Risk self-perception among Spanish male employees

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(PRELIMINAR VERSION. PLEASE DO NOT CIRCULATE)

Abstract:

This article follows literature focused on analysing the influence of objective risk factors on risk perception, on the basis than knowledge on this relationship is an important prerequisite for designing and ensuring preventive measures. More specifically, the objective of this study is to analyse the relationship between the risk perceived by the worker in the workplace and the real (objective) risk associated to the position he/she performs, taking into account an ample set of personal and job-related characteristics. Additionally, we are particularly interested in testing three hypotheses regarding such relationship between perceived and actual risk: i) the risk perceived by an employee in the job is associated with the average value of the fatal accident's real risk of that employee's reference group; ii) risk aversion is influenced by family composition; and iii) greater knowledge of the characteristics of the job, due to union affiliation, increases the perception of the risk of accidents.

With data from the Statistics of Work Accidents and the Survey of Quality of Life at Work for the years 2007 to 2010 in Spain, regression analyzes are carried out, firstly, by means of ordinary least squares (OLS) and by ordered probit models to, subsequently control the possible endogeneity working hours and union membership variables with two stages least squares and maximum-likelihood estimation. Irrespective of the estimation method used, the results confirm the three hypotheses tested. The basic conclusion is that it is important to gain knowledge on the elements that distort the self-perception of risk at work in order to implement measures to reduce the gap between subjective perception and actual risk. This eventually will allow a better fit between the characteristics of the worker and those of the workplace, thus reducing the probability of occupational accidents.

Keywords: workplace accident; subjective perception; risk aversion; employee; union.

1. Introduction

In recent decades, advances in health and safety at work have been key factors for an improvement in the conditions in which workers perform their tasks, especially in more dangerous jobs. Despite this, injuries and accidents in the workplace remain nowadays a serious safety concern worldwide, causing numerous direct (physical) and indirect (psychological) costs for the worker.[1]

For the adoption of measures aimed at increasing occupational safety, it is important to bear in mind that the degree of real risk that exists in the workplace may not coincide with the employee's perception of that risk (Sjöberg, 2000; Kouabenan, 2009; Leoni, 2010). While real risk captures the extent to which individuals are exposed to danger when working (injuries, accidents, diseases) and is objective, risk perception refers to individuals' subjective assessment of the risk (the likelihood of such undesired consequences occurring). According to Sjöberg et al. (2004), risk perception includes evaluations of the probability as well as the consequences of a negative outcome. A deviation between the actual risk of a job and the perception that the worker has of this risk can exacerbate (or lessen) the risk of accident. If employees perceive their work to be at a high level of risk, they are likely to behave safely to avoid risk; if they do not, their likelihood of suffering workplace injuries and accidents increases. Knowing the relationship between the real risk of suffering an accident and the perception that the worker has of the risk they face are key when implementing policies that reduce the risk in the workplace. If certain tasks are dangerous, but are not so perceived by the worker, the established safety measures may not be enough.

Differences between risk perception and real risk can be rationalized upon the difference between "rational" risk perception and "emotional" risk perception (Xia et al. 2017).[2] From a rational perspective, workers are likely to perceive risk through deliberate calculations of risk criticality. However, such a rational treatment of risk is usually only possessed by experts in a particular field, while laypeople tend to perceive risk based on emotions, i.e., perceive risk through direct and intuitive judgment. Such kind of risk perception can be irrational and influenced by diverse factors, such as

[1] There are also economics costs both for workers, since injury-compensation schemes are lower than wages, and for firms, due to the loss of worked hours and work disruption.

[2] This line of reasoning follows that of, for example, "anticipated" vs. "anticipatory" emotions (see Loewenstein et al., 2001). Similar arguments are posed in Epstein (1994); Slovic et al., (2004) or Weber et al. (2002).

characteristics of risk, personal variables, and cultural and socioeconomic background (Kouabenan, 2009). Despite its complexity, emotional perception of risk are usually assessed by asking about an individual's direct perception of risk; that is, the worker's direct and intuitive feeling of a specific risk.

In consequence, it seems important to gain knowledge on the elements that distort the self-perception of risk at work in order to implement measures to reduce the gap between subjective perception and actual objective risk. This eventually will allow a better fit between the characteristics of the worker and those of the workplace, thus reducing the probability of occupational accidents. Subjective risk perception is a positive predictor of the rate of accidents, but total alignment does not exist, but a number of factors makes risk perceptions a bit different from objective risk. Misperception of risk may cause risky and unsafe behavior of workers, thereby possibly leading to accidents and poor safety performance in the workplace.

Against this background, this article follows studies focused on analysing the impact of beliefs and safety culture on accident prevention, underlining that the perception of risk is an important prerequisite for designing and ensuring preventive measures to be effective. More specifically, the objective of this study is to analyse the relationship between the risk perceived by the worker in the workplace and the actual (objective) risk associated to the position he/she performs, taking into account an ample set of personal and job-related characteristics. Additionally, we are particularly interested in testing three hypotheses regarding such relationship between perceived and actual risk. These hypotheses, to be posed in the next section, are related with the issues of reference group, family and safety culture.

A remarkable contribution of our study is that we deal with the issue of endogeneity raised by bidirectional causality between risk perception and some of the explanatory variables. In particular, while it is expected that working longer hours or being in a safety environment may influence the degree of risk perception, it is also possible that such degree of risk perception may affect the number of hours finally worked or the willingness to contribute to the safety climate in the organization. These possibilities are more deeply discussed below. Appropriate econometric tools are used in the article to cope with the problem of simultaneity when using ordered variables.

The analysis is undertaken with Spanish data from the Statistics of Work Accidents and the Quality of Life at Work Survey (QLWS) for the years 2007 to 2010.[3] A regression analysis is carried out, firstly, by means of both ordinary least squares (OLS) and by ordered probit (OP) models to, in a second step, controlling the possible endogeneity of some variables through both two stages least squares (2SLS) and maximum-likelihood estimations (MLE).

Based on our results, three elements are found to be relevant in shaping the relationship between actual risk and subjective risk: the worker's reference group, family issues and organizational and safety culture (proxied by unionization). Whereas the positive association between actual and perceived risk hardly changes across specifications, being in a union or having dependents in the family positively affects risk-perception. Additionally, the higher the risk exists in a particular occupation, the lower the perception of risk by a worker belonging to that occupation. These results are maintained whichever the estimation method used but, after dealing with causality, results reveal that the positive association between actual and perceived risk is weakened, thereby raising concerns about the appropriate relationship between those two measures of risk.

This article contributes to the literature on the relationship between objective and subjective measures of risk by showing the relevance of the co-workers, family issues and organizational safety culture in shaping such a relationship. Gathering information from workers and firms on these aspects may help to manage risk and the design of preventive measures. From the technical point of view, it is also shown that dealing with endogeneity very much affect the association between actual and perceived risk which confirms the existing deviation between both measures of risk.

2. Theoretical background and hypotheses

In recent decades, there have been numerous changes in the composition of the workforce due to factors such as the outsourcing and globalization of the economy and demographic issues. The consequences of these changes on health and safety at work have been studied from a multidisciplinary point of view (Pouliakas and Theodossiou, 2013). As regards the specific topic of risk prevention and safety behavior a special focus has been addressed to study the differences between the actual (or objective) risk

[3] 2010 is the last wave this survey was launched.

a worker faces in the workplace as against the subjective risk an individual perceives while being at the job. It is important to understand how risk is perceived in order to propose adequate interventions in unsafe or risky behavior and to design preventive measures for an effective risk management.

While the actual risk can be quantified by calculating the probability of suffering an accident, the perceived risk is totally subjective and, therefore, can vary for each worker. Risk perception is a complex phenomenon that is determined by social, psychological, physical, political and cultural factors (Dake, 1991, 1992; Slovic, 1994), and that, ultimately, depends on a set of values, concerns or knowledge (Xia et al., 2017). Specifically, it is contingent upon a great number of factors linked either to the risk itself, to characteristics of the individual or to the culture and values of the organization (Kouabenan, 2009). Thus, regarding the first point, subjective evaluations of risk can be influenced by beliefs about the risk, such as its familiarity, its probability of occurring, its controllability, the nature and severity of its consequences (immediate or delayed effects), and other aspects external to the worker, such as whether it is voluntary or imposed, natural or technological. Additionally, risk perception may be affected by beliefs about individual or social psychological variables (age, sex, experience, education, personality, motivation, values, etc.), cognitive variables (information processing capacity, knowledge, amount of information available, and expertise), and evaluations of personal exposure and ability to cope with risk (perception of one's skills, vulnerability, precautions taken, control efforts, etc.). Finally, risk perception is also influenced by cultural, political, or strategic variables unique to the organization (organizational culture, safety policy, social norms, etc.).

When workers' perception of risk deviates significantly from objective statistical data, workers may not accurately evaluate related risks in the workplace (Loewenstein et al., 2001; Micic, 2016). Since risk perception is subjective, when workers perceive risk, they are likely to adopt different ways to judge it. The distinct behaviours when facing similar risks results from different "readings" of the risk. Little is known about the mechanisms through which different risk perceptions influence safety behavior, suggesting that it is necessary to study the variables that can reduce the employees' risk perception in occupational settings. Understanding the motivational, emotional, and attentional processes leading to an over- or under-estimation of risk appears highly desirable. By gaining insight into beliefs and taking them into account, we can enrich risk accident analysis and design preventive measures that are more suitable.

Biased risk perceptions may have origin in unrealistically positive self-evaluations, unrealistic optimism or in the illusion of invulnerability (Taylor and Brown, 1994; Kouabenan, 2009). Such illusory beliefs may lead to substantial differences among experts or managers and laypeople (or workers in general) in how risks are perceived. These differences may be why we find different attitudes toward risk. They may also affect the perceived credibility of preventive measures, in general conceived by experts or top management, yet specially addressed to individuals who are not specialists but are directly affected by risks.

To summarize, workers who cannot be considered as experts in terms of risk management tend to perceive risk in a direct and emotional way, so that heterogeneity in risk perception across individuals are likely to arise. Rational risk perception can significantly influence emotional risk perception, but there are other potential variables that can exert influences on emotional risk perception, such as personal variables and organizational, cultural and socioeconomic factors. The tendency to under- or over-estimate a certain risk variables across socio-demographic groups of the population (Leoni, 2010). Among personal variables, the age, the educational level or family status may influence in risk perception, whereas hours worked, firm size, tenure, occupation, sector or type contract, among many other job-related circumstances, may play a role as well (Dionne et al., 2007; Hakes and Viscusi, 2004).[4] Whereas many of these variables are included in our analysis, we give a special emphasis on testing the following three hypotheses:

i) Worker's risk self-perception may be influenced by the group of workers to which the worker belongs (Christian et al., 2009; Liang et al., 2009). Perception of risks and safety procedures can vary greatly according to different occupations within an organization. A similar degree of actual risk in the job is expected to be perceived in a more attenuated way if the group to which the worker belongs assumes, on average, higher risks. Members of certain occupations generally highly exposed to risk may have a tendency to minimize it, perhaps because they take as standard the expected level of risk of the group to which they belong.

ii) The worker's perception of risk is influenced by the personal and family situation. Risk aversion will be greater when there are more family responsibilities,

[4] There is no information in the QLWS on workplace hazards. In the empirical part of the paper, we employ the variables of occupation, industry and firm size as proxies for differences in the workplace risk.

so that a worker will perceive a greater risk than another without those responsibilities for the same level of objective risk. We test, for example, whether a worker will perceive more risk if he has young children or dependent adults.

iii) Safety culture may help in reducing risk. In this case, we use as a proxy for safety climate whether a worker is or not unionized. Belonging to a union can influence the worker's perception of risk because it entails greater knowledge about the characteristics of the job, the measures taken to reduce risks and compliance with these measures (Christian et al., 2009). Thus, the worker may be more aware of the level of risk and therefore perceive a higher level of risk than a non-unionised worker.

3. Methods and materials

3.1 Estimation strategy

3.1.1 The benchmark model

To assess the relationship between Self-Perceived Risk (PR) and actual risk, as well as to test the three hypotheses aforementioned, we use standard analysis regressions of PR on a large set of controls as shown in Equation (1)

$$PR_{it} = \alpha + \lambda_t + \beta_0 X_{it} + \beta_1 Y_{it} + \beta_2 HW_{it} + \gamma_0 RR_{it} + \varepsilon_{it} \quad (1)$$

where the self-reported risk perception of individual *i*, in year *t* depends on the year dummies (λ_t), and vectors of individual socio-demographic (X_{it}) and job characteristics (Y_{it}), as well as on individual hours worked (HW_{it}), and on the actual risk of accident at work (RR_{it}).[5] The dependent variable PR is measured on a scale -from 0 (zero risk) to 10 (maximum risk)- from the answer to the question: "Indicate the level of risk or dangerous situations that you feel in your current job". HW is included as a specific variable because it is a variable that can show reverse causality, a problem that is discussed below. This basic model is expanded to test each of the three hypotheses, as follows:

$$(1) \quad + \gamma_1 RR^r_{it} \quad (2)$$

where RR^r_{it} indicates the actual risk of the reference group (defined as the group of the same sex, age range and educational level).

$$(1) \quad + \gamma_2 F_{it} \quad (3)$$

where F_{it} is a variable that includes family characteristics that may be related to risk perception.

$$(1) \quad + \gamma_3 UM_{it} \quad (4)$$

where UM_{it} is a dummy variable that indicates that the individual belongs to a union.

The analysis strategy begins with the OLS estimation of the model expressed in equation (1), in which the dependent variable is considered as cardinal. The variables that allow testing the three hypotheses are included in turn. The second stage of the strategy consists of an analysis that explicitly takes into account that the dependent variable takes discrete ordered values between 0 and 10, so an ordered probit (OP) model is used.

3.1.2 Endogeneity

[5] Literature agrees of an increased risk associated with working long hours (Dembe et al., 2001; Salminen, 2010).

In both cases, OLS and OP, it must be taken into account that the results of estimates may show endogeneity due to the reverse causality that can occur in two variables in particular: hours of work and membership of a union. Thus, risk perception and hours of work may be bi-directionally related. Whereas working more or fewer hours may have an impact on risk perception, it is also possible that self-perceived risk may influence hours worked, provided the employee has some capacity to manoeuvre in choosing the number of hours or in the length of the working day as, for example, in accepting or not working overtime or shifting the type of contract (full from/to part-time). Regarding union membership it may happens that individuals who especially care for safety at work are more prone to enrol in unions. In order to account for the likely endogeneity among the dependent variable of interest, risk perception, and these two explanatory variables, we can proceed in two ways, depending again on whether the dependent variable is considered as cardinal u ordered.

When risk perception is assumed to be cardinal, a first approach involves the use of a standard Instrumental Variables estimation to control for endogeneity. This attempts to instrument hours worked and union membership in order to obtain consistent estimates through 2SLS or GMM, and tests for exogeneity of the regressors and for the validity of instruments can be routinely used. To aid identification of the effects of interest, a set of exclusion restrictions are formulated. We need to make assumptions about the variables that affect worked hours and union membership but, conditional on these, have no residual impact on job satisfaction. Specifically, we use the average number of hours worked according to industry-occupation-workday-gender-period as an instrument of the hours worked by an individual. The variable so constructed is expected to be much correlated with the actual number of hours worked, but there is no reason to think that this indirectly influences individual worker risk perception. (For the use of this type of instrument, see Cornelissen et al. (2011), and references therein). Regarding union membership, we have used a subjective variable indicating knowledge of employees about union activities. This is expected to be somewhat correlated with membership, but not at all to self-perceived risk at the workplace.

Specifically, the exclusion restrictions can be modelled as

$$HW_{it} = \alpha + \lambda_t + \beta_0 X_{it} + \beta_1 Y_{it} + \beta_2 HW^*_{it} + \gamma_0 RR_{it} + \nu_{it} \quad (5)$$

$$UM_{it} = \alpha' + \lambda'_t + \beta'_0 X_{it} + \beta'_1 Y_{it} + \beta'_2 UM^*_{it} + \gamma'_0 RR_{it} + \varepsilon_{it} \quad (6)$$

where X_{it}, Y_{it} and RR_{it} are the same explanatory variables included in Equation (1), and HW^*_{it}, UM^*_{it} represent the instruments as defined above. The fitted values for *HW* and *UM* obtained in these equations are introduced in the estimation of equations (1) to (4).

Since the treatment of endogeneity when the dependent variable is ordered is not straightforward, this two-step method can be viewed only as an approximation of the correct estimator (see e.g. Van de Ven and Van Praag, 1981; and Bryson et al. 2004). A more efficient approach is to take into account the ordered and discrete nature of Risk Perception. This second alternative takes advantage of the simultaneous estimation of different equations by allowing the unobserved individual components of such equations to be jointly distributed.

More precisely, this second approach consists of the joint estimation of the equations of interest [(1) to (4)] by an ordered probit, together with selection equations on union membership and on hours worked [equations (5) and (6)]. The simultaneous estimation of these equations is included in the general class of multiple equations models with discrete endogenous variables [Heckman (1978, 1979)]. Following Roodman (2011), we model job satisfaction and potential endogenous regressors as a system of equations, which is estimated on a simulated maximum likelihood method from multivariate normal distribution functions. This resembles the Geweke-Hajivassiliou-Keane (GHK) simulator. The joint modelling of the equations allows for the error terms to be correlated across equations, and thus for any endogeneity in the modelled equations. The cross-equation correlations of estimated errors (ρ) perform as a test of the endogeneity of regressors. When ρ is significantly different from zero, exogeneity is rejected. This latter approach is preferred to traditional IV estimation, since it takes into account the ordered nature of the dependent variables and, furthermore, the possible lack of strong or valid instruments. Thus, the endogeneity is corrected by way of the error correlation estimates (Roodman, 2011).

3.2 Dataset

Data from 2007 to 2010 of fatal accidents in Spain are provided by the Statistics of Work Accidents (Ministry of Labor). The risk of fatal accident in a workplace is expressed as an incidence rate (number of fatal accidents per 100,000 workers). The risk perceived by workers in the workplaace, as well as the other variables that express the personal characteristics of individuals and their jobs, come from the Quality of Life at Work Survey (QLWS). The QLWS is an annual household-based survey of individuals

selected to be nationally representative from the employed population over age 16, for the period from 2006 to 2010. It consists of a sample of repeated cross-sections, whose objective is to provide a tool for gathering substantive information concerning employee social relations, situations, attitudes, and values in the workplace, and examines variables of personal and job characteristics, including certain workplace environmental conditions.[6] The variable indicating the risk perceived by the worker ranges from 0 (low risk) to 10 (very high). To select a more homogenous sample, only male employees who work more than 30 hours a week are retained, so that the final sample consists of 13,096 individuals.

Table 1 reports the definition and the mean values of the relevant variables of the study. The data show that the average risk of fatal accident during the referred years was 8.45 for every one hundred thousand workers, while the average perceived risk was 4.19 (recall that is valued between 0 and 10). Table 2 displays the mean values of the risk of fatal accident and of the perceived risk by different groups of workers. The construction sector was the most dangerous, and so was perceived by workers, while the services sector showed the lowest value for both risk variables. In agriculture, the risk was higher than in manufactures and services whereas the perception of workers was similar to that of services and below that of manufacturing workers. By occupations, non-skilled manual workers showed both the highest fatal risk, but skilled manual workers perceived more risk than those non-skilled. By age group, the elderly presented more risk, although they did not perceive it that way. The actual and perceived risks were lower among the more educated, which is much related with skilled-non-manual occupations. Temporary workers had much higher risk than permanent ones but differences in risk perception were not so clear. By seniority, less tenured workers presented more actual risk but they did not perceive more risk than those who have more seniority. The average risk of workers who have dependents (children or dependent adults) was roughly the same as that of workers who do not have them, but the perception of risk was higher for the former. Regarding whether or not they belong to a union, workers who do belong were exposed to less risk, but their risk perception was higher than that of non-members. It is deduced from this first piece of evidence that objective and subjective risk do not move together and, in some cases, even they are

[6] Our sample is constructed from pooling the last four consecutive available waves, from 2007 to 2010. Using a longer sample is possible, but not advisable. The questionnaire was different before and after 2004. The survey was not carried out in 2005 and, in 2006, information was not present for some of our variables of interest. All this leads us to collect information only for the period 2007-2010.

inversely related, as for example age or tenure. In summary, we observe that there are some distortions regarding the perception of risk by workers and the actual risk that is borne in employment. The next section investigates this matter in a more detailed way.

INSERT TABLES 1 AND 2 ABOUT HERE

4. Results

Table 3 shows the results of estimating the relationship between each of the (observable) personal and job characteristics, and self-perceived risk at work, for the selected sample of employees by using OLS. Model (1) corresponds to the basic specification in Equation (1), whereas the rest of the Models (2) to (4) refer to the equations used to test the three hypotheses. At this stage, the bias associated with potential endogeneity is not addressed so that causality is not investigated and coefficients should be interpreted as only partial correlations. Focusing on the parameters what are common to all specifications, the following patterns are found (note that the results are qualitatively consistent across all regressions).

Age variables exhibit an inverted-U shape, indicating that, in the early years, risk perception increases with real risk up to individuals reach 35 years old, and then declines.[7] As individuals get older, risk perception is decreasing whereas incidence rate of fatal accidents is increasing, driving risk perception apart from real risk. Higher education is associated with lower risk perception, whereas foreign workers perceive less risk, *ceteris paribus*, than native Spanish workers. Regarding work-related variables, RP increases with tenure, hours worked, or firm size; RP is higher for those over-educated but lower for those being in a first job. With respect to activity branches, workers in the construction sector are who perceive risk the most, followed by manufacturing and services and, finally, the primary sector. More risk is perceived by manual workers, with skilled non-manual workers being those who perceive risk the least. Quite surprisingly, the type of contract results non-significant.

Turning now to the variables of interest, the actual risk of fatal accident is associated in a positive and statistically significant way with the perception of risk in the workplace, with an estimated coefficient that hardly changes when additional variables, allowing for the hypotheses tested are included (see row 1 in Table 3). However, the relationship seems to be somewhat weak since estimated elasticity is lower than 1.5. That is, if real or actual risk doubles at the mean value (changes from 8.5 to 17 fatal

[7] The age at which Risk Perception reaches a maximum is computed as follows $MaxAge=(50*\delta_1)/(-\delta_2)$ where δ_1 is the coefficient associated to *Age* and δ_2 is the coefficient associated to $(Age)^2/100$.

accidents for every hundred thousand workers), risk perception increases from 4.19 to 4.25 only. Therefore, a first important result is, being other variables equal, subjective risk moves together with objective risk, but the relationship is weak.

Regarding the first of the hypotheses, it is observed that when the risk of the reference group (computed as the average risk of workers in their age group and educational level) is included, the perceived risk is reduced. As advanced in the hypothesis, this can be interpreted as that the risk of the reference group of a particular worker is considered a normal risk for that worker, so that such a worker compares the risk with that of the group, conducting that the perceived risk is lower the higher the risk of the group. Looking at the second hypothesis, when a variable indicating that the worker has dependents is included, the perception of risk increases. As was anticipated in the descriptive analysis, workers with family responsibilities seem to be more risk averse. Finally, union membership increases the perception of risk.

These results show evidence in favour of the three hypotheses posed. However, an OLS analysis that ignores, on the one hand, the ordinal nature of the dependent variable and, on the other hand, the possibility of endogeneity of working hours and of the variable "union", requires caution in the evaluation of the results found.

INSERT TABLE 3

The next step in the estimation strategy is an ordered probit model without considering endogeneity. The upper part of Table 4 shows the marginal effects corresponding to a high perception of risk of accident (i.e., a perception of a risk greater than 7) for the different specifications under consideration. Only the results corresponding to the variables of interest are shown (the rest of the control variables offer results similar to those observed in the previous estimate). The results again show that more risk is perceived when the actual risk is higher, there are dependents in the worker's household or the worker belongs to a union, while less risk is perceived when the risk of the reference group is higher. Although the marginal effects are not directly comparable with the estimated coefficients of the regression in Model (1), the evidence provided shows qualitatively coinciding results, confirming that assuming cardinality or ordinality in the subjective values has little effect on the empirical qualitative results.[8]

[8] Ferrer-i-Carbonell and Frijters (2004) has produced evidence that assuming either ordinality or cardinality of happiness scores has little effect on the qualitative empirical results. As a result, OLS estimation is sometimes preferred to ordered probit or logit models because of the straightforward interpretation of the coefficients.

INSERT TABLE 4

In what follows, the issue of endogeneity is addressed by the two alternative methods aforementioned. The second block in Table 4 offers estimates by 2SLS of equations (1) to (4) once hours worked and union membership are instrumented as in equations (5) and (6), and their fitted values introduced in the main equations.[9] At this point, risk perception is considered as cardinal. Standard Wu-Hausman test rejects the exogeneity of both variables. The choice of appropriate instruments has been investigated. Regarding the instrument for hours worked, and following Cornelissen et al. (2011), we tried different instruments constructed as sample averages across different groups (industry, occupation, region, …), and testing for the appropriateness of such instruments. As mentioned above, finally, the average number of hours of work by industry, occupation and type of working day was the instrument chosen for hours worked according to R^2 and Shea's partial R^2. For union membership, establishment age or an indicator of whether a workplace belongs to a multi-establishment firm or is a standalone workplace, as used for example in (Bryson et al. (2010), are not available in our data set. Among the ample set of possible instruments we attempted, the one that produced the best results, against in terms of R^2 and Shea's partial R^2, of the regression of the potentially endogenous membership variable and the instrument, was the worker's evaluation of the knowledge of union activity. This subjective variable ranges between 0, no knowledge, and 10, full knowledge. In all the cases, there was little evidence against the weakness of such instruments.[10]

The estimated coefficients for the actual risk are still positive and statistically significant, but a bit lower than those obtained in Table 3, which indicates that the influence on the perceived risk is not so high when taking into account the double direction of causality. A similar behaviour is observed when testing the three hypotheses, confirming results and conclusions discussed before.

As a way of gaining robustness in our results when considering the issue of endogeneity, we now take into account the ordered nature of job satisfaction and estimate the systems of equations by conditional simulated likelihood, resembling the

[9] Note that only in Equation (4) both hours worked and union membership are simultaneously introduced. In Equations (1) to (3) only the variable hours worked appears as a regressor.

[10] These measures of the goodness of fit are obtained from the first-stage regressions of potential endogenous variables on the set of exogenous and instruments; equations (5) and (6). Results are not shown but are available from the authors upon request.

GHK simulator (Roodman, 2011). We do so by allowing for the possibility that, in Equations (1) to (3), unobserved heterogeneity in perceived risk may be correlated with the process by which individuals choose the number of hours worked. In the case of Equation (4), it is additionally allowed for joint determination in perceived risk, hours worked and union membership. The systems are not fully recursive, since hours worked and union membership variables enter the equation explaining job satisfaction, but the reverse does not apply. The estimated results are provided at the bottom of Table 4. In Models (1) to (3) hours worked is taken as the only endogenous variable, while Model (4) allows for endogeneity of union membership as well.

The estimated correlation between the error terms of risk perception and hours worked equation, r_{12}, is statistically significant in all models, showing a negative sign in all specifications. Significance confirms the endogeneity of hours worked, whereas the negative sign indicates that unaccounted factors that tend to increase the numbers of hours worked, also tend to reduce risk perception. Regarding union membership, a similar finding is observed, see Model (4). The estimated correlation between the error terms of the perceived risk and the membership equation, r_{13}, is statistically significant and negative, showing that unobserved characteristics favouring union membership lead to lower risk perception. Finally, there is unaccounted-for correlation between the errors of the hours worked and membership equations, with r_{23} being statistically and significantly estimated at 5%, supporting the null than both are positively related, so that so that unobserved characteristics favouring union membership lead to higher hours worked.

Focusing on the variables of interest, estimated coefficients are again of the same sign as in previous estimates, although they are somewhat lower in absolute value. This similar pattern to that observed in Tables 3 and 4, second block, suggests that the evidence on favour of the three hypotheses tested is robust, although their influence on the perception of risk it is not as high as it was initially appreciated.

5. Discussion

This research explored the relationship between subjective risk perception of employees and objective, actual risk in the workplace, by using stepwise procedure that takes into account both the ordered nature of the dependent variable, risk perception, and the possibility of biases arising from simultaneity among some variables. Most of the

results were common, and therefore robust, to any specification used in the regression analysed, even though some results are worth explaining.

First, it was found than perceived and observed risk were significantly correlated: higher objective actual risk positively affects subjective risk perception, once an ample set of personal and job-related characteristics are controlled for. This confirms that personal and organisational variables influence "emotional" risk perception. Second, a number of hypotheses were tested to show that the occupational group, family responsibilities and safety climate were all also related with self-perceived risk in the workplace. Finally, when considering simultaneity in some decisions and in risk perception, the influence of actual risk in risk perception reduced, but still was significantly positive, and the three hypotheses continued to be non-rejected.

5.1 Implications for theory and practice

First, this study is based on the grounds that risk perception is subjective and distinct from observed or real risk (Slovic, 1979; Loewenstein et al., 2001). Whereas objective statistical data of accidents is habitually unknown to employees, they provide an intuitive, non-analytical judgment of risk, which is commonly known as emotional risk perception (Xia et al., 2017). This notion of risk can be approached by directly asking workers their feelings since they produce it in a non-deliberate, irrational way. To investigate the relationship between both measures of risk, we considered an ample set of personal and organisational characteristics that influence risk perception (Kouabenan, 2009; Xia et al., 2017). Understanding how risk is perceived by employees and how this perception deviates from objective statistical real data may be helpful for managerial personnel to accurately design procedures to increase information and avoid accidents.

Second, this investigation can serve to deepen into the influence of additional factors that literature suggested may influence risk perception such as co-workers behaviour (Liang et al., 2009), occupational group (Leoni, 2010), safety climate (Christian et al., 2009; Xia et al., 2020), hours worked (Greubel and Nachreiner, 2013) and other, as for example family responsibilities, hardly considered in previous studies. Our variable of actual risk of reference group ideally tries to capture the fact that self-perceived risk varies depending on the group of workers to which the worker belongs. Closeness in age, gender, educational level or occupation may influence how workers may perceive an objective risk against other workers with very different characteristics.

Results in Table 3 are described in detail to specify how risk perception varies across personal and job characteristics confirming that protective safety measures must take account of the distinctive features of workers. In this sense, it is important for accident prevention a good safety climate, which would require of more informed employees behaviours directly to workers or through the role of unions or union delegates. Results revealed the relevance of family responsibilities such that when implementing preventive measures, firm management must pursue a better matching between real objective risk and risk perception. If parents are more risk averse than non-parents, the latter may face riskier tasks becoming more prone to suffer accidents.

Third, take as a whole, this study mace clear that risk perception may deviate significantly from statistical, objective information of accidents, and the "reading" of such a risk by employees differs markedly across many characteristics that are considered. While a global policy of risk management must be at front in the workplace, some specific characteristics such as age, tenure or having dependants must be especially addressed.

5.2 Strength, limitation and future directions

A first strength of this research is the use of national representative data from a survey to measure risk perception at the individual level, which simultaneously provides information on an ample array of individual characteristics. This information is completed with statistics of the entire record of work accidents in Spain for each year of the sample. A second strength of the paper is the careful treatment of the issue on simultaneity among some explanatory variables and the dependent variable, even in the case of using cross-sectional information. We focused on the cases of hours worked and unionisation. In the first case, the normal direction is that individuals who work longer hours may feel more risk in the workplace, since they are working more hours. However, a reverse causation may work in the direction that individuals who feel jobs are less risky may eventually work more hours. Analogously, when workers unionise they receive more information about work conditions, among which risk environment and safety measures may outstand. In consequence, they may lower their risk perception. However, it may well be that workers who are more averse to risk and hence have a greater perception of risk, may wish to unionise to gain acknowledgments of prevention measures.

The double direction of causation may mask the final relationship between variables and risk perception. To disentangle these two effects, simultaneity was coped with instrumental variable estimation through either 2SLS or MLE. Using appropriate instruments, the causality from hours worked and unionisation was isolated, granting that the final effect is free from reverse causation. This resulted in that once simultaneity was controlled from, the coefficients of the variables of interest, reduced their magnitude, remaining still statistically significant. That is, part of the initial influence of actual risk on risk perception was due to reverse causation.

This research has also some limitations, mostly derived from data availability. First, the last wave of the QLWS corresponded to 2010. Since then, no national-based survey provides information on individual risk-perception in the workplace. Second, the data used to test the proposed hypotheses were cross-sectional. Longitudinal information would help to identify the possible causal relationship for more variables influencing risk perception, for which is difficult to find appropriate instruments. Third, the lack of other additional variables that might be correlated with risk perception, such as those which have to do with cultural, political, strategic policy of the organisation (social norms, group pressures, safety,…); with related to the risk itself (nature, severity, familiarity of the employee,…) and those linked to psychological and cognitive traits. More information on this kind of variables will allow for a better identification of the true relationship between real objective risk and how it is perceived by employees.

Several actions would improve this research, among which the availability of more data is difficult to reach in the short run. More affordable ways to expand this study would be to consider alternative definitions of risk, not only considering the severity of accidents, but also if they are computed for specific groups. This is left for future research. Second, a more comprehensive analysis on the all relationships among all the variables, and how they are interconnected.

An important question is that a better understanding of how risk is perceived by employees is necessary in order to they behave more safety (Arezes and Miguel, 2008; Gyekye, 2006). However, this plausible link between risk perception and protective behaviour has been challenged (Rundmo, 2001; Kouabenan et al. 2015). More recently, it has been argued that perceptions of workplace risks may result in a job hindrance or a job challenge (Oah et al., 2018; Xia et al., 2020). According to this, a major awareness of risks may lead workers to require sustained physical and/or mental resources, causing

stress or strain to employees, and preventing them from adequate safety behaviour. This study did not explore this possibility and may well be a future line of research.

6. Conclusion

Subjective risk perception, identified as emotional risk perception, is only weakly related to objective/statistical risk of accident, identified as rational or actual risk, once it is controlled for an ample array of personal and job characteristics. The "reading" of a similar risk is different for individuals depending on characteristics. Thus, older workers perceive less risk and, however, are more likely to suffer an accident. In a similar way, workers with family responsibilities or those unionised, who suffer less accidents, perceive higher risk in the workplace.

With pooled data from the 2007-2010 waves of the ECVT and the Statistics of Work Accidents for those years, our estimates of a basic specification regressing risk perception with actual risk and other determinants have identified their influence and the direction of such influence. In particular, results confirmed the positive correlation between subjective and objective risk, either when expressing subjective risk perception in ordinal or cardinal terms. We have specifically tackled the potential sources of endogeneity bias, such as simultaneity or self-selection. We have controlled for simultaneity by estimating with a 2SLS procedure, assuming that risk perception is cardinal, and also through the joint estimation of the three-equation system with simulated maximum likelihood.

The results provided by all the analyses carried out are robust, since once the initial estimation problems have been corrected, the results are essentially the same, even though the significance of actual risk dramatically reduces as simultaneity is addressed. It can be affirmed that the three hypotheses raised are fulfilled, which allows to give guidelines to improve the perception of risk and the effectiveness of the training in prevention of the risks of the workers. The first will be to design specific information on job hazards for employees of different ages and educational levels. The second is to take into account in this training if the workers have dependents in their charge. Finally, training on prevention should be intensified for workers who do not belong to any union.

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Table 1
Definition and mean of study variables.

Variable	Definition	Mean
Self-perceived risk	Subjective risk. Range from 0 to 10	4,19
Actual risk	Incidence rate (per 100,000 workers) of fatal accident	8,45
Dependants	1: Children or dependant adults in the household: 0, no.	0,36
Union	1: Unionised. 0: non-unionised	0,23
Age	Age	41,89
$Age^2/100$	Age square divided by 100	18,68
Compulsory education	Highest educational attained: Compulsory education	0,45
Secondary education	Highest educational attained: Secondary non-compulsory education	0,33
Higher education	Highest educational attained: Tertiary education	0,22
Nationality	1: Spanish. 0: Otherwise	0,68
Tenure	Tenure in the current job (in years)	11,23
Over-education	1: Worker is over-educated. 0: Otherwise	0,15
First job	1: Worker is in the first job. 0: Otherwise	0,21
Permanent job	1: Worker is in a permanent job. 0: Otherwise	0,81
Hours worked	Average number of worked hours per week	42,11
Firmsize < 11	Firms less 11 workers	0,22
Firmsize 11-50	Firms between 11 and 50 workers	0,27
Firmsize 51-250	Firms between 51 and 250 workers	0,17
Firmsize >250	Firms more 250 workers	0,34
Agriculture	1: Work in first sector. 0: Otherwise	0,04
Manufacturing	1: Work in manufacturing sector. 0: Otherwise	0,24
Construction	1: Work in construction sector. 0: Otherwise ción	0,18
Services	1: Work in services sector. 0: Otherwise	0,54
Skilled, non-manual	1: Worker in skilled, non-manual occupation. 0 Otherwise	0,29
Non-skilled, non-manual	1: Worker in non-skilled, non-manual occupation. 0 Otherwise	0,16
Skilled, manual	1: Worker in skilled, manual occupation. 0 Otherwise	0,28
Non-skilled, manual	1: Worker in non-skilled, manual occupation. 0 Otherwise	0,26

Note: Paid employees working 30 hours or more (except the military).

Table 2
Means of Fatal accident and self-perceived risk by group of workers

Variable	Risk of fatal accident (per 100,000 workers)	Self-perceived Risk
Overall	8,45	4,19
Agriculture	10,89	3,80
Manufacturing	8,42	4,51
Construction	14,17	5,32
Services	6,46	3,71
Skilled, non-manual	2,83	2,83
Non-skilled, non-manual	4,90	3,81
Skilled, manual	11,68	5,12
Non-skilled, manual	13,48	4,96
Age 16-25	8,46	4,27
Age 25-40	6,38	4,39
Age 41-55	9,53	4,21
Age > 55	10,91	3,60
Compulsory education	11,65	4,75
Secondary education	7,44	4,27
Higher education	3,49	2,93
Fixed-term contract	13,17	4,63
Permanent contract	7,37	4,09
Tenure < 1 year	18,40	4,31
Tenure 1-5 years	9,84	4,32
Tenure 6-15 years	7,58	4,32
Tenure > 15 years	5,53	4,04
Dependants in the household	8,47	4,51
No dependants in the household	8,47	4,17
Unionised worker	7,38	4,79
Non-unionised worker	8,79	4,02

Table 3
Linear regression analysis. OLS Estimation

	Model (1)		Model (2)		Model (3)		Model (4)	
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE.
Actual risk	0,007***	0,002	0,008***	0,002	0,007***	0,002	0,007***	0,002
Actual risk (Reference group)			-0,065**	0,026				
Dependants					0,410***	0,111		
Unionised							0,802***	0,067
Age	0,119***	0,018	0,127***	0,018	0,119***	0,018	0,104***	0,018
$Age^2/100$	-0,173***	0,021	-0,173***	0,021	-0,175***	0,021	-0,156***	0,021
Secondary education	-0,051	0,069	-0,306**	0,123	-0,051	0,069	-0,081	0,068
Higher education	-0,500***	0,098	-1,021***	0,229	-0,493***	0,098	-0,493***	0,097
Nationality	0,318***	0,106	0,332***	0,106	0,309***	0,106	0,264**	0,106
Tenure	0,014***	0,004	0,014***	0,004	0,014***	0,004	0,009***	0,004
Over-education	0,248***	0,076	0,252***	0,076	0,245***	0,076	0,205***	0,076
First job	-0,166**	0,070	-0,158**	0,070	-0,166**	0,070	-0,140**	0,069
Permanent contract	0,031	0,076	0,032	0,076	0,035	0,076	0,005	0,076
Hours worked	0,043***	0,004	0,043***	0,004	0,043***	0,004	0,047***	0,004
Firmsize 11-50	0,357***	0,079	0,357***	0,079	0,354***	0,079	0,316***	0,078
Firmsize 51-250	0,457***	0,088	0,458***	0,088	0,455***	0,088	0,363***	0,088
Firmsize >250	0,826***	0,078	0,824***	0,078	0,821***	0,078	0,649***	0,079
Manufacturing	0,886***	0,154	0,885***	0,154	0,890***	0,154	0,826***	0,153
Construction	1,536***	0,154	1,531***	0,154	1,542***	0,154	1,513***	0,153
Services	0,817***	0,151	0,818***	0,151	0,821***	0,151	0,745***	0,151
Non-skilled, non-manual	0,794***	0,094	0,805***	0,094	0,793***	0,094	0,720***	0,093
Skilled, manual	1,934***	0,098	1,937***	0,098	1,934***	0,098	1,860***	0,097
Non-skilled, manual	1,859***	0,096	1,860***	0,096	1,859***	0,096	1,769***	0,096
Year dummy	Yes		Yes		Yes		Yes	
Regional dummy	Yes		Yes		Yes		Yes	
Corrected R^2	0,13		0,13		0,13		0,14	
Observations	13.096		13.096		13.096		13.096	

Tabla 4
Ordered probit, IV and GHK estimations.

Ordered Probit: marginal effect of high perceived risk (between 7 and 10)								
	dy/dx	SE	dy/dx	SE	dy/dx	SE	dy/dx	SE.
Actual risk	0,001***	0,0003	0,001***	0,0003	0,001***	0,0003	0,001***	0,0003
Actual risk of reference group			-0,007**	0,003				
Dependants					0,051***	0,015		
Unionised							0,102***	0,001
Log Likelihood	-13005,8		-13003,9		-13000,2		-12943,7	
Instrumental Variables estimation (2SLS)								
	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Actual risk	0,005**	0,002	0,006**	0,002	0,005**	0,002	0,005**	0,002
Actual risk of reference group			-0,044*	0,027				
Dependants					0,405***	0,117		
Unionised							0,549***	0,23
R^2	0,04		0,04		0,04		0,04	
Wu-Hausman endogeneity test								
H0: Hours worked: exogenous	66,912	0,000	66,976	0,00	66,581	0,000	80,704	0,000
H0: Unionised: exógena							10,345	0,000
Participation equation (weak instrument test). Shea's partial R^2								
Average hours worked	0,302	0,342	0,321	0,353	0,325	0,354	0,324	0,35
Unionised							0,1011	0,114
GHK simultaneous estimation (máximum likelihood)								
	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Actual risk	0,002**	0,001	0,002**	0,001	0,002**	0,001	0,002**	0,001
Actual risk of reference group			-0,017*	0,01				
Dependants					0,145***	0,043		
Unionised							0,47***	0,059
r_{12}	-0,012***	0,005	-0,322***	0,043	-0,042***	0,005	-0,335***	0,041
r_{13}							-0,291***	0,04
r_{23}							0,125**	0,062
Log Likelihood	-54815,7		-54790,2		-54810		-60125,8	

Note: dy/dx. Marginal effect on self-perceived risk as a consequence of an unitary increase of the independent variable.

*p<0,1; ** p<0,05; *** p<0,01. Rest of controls as in Table 3.