to which enterprises and States comply with and seek to enforce *OSH regulations* (e.g. the number of binding and non-binding OSH regulations that are ratified; the number of/proportion of workforce covered by OSH inspections) (ILO, 2006); (*iii*) Investment in *OSH prevention activities* by both enterprises and national authorities, such as steps or measures taken to prevent or reduce occupational risks and to protect the health and safety of employees. Some indicative evidence on the above indicators follows:

4.1.1 Social Security Expenditure on OSH

Adema and Ladaique (2009) report that according to the OECD Social Expenditure Database (SOCX), gross public social expenditure on average across the OECD increased from 16% of GDP in 1980 to 21% in 2005, with public pensions (7% of GDP) and public health expenditure (6% of GDP) constituting the largest items. In 2005, total health expenditure was highest in the US (at 15.7% of GDP), Switzerland (11.2%) and France (11.1%), compared to 8.9% of GDP on average across the OECD (OECD, 2008). In the year 2005 approximately 2.6% of the GDP of the OECD group of countries was devoted on average to expenditure on Incapacity Benefits (including care services, disability benefits and pensions, benefits accruing for occupational injuries and diseases and employee sickness payments). Significant variations by country are observed, with Mexico (0.1%), Turkey (0.2%) and Korea (0.6%) lying at the lower end of the spectrum, the US (1.3%), the UK (2.4%) and the EU-19 group of countries (3%) found in the middle, and the Scandinavian countries [Sweden (5.6%), Norway (4.4%) and Denmark (4.3%)] featuring at the top (OECD, 2009).

4.1.2 OSH Regulations

There are important discrepancies in the OSH laws and regulations of various countries, especially with respect to the criteria required for the receipt of sickness/disability benefits, the duration of benefit provision and the magnitude of

social insurance compensation. The ILO has a central role in providing recommendations and guidance for national OSH policies. Although the ILO publishes instruments, which outline varying levels of obligations for member countries, the latter have to ratify each instrument before implementation takes place. Ratification does not guarantee implementation. The recommendations are for national governments to implement or use as a guiding policy.

A number of studies investigate the factors that underlie the decision to ratify and adopt OSH-related ILO conventions. The length of ILO membership, national income status and regional affiliation are shown to be associated with a higher number of ratifications by member states (Wilson *et al*., 2006). Horny *et al*. (2009) focus on developing countries, for which OSH is seldom given priority status due to its costly nature. They employ an empirical methodology that allows for the fact that ratification behaviour is influenced by unobserved characteristics both of countries and of different conventions. The presence of such effects is argued to stem from the fact that some conventions may be more easily ratified than others, since they differ in terms of their degree of flexibility or complexity. Finally, other factors that are identified as possible obstacles to the ratification process include the lack of infrastructure, the lack of political will, incompatibility with national legal systems and peer effects (Chau and Kanbur, 2001).

In terms of the effectiveness of OSH regulations in promoting OSH labour standards, Wilson *et al*. (2007) assess the relationship between the ratification status of OSH-related ILO conventions and the reported occupational fatality rates of ILO member countries, after controlling for possible confounding factors (such as income levels and length of ILO membership). They show that non-ratifying countries generally have statistically higher fatal injury rates. Based on this evidence, they argue that all countries should promote ratification of ILO conventions aimed at improving OSH conditions. In a study for Spain, Arocena and Nunez (2009) also highlight the importance of OSH legislation in reducing workplace accidents in "advanced" manufacturing sectors (i.e. industries utilising a high degree of technology and skilled workforce). However, they fail to identify any significant change in the incidence of accidents in traditional manufacturing sectors following the adoption of new OSH legislation.

A notable study of HSE (2006) examines the relationship between the OSH activity of firms and sectoral performance in the UK, using a gross output growth accounting framework. This research is important as it addresses the question about whether the adoption of costly OSH regulations are likely to compromise the performance of firms and have negative effects on their economic activity. It utilises Cambridge Econometrics' annual time series of input-output consistent volume and value indices of change for 42 sectors of the UK economy from 1970 and the Bank of England Industry Dataset (2003). Moreover, it incorporates data on OSH activity and stringency measures in collaboration with the HSE in the UK. No clear evidence is provided on the impact of OSH stringency on productivity, although it is suggested that the former might have a negative *short-term* effect on output as firms struggle to meet stricter regulatory requirements. However, in the *long-run*, the so-called Porter hypothesis (Porter, 1991) asserts that newer and better technologies are likely to be adopted as a response to regulatory incentives, thereby enhancing productivity over time. The study acknowledges that the absence of sufficient time-series data does not permit the identification of any time trend on the impact of stringency data on productivity, given that such effects may become apparent after a substantial time lag.

5.1.3 OSH Prevention

A number of papers show that firms that take a more proactive stance toward the development of a comprehensive workplace risk prevention system are more likely to have lower accident rates than those which only follow the minimum legal requirements. Hunt and Habeck (1993) examined a sample of 220 firms in the US State of Michigan in order to establish the relationship between certain workplace risk prevention parameters and indices for the frequency and severity of accidents. The study suggests that there is a need for firms to generate and process internal information, investigate accidents and incidents fully, foster the emergence of a "prevention culture" and promote programmes to enhance workplace ergonomics. Wilson (1996) shows further that health promotion programmes (e.g. ergonomic management, anti-smoking campaigns, purchase of personal protection equipment, stress management seminars, nutritional awareness) that take the form of comprehensive rather than single-goal programmes are most likely to succeed if there is appropriate coordination at all levels of an organisation (upper management, OSH professionals and personnel). Furthermore, in a study for Spain, Arocena *et al*. (2008) construct a risk prevention index that quantifies the intensity of firm's preventive effort, using a sample of 213 industrial firms. This measure is based on questions regarding six preventive dimensions, such as measures designed to eliminate risk at source, training, communication and workers' participation, risk control, actions taken in view of foreseeable changes, documentation and emergency prevention, preparedness and response. Using a negative binomial regression that takes account of non-observable firm heterogeneity, they show that the intensity of occupational risk prevention is crucial to reducing the number of accidents. They also illustrate that there are important synergies between innovative preventive effort and organisational factors with respect to their effect on the reduction of the number of injuries in a workplace.

The provision of OSH training to employees constitutes an additional strong preventative action that is associated with reduced workplace injuries and disease. In a wide-ranging literature review of published reports drawn from the period 1980 to 1996, Cohen and Colligan (1998, p. iv) find "overwhelming evidence to show the merits of training in increasing worker knowledge of job hazards, and in effecting safer work practices and other positive actions in a wide array of worksites". The study shows that factors such as the size of the training group, the length/frequency of training, the method of instruction, the trainer credentials, and other extra-training factors (e.g. goal setting, feedback, motivational incentives, and managerial actions) are significant determinants of the success of the training process. However, attention is drawn to the fact that many intervention studies fail to adequately decouple the provision of training from other forms of intervention (e.g. engineering, ergonomic).

4.2 OSH hazards/Work conditions

Figure 4 shows that a large proportion of employees in modern job markets are exposed to work-related health risks. Usually, the impact of work-related health risks on the health and safety of employees is analysed separately according to the effect of (*i*) *physical agents* (e.g. noise, vibration, radiation, room temperature), (*ii*) *chemical agents* (e.g. asbestos, lead, benzene, pesticides), (*iii*) *ergonomic conditions* (e.g. inconvenient work postures, repetitive movements, lifting of heavy materials), (*iv*) *working time arrangements* (long and irregular workdays, shifts, night work) and (*v*) *workplace violence* (bullying, harassment, discrimination). The current study follows this practice below:

[INSERT FIGURE 4 ABOUT HERE]

4.2.1 Physical agents

From a European perspective, the five waves of data from the European Survey of Working Conditions (ESWC) indicate that around 25-30% of all workers interviewed report exposure to *noise* in their workplace. Noise at the workplace is especially pronounced in industries with predisposition to use heavy metallic instruments, like engineering or shipyards (Mery, 1973; Pyykko *et al*, 2007). 'Blue-collar' workers, the young and those employed in smaller firms, temporary contracts or casual labour are found to be at a higher risk of noise exposure at work and of subsequent hearing loss (EASHW, 2000). Noise related to work is a leading cause of several auditory diseases which can lead to further serious manifestations of disease (Pyykko *et al*., 1989; Robinson, 1971). *Vibrations* at the workplace are another common risk factor associated with the working environment, affecting approximately a quarter of the total European labour force and up to a half of those in industry (EASHW, 2000). Hypertension, back ache and dermatitis are the three most common health problems observed due to noise and vibrations (Hannunkari *et al*., 1978).

4.2.2 Chemical agents

Many jobs, particularly in the primary and secondary sectors, involve exposure to chemicals which often have adverse consequences for health (White and Proctor, 1997; Wong and Trent, 1999). Based on data from the ESWC, a non-negligible proportion of the European workforce (between 15-25%) handles dangerous substances in their workplace, or inhales vapours, fumes, dusts or other unhealthy materials (EASHW, 2005, p. 22). The occupational medicine literature highlights the negative health effects associated with the exposure of agricultural workers to pesticides (Hanke and Jurewicz, 2004), and of workers in the secondary sector of the economy to solvents, paints and various organic substances. For instance, a number of research papers draw attention to a possible relation between exposure to (organic) solvents and incidence of neural disorders, as assessed by measurements of nerve action potential, nerve conduction velocity and/or memory loss and personality disorders, most probably due to the lipophilic character of solvents (Grasso *et al*., 1984; Wang and Chen, 1993; Kaukiainen *et al*., 2008). Other common neurotoxic substances that are identified in the workplace include lead, mercury and biological agents, which are classified as important reproductive hazards (EASHW, 2000, p. 164). Notwithstanding the deployment of objectively-based investigations relying on electroencephalography, computer axial tomography scan and electrophysiology, most studies are unable to establish a causative link between chemical substances and health due to the difficulty of controlling for a number of other important determinants of bad health, such as alcohol consumption, ageing, use of drugs/medication, diet etc.

Carcinogen substances (e.g. acrylamide, asbestos, benzene etc.) are prevalent particularly in industrial sectors, and there exist a number of studies investigating the association of these with the incidence of cancer and other diseases (Collins *et al*., 1989; Marsh *et al*., 1999; Swaen *et al*, 2007). However, there is a lack of reliable statistical information about the harmful consequences of carcinogens or the beneficial effects of any preventative actions since the effects of these substances on health are manifested over a long period of time. Also many official registers fail to record details necessary to clearly establish the relationship between a number of work-related incidents and carcinogen exposure.

4.2.3 Ergonomic conditions

Bad ergonomic workstations and other adverse working conditions, such as strenuous work postures, lifting of heavy loads, or repetitive movements during the performance of job tasks can have many adverse consequences on health.

Musculoskeletal disorders constitute the most severe manifestation of an unsuitable work environment, and are found to affect a significant portion of the workforce. Approximately a third to a half of the European labour force is said to be subjected to Repetitive Strain Injury (RSI), carpal tunnel syndrome and tenosynovitis, all of which are associated with repetitive movements (EASHW, 2000, p. 38-40). Workers employed in the manufacturing sector suffer to a greater extent, although Health and Social Workers are also frequently affected. Even with the widespread automation of the production process, and the onset of the Information Technology (IT) era, poor working conditions are associated with severe health and safety problems, especially in periods of high demand in which the speed of production is accelerated.

4.2.4 Working time arrangements

Adverse working time arrangements, in the form of long and irregular workdays and shift work, have detrimental effects on both physical and psychological health. Working long hours (typically defined as work in excess of 10 hours per day or 48 hours per week) appears to be associated with an increased risk of ischemic heart disease and myocardial infarction (Sokejima and Kagamimori, 1998; Liu and Tanaka, 2002; Artazcoz *et al*., 2007) and hypertension (Nakanishi *et al*., 2001). Extended work hours are also believed to interfere with the diurnal rhythm that results in decreased sleep, thus magnifying the adverse effect of psychical tiredness on health outcomes in the long run (e.g. increased heart rate, elevated blood pressure, lower cortisol secretion) because of inadequate recuperation (Kripke *et al*., 1979; Tochikubo *et al*., 1996; Lusardi *et al*, 1999; Dahlgren *et al*., 2005; 2006). Similar effects of disturbed biological rhythm, digestive disorders and subsequent physiological disturbances are reported for those employees who face erratic shifts and night work (Mott *et al*., 1965; Boggild and Knuttson, 1999; Costa, 2003; Bjorvatn *et al*., 2007).

Adverse working time arrangements are also found to be significant determinants of the sickness absence behaviour of workers (Lusinyan and Bonato, 2007), the incidence of workplace injuries (Currington, 1986; Wooden, 1990), musculoskeletal disorders (Wergeland *et al*, 2003) and of the risk of exhaustion and burnout (Kalimo and Toppinen, 1997). For instance, Dembe *et al*. (2005) argue, using a large sample of American workers from the National Longitudinal Survey of Youth (NLSY) database, that working at least 12 hours per day is associated with a 37% increased hazard injury rate and working at least 60 hours per week with a 23% increased hazard rate. Moreover, overtime work significantly increases the risk of an occupational injury by 61%. Working time arrangements have obvious consequences in terms of affecting the work-life balance of workers, which is shown to be related to a lower level of self-assessed well-being (EUROFOUND, 2002; Pouliakas and Theodossiou, 2010[a]). Finally, Krause *et al*., (1997) emphasise that retirement due to disability is frequently caused by long working hours, especially if exceeding 60 hours per week.

4.2.5 Workplace violence

Workplace violence manifests in a number of alternative forms, including physical or mental violence, bullying, (sexual/racial) harassment and discrimination. Although the extent of the phenomenon is likely to be underreported, data from the ESWC indicate that about 2-3% of workers suffer from sexual harassment, and 9% are exposed to bullying and victimisation at work, while the incidence of physical violence lies somewhere in between.

Importantly, workplace violence has significant implications for worker retention, absenteeism, productivity and health and safety issues that are scarcely featured in the economic or policy debate (Paoli and Merllie, 2001). A number of adverse health effects associated with workplace violence are identified, which include psychopathologic,

psychosomatic and behavioural symptoms (Cassitto *et al*., 2003). Individuals working as health and social work professionals, in hotels and restaurants, in education and public administration, and generally in occupations that require interface with the public are usually at higher risk of suffering from workplace violence (ibid, 2003). In particular, nurses, police officers, healthcare workers, security guards and correctional officers are mostly affected by workplace violence and are found to have longer absence from work (Brousse *et al*., 2008). Worryingly, women are more likely to be exposed to this phenomenon, which often accounts for their more frequent absence from work relative to men (EASHW, 2000, p. 46-47).

4.3 OSH outcomes

4.3.1 Accidents at Work

Gyekye and Salminen (2006) argue that the probability of work-related accidents has its roots in two major causes, namely the internal dispositional characteristics of workers and external causal factors such as the characteristics of the working environment. Dembe *et al*. (2004) also take into account the broader social, economic and cultural context.

In their attempt to identify the factors that are correlated with workplace injuries or accidents researchers use a number of empirical methodologies that accommodate the nature of the "accident at work" indicator as dependent variable. For instance, given that the number of work-related injuries is the most common indicator in OSH studies, a great number of "zero" responses are usually collected. Count data techniques are therefore typically used in such cases, such as Poisson analysis (Alamgir *et al*., 2007) or a negative binomial model that takes into account the non-normal distribution of occupational accidents (Strong and Zimmerman, 2005; Blanch *et al*., 2009). Askenazy (2006) uses a bivariate probit model that takes into consideration the (non-random) process of reporting an injury by employees. Other researchers use categorical variable models such as ordered probit (Barling *et al*., 2003) and logistic regressions (Maiti and Bhattacherjee, 1999; Ghosh *et al*., 2004; Strong and Zimmerman, 2005; Gauchard *et al*., 2006).

The literature suggests that there are significant variations in the rate of workplace injuries across individuals of different gender and distinct economic sectors. Men are most at risk from suffering an (predominantly fatal) accident (Krause *et al*., 2001; Askenazy, 2006). The sectors of manufacturing, construction, agriculture and transport exhibit a higher incidence rate compared to other industries. Krause *et al*. (2001) show that there exists consistent evidence of a close link between socioeconomic and occupational characteristics (such as low education, low income, unemployment history, blue-collar employment, long hours of work, monotony, job dissatisfaction, no autonomy at work) and a high incidence of work-related accidents.

The incidence of occupational accidents is correlated with a number of other factors, such as company size (medium-sized companies are more often at risk), age (ageing and experience are negatively related to non-fatal accidents, though the reverse is true for fatal accidents) and outsourcing of labour (European Commission, 2009). Dembe *et al*. (2004) provide an extensive study of the factors associated with the occurrence of occupational injuries and illnesses. Using US data from the NLSY on a sample of working adults (aged 33-41), they find that the incidence of occupational injuries is related to several demographic factors, such as low family income and rural residence, and several job characteristics, including working in a high-hazard occupation (entailing high physical effort) and job dissatisfaction. The authors suggest that targeted prevention strategies are required for reducing the likelihood of

occupational injuries, such as worker self-assessment of the total physical effort demanded by a job and periodic monitoring of workforce job satisfaction.

The extensive summary of ten studies that examine the relationship between organisational and workplace factors and injury rates by Shannon *et al.* (1997) focuses on the influence of joint health and safety committees (e.g. representation; duties), the management style and culture (e.g. delegation of authority) and the organisational philosophy on OSH (e.g. role of top management, OSH training). They find that variables which are 'consistently' correlated with lower injury rates are those that reflect "a genuine concern by management for its workforce", such as empowerment of the workforce, encouragement of long-term relations and systematic evaluation of safety hazards (among others). No support is unearthed for the use of discipline for safety violations or of other variables which are subject to policy manipulation.

Fenn and Ashby (2004) use the 1998 wave of the British Workplace Employee Relations Survey (WERS) to show that employees in larger firms have a lower probability of being injured or falling ill. They propose that larger firms may be more safety conscious given that they face a greater degree of intensive monitoring by regulators, safety inspectors or insurers and/or that small firms may lack investment in safe technology or health and safety programmes. The authors report that even after controlling for endogeneity, firms with a higher proportion of unionised employees and with health and safety committees are associated with a greater risk of reported injuries and illnesses. This is likely to arise due to the superior reporting of workplace accident incidences within establishments where the aforementioned internal governance mechanisms are present.

A number of studies show that there is an inverse relationship between injury claim rates and unemployment rates (Brooker *et al*., 1995; Boone and van Ours, 2002). This is attributed to the fact that in times of boom effort levels of workers are higher and more inexperienced workers are hired as higher demand adds undue pressure on employers. During such times workers on temporary and casual contracts are also hired, so there is no incentive to the firm to train such workers on matters of OSH (Guadalupe, 2003). Temporary workers are also unfamiliar with the workplace surroundings and with the operation of machinery and equipment. Related to this are the findings of Probst and Brubaker (2001), who show that employees who report high perceptions of job insecurity exhibit a decreased safety motivation and compliance. This, in turn, is related to higher levels of workplace injuries and accidents. Guadalupe (2003) shows using Spanish data that having a fixed term contract increases the probability of having an accident by four to seven percentage points, which persists even after correcting for the systematic selection of workers into different contracts. This finding is disputed by Amuedo-Dorantes (2002), who concludes that the higher rate of work accidents observed in the case of temporary workers may be attributed to their inferior working conditions, because, once these are controlled for, they show an even lower probability of suffering a work accident than their permanent counterparts. Garcia-Serrano *et al.* (2008) provide further support to this evidence, using administrative register data from Temporary Help Agency (THAs) workers in Spain. They find that THAs exhibit a lower probability of suffering a serious/fatal accident and lower duration of absence compared to workers holding "direct" temporary contracts and those on open-ended contracts, after controlling for a set of personal, job and accident characteristics. They interpret this as indication that agency workers potentially benefit from specific safety and health training programmes provided by THAs. Finally, Hernanz and Toharia (2006) analyse the effect of contract type on the rate of work related accidents in Italy and Spain, using the 1999 Labour Force Survey '*ad hoc* module'. They find that, once personal and job characteristics of

workers are controlled for, the difference in the probability of suffering a work accident between open-ended and temporary workers vanishes.

In an important study, Boone and van Ours (2006) investigate in more detail whether the procyclical nature of workplace accident rates is truly related to greater employee stress, lack of experience or the short term nature of employment that is more prevalent during periods of booming economic activity. The authors develop a model whereby high accident rates during periods of low unemployment arise as a spurious phenomenon caused by the reporting behaviour of workers. Specifically, they assert that the reporting of an accident is likely to dent a worker's reputation and raise the probability of lay-off. Hence one expects to observe a lower reporting of accidents by workers in periods of high unemployment, when the likelihood and the cost of layoff is greater, and vice versa. Evidence of such a mechanism is found on data from 17 OECD countries, as a negative relation between unemployment and workplace accidents is only found for *non-fatal* accidents. As one would also expect to observe a similar negative correlation with *fatal* injuries in periods of a boom, the authors conclude that from a policy perspective there is no urgent need to worry about workplace safety when in cyclical upturns work-related accidents increase. Similar evidence highlighting the manipulative behavioural reactions of individuals in such circumstances is found by Meyer *et al.* (1995). In a "natural experiment" setting they compare injured individuals before and after increases in the maximum benefit amount. They find that time out of work increased for those eligible for the higher benefits.

Lastly, job satisfaction and other individual subjective evaluations of working conditions have been used as predictors of the probability of injury during work (Barling *et al.*, 2003; Ghosh *et al.*, 2004; Gyekye and Salminen, 2006; Gauchard *et al.*, 2006). This research shows that job satisfaction may act as a mediating factor that lowers the chance of a work-related accident occurring.

It is noteworthy that most of the above-mentioned correlations are obtained by analysis of cross-sectional samples. It is thus possible that the relationships found may suffer from reverse causality, namely that it might be the case that high accident rates force companies to adopt certain policies, rather than the other way round.

4.3.2 Occupational Diseases

Indicators of occupational diseases refer to diseases which are approved by the national authorities and therefore suffer from problems of comparability among countries. Furthermore, establishing the causes of work-related diseases is complex, as other factors may increase disease exposure so work-related risks may simply aggravate a pre-existing illness. An additional problem is that it sometimes takes decades for some occupational diseases to develop (e.g. respiratory diseases). The most prevalent health problems caused by work include musculoskeletal disorders, respiratory and skin diseases, stress, depression, anxiety and pulmonary disorders (Krause *et al.*, 2001).

- *Musculoskeletal disorders* (MSDs) are defined as health problems of the human locomotor apparatus i.e. muscles, tendons, the skeleton, cartilage, ligaments and nerves. According to the EAHSW, MSDs are the most common work–related health problem in the EU-27. About 25-30% of European employees are affected by them (e.g. 27% complain of backache and 23% of muscular pains). MSDs are related to physical, ergonomic and psychosocial factors, such as vibrations from tools or machinery, painful or tiring positions at work, repetitive movements, carrying or moving heavy loads, working with computers, high work demand and fast pace of work, and, in general, with jobs involving physical exertion on the body (Cady *et al.*, 1979).

According to the comprehensive survey of EASHW (2000), the agricultural and construction sectors are the most affected sectors, although the incidence is high in most sectors of the modern economy. Moreover, women are less exposed to physical risk factors, although hand or arm movements and work involving painful or tiring positions are experienced equally by both genders. Importantly, manual workers are at most risk of suffering from MSDs. Workers in precarious employment, such as those on fixed-length contracts, are also significantly more exposed to repetitive work and work in painful or tiring positions.

The extensive review of epidemiologic evidence by NIOSH (1997) reports credible evidence of a strong association between work-related MSDs of the neck, upper extremity, and low back and certain work-related physical factors. This is specifically the case when there are high levels of exposure and in particular a combination with exposure to more than one physical factor (e.g. repetitive lifting of heavy objects in extreme or awkward postures).

- *Respiratory and skin diseases*: According to data from the European Statistics of Occupational Diseases (EODS), 88% of occupational skin disease cases (e.g. dermatitis) and 36% of occupational respiratory disease cases (e.g. asthma and chronic obstructive pulmonary disease) are related to chemical exposure. Occupational asthma is a common disease affecting workers, especially in the sectors of agriculture and manufacturing. Occupational dermatitis is prevalent in mining. Occupational asthma and dermatitis are reported to have the greatest effects on productivity costs, ranging from 16.5 to 23 billion Euros, respectively (Pickvance, 2005). Some of the (malignant) respiratory diseases (e.g. respiratory cancer, asbestosis and silicosis), however, can take decades to develop (e.g. a 30 year time span), and are therefore underreported. For instance, only until recently were *mesotheliomas* recognised as an asbestos-related occupational disease.

- *Psychosocial health problems*: Factors of work organization such as job control, job demand, work pace and hierarchical relations are involved in provoking or aggravating psychosocial health problems, such as stress, anxiety and depression. EASHW (2000) reports that around 30% of the European population is exposed to stress primarily caused by work. In contrast to other job-related hazards, psychosocial health problems typically affect individuals employed in the Health and Social Work and Education sectors, rather than in blue-collar jobs. Nevertheless, working conditions such as heat, noise, shift work, and precarious contracts contribute to rising stress levels. Other important determinants of psychosocial health problems include high speed work, occurrence of unforeseen interruptions at work, lack of control over working methods, mismatch between skills and workload and burnout.

Wege *et al*. (2008) draws attention to work-related stress given the high incidence of stress-related disorders that are reported around the world. The Cox model explains stress as an inherent incapability by individuals to fulfil their expectations, which at extremes can lead to a wide range of mental and physical disorders and can result in deranged relations at the workplace and job dissatisfaction (Cooper. *et al*, 1987; Gibbons and Newton, 1998; Ali and Lindstrom, 2008). Several occupations that are often subjected to tight and erratic time schedules and heavy workload, such as healthcare professionals (e.g. nurses, junior doctors) or managerial workers, are typically found to experience hypertension and elevated levels of stress (Michie and Williams, 2003; Cifuentes *et al*., 2008; Yamasue *et al*, 2008).

Joensuu and Lindsstrom (2003) provide an extensive review of the role of stress and work factors in terms of affecting sickness absence. They report that in Sweden the percentage of long-term absentees due to psychological problems increased from 14% in the early 1990s to 25% in 2001. The effect of stress is mainly reflected in absences lasting for several months, and is argued to have aetiological influence on many health problems and a detrimental effect on most, if not all, dispositions related to health and well-being.

Importantly, an emerging theme in the literature is the study of the interaction of physical features of the work environment with other psychosocial elements. Leather *et al*. (2003), for instance, examine the relationship between ambient noise levels and job stress, while Foppa and Noack (1996) show that stress at work is associated with musculoskeletal pain. More research is nonetheless required that will detect the underlying links and causalities associated with stress-related psychosocial problems and the relationship with the work environment.

4.3.3 Sickness Absence

The causes of absenteeism are in general multi-faceted, and are influenced not only by the health status of individuals, but also by the social insurance system, the work environment, biological factors, attitudes and commitment to work, macroeconomic conditions and other social and psychological determinants. Regardless of the above complexities, the relevant literature distinguishes the causes of absence into two main components. On the one hand, it is viewed as the manifestation of workers' labour supply decisions trading-off their limited input of time between the substitutable activities of 'work' and 'leisure' (Allen, 1981; Brown and Sessions, 1996). On the other hand, ill health and infirmity is believed to be a predominant factor underlying worker's propensity to take days of leave (EUROFOUND, 1997, p. 21).

It is hard to obtain accurate measures of absence, especially since cross-country administrative data sources are relatively incomparable due to the marked differences in social insurance systems (in terms of the level of sickness benefit, length of time before payment, request of medical certificate *inter alia*). For this reason, a number of authors attempt to measure the incidence and determinants of absenteeism via subjective measurements of lost work hours (Fenn and Ashby, 2004; Heywood *et al*., 2008; Pouliakas and Theodoropoulos, 2010) or by exploiting the discrepancy in actual and usual hours of work from standard Labour Force Surveys (Barmby *et al*., 2002).

Applied psychologists are the first to study the causes of worker non-attendance, attributing its incidence primarily to the existence of job dissatisfaction (Steers and Rhodes, 1978). Nevertheless, some of the earliest economic studies, such as those by Barmby *et al*. (1991, 1995) in the UK, Ruser (1991) in the US, Johansson and Palme (1996) and Henrekson and Persson (2004) in Sweden focus on the dynamic labour supply responses of employees to sick pay compensation or to other economic incentives that they face. These authors provide evidence of well-determined effects of the sick pay scheme and of the terms of the work contract (such as the wage) on the incidence and duration of absence. Other papers suggest that there are optimal reactions of employees to manipulations in their compensation via the provision of financial incentives (such as performance-related pay) (Wilson and Peel, 1991; Brown *et al*., 1999; Engellandt and Riphahn, 2004; Hassink and Koning, 2009; Pouliakas and Theodoropoulos, 2010). In addition, there appear to be cyclical fluctuations in the absence rate (Leigh, 1985; Kaivanto, 1997; Arai and Thoursie, 2005; Askildsen *et al*. 2005; Engstrom and Holmlund, 2007), since high unemployment is believed to act as a "discipline device" on the shirking behaviour of workers (Shapiro and Stiglitz, 1984).[4]

Furthermore, demographic factors are identified as important determinants of absenteeism. The female sickness absence rate is consistently higher than the male one (Barmby *et al*., 1991; Vistnes, 1997),[5] a higher pattern of lost man-hours is observed with age (Ercolani, 2006), the presence of young kids in a household increase the likelihood of absence (Vistnes, 1997; Dione and Dostie, 2007) and the region of residence affects differences in absence rates (Barham and Begum, 2005). Furthermore, absence rates vary according to a plethora of job characteristics. Specifically, they decrease with rising earnings (Ercolani, 2006; Dione and Dostie, 2007) and increase with tenure, although absenteeism turns out to be low during probationary periods of work in which workers strive to impress their employers

(Riphahn and Thalmaier, 1999; Ichino and Riphahn, 2005). Industrial differences are notable, with industries with the highest absence rates typically found in the public sector (Ercolani, 2006; Scoppa, 2008). The proportion of employees on fixed term/temporary agency contracts, who face a greater risk of job loss, is negatively related to the absence rate (Hernanz and Toharia, 2006; Bradley *et al*., 2007), while a positive link between unionisation and absenteeism is also found (Leigh, 1981; Allen, 1984; Chaudhury and Ng, 1992). A number of studies explicitly examine the correlation between the size of the firm and absenteeism (Barmby and Stephan, 2000; Fenn and Ashby, 2004). They show that absence rates are higher in larger-sized firms compared to smaller ones. This may imply that big firms may face difficulties in monitoring their workforce, or that they are able to insure against absence via a buffer-stock of (substitute) workers.

Furthermore, the highest absence rates observed in secondary sector occupations, typically characterised by contact with hazardous materials and hard manual work (e.g. process, plant and machine operatives), constitutes some evidence of a correlation between absenteeism and poor working conditions. Ose (2005) shows that "bad" job attributes (high levels of noise in the work area, a high degree of monotonous work, heavy or frequent lifting or poor work postures) in the Norwegian labour market contribute to ill health, which, in turn, results in increased long-term absence. In a systematic literature review, Michie and Williams (2003) identify as key factors associated with psychological ill health and sickness absence in staff the following: long work hours; work overload and pressure and the effects of these on personal lives; lack of control over work; lack of participation in decision-making; poor social support and unclear management and work role. Finally, Bokerman and Illmakunnas (2008) consider the interaction of a whole host of adverse working conditions variables, job dissatisfaction and sickness absences via a recursive multivariate probit model in the Finnish labour market context. They show that the prevalence of 'harms' at the workplace is associated with job dissatisfaction and dissatisfaction is, in turn, related to sickness absence. This implies that the improvement of working conditions should be considered a policy priority and an integral part of any policy scheme that is intended to decrease the incidence of absenteeism.

Variables reflecting the working time of individuals are often examined as covariates of the absence rate, since these have important implications for the mismatch of desired and contractual hours (Drago and Wooden, 1992; Brown and Sessions, 1996). Other factors that are examined include whether employees engage in shift work, whether they are on part-time contracts or if they are entitled to any other forms of flexible working time arrangements (e.g. annualised hours, flexitime, working from home). Lusinyan and Bonato (2007) argue that flexible working time arrangements are generally found to be associated with lower employee absence because they reflect the extent to which the constraint of contractual hours is relaxed. However, it is important to bear in mind that it is firms which find absence to be less costly that are more likely to offer flexible working time schedules in the first place, so estimates of the effect of non-binding hours on absence usually suffer from endogeneity bias. Moreover, shift work and irregular working time patterns are found to interfere with the biological and social rhythms of employees (Finn, 1981), so these are believed to contribute to higher absence due to the higher physical and mental burden faced by individuals.[6]

Recent research has focused explicitly on the internal workings of organizations, in an attempt to identify the equilibrium rate of absenteeism within a given labour market. Coles *et al*. (2007) use a unique matched employer-employee dataset from France, showing that the nature of the production technology of firms can play a significant role in terms of the *shadow price for absenteeism* (i.e. the amount that firms are willing to pay to achieve a unit reduction in the absence rate). Specifically, they argue that absence is more costly in firms employing a so-called "assembly" or

"just-in-time" production technology. The latter are therefore more likely to respond to absence via higher monitoring and the provision of additional and/or more generous sick pay. Coles *et al.* (2007) augment their analysis with the supply-side of the market, by identifying the required increase in workers' pay for a marginal reduction in their hours of absence. In this manner, they obtain structural estimates of the equilibrium rate of absence in their dataset.

In a similar spirit, Pauly *et al.* (2002), Heywood and Jirjahn (2004) and Heywood *et al.* (2008) focus on the interrelation between teamwork, monitoring and absence. It is confirmed using representative samples of German and UK establishments that firms with interdependent productivity (team production) face a higher cost of absence, and as a consequence expend additional resources on the task of monitoring absence. Firms with teamwork subsequently face a lower absence rate relative to those that do not rely on productive interactions among workers.

The difficulty of obtaining internationally comparable data on worker absenteeism has hampered any attempts of analysing cross-country differences in patterns. Barmby *et al.* (2002) use comparable data from nine countries of the Luxembourg Employment Study to carry out multivariate analyses of absence rates. They highlight similar forces operating across advanced Western economies. In addition, Bergendorff *et al.* (2004), Osterkamp and Rohn (2007) and Lusinyan and Bonato (2007) find higher absence rates in the Netherlands, Norway, Sweden and the UK relative to other nations. The authors investigate the relationship between international sickness absence rates and institutional characteristics of labour markets, after controlling for differences in age structures, health, unemployment and participation rates (among others). They confirm that the level of sick pay and the generosity in terms of granting sick leave are important determinants of cross-country differences in sickness absenteeism. They also corroborate that absenteeism is significantly and positively related to the strictness of employment protection that increases the cost of dismissal to employers, though this finding is disputed by Frick and Malo (2008).

Finally, it is worth mentioning that a number of researchers have recently turned their attention to the determinants and consequences of the related phenomenon of *sickness presenteeism*, defined as the tendency of workers to attend employment despite illness (Chatterji and Tilley, 2002; Skatun, 2003; Dew *et al.*, 2005). Though research on this issue is still in its infancy, concerns have been raised given evidence that sickness presenteeism is related to future sickness absenteeism (Aronsson *et al.*, 2000; Bergstrom *et al.*, 2009; Bockerman and Laukkanen, 2010), and that the cost of the former in terms of lost productivity may be substantially greater than that of the latter (Goetzel *et al.*, 2004).

4.3.4 Job Satisfaction/Job Quality

Job satisfaction is ranked consistently as one of the most important factors of life satisfaction and of the quality of life (EPICURUS, 2007). A plethora of studies examine the determinants of job satisfaction and its relation with aspects of individual health and overall well-being (Frey and Stutzer, 2002). This is stimulated by evidence that job satisfaction, used as a proxy for the overall "quality" of work, is a measure that is strongly correlated with aspects of employee behaviour and performance, such as absence or quits (Freeman, 1978; Clegg, 1983).

Green and Tsitsianis (2005) argue that factors such as the intensification of work effort and declining task discretion are appropriate culprits for the falling job satisfaction that is observed in the UK in the 1990s. Using a unique dataset of lower-skilled workers from seven European workers, the EU EPICURUS project (2007) and Pouliakas and Theodossiou (2009) also show empirically that a plausible factor that may contribute to lower job satisfaction in Europe might be inferior working conditions. Their analysis is based on the construction of an index capturing the "quality" of working conditions, based on the subjective perceptions of workers to whether their job is dangerous (risk of physical

injury, contact with dangerous products etc.), physically tiring, or of low quality in terms of the work environment (noise, dirtiness, heat etc.). It is found that inferior working conditions are associated with reduced employee motivation and job satisfaction, which is, in turn, likely to lead to a higher incidence of workplace illness, injury or absence.

Stansfeld *et al*., (1998) argue that job satisfaction may have an indirect influence on workers' health through both physical and psychosocial employment conditions, and that improvements in job satisfaction over time appear to prevent workers from (further) health deterioration. Moroever, the meta-analysis of Faragher *et al*. (2005) provides a systematic and thorough review of the research evidence linking work related stress factors with ill health. Of the factors evaluated within this study, employee self-reported job satisfaction emerges as having by far the strongest link with overall wellbeing. Furthermore, after analysing almost 500 studies of job satisfaction, a clear indication of a strong relationship between job satisfaction and both mental and physical health is found. The correlations identified are numerically large and highly significant (both statistically and clinically). The relationships are particularly impressive for aspects of mental health, specifically burnout, lowered self-esteem, anxiety, and depression, where it is confirmed that dissatisfaction at work can be hazardous to an employee's mental health and wellbeing, though the correlation with subjective physical illness is more modest.

In order to overcome the measurement error problems of self-reported assessments of health status that hamper most studies on this issue, and to address the issue of cross-sectional causality, Fischer and Sousa-Poza (2009) employ objective measures of health from the German Socio-economic Panel (GSOEP) database. Importantly, they find that employees with higher job satisfaction levels feel healthier, are more satisfied with their health, and that improvements in job satisfaction over time appear to protect workers from (further) health deterioration.

5. Consequences of (Lack of) Health and Safety at Work

In contrast to the identification of the causes of various indicators and health and safety at work, the investigation of their economic and social consequences via multivariate statistical analysis is sparse. However, it is important to understand and identify the effects of lack of OSH on the economic activity of individuals and their quality of life. For example, work-related injuries/illnesses are likely to hamper the ability to work and workers' *ex post* productivity following an incident. The working time lost during a recovery period may also have implications for their stock of human capital and their subsequent earning capabilities (Woock, 2007). Furthermore, individuals that experience injuries and diseases related to work may face a higher probability of unemployment, experience early exit from the labour market or face increased difficulties to re-enter into a suitable job (Pransky *et al*., 2005). Newton *et al*. (2007) provides evidence that a significant portion of the European labour force remains idle following the occurrence of an accident/illness, as individuals do not feel capable of performing the work that they performed prior to the incident. Weil (2001) provides a summary of the aforementioned costs and argues that the empirical estimates to date tend to underestimate their true magnitude since the quantification of all the relevant costs is very difficult in practice.

A recent study, commissioned on behalf of the UK HSE, attempts to quantify the impact of ill health on the macroeconomic and labour market outcomes of the UK economy (HSE, 2008). It investigates the link between health and economic performance by examining whether health, in general, and ill health caused at work, has an impact on individual productivity and the level of employment. The effect of health on GDP is also explored using a macroeconomic approach that is based on the estimation of a growth equation using UK regional data. Specifically, data

from National Statistics on Government Office Regions are used, covering the period 1995 and 2005. The Annual Population Survey is employed to extract information in employment and educational attainment of the labour force. Health variables are obtained via the commonly used General Household Survey (GHS) and the LFS/RIDDOR data provided by the HSE. The regressions show that a higher stock of people with poor health and long-standing illness is associated with negative economic growth, with an elasticity of 0.02. This effect is relatively robust to the inclusion of controls for industry structure. The same study utilises microeconomic techniques to estimate the impact of bad health on individual productivity and employment status. Using the standard Mincer (1974) specification of an earnings equation on data from the British Household Panel Survey (BHPS), it is found that an individual's health has a strong and significant impact on productivity. Specifically, those who are in excellent health earn 4-7% more than those whose health is average, while those with poor health earn 7-15% less. Moreover, the probability of being in work is found to decline as the individual's health status worsens, with those benefiting from excellent (poor) health having a 17% (34%) higher (lower) probability of being in employment compared to those with average health.

Crichton *et al.* (2005) examine the effects of work-related accidents on the future labour market outcomes of individuals, using data from New Zealand. After employing a suitable econometric analysis, they highlight that injury severity (defined as those cases where individuals receive earnings compensation for more than 3 months) is associated with negative future prospects. They show that injured individuals of longer duration have lower employment rates and incomes after returning to the labour force, with women, older-aged individuals and the lower-paid being more susceptible to such negative outcomes. Similar findings are provided by Reville and Schoeni (2001), who report that lower employment opportunities and increased income losses are observed for workers with permanent partial disability due to occupational factors. Moreover, the economic loss is found to be ameliorated when the severity of injury is smaller. Workers in the manufacturing sector also seem to suffer from the greatest economic losses when compared to the rest of the workforce. It is therefore proposed that national policies should have a dual purpose, namely to provide economic support to such target groups via adequate compensation benefits and also to improve prevention programs that will increase OSH. In line with the above, Woock (2007) finds that the annual earnings losses are highest for workers who suffer from a work-limiting disability following injury.

Retirement decisions due to work-related injuries/illnesses are also analysed. Pransky *et al.* (2005) argue that job satisfaction is a significant determinant and mediator of the work-related illness and retirement nexus. In fact, 11% of workers in their sample planned to retire earlier due to experience of a work injury. Tüchsen *et al.* (2009) show that experiencing a work-related injury is a strong determinant of individuals' decision to take a disability pension retirement, although this is only found to hold for their male sample. Finally, Dembe (2001) highlights that in addition to the more traditional costs of occupational injuries (such as workers' insurance payments, medical costs, time needed to return to work), the social consequences of accidents in terms of their marked effect on the lives and daily activities of affected workers and their families are sizeable and have generally been neglected by academics and policymakers.

6. Issues for Future Research

Notwithstanding the greater availability of data sources on health and safety at work, the available research remains incomplete, obscure or uncertain for many relevant topics. The harmonisation and international comparability of appropriately-designed OSH indicators in terms of comparable definitions, data collection methodologies and quality

remains one of the major challenges of future research. Nevertheless, such a task is hindered by substantial differences in social laws and administrative regulation practices across countries which cannot be easily incorporated in the usual statistical methodologies.[7]

Future research need to carefully consider the causes and effects of mutifactorial physical risks, such as the combined exposure to elements of the physical work environmental and psychosocial risk factors. Many of the OSH risks are caused or aggravated by job insecurity and the strain that workers experience as part of the demands of modern job markets, poor ergonomic design of workplaces and the lack of adequate training of workers on issues of health and safety. An interdisciplinary approach on OSH, as suggested in this survey, may therefore assist in identifying the key issues and initiatives required to strengthen the health and safety of workers in modern economies.

OSH research should take further account of the changing demographic evolution of the workforce, which involves an increasing proportion of female, racially diverse and older-aged employees. It is important for future studies to investigate closely the presumably different implications of job risks and of arduous working conditions for the health of the latter sub-groups (e.g. the effects of biological agents on reproductive health, effect of atypical work hours on hypertension and the sleep disorder patterns of the elderly, impact of ill health on early retirement and pension systems). Migrants and ethnically or racially diverse workers are also a cause of particular concern, since such individuals are typically employed in high-risk and informal sectors, they face linguistic and cultural barriers that prevent appropriate OSH communication and training, and they are often not covered by social security systems (HSE, 2004). Indeed, given that a substantial part of the working population is employed under the vulnerable conditions of the *informal economy*, often possessing low levels of skills and experiencing low/irregular incomes and long working hours, extension of OSH measures to include such informal workers is a challenge for the future (ILO, 2008, p. 19).

Research work needs to clarify the underlying causes of the falling accident rates observed in advanced Western economies in recent years, as some are attributing this trend to the exportation of dangerous activities to Third World countries, while others are pointing towards the use of new technologies, better training, or an increase in informal employment (EASHW, 2002). Clear-cut policies that will tackle the health and safety deficiencies in the workplace in the future can only be set by accurately understanding the sources of work-related hazards.

In addition, the effectiveness of OSH rehabilitation or reintegration activities undertaken by firms (that can ensure smooth return to work after a major incident) are yet to be explored. Such activities are likely to range from medical or vocational rehabilitation (e.g. training injured/disabled employees in new tasks related to a new position within a firm), to whether the workplace is conducive to reintegration (e.g. adapting workplaces). The importance of OSH management by enterprises (e.g. the proportion of firms that keep records of/investigate OSH incidents) in terms of the potential productivity efficiencies and the impact on worker well-being has also not been adequately investigated by researchers. The greater vulnerability of Small and Medium-Sized Enterprises (SMEs), in particular in terms of the dearer credit-constraints faced that inhibit their ability to undertake adequate OSH prevention or rehabilitation policies, is an issue of further concern. Moreover, very few studies exist to date that examine the labour market prospects of employees that return to work following a long-term period of sickness absence or disability. The extent to which the return of such workers is beneficial (or detrimental) to company performance is therefore an area that merits further attention.

Identifying the causal relationship between work factors, the health status of individuals and various economic and labour market outcomes is fraught with issues of endogeneity, subjectivity bias and measurement error. More research is therefore necessary to identify the economic and non-economic costs of ill health and workplace injuries/illnesses on

individual performance and welfare. The investigation of the (long-term) effects of work-related illnesses is likely to become more important in the near future, as new and improved datasets will allow a more accurate measurement of their incidence, while correlations with various demographic and job-related characteristics will become more easily identified.

Finally, it remains the case that few studies embark on economic evaluations (cost-benefit analysis) of policies relating to preventive health care at work. The numerous methodological obstacles that inhibit accurate economic evaluations of such policies therefore need to be overcome in future research.

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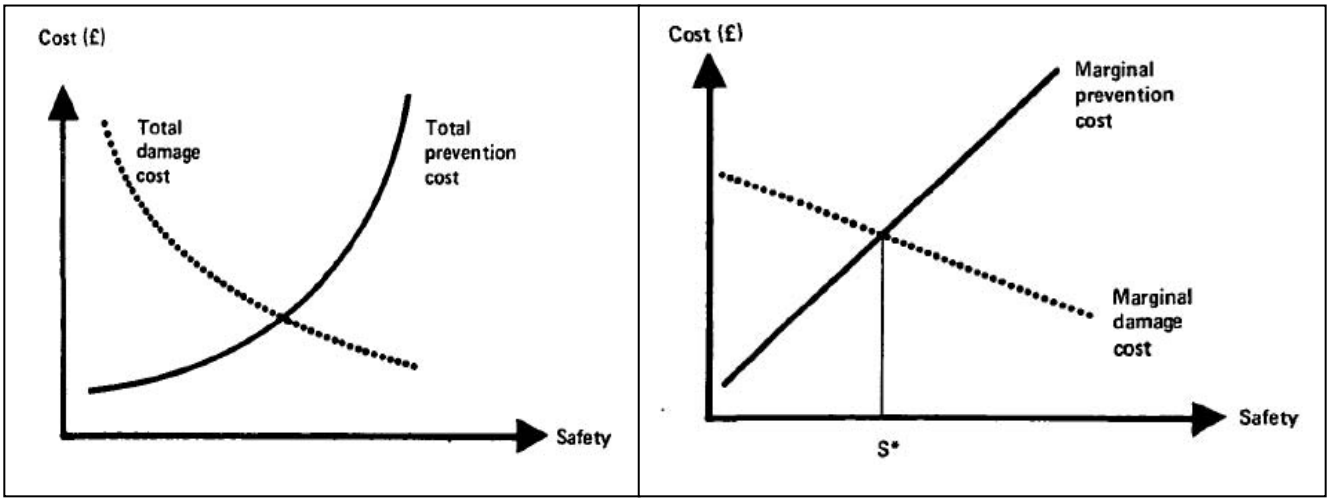

Figure 1 Simplified Framework for the Efficiency of OSH
Source: Henderson, 1983, p. 78-79.

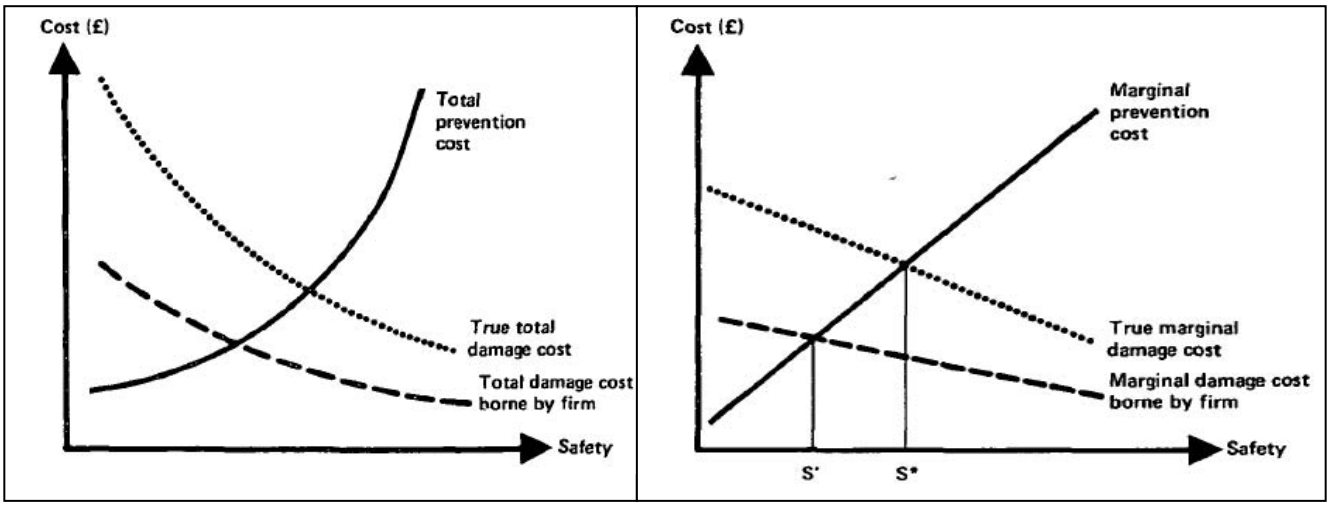

Figure 2 Simplified Framework for the Inefficiency of OSH
Source: Henderson, 1983, p. 80.

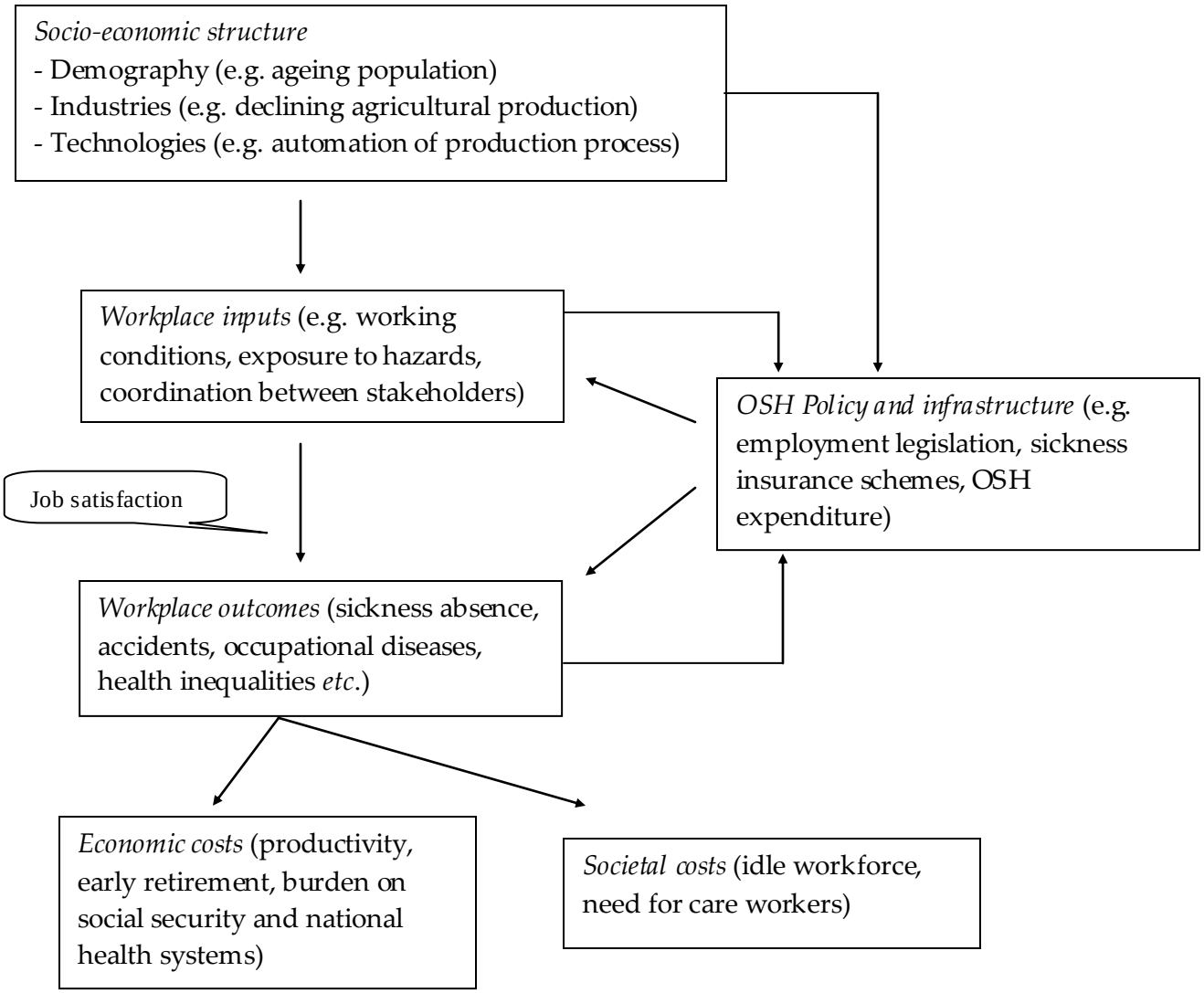

Figure 3 A Structural Model of Measures and Interactions of OSH
Source: Rantanen *et al*. 2001, p. 17.

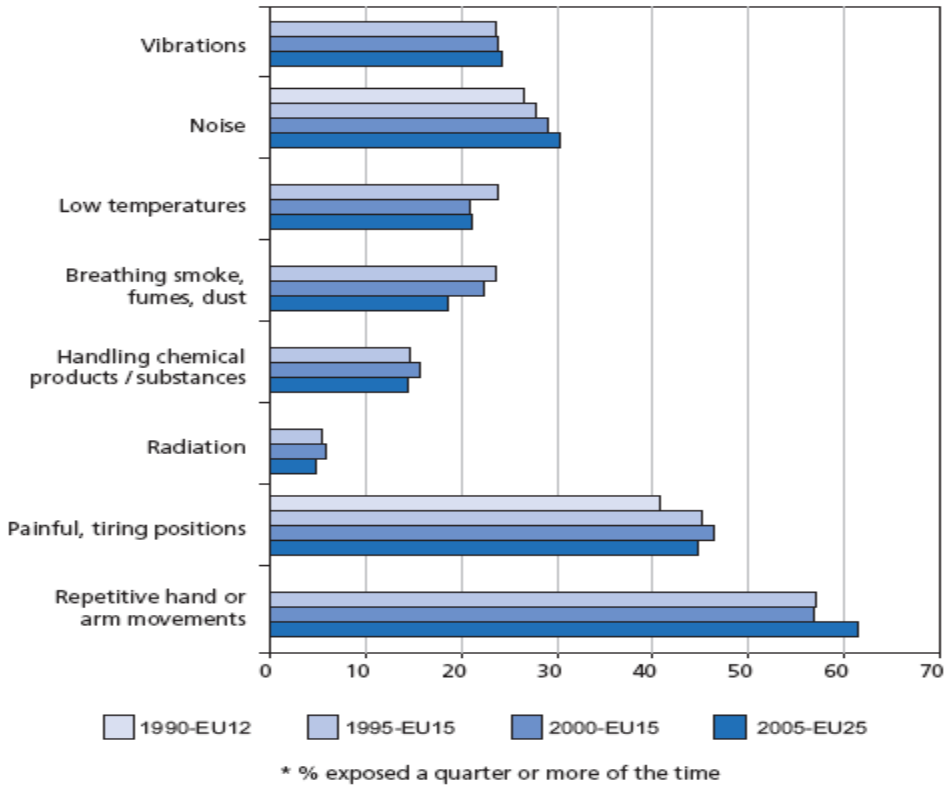

Figure 4. Exposure to Physical Risks at Work in the EU-27 Countries, 1990-05

Source: European Foundation for the Improvement of Living and Working Conditions, 2007.

Table 1 Selected Measures and Indicators of OSH

OSH Measures	*Examples of OSH monitoring indicators*
1. OSH Policy/Infrastructure	
The Size of the Social Insurance System	% of GDP devoted to expenditure on incapacity benefits, including sickness allowances and disability benefit
Enforcement and Compliance with OSH Activities	ratification rate of ILO conventions on OSH coverage of workers' compensation system as % of total number employed and/or sectors of economic activity proportion of human resources devoted to labour safety inspection and enforcement number of OSH offences prosecuted and convicted
OSH Training	% of workforce in firms receiving training on OSH % of firm budget devoted to OSH training activities
OSH Management	% of enterprises that engage in OSH risk assessments % of enterprises that keep records of work-related accidents/illnesses/sickness absence % of enterprises that have official OSH policies and infrastructures in place (e.g. joint worker-manager committees to discuss OSH-related issues and frequency of meetings; OSH employee representative; targets for OSH performance) % of enterprises that have arrangements in place to support the return to work of employees on long-term sickness absence/illness/disability
OSH Cost	% of firm budget devoted to the promotion of OSH in the workplace and prevention of work-related accidents/injuries/illnesses % of firm budget devoted to the compensation of injured/ill/disabled workers % of permanent or temporary employees used to replace sick or injured staff
2. OSH Hazards/Working Conditions	
Presence of Physical Agents in the Workplace	% of employed exposed to high levels of noise, vibration, radiation, abnormal room temperature etc.
Presence of Chemical Agents in the Workplace	% of employed exposed to/in regular contact with dangerous products or substances (e.g. asbestos, lead, benzene, pesticides etc.)

Ergonomic Conditions in the Workplace	% of employed subjected to inconvenient work postures, repetitive movements, lifting of heavy loads etc
Working time arrangements	% of employed working very long hours (at least 50h/week), or in irregular shifts (especially nights shifts)
Psychosocial Problems	% of employed with stress-related problems and mental disorders
	% of employed subjected to threat of physical violence/harassment/threats/attacks at work.
3. OSH Outcomes	
Fatal work accidents	Incidence of fatal accidents at work per 100,000 employees
Non-fatal work accidents	Incidence of non-fatal accidents at work with more than 3 days of absence per 100,000 employees
Work-related illnesses	Incidence of ill health related to an officially defined occupational disease per 100,000 employees Incidence of ill health related to an officially defined occupational disease per 100,000 employees who were working in the last 12 months
Sickness absence	% of usual working hours lost in a reference week due to incidence of absence related to sickness or ill health
Job Satisfaction / Job Quality	Average level and trend of subjective employee well-being score by country Indices of several aspects of working conditions (e.g. physical, psychosocial, work autonomy, work intensity, intrinsic satisfaction)
Labour market prospects	Differences in participation probabilities between formerly injured/ill/disabled employees and healthy employees Differences in wage outcomes between formerly injured/ill/disabled employees and healthy employees

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Endnotes

[1] Deleire and Levy (2004) in the US and Grazier and Sloane (2008) in the UK show that individuals exhibiting strong aversion to risk (which is proxied by family structure) make occupational choices that are biased in favour of safer jobs.

[2] A source of bias that has also been usually taken into account in the literature when examining CWDs for work-related injuries/illnesses is the endogenous choice of union membership, since wage levels are restricted by collective bargaining. While, a number of studies have found evidence in favour of the hypothesis of the endogeneity of union membership (Marin and Psacharopoulos, 1982; Siebert and Wei, 2003), others have failed to find a convincing pattern (Arabsheibani & Marin, 2000). Researchers have also interacted the fatal risk variable with a number of variables to explore the potential heterogeneity in CWDs. For example, Thaler and Rosen (1976) and Viscusi (1993) use interaction effects with age, since they argue that there may be age-related differences in the inclination to undertake job-related risk.

[3] Though descriptions of the elements that constitute an appropriate *indicator* of OSH may vary, indicators should provide informational know-how regarding the consequences of working conditions for the health and safety of individual employees, and about any potential measures that may be taken to affect it both at the present period and over time (Rantanen *et al*., 2001).

[4] Other researchers have drawn attention to a potential "selection" mechanism, whereby absence-prone or "bad" workers are more likely to be fired in recessionary periods and (re-)hired during booms (Arai and Skogman Thoursie, 2005). Nevertheless, the strength of procyclicality even amongst countries with high employment protection legislation casts some doubt on the latter explanation (Lusinyan and Bonato, 2007).

[5] This has been typically attributed to the differential out-of-work commitments of the two genders (e.g. domestic duties such as the rearing of children). Ichino and Moretti (2006), instead, show that a significant fraction of the male-female absenteeism gap can be explained by a 28-day cycle, which vanishes for workers aged 45 or older. They interpret this as evidence that the menstrual cycle is responsible for the typically higher level of female absenteeism.

[6] Tuchsen *et al*. (2008), however, fail to find any conclusive evidence of a link between shift work and absenteeism in a sample of Danish workplaces, after controlling for an extensive list of relevant factors (such as age, education, body mass index, smoking status, alcohol consumption, leisure time physical activity and other psychosocial and physical work environment factors).

[7] Indeed, the EU has made marked progress towards this goal via the construction of the *European Labour Force Survey* (LFS), the *European Surveys on Working Conditions* (ESWC), the *European Survey on Accidents at Work* (ESAW) and the *European Statistics on Occupational Diseases* (ESOD) databases.