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ORIGINAL PAPER

A methodological proposal to evaluate the cost of duration moral hazard in workplace accident insurance

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Abstract The cost of duration moral hazard in workplace accident insurance has been amply explored by North-American scholars. Given the current context of financial constraints in public accounts, and particularly in the Social Security system, we feel that the issue merits inquiry in the case of Spain. The present research posits a methodological proposal using the econometric technique of stochastic frontiers, which allows us to break down the duration of work-related leave into what we term "economic days" and "medical days". Our calculations indicate that during the 9-year period spanning 2005–2013, the cost of sick leave amongst full-time salaried workers amounted to 6920 million Euros (in constant 2011 Euros). Of this total, and bearing in mind that "economic days" are those attributable to duration moral hazard, over 3000 million Euros might be linked to workplace absenteeism. It is on this figure where economic policy measures might prove more effective.

Keywords Workplace accident insurance · Moral hazard · Stochastic frontiers · Economic days · Physiological days

JEL Classification I13 · I18 · J28 · J32 · H51

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Introduction

The present work seeks to gauge the financial cost of sick leave subsequent to a workplace accident, and which is exclusively due to worker opportunistic behavior. One initial point worth highlighting is that the financial cost linked to workplace accidents is extremely high. In this sense, a report by the *Comisiones Obreras* trade union [14] estimates that the cost of workplace accidents in Spain amounted to 11,988 million year 2002 Euros, 1.72% of said year's Gross Domestic Product. However, it should be pointed out that this covers a wide array of situations and categories[1] in the costs associated to workplace accidents.

In the economic literature addressing work-related accidents, one common theme has been to explore the problems of moral hazard posed by the regulation of workplace health and safety, a topic dealt with, for instance, by Fortin and Lanoie [18]. Said work points to four kinds of moral hazard related to workplace accident insurance. Firstly, *ex ante* injury hazard, which involves workers exercising less care and precaution due to the insurance guaranteeing them an income should they suffer an accident. The second type is termed *ex ante* causality hazard and emerges because of the difficulty in identifying which accidents have actually occurred at work. The third case is so-called *ex post* duration hazard, and leads to the number of days off extending beyond what is justifiable. The fourth type is known as insurance substitution hazard, and may encourage workers to seek a more generous

[1] From a more limited standpoint, yet nonetheless one which also reflects the enormity of the costs associated with occupational accidents, and in what is now considered a classical quote in the literature in this field, Krueger [30] estimates that in a typical year in the USA, for every day lost due to strikes, 50 days are lost to work accidents.

payout through accident insurance than they would otherwise obtain through unemployment insurance, which might prove less lucrative. The present research focuses particular attention on the third type of moral hazard, although we believe that the fourth kind may also be operating to a certain extent.

Sick leave duration is a far more complicated topic than would appear at first glance. Comparing different groups reveals that said measure is highly sensitive to the number of minor accidents reported. As a result, microdata, which allow the nature and seriousness of the injury to be considered, are felt to provide key insights. Another point to be taken account of is that sick leave duration involves two clearly different features: one which is mainly medical, and concerns a person's natural recovery time following an injury, and another that is mainly financial, and which relates to an individual's capacity to choose, and possibly indulge in opportunistic or strategic behavior.

The literature has focused on the idea of moral hazard (when worker's compensation systems are involved) and absenteeism but without taking into consideration the double nature of the days off. In our view, the two components differ, which is why we consider they merit being approached differently. From an econometric standpoint, we use stochastic frontier techniques to distinguish between the two factors. This methodology has been used frequently in health economics, as outlined in "State of the question". However, the interpretation given in this paper is quite different.

Estimating a lower or "cost" frontier, which is determined primarily by medical factors, enables us to measure minimum sick leave duration, interpreted here as an indicator of the unavoidable period required for a worker to return to work after regaining an acceptable state of health. Actual sick leave duration will exceed said minimum. The difference will be attributable to behavior based on the rational decisions of the "*homo economicus*" of microeconomic theory. We therefore model said difference, namely the "inefficiency" term, within stochastic frontier literature, through what are essentially economic variables such as the type of contract, workers' compensation, industry, etc.

As pointed above, the economic literature dealing with sick leave duration from the standpoint of work absenteeism and work accidents has tended to treat all the days taken off equally. We believe that differentiating between "medical days off" and "economic days off" will allow us to explore the issue at hand more accurately. Our main interest lies in "economic days off". The Spanish Royal Academy of Language (in its first and closest definition to the employment context) defines work absenteeism as: "*Deliberate absence from work*". The Oxford English dictionary defines said concept as: "*The practice of regularly staying away from work or school without good reason*". These two definitions clearly show that interpreting work absenteeism as the days required for adequate medical recovery is a conceptual error.[2] The main contribution of the present work lies precisely in the methodological proposal of breaking down sick leave duration into two components and attributing the financial cost of absenteeism to purely "economic days off".

The remainder of the work is organized as follows. The section "State of the question" offers a review of the literature exploring the determinants of sick leave duration resulting from workplace accidents. Commonly used econometric procedures are referred to, as are some of the chief conclusions to emerge. "Institutional setting" provides, on the one hand, a detailed description of the legislative setting regarding the Spanish sick leave insurance. On the other hand, a comparison among the institutional setting of various European countries is also presented. There then follows a section on the "Methodology" employed to obtain the main results. As already mentioned, these are econometric procedures based on so-called "stochastic frontiers". The section "Database" presents and describes the database used in the present work: Statistics of Accidents at Work (SAW). This section also provides some descriptive information prior to the subsequent and more rigorous econometric analysis. The "Results" section discusses the principal findings to emerge, and comprises three sub-sections: the first considers the estimated parameters based on a multivariate regression analysis, the second compares the estimates of the "medical days off" and "economic days off", calculating a purely financial cost of workplace absenteeism, and the last offers some possible extensions. In the section "Decomposing the duration logarithm", some robustness checks are carried out. First we discuss and test whether presenteeism could be biasing our estimates (with a negative answer). Second, we run a set of alternative econometric specifications to check the sensitivity of our results. These turn out to be rather stable. The final section presents the main conclusions.

[2] At this point, it is necessary to make a comment on presenteeism or, to put in other words, the situation when a worker goes to work while sick or before having recovered from an injury. Should this idea be an issue in our database, the estimates would not be reliable. However, as it will be shown in a later section, on the one hand, the wide coverage of the Spanish public health insurance makes us think that presenteeism should not be an important question in this country as compared, for instance, to the United States. On the other hand, we test directly whether those workers with worse working conditions exhibit some signals of presenteeism. We do not find evidence of such behavior in our data. As most European countries have (relatively) generous public health insurance, and show less variability in the worker's working conditions than in Spain (particularly, the weight of fixed-term contracts is much lower than in Spain), we feel that our methodology might be implemented without fearing of being affected by presenteeism in such European countries.

State of the question

From an economic standpoint, the literature exploring sick leave duration resulting from workplace accidents first emerged several decades ago. In the 1980s and 1990s, much of the scholarly inquiry addressing these topics commenced in the United States and Canada. A thorough review of all of this literature may be found in Fortin and Lanoie [19] and, more recently, in Chap. 16 of the Handbook of Insurance [12].

All of these works were grounded on the fact that, as a result of the health compensation insurance that covered part of their lost salary, employees could vary the moment they returned to work following a workplace accident. Yet, the way in which this matter has been analyzed in econometric terms has varied enormously. Some early studies used aggregated databases (industry or state/province) to draw their conclusions [16, 31]. As a result of the composition effects caused by aggregated data, some researchers have more recently resorted to using microdata. One standard technique involves taking the duration logarithm as a dependent variable and estimating through ordinary least squares [13, 30, 35]. However, when faced with censored data, the most appropriate approach adopts duration models. Two seminal works exploring sick leave duration through proportional risk models are those of Butler and Worrall [9], and Johnson and Ondrich [28]. A more detailed discussion on the different estimation methods within this context, and their advantages and disadvantages, can be found in Fortin and Lanoie [18].

In relation to the effect that more generous health insurance has on sick leave duration, Butler and Worrall [9] report that a 10% increase in compensation leads to a rise in sick leave of close to 4%. Yet others, such as Krueger [30] or Johnson and Ondrich [28], have estimated higher elasticities. Nevertheless, some studies also state that this finding is not evident a priori, particularly when using aggregate data. Better compensation may also spark an increase in the number of minor accidents reported. This composition effect would reduce average duration [11, 40, 50]. For this reason, several authors have proposed to use microdata in order to disentangle both effects. That is what we precisely do in this article.

The United States has a health system that, in general, allow workers to receive a compensation in the case of a work related injury or sickness. When the injury or illness is non-work-related, it is much more difficult for an American worker to receive compensation.[3] On the other hand, most European countries guarantee that workers receive paid leave for work-unrelated sickness This is why most American studies refer to worker's compensation (including only work-related injuries) whereas European studies tend to analyze sick leave insurance (covering both work and non-work-related injuries).[4] Taking into account this difference, Puhani and Sonderhof [48], and Ziebarth and Karlsson [56, 57] analyze the effects of sickness insurance regulations over sick leave duration in Germany. Puhani and Sonderhof [48] and Ziebarth and Karlsson [56] find that a reduction in compensation (from 100% to 80% of wage losses) reduces sick leave duration and increases the number of injuries reported. On the other hand, Ziebarth and Karlsson [57], using a difference-in-differences estimator and matching techniques establish that, when sick pay replacement rate is augmented from 80% to 100%, an increase by at least 1 day per worker and year in workplace absences is obtained.

From a methodological point of view, stochastic frontier techniques have already been employed to analyze some questions in the health economics literature, especially in the assessment of the efficiency of health institutions like hospitals. A survey on this type of study can be found in Hollingsworth [27]. It has to be pointed out that some authors like Newhouse [43] are reluctant to use such a technique because of the heterogeneity in the dependent variable. This drawback occurs when the right-hand side variable in the regression is conditioned by the quality of the service, as in the case of hospital care. Nonetheless, it is worth mentioning that our approach here is quite different, and is thus not subject to this criticism. This is because, whereas in the previous studies the observational unit was a health institution (hospitals or nursing homes), in this paper we focus on individuals. In this way, we avoid differences in quality, and deem that the dependent variable is highly objective.

As regards the costs associated with sick leave, there are two types of works: those focused on what we might call indirect costs, and those centered on direct costs. Within the "indirect cost" category, we would include studies on costs borne by employers due to substitution of the injured worker and the loss of productivity [3, 45], and other related costs borne by employees (basically loss of future wages). Some examples of this second type of "indirect cost" category are found in studies by Boden and Galizzi [7], Rayce et al. [49] or Andersen [5]. However, our work should be placed within the "direct cost" group. In other words, we are interested in the costs related to the payment received by the employee (i.e., the worker's compensation), in line with the studies of Park and Butler [44] and Guo and Burton [25].

[3] Although as Ziebarth and Karlsson [57] point out: "*Relatively few people know that six US states and Puerto Rico have forms of sickness insurance that are quite similar to those in Europe*".

[4] Spain is an example of such a European country. Despite this, our research is focused on workplace accidents because our database only records this kind of case. In this sense, our study is closely related to the American literature.

For the case of Spain, some preceding works have explored sick leave duration following occupational injury. Corrales et al. [15], Moral et al. [42] and Martín-Román et al. [34, 35] analyze sick leave from different perspectives although adopting a common approach based on duration models. Corrales et al. [15] study differences in duration amongst the various regions in Spain. Moral et al. [42] compare sick leave duration differences between men and women, whilst Martín-Román et al. [35] focus their analysis on the recovery periods from injury of self-employed workers, paying particular attention to the economic cycle.

The most similar work from an econometric perspective is that of Martín-Román and Moral [36], which used the stochastic frontier technique to compare the working conditions of national and immigrant workers through the duration of their sick leave. The present study, however, takes this one step further by enabling the days to be reflected in monetary terms so as to clearly identify the cost associated to duration moral hazard.

Institutional setting

The situation of temporary incapacity (TI) occurs when a worker has to leave his/her job temporarily as a result of injury or illness, whether work-related or non-work-related. When said contingency takes place, the Social Security system covers medical expenses on the one hand, and pays benefits that partially substitute lost wages on the other. In Spain, the fundamental law that regulates TI benefits is the Social Security General Law (SSGL). This law distinguishes between accidents (or illnesses) that have occurred at the workplace or out of the workplace.[5] Article 156 of SSGL defines an occupational accident as any bodily injury suffered by a worker because of paid employment.

Medical expense coverage, as in other European countries, is virtually universal in Spain. In other words, a worker who is on sick leave does not have to pay for his/her treatment and other related costs because it is a system publicly funded and provided. This is the case regardless of whether the injury is work-related or not. Nonetheless, the amount of income received as temporary disability benefits differs if the injury is occupational or not. Article 129 of the SSGL states that TI benefits can be assessed as the result of multiplying a coefficient times a contributory base (mainly the wage earned in the previous months). In relation with the coefficient, if TI is the result of a non-work related illness or injury then the benefit scheme has three parts. First, the worker receives nothing during the first 3 days of sick leave. Second, the worker receives 60% of the reference wage from the 4th day to the 20th day. Lastly, the employee obtains 75% of the contributory base from the 21st day onwards. On the other hand, if TI is a consequence of an accident or an illness that occurs at work, then the worker will receive a subsidy of 75% of the reference wage from the day after the physician issues the sick leave certificate. Table 1 summarizes this information.

The applicable legislation with regard to the contributory base is in article 13 of Decree 1646/1972 of 23 June, implementing Law 24/1972 of 21 June. In sum, the contributory base is a function of the previous wage (with upper and lower limits) earned by the worker before the sick leave takes place.[6] As regards assessing the contributory base, the only significant difference between occupational and non-occupational contingencies deals with the overtime contribution. In the case of non-occupational sick leave, overtime is not taken into account, yet if the sick leave is work-related, the annual average of overtime has to be calculated to assess the contributory base (Article 109.2.g of SSGL). It is also worth mentioning that there have been no changes in the contributory base during the period of analysis of this study.[7]

This type of Social Security system is not exclusive to Spain. From an international point of view, disability benefits vary greatly among countries, but most European countries provide benefits for workers who are temporarily disabled because of their job. Sometimes the employer is required by law or collective agreement to maintain the worker's salary for an initial period. In Austria, Belgium, Denmark, Germany and Luxembourg[8] the full earnings of the employee must be maintained; otherwise, in Italy and Sweden only part of the salary is covered. After this period, daily benefits are paid by the occupational injury insurance organization.[9]

The amount of daily benefits (except in Ireland and the UK) is calculated as a percentage of the victim's reference wages (ranging from 50% in Austria to the full net earnings in Luxembourg and Finland). In Austria, France, Italy and Portugal, benefits may be increased if they are still claimed after a certain period (between 28 days and 1 year depending on the country). Table 2 summarizes the main characteristics of the disability compensation for a group of European countries in 2004 (1 year before the beginning of our study).

[5] In this paper, we focus on TI. Injuries leading to permanent incapacity are less likely to be associated with moral hazard problems.

[6] The interested reader can find a quite detailed discussion of the regulation of TI benefits in Spain in Galiana-Moreno and Camara-Botia [21].

[7] There have been no substantial changes in the general insurance policy either. The only remarkable change is the inclusion of the self-employed workers within the system. However, we remove them from our database so as to avoid biased comparisons.

[8] In Luxembourg only permanent employees are covered.

[9] Health insurance organization in Denmark, the UK and Sweden.

Table 1 Temporary incapacity (TI) payments by type of injury. Source: own elaboration

	% of contributory base (days)		
	From 1st to 3rd, (%)	From 4th to 20th, (%)	From 21st onwards, (%)
Work-related	75	75	75
Non-work-related	0	60	75

Table 2 Temporary disability compensation in 2004Source: Eurogip [17]

Country	Waiting period	Paying organization	Amount of daily benefits (% reference wage)	Max duration of payment (from the day of the injury or diagnosis of the disease)
Germany	–	Employer	Wage maintenance	6 weeks minimum
		Occ Inj ins	80%	78 weeks
Austria	–	Employer	Wage maintenance	8 weeks minimum
		Sickness ins	50% during 42 days 60% later on	26 weeks
		Occ Inj ins	60%	Possible extension only if hospitalization
Belgium	–	Employer	Wage maintenance	1 month
		Occ Inj ins	90%	Until healing/med stabilization
Denmark	–	Employer	Wage maintenance	2 weeks
		Sickness ins	Flat rate based on wage (max: €418/week) often supplemented by the firm	52 weeks (possible extension by 26 weeks)
Spain	–	Occ Inj ins	75%	12 months (possible extension by 6 months)
Finland	–[a]	Occ Inj ins	Flat rate based on wage[b] 100% of net wages	First 4 weeks after that, for 1 year
France	–	Occ Inj ins	60%	28 days
			80%	Until med stabilization/healing
Italy	3 days	Employer	60% Wage maintenance	3 days
		Occ Inj ins	60%	90 days
			75%	Until med stabilization/healing
Luxembourg (May 2005)	–	Employer	Wage maintenance	Current month + at least following 3 months
		Occ Inj ins	Wage maintenance	52 weeks
Portugal	–	Occ Inj ins	70%	12 months
			75%	Until med stabilization/healing
Switzerland	3 days	Occ Inj ins	80%	Until healing/med stabilization
Sweden	1 day[c]	Employer	80% Wage maintenance	From day 2 to 14
		Sickness ins	80%	Until healing/med stabilization
UK (2002)	3 days	Sickness ins	Flat rate of € 72 per week	First 28 weeks
			Flat rate of € 85 per week	52 weeks

[a] The disability must last at least 3 days

[b] The amount per day depends on annual income: if income less than €1026 (and provided that the sick leave lasts more than 55 days) = €11.45; if income ranges between €1027 and €26,720 = 70% of 1/300th of income above; if income ranges between €26,721 and €41,110 = €62.35 + 40% of 1/300th of income above €26,720; if income exceeds €41,110 = € 81.53 + 25% of 1/300th of income above €41,110

[c] Compensation is paid for this waiting day afterward, once the occupational nature of the accident or disease has been recognized

Methodology

As explained in the introductory section, the current work seeks to measure the cost of compensation associated with duration moral hazard. To achieve this, sick leave duration must be broken down into two parts. The first is linked to purely medical aspects, and the other is the result of worker's opportunistic behavior. As stated above, studies analyzing sick leave duration in the economic literature have used a number of different estimation techniques. Many of these works employ simple econometric regression techniques applying ordinary least squares [13, 30].

Other authors use the "natural experiments" approach to gauge changes in legislation that may affect sick leave duration [40]. Researchers have recently begun to apply "hazard models," which outperform simple regression models when analyzing duration, particularly when data censoring exists [39].[10] However, none of them decompose between "medical days off" and "economic days off" as we do in this article.

The approach taken in the current work is quite different. It is based on stochastic frontier techniques, and follows that of Martín-Román and Moral [36]. The starting point is to assume a standard sick leave duration (D_i^s), which is a consequence of medical and physiological factors, and which marks the lower boundary. This minimum period of recovery from injury prior to returning to work may be represented by the following expression:

$$d_i^s = \ln(D_i^s) = X_i\beta + v_i. \tag{1}$$

X_i being a vector of individual characteristics, β a vector of coefficients and v_i a random error of mean *0* and variance σ_v^2.

However, the insurer perceives a real duration (D^r) which tends to be longer than the standard duration ($D^r \geq D^s$). Within this actual duration, as well as the medical or physiological aspects already mentioned, the worker's ability to prolong their period of recovery plays a major role. This leads us to assume a problem of asymmetric information associated to monitoring workers that insurance companies need to engage in while employees are absent from work. As a result, the actual duration is the sum of the standard duration plus a random non-negative disturbance as shown by the following expression:

$$d_i^r = \ln(D_i^r) = d_i^s + u_i, \tag{2}$$

where u_i is another error term with a positive mean and variance σ_u^2. Consequently, the standard duration constitutes a lower frontier[11] explained on the basis of the age of the worker, the particular nature of the injury, and how serious it is, or which part of the body is affected, among others. All of these variables determine the recovery period based on strictly medical considerations. As a result, d_i^r may also be expressed as follows:

$$d_i^r = X_i\beta + v_i + u_i. \tag{3}$$

Having a compound disturbance means that the most appropriate method of calculation is maximum likelihood estimation using the stochastic frontier technique, and assuming a specific distribution for u_i.[12] Provided the disturbances and regressors are independent, estimating least squares gives non-biased, consistent, and efficient estimators. Yet, there is inconsistency in the constant term, and the variances of the two disturbances cannot be separated.[13]

Furthermore, the stochastic frontier technique also allows the disturbance differentiating between real and standard durations to be modeled. Consequently, we can identify which variables might influence the duration that is not justified for medical or physiological reasons. In line with Battese and Coelli [6], the effects of inefficiency might be explained based on a vector Z of variables, applying the following expression:

$$u_i = Z_i\varphi + \omega_i. \tag{4}$$

with $\omega_i \geq -Z_i\varphi$

In (4), φ is the vector of parameters to be estimated, and ω_i is a set of random variables assumed to be independent and equally distributed that come from the distribution chosen for u_i. In this case, although estimating the maximum likelihood proves more complex, $\beta, \varphi, \sigma_v^2$ and σ_u^2 may be obtained jointly.

Finally, the estimations of u_i can also be obtained through the mean or the model of $f(\mu_i/\varepsilon_i)$, knowing that $\varepsilon_i = v_i + u_i$ [29], and for each subject the value of their efficiency can be calculated by means of the following expression:

$$\mathrm{EF} = \frac{f(X_i\beta)\exp(v_i + u_i)}{f(X_i\beta)\exp(v_i)} = \exp(u_i). \tag{5}$$

Once the duration logarithms have been decomposed, in order to calculate the financial cost, the number of "economic days off" and "physiological days off" need to be attained. Using a logarithmic specification for the baseline estimations requires a subsequent transformation, which involves applying an exponential function to undo the logarithm. Nevertheless, this procedure causes a prediction underestimation [55], as is shown in the following expression:

$$D^r = \exp^{d^r} > \exp^{\left(\hat{d}_i^s\right)} \cdot \ \mathrm{EF}. \tag{6}$$

Following on from Wooldridge [55], the underestimation shown in Eq. (6) may be corrected by means of an accessory regression[14], which provides us with a rescaling

[10] Corrales et al. [15] and Moral et al. [42] apply duration models for the Spanish case.

[11] Within the methodological framework of the present paper, this lower frontier would be associated with what the literature has termed as the cost frontier.

[12] Aigner et al. [2] use a semi-normal distribution, Meeusen and Van den Broeck [38] opt for an exponential distribution, Stevenson [52] uses a normal truncated distribution, and Green [22, 23] chooses a gamma distribution.

[13] Not being able to estimate the value of the variances separately means that the corresponding tests cannot be carried out to validate inefficiency.

[14] This regression gives predictions that are biased but nonetheless consistent and not subject to error normality.

parameter that solves that problem. This regression is presented in Eq. (7).

$$D^r = \hat{\alpha}_0 \cdot \exp^{\left(\hat{d}_i^s\right)} \cdot \mathrm{EF}. \quad (7)$$

Using $\hat{\alpha}_0$, to rescale the logarithmic transformation, the equivalence in days of each component may be calculated as follows:

$$\begin{aligned} D^r &= \hat{\alpha}_0 \cdot \exp^{\left(\hat{d}_i^s\right)} EF \\ &= \hat{\alpha}_0 \cdot \exp^{\left(\hat{d}_i^s\right)} + \hat{\alpha}_0 \cdot \left(\exp^{\left(\hat{d}_i^s + \hat{u}_i\right)} - \exp^{\left(\hat{d}_i^s\right)}\right) = \hat{D}^s + \hat{D}^i, \end{aligned} \quad (8)$$

where $\hat{D}^s$ is the duration related to medical and physiological factors, and $\hat{D}^i$ refers to the duration linked to inefficiency.

Database

When calculating the cost of workplace accidents in terms of paid compensation, the variable which emerges as key is sick leave duration. As a result, the database offering the best information is the *Statistics of Accidents at Work* (SAW) published by the Ministry of Labor and Social Security. This is a register of all accidents that lead to absence from work each year in Spain, and which also includes information concerning the workers, accidents, injuries, and the particular job in question.

The data used in this work correspond to full-time workers whose sick leave commenced between 2005 and 2013. Filtering out the figures corresponding to self-employed workers, and removing the injuries leading to worker fatalities, leaves a total of 6,259,756 workplace accidents. Of these, 931,184 correspond to 2005, 949,208 to 2006, 977,151 to 2007, 823,723 to 2008, 643,852 to 2009, 587,085 to 2010, 521,929 to 2011, 417,415 to 2012 and 408,209 to 2013.

The decreasing trend registered in our database from 2007 onwards deserves to be commented. There are two main reasons for this empirical regularity. The first motive for this decline in the number of workplace accidents is the strong reduction of the economic activity during the so-called Great Recession in Spain (which has been longer than in other countries). It is quite evident that the fewer the number of people at work, the lower the number of workers at risk. It is straightforward that, with a lower level of workers at risk there will be less workplace accidents. Secondly, with the economic crisis, there has also been a depressing effect on what the literature has come to call claim-reporting effect. Put it another way, when the economic situation worsens, workers are afraid of losing their jobs should they report a workplace accident. As a consequence, minor injuries are underreported when the unemployment rate is high.

Table 3 offers an initial review of the data concerning the length of each period of sick leave broken down into the year it occurred, as well as a range of characteristics regarding the accident or the person involved. The first two groups of characteristics deal with purely medical aspects such as the nature of the injury, its severity, or the place where medical attention was first provided. The longest periods can be seen to correspond to accidents involving a heart attack, or those leading to traumatic amputation, or a fracture. Other features to emerge are that serious injuries[15] lead to periods of sick leave that are five times longer than non-serious injuries, or that cases dealt with in primary care centers last half as long as those treated in hospital.

The other groups of variables deal with other characteristics such as gender, the type of contract, or nationality. Broadly speaking, women tend to have longer periods off than men, workers with open-ended contracts have longer sick-leave periods than workers on temporary contracts, and national workers tend to take longer sick leave than immigrant workers. This is particularly true when comparing with workers from developing countries.[16]

A further aspect worth taking into account concerns the year when sick leave was taken. Broadly speaking, sick leave can be seen to grow over the years, increasing from 24.1 days in 2005 to 31.8 in 2013. Yet, this rise is by no means constant over the period. After some years of stability, which even witnessed a slight fall up to 2008, there was a sharp increase in 2009, which remained steady with slight variations in 2010 and 2013. This evolution over time has also led to a change in the differences in duration between certain characteristics. For instance, the last years of the sample reveals how differences in duration in terms of the type of contract diminished substantially. The same was also true amongst immigrants from developed countries and Spanish nationals. The most striking case emerges in the case of gender, where differences in duration are inverted. Whereas in 2005, female sick leave was 2 days longer than male sick leave, in 2011 and 2012 it was slightly shorter.

Finally, and from the standpoint of costs, a reduction in the aggregate cost of accidents over time can be seen (with the exception of the last year of the sample).[17] This result

[15] It is a medical decision what determines the seriousness of an injury in the SAW. An injury can fall into four categories: (1) minor injuries, (2) serious injuries, (3) very serious injuries and (4) fatal injuries. We group together those "serious" and "very serious" injuries in the SAW under the label "serious" in this paper. Obviously, we have removed from our database all injuries ending in a death (fatal injuries).

[16] For the purposes of this paper, Central and South America, Asia (except Japan) and East Europe are considered "developing countries".

[17] In order to compute the aggregate cost, we proceed in two steps. Firstly, we multiply the number of days of sick leave by the corresponding compensation for each individual register in our database. Then, we add all the individual costs for the whole year so as to obtain the aggregate figure.

Table 3 Mean durations and costs of accidents leading to workplace absence incurred by full-time workers in terms of various characteristics and years

	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Not specified	23.7	23.0	24.0	22.0	26.9	27.4	27.6	26.6	30.5	24.5
Injuries	18.2	18.4	17.7	16.9	20.1	21.0	21.5	21.3	23.0	19.1
Fractures	57.6	54.6	66.9	58.3	71.2	73.9	72.8	71.8	74.8	65.2
Sprain	22.8	22.8	23.3	21.7	26.0	27.1	27.9	27.9	29.6	24.8
Traumatic amputation	74.1	61.5	81.0	74.1	84.4	89.2	85.4	80.5	85.3	77.3
Concussion	25.1	23.9	25.1	23.9	29.5	30.6	31.2	31.9	31.7	27.0
Burns	18.3	18.7	18.6	16.2	19.6	20.5	19.4	19.0	21.2	18.8
Poisoning	16.5	15.4	14.2	13.1	15.9	16.5	16.7	15.9	15.3	15.4
Choking	19.7	20.4	17.9	10.6	11.5	21.6	17.4	18.1	19.9	14.6
Noise, heat	15.4	14.8	14.4	14.3	19.3	22.5	22.3	21.5	21.0	17.9
Psychological trauma	26.8	31.8	35.7	30.4	44.2	36.6	35.6	37.4	37.1	34.0
Multiple injuries	45.5	41.2	49.7	41.4	48.6	49.6	49.0	48.4	49.3	46.6
Heart attack	92.4	71.5	117.8	89.2	145.9	142.9	151.6	140.5	138.3	119.0
Light	23.0	22.9	23.4	21.9	26.6	27.8	28.4	28.7	30.6	25.1
Serious	116.9	94.4	148.7	131.4	161.6	165.6	164.2	159.6	166.0	138.2
Primary health center	22.2	22.2	22.8	21.4	25.7	26.8	27.4	27.6	29.3	24.2
Hospital	41.2	38.6	45.8	40.9	52.9	53.9	53.2	53.1	54.4	46.5
Female	25.7	25.3	25.7	23.9	28.5	29.4	29.6	29.9	32.1	27.4
Male	23.7	23.3	24.5	22.6	27.6	29.0	29.7	30.0	31.7	25.8
Temporary	22.5	22.3	23.2	21.8	26.8	28.3	29.1	29.4	31.3	24.4
Open-ended	25.8	25.2	26.1	23.8	28.4	29.5	30.0	30.2	32.0	27.5
Spain	24.4	24.1	25.3	23.3	28.3	29.6	30.1	30.4	32.2	26.6
Developed	22.4	22.0	23.4	22.5	27.7	29.4	29.5	30.6	31.8	25.2
Non-developed	20.2	20.5	20.7	20.4	24.3	24.9	25.8	26.2	27.7	22.5
Total	24.1	23.7	24.7	22.9	27.8	29.1	29.7	30.0	31.8	26.2
Costs										
By accident	964.5	955.3	1016.7	962.2	1228.5	1286.0	1291.7	1295.7	1391.0	1105.4
Aggregated (thousand million)	0.898	0.907	0.993	0.793	0.791	0.755	0.674	0.541	0.568	6.92

Source: Author's own based on *Statistics of Accidents at Work* (SAW) data. Costs are calculated in constant year 2011 Euros

might be linked to the financial crisis and to the loss of jobs, which has also led to a drop in the number of those subject to risk. Nevertheless, a noticeable increase in the cost per accident is also in evidence due to longer sick leave periods in the final years of the sample.

Results

Based on the above descriptors, the question to be answered concerns to what extent said cost is the result of purely physiological or medical aspects, and to what extent it may be triggered by duration moral hazard. To answer this question, the following steps are taken: firstly, and for each sick leave spell, the duration logarithm is decomposed by applying a stochastic frontier estimation, and secondly the logarithms are transformed into days and multiplied by the daily compensation in order to obtain the value of the costs.

Decomposing the duration logarithm

When calculating how much compensation expenditure is associated to duration moral hazard, it is necessary to identify which part of the sick leave is the result of purely medical aspects, and which part might be attributed to individual behavior. As already mentioned in the "Methodology" section, one way of distinguishing between these two components is to estimate stochastic frontiers in terms of costs. By applying this technique, the dependent variable may be decomposed into a minimum value (minimum cost) and a one-sided error term linked to inefficiency (unjustified excess costs). We link the first part to the duration, which would be expected due to purely physiological or medical aspects (minimum duration), and the second to questions concerning worker behavior and to duration moral hazard (non-justified excess duration).

The first question to be resolved when specifying the frontier model is to pinpoint which variables form part of the frontier, and which are to be included in inefficiency. Since the frontier represents a minimum duration, we feel that it can only be due to medical and physiological reasons. As a result, the variables chosen were the type of injury (12 dummies), the injured part of the body (7 dummies), a variable measuring whether the accident is serious, another indicating whether the injury was initially treated in hospital, another reflecting whether the patient needed to be admitted to hospital, and another indicating whether the injury was a recurrence of a previous injury. The age of the injured worker is also added because we consider that it may have effects on the recovery period. Age squared is likewise included to identify possible non-linear effects in the model.

The second part of the specification process involves selecting the variables to be introduced in the model as explanatory factors of inefficiency. These are variables that have often been taken into account in the economic literature addressing workplace absenteeism and moral hazard in work accident compensation insurance. In the present work, two models are estimated specifying inefficiency. The first includes controls for the occupation (8 dummies),[18] for the sector in which the employee works (3 dummies),[19] for the region where the accident occurred (16 dummies),[20] for the year the leave was taken (8 dummies),[21] and the nationality of the injured worker (2 dummies). Apart from these, a further dummy is also included reflecting whether the worker has an open-ended contract[22] as well as another variable detailing the amount of compensation involved.[23]

In the second model, in addition to all the previously mentioned variables, a variable reflecting gender is included as is another indicating whether the accident led to an injury classed as "difficult to diagnose".[24] This latter regressor is included since the literature has reported that the injuries most likely to induce opportunistic behaviour by workers are so-called "difficulty to diagnose" injuries [18], easy to conceal injuries [51] or "soft tissue" injuries [10]. These injuries are basically sprains and lumbago.

As already mentioned, in the present work a cost frontier is estimated[25] where inefficiency is modeled, and where the residuals are assumed to follow an exponential distribution. STATA provides three different statistical distributions: half-normal, truncated-normal, and exponential. However, and following Greene [22]: "the assumption of half-normality has seemed unduly narrow". Due to this, we only performed the regressions by using the truncated-normal and exponential distributions. Nonetheless, and as a consequence of the high similarity of the results for both statistical distributions, we only present here those associated with the exponential distribution for the sake of brevity.[26]

Table 4 shows the results of these estimations for three specifications. In the first, only those affecting the frontier are included as explanatory variables. The other two specifications include the modeling of inefficiency referred to in previous paragraphs.

The upper part of Table 4 reflects the values of the variables that affect the frontier. Irrespective of the specification chosen, all the coefficients can be seen to be highly significant and display the expected sign. Furthermore, the effect of the variables emerges as stable in the three models regardless of whether inefficiency is modeled or not. It can thus be seen that the longest standard durations correspond to accidents leading to fractures and traumatic amputation, to serious injuries, and those which require hospitalization, as well as recurrences of previous injuries. Finally, a positive and increasing effect of the age on the standard duration can be observed, which is reasonable from a physiological point of view.

The lower part of Table 4 reflects the coefficients of the variables included to model inefficiency. As occurs with the variables at the frontier, all of the variables prove to be highly significant and display stable signs and values in the two models. It should also be pointed out that, apart from the variables shown in Table 4, dummies have been included to control possible spatial, activity and

[18] Even though there are two different classifications of occupations (CNO-94 and CNO-11), nine homogenous groups were constructed. The groups included are: CNO1 (Managers), CNO2 (Professional, technicians and scientists), CNO3 (Technicians and associate professionals), CNO4 (Clerical support workers), CNO5 (Transport, trade, service and sales workers), CNO6 (Skilled agricultural, forestry and fishery workers), CNO7 (Occupations unique to primary industry, processing, manufacturing and utilities), CNO8 (Plant and machine operators and assemblers) and CNO9 (Unskilled workers).

[19] The activity sectors are agriculture, industry, building and services.

[20] Corrales et al [15] find significant differences in sick leave duration resulting from workplace accidents in the various regions in Spain.

[21] The literature has found that, in recessions, the rate of workplace accidents goes down [8] and that sickness absences are procyclical [32, 46].

[22] The literature has often stressed the importance of the type of contract on workplace accident rates [4, 24, 26].

[23] For a review of the effects of compensation on workplace accident rates, consult the review conducted by Fortin and Lanoie [18].

[24] In this sense, Moral et al. [41] report differences in the percentage of difficult to diagnose accidents reported by national and immigrant workers. In a more recent paper, Martín-Roman and Moral [37] find a higher proportion of hard-to-diagnose injuries on Mondays.

[25] The logarithm likelihood ratio tests find a cost frontier with significance level of 1%. However, when positing a production frontier, this does not prove significant.

[26] The results for the truncated-normal distribution are available from the authors upon request.

Table 4 Results of estimating stochastic frontiers on the logarithm of workplace sick leave duration[a]

Log (duration)	Coefficient	Z	Coefficient	Z	Coefficient	Z
Injury (reference: non-specified injuries)						
Injuries	−0.145	−64.06	−0.137	−60.39	−0.135	−60.34
Fractures	0.954	356.86	0.953	356.78	0.955	360.27
Sprain	0.028	12.40	0.028	12.68	−0.007	−3.01
Traumatic amputation	0.874	101.34	0.880	102.62	0.881	103.69
Concussion	0.050	18.15	0.053	19.03	0.054	19.6
Burns	−0.180	−44.75	−0.172	−42.91	−0.171	−43.09
Poisoning	−0.373	−38.06	−0.364	−37.41	−0.365	−37.8
Choking	−0.487	−43.34	−0.461	−41.64	−0.462	−42.08
Noise, heat, radiation	−0.148	−14.51	−0.149	−14.68	−0.149	−14.76
Psychological trauma	0.116	12.73	0.101	11.04	0.102	11.32
Multiple injuries	0.249	59.65	0.246	59.11	0.249	60.33
Heart attack	0.524	42.30	0.485	38.51	0.498	40.05
Controls for the injured part of the body have been included						
Hospital care	0.197	130.33	0.196	129.16	0.196	129.88
Hospitalization	0.603	200.72	0.595	197.79	0.599	200.4
Serious	0.929	191.45	0.938	193.84	0.938	195.58
Recurrence	0.404	185.82	0.396	181.83	0.394	180.55
Age	0.011	46.27	0.009	37.60	0.009	36.87
Age squared	1.23E–05	4.13	2.64E–05	8.82	2.69E–05	9.03
Constant	1.674	259.16	1.732	266.78	1.754	270.36
Modeling inefficiency						
Year of sick leave (reference: 2005)						
2006			−0.145	−28.10	−0.146	−28.19
2007			−0.018	−3.54	−0.023	−4.46
2008			−0.248	−45.11	−0.255	−46.35
2009			0.114	21.04	0.104	19.20
2010			0.161	28.95	0.150	27.02
2011			0.195	34.10	0.186	32.60
2012			0.165	26.14	0.158	24.96
2013			0.288	48.52	0.278	46.84
Nationality (reference: Spanish)						
Developed			−0.163	−11.12	−0.152	−9.70
Undeveloped			−0.298	−52.64	−0.288	−47.00
Open-ended contract			0.030	9.52	0.030	9.31
Compensation			0.004	34.36	0.005	44.65
Male					−0.217	−57.42
Difficult to diagnose					0.163	37.51
Constant			−1.168	−46.48	−1.143	−45.18
Lambda	0.699					
Likelihood-ratio test of sigma_u = 0: chibar2(01) = 8.5e + 04 Prob >=chibar2 = 0.000						

[a] When modeling inefficiency, 8 variables have been included to control for worker occupation, 3 to control for sector of activity and 16 to control for the regions in Spain

occupational effects when calculating inefficiency. It can be seen that the regions that display the lowest levels of inefficiency are the Balearic Islands, Catalonia, Madrid, La Rioja, and Navarra, that agriculture is the most inefficient sector, and that the occupations exhibiting the highest levels of moral hazard correspond to managers, senior consultants and support staff as well as skilled workers in the primary sector.[27]

Overall, it can be seen that the years prior to the crisis, together with 2008, evidence the lowest levels of duration moral hazard. However, over the last 5 years of the sample period the situation was the opposite and there was a substantial rise in inefficiency. This observation might seem counterintuitive at first sight. However, as a consequence of the sick leave regulation in Spain, some workers could be using TI insurance as a substitute for unemployment insurance (UI) if the worker is not entitled to receive the UI, or as a way to lengthen the UI spell when the worker is entitled to it.[28] In fact, the interaction between UI and workplace accident insurance has already been documented in the literature. Thus, Fortin et al. [19, 20] find, for the Canadian case, longer durations in the workplace accident insurance when the UI generosity is reduced (particularly among the difficult-to-diagnose injuries). In the same vein, Whelan [54] also finds, for the Canadian case again, that a less generous UI is related to a higher number of workers making use of the workplace accident insurance. Another study reaching similar conclusions is Butler et al. [12]. These authors state that the worker's compensation (i.e., the workplace accident insurance) is a good option for those workers facing a workforce reduction in their companies. An article of the utmost importance for understanding this phenomenon in our data is that of Guadalupe [24], because she makes use of Spanish data, as we do. This latter author concludes that some workers not entitled to receive UI (particularly young workers) tend to report more workplace accidents, other things being equal. Put another way, to a degree there is an "insurance substitution", which might be more acute in harsh times like the Great Recession.

With regard to injured worker nationality, lower rates of absenteeism are apparent amongst foreign workers, particularly those from less developed countries. It can also be seen that unjustified duration is longer in the case of workers who have an open-ended contract, and that it grows in relation to the size of the compensation received. Finally, as regards the variables added in the last specification, inefficiency increases when the injured worker is female, and when the reported injury is classified among those deemed as difficult to diagnose.

It may therefore be concluded that all the variables included in the specification of inefficiency show signs that are consistent with the results reported in the literature, which would appear to bear out the robustness of the estimation carried out.

"Medical days off", "economic days off" and financial costs

Preliminary frontier estimation allows the value of the inefficiency to be calculated and separated from the so-called standard duration for each of the injured parties. As a result, the following step computes the values of the durations based on the decomposition obtained for the logarithm of the days off work. This assessment will provide a calculation of the compensation costs associated to the standard duration and to the duration moral hazard cost.

Once we have undone the logarithmic transformation, durations are calculated based on the auxiliary regression shown in Eq. (7) and the decomposition in Eq. (8). The cost assessment is made by multiplying the estimated duration for each injured worker by the daily individual compensation (obtained from each record in the SAW). Once we have computed every "individual cost", we aggregate them to obtain the overall figure. We would like to stress that the calculation is made by taking into account each record in our micro-database first. The aggregation is done in a second stage. Table 5 provides a summary of the results obtained for days off and for the cost of compensation. The three first rows refer to standard duration, duration linked to moral hazard, and the sum of the two, both in terms of the mean and in aggregated terms. The last three show the cost of compensation associated to each of the previous durations.

The results in Table 5 show that of the 26 days which the mean sick leave period lasts, just over 14.5 are due to purely physiological aspects and represent what we term standard duration. The remaining 11.5 days constitute the part of sick leave linked to duration moral hazard. In aggregated terms, it can be seen that sick leave associated to purely medical reasons entailed a loss of more than 91 million working days, whereas 72.3 million days were the result of discretional worker behavior.

If we translate these figures into money, the mean cost of sick leave in compensation paid to workers comes to 1105.8 Euros. Of this total, almost 611.77 Euros may be accounted for by purely medical or physiological reasons,

[27] The full estimations with the coefficients not included in Table 4 are available to those interested upon request from the authors.

[28] In this sense, it is worth pointing out that article 283 of the current General Law of the Social Security (Royal Decree Law 8/2015) establishes that if the labor contract of an injured (at work) employee expires while he/she is in a TI spell, such a worker will continue receiving the compensation until the sick leave ends. At that moment, the employee becomes legally unemployed should the extinction of the labor contract falls into any of the categories within the article 267.1. If that were the case, the worker would receive the UI compensation (if entitled). More importantly, the number of days while in TI is not taken into account (i.e., is not discounted) in the calculation of the UI benefit period. With this legal framework in mind, it is easy to think that during the Great Recession some workers have taken advantage opportunistically of the workplace accident insurance, prolonging their sick leave spells with an economic motivation.

Table 5 Breakdown of the estimated duration and the financial cost associated to the compensation of occupational sick leave. Source: Author's own based on SAW data

	Mean values	Aggregated values
Days off		
Standard	14.56	91,156,069.21
Inefficiency	11.56	72,333,859.29
Total	26.12	163,489,928.50
Cost of compensation[a]		
Standard	611.77	3,829,547,203.49
Inefficiency	494.03	3,092,485,347.53
Total	1105.80	6,922,032,550.02

[a] Constant 2011 Euros

whereas 494.03 Euros are the result of worker behavior. Following on from this, the total expenditure on compensation over the period 2005–2013 resulting from full-time worker sick leave comes to 6922 million Euros. Of this total, over 3800 million is due to days that came under the umbrella of standard recovery, whereas over 3000 million were linked to work absenteeism.

Some extensions

The methodological proposal presented in this work allows us to obtain, in a first step, and for each accident, the efficiency level. In addition, it is also used to break down the whole duration of each sick leave period into "economic days off" and "medical days off". This type of analysis provides an array of results that may be useful so as to propose economic policy measures. Some examples of these results are the possibility of knowing the injuries more prone to present opportunistic behavior, the occupations with the longest and the most burdensome sick leaves for the Social Security system, or the changes in the sick leave decomposition over years.

Figure 1 shows the average efficiency degree according to different types of injury. This information comes from the estimates carried out for each injury consistent with expression (5). The outcomes are distributed along a spiral, indicating that those injuries whose recovery period can be determined more objectively coincide with those where the opportunistic behavior is lower Specifically, the injuries where the "economic days off" have less relative weight are traumatic amputations, fractures and burns. On the other side, the injuries with a higher inefficiency level are psychological traumas, heart attacks[29] or sprains. Within the latter group, sprains are numerically the most important category, quantitatively speaking. As in the literature on this topic has frequently considered that moral hazard situations are more common among such injuries, our results are quite consistent with previous studies, despite using a different methodology.

Figures 2 and 3 depict both the duration and cost analysis disaggregated by occupation. Figure 2 presents the breakdown of the average sick leave duration into its two components: economic and physiological. We can observe that the number of "economic days off" is always lower than the standard duration (i.e., the "physiological days off") in the nine occupational categories taken into account. Other interesting finding is that, as long as we move down the "occupational ladder," the two components become shorter.

In Fig. 3, on the other hand, Social Security costs are examined. As it can be seen, the cost due to the standard duration is higher than that associated with moral hazard. At the same time, both types of cost grow with occupational level. This result is a consequence of a two-fold motive. On the one hand, the above mentioned evolution of the "economic" and "physiological days off" and, on the other, increasing compensation related to higher occupational levels.

Figure 4 shows how the estimated duration changes over time. In general terms, it might be affirmed that "the medical days off" do not change very much until the year 2008, and from then onwards there is a slight increase until the end of the period considered. This result is coherent with a reduction in the reporting of the minor injuries during the years of the Great Recession. On the other hand, the evolution of "the economic days off" is relatively "flat" in the first years of the period. Then, there is a small reduction in 2008, and later a substantial increase from 2009 on. It might be highlighted that "economic days off" practically equalled "medical days off" in 2013. The rationale behind this empirical observation is, as mentioned above, that some workers might be making use opportunistically of the workplace accident insurance instead of (or together with) UI. For instance, when not entitled to UI, some workers can earn public income through this route. On the other hand, when entitled to UI, due to the Spanish legislation it is easy, even highly likely, that some workers prolong their spells off work combining UI and workplace accident insurance. This phenomenon ought to be more important in harsh times like the Great Recession.[30]

[29] Although a heart attack has an objective diagnosis, its recovery period depends on the patient's behavior.

[30] See again Fortin et al. [19, 20] for the Canadian case or Guadalupe [24] for the Spanish one.

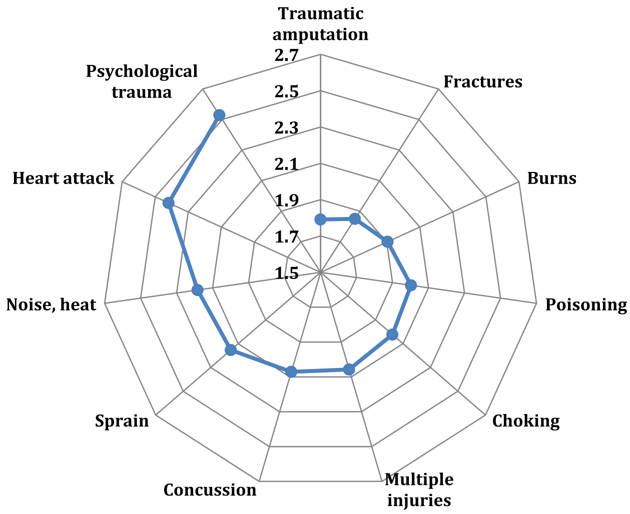

Fig. 1 Inefficiency level by type of injury. Source: author's own based on SAW data

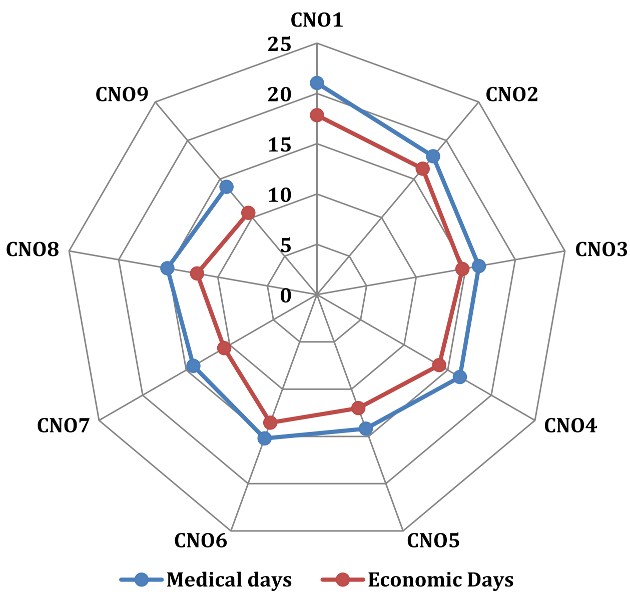

Fig. 2 Average of "economic days off" and "medical days off" by occupation. Source: author's own based on SAW data. Note: The classification of occupations used is CNO, with the lower the number, the higher the skill: CNO1 corresponds to managers and CNO9 to unskilled workers

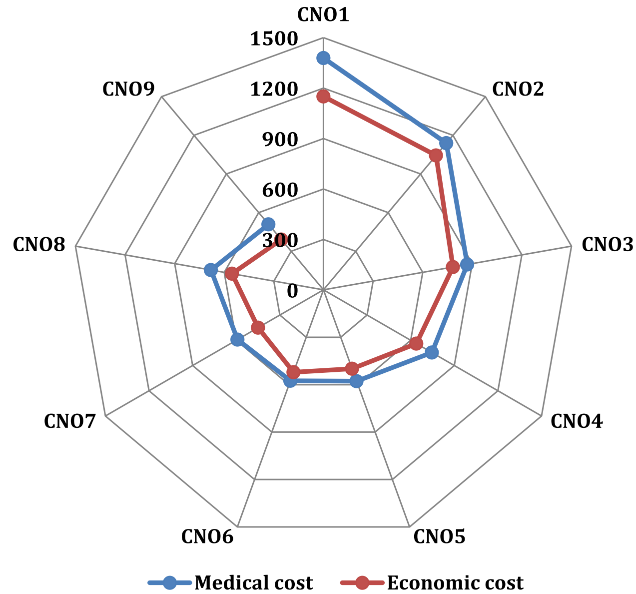

Fig. 3 Average cost of standard duration and "moral hazard" by occupation. Source: author's own based on SAW data. Note the classification of occupations used is CNO, with the lower the number, the higher the skill. CNO1 corresponds to managers and CNO9 to unskilled workers

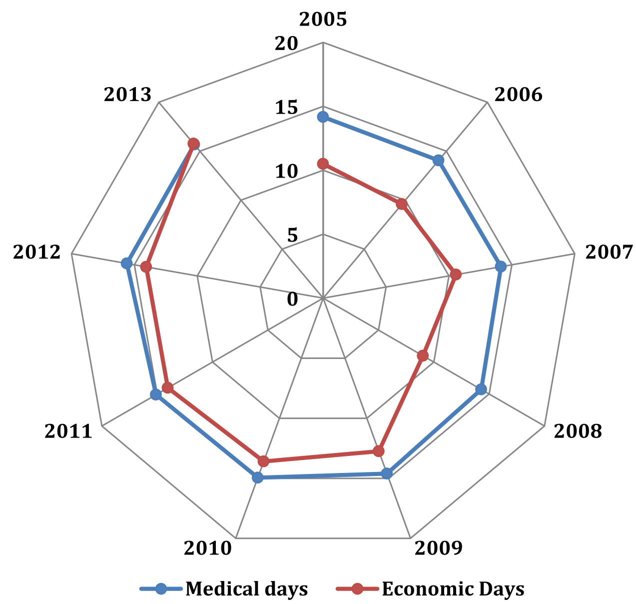

Fig. 4 Average of "economic days off" and "medical days off" by year. Source: author's own based on SAW data

Robustness and stability

In this section we conduct two types of robustness analysis. On the one hand, we tackle the question of presenteeism, which might be biasing our assessment of the costs of absenteeism. One the other hand, we carry out a sensitivity analysis departing from the baseline regression. Several different econometric specifications are used, and we compare our main outcomes with those obtained from these alternative econometric specifications.

Presenteeism

When analyzing the issue of absenteeism from the point of view of sick leave duration, the question of presenteeism should be tackled. This situation occurs when an employee goes to work while sick, or before having recovered from an injury. The literature has already addressed this issue and its consequences. For instance, Susser and Ziebarth [53] find that presenteeism is more common among women, among low-income workers, and among those who are between 25 and 34 years old. In the same vein, but for the Spanish case, Agudelo-Suárez et al. [1] point out that presenteeism is more frequent among workers with more precarious jobs (mainly fixed-term contracts) and poorer working conditions.

In the case of workplace accidents, there are two sources of presenteeism, one affecting the incidence and another affecting the duration. Put another way, (1) a worker could not report an injury after a workplace accident (particularly if it is a minor injury) and (2) a worker might shorten his/her recovery period and come back to work without being fully healed. Regarding the phenomenon analyzed in this paper, only the second reason would be relevant (as we are studying duration moral hazard). In this second case, there would be, in turn, two reasons to expect a presenteeist behavior: (1) the income loss due to the lower replacement rate of the sick leave compensation, and (2) the fear of being fired by the employer as retaliation for not being at work.

In the Spanish case, the income loss due to the sick leave does not seem to be an important reason for presenteeism. This so because, on the one hand, the injured worker receives the compensation just the day after the accident took place. In addition, it is not only that the legal replacement rate (paid by the Social Security) is relatively high, 75% of the regulatory basis (which is basically the previous salary), but that this percentage has been raised quite frequently by collective bargaining agreements in the period considered in this study. In this vein, according to López-Tarruella [33], over 80% of the Spanish collective bargaining agreements include legal clauses increasing that percentage to reach, in most cases, 100% of the previous salary. This is relevant since, in accordance with Pichler and Ziebarth [47], presenteeism is reduced when monetary incentives during the sick leave period are available.

A different question is the fear of being laid off. Spain is a country with a dual labor market. In some of the years considered in this study, the weight of temporary employment exceeded one-third of total salaried employment. It is also well known that working conditions differ substantially between open-ended and fixed-term contracts in Spain, particularly those affecting the likelihood of being fired. Following this line of reasoning, if presenteeism were a significant issue, we should expect higher levels among temporary workers than among workers with an open-ended contract. With this idea in mind, and from the outcome of our empirical analysis, it is easy to carry out a test to check for this possibility.

In Table 6, we show the mean value of the standard duration with a breakdown by seniority and type of labor contract. As mentioned above, the reason for this distinction can be found in the works by Susser and Ziebarth [53] and Agudelo-Suárez et al. [1], who indicate that higher levels of presenteeism should be detected in those socioeconomic groups with worse working conditions. In Table 6, we controlled by age for a two-fold motive: (1) age is a key variable in understanding differences in duration, and (2) there is a high concentration of fixed-term contracts among the youngest workers, who also have less seniority. The results make clear that no significant difference between groups exists within each age range. This empirical evidence, together with the arguments discussed above, makes us think that presenteeism is not an issue in our database, and that we can rely on our estimates.

Sensitivity analysis

In this subsection, we present the results of a sensitivity analysis. We ran a set of regressions with different specifications to test the stability of our results. Our baseline model in Table 7 is Model I, which is the same specification used in the results section (Table 5). In Model II, we add to the frontier the gender variable. This specification is considered since it is possible that the same injury might have a distinct effect on men and women. In the other two models, the inefficiency specification is modified. Thus, in Model III we remove the gender and “difficult to diagnose” variables, whereas, in Model IV, we include the age and the tenure of the worker. Model III is used to test the robustness of the results when key variables for the inefficiency are omitted. With regard to model IV, it allows us to analyze changes in the worker’s behavior because of his/her age or seniority.

In Table 7 we show the results both in terms of “days” and “monetary costs” for the four models analyzed. As a general comment, it can be stated that the figures, both mean and aggregate, are rather similar, regardless of econometric specification. The largest difference from the baseline model is found when it is compared to Model IV, although it is worth mentioning that the order of magnitude of such a difference is not very significant. As regards the mean duration, “the medical days off” vary between 14.30 in Model IV and 14.59 in model II. Nonetheless, the mean absenteeism barely changes four hundredths among the four models.

Regarding the aggregate costs, the largest difference is again found when Model IV is taken into consideration. The costs associated with the standard duration are 2.2 percentage points lower in Model IV than in the baseline model. On the other hand, the costs related to absenteeism are 0.7 percentage points higher in Model IV than in Model I. As a conclusion, all these results together seem to prove that the cost estimation, and particularly that associated with the “economic days”, does not vary excessively regardless of model specification. This is a signal of the robustness of the methodology proposed here.

The detailed results on which Table 7 is based may be found in Table 8. All in all, the coefficients are quite

Table 6 Mean standard duration by type of contract, seniority and age group. Source: author's own based on SAW data

	Type of contract		Seniority		
	Fixed-term	Open-ended	Less than 1 year	From 1 to 5 years	More than 5 years
Less than 21	11.3	11.2	11.3	11.2	11.6
From 21 to 30	12.2	12.3	12.2	12.2	12.3
From 31 to 40	13.8	13.8	13.8	13.8	13.9
From 41 to 50	15.9	16.0	16.0	15.8	16.1
From 51 to 60	18.6	18.8	18.8	18.6	18.9
More than 60	20.7	21.2	21.1	21.0	21.5

Table 7 Breakdown of the estimated duration and the financial cost associated to the compensation of occupational sick leave. Source: Author's own based on SAW data

	Model I		Model II		Model III		Model IV	
	Mean	Total	Mean	Total	Mean	Total	Mean	Total
Days off								
Standard	14.56	91,156,069.2	14.59	91,306,929.3	14.55	91,063,612.6	14.30	89,502,992.8
Inefficiency	11.56	72,333,859.3	11.56	72,370,729.3	11.59	72,523,216.9	11.60	72,584,124.3
Total	26.12	163,489,928.5	26.15	163,677,658.6	26.14	163,586,829.5	25.90	162,087,117.2
Cost of compensation[a]								
Standard	611.77	3,829,547,203.5	611.63	3,828,684,609.1	611.28	3,826,484,304.9	598.30	3,745,218,274.6
Inefficiency	494.03	3,092,485,347.5	495.36	3,100,830,854.2	495.11	3,099,287,824.4	497.46	3,114,000,128.9
Total	1,105.80	6,922,032,550.0	1,106.99	6,929,515,463.3	1,106.39	6,925,772,129.3	1,095.76	6,859,218,403.5

[a] Constant 2011 Euros

similar throughout the different econometric specifications. Also the level of significance of the covariates is similar in the four models. Maybe the most interesting result emerges when gender is included in the modeling of the frontier (Model II). Consistent with this specification, men exhibit higher levels of absenteeism than women. Although outside the scope of this paper, delving into this issue might be a relevant research question for future work. In any case, it should be stressed, as already mentioned, that the overall cost assessment is not influenced by this fact. Another appealing result can be observed in Model IV, when the worker's age and tenure are incorporated into the inefficiency term. Whereas in the rest of the econometric specifications, open-ended contracts are associated with higher absenteeism, in Model IV age and tenure capture this effect (which is quite logical due to the high correlation among those variables). As in the previous case, cost calculation is not significantly affected.

Conclusions

Duration moral hazard in sick leave occurs when workers prolong the time they are off work thanks to compensation insurance that covers their loss of earnings. The cost of this in economic terms merits detailed study and an accurate calculation so that economic policy measures aimed at minimizing its impact may be taken. With this purpose in mind, the present work proposes a method that allows the economic cost of workplace accidents to be split into two components, which we feel to be highly contrasting in nature: the amount associated to the worker's period of recovery, and the other which reflects injured worker's opportunistic behavior.

An initial exploratory analysis of the data reveals that during the period spanning 2005–2013 expenditure on full-time salaried worker compensation fell by around 30%. Said reduction is due exclusively to a fall in the number of accidents given that the unit cost of each accident has grown by over 35%. This evolution in the costs bears out the importance of analyzing which part of the increase in the unit cost is due to accidents being more serious, and which part is due to duration moral hazard.

The stochastic frontier analysis carried out in this research reveals that, of the more than 26 days average sick leave period arising from an accident, over 11.5 days are the result of worker opportunistic behavior. Translated into costs, these figures mean that, of the total amount spent on compensation, close to 45% is attributable to duration moral hazard (or perhaps insurance substitution hazard). As a result, during the 9-year period analyzed, over 72 million working days are lost because of worker behavior,

Table 8 Results of estimating stochastic frontiers on the logarithm of workplace sick leave duration[a]

Log (duration)	Model I		Model II		Model III		Model IV	
	Coeff	Z	Coeff	Z	Coeff	Z	Coeff	Z
Injury (reference: non-specified injuries)								
Injuries	−0.135	−60.3	−0.135	−60.18	−0.136	−60.4	−0.13	−59.7
Fractures	0.955	360.3	0.956	361.09	0.953	356.8	0.96	361.7
Sprain	−0.007	−3.0	−0.012	−4.9	0.028	12.7	−0.01	−2.6
Traumatic amputation	0.881	103.7	0.886	104.1	0.880	102.6	0.89	104.3
Concussion	0.054	19.6	0.053	19.2	0.053	19.0	0.05	19.6
Burns	−0.171	−43.1	−0.175	−44.1	−0.172	−42.9	−0.17	−42.3
Poisoning	−0.365	−37.8	−0.369	−38.3	−0.364	−37.4	−0.36	−37.6
Choking	−0.462	−42.1	−0.463	−42.2	−0.461	−41.6	−0.46	−42.1
Noise, heat, radiation	−0.149	−14.8	−0.150	−14.9	−0.149	−14.7	−0.15	−14.7
Psychological trauma	0.102	11.3	0.102	11.4	0.101	11.1	0.10	11.6
Multiple injuries	0.249	60.3	0.248	60.2	0.246	59.1	0.25	60.9
Heart attack	0.498	40.1	0.496	39.8	0.485	38.5	0.48	37.9
Controls for the injured part of the body have been included								
Hospital care	0.196	129.9	0.196	129.5	0.196	129.2	0.197	130.2
Hospitalization	0.599	200.4	0.598	200.0	0.595	197.8	0.598	199.8
Serious	0.938	195.6	0.940	195.6	0.938	193.9	0.942	195.8
Recurrence	0.394	180.6	0.392	180.0	0.396	181.8	0.393	180.3
Age	0.009	36.8	0.009	36.2	0.009	37.6	0.007	30.4
Age squared	2.7E−05	9.0	2.8E−05	9.3	2.6E−05	8.8	−2.4E−06	−0.8
Male			−0.098	−67.2				
Constant	1.754	270.4	1.836	278.3	1.732	266.8	1.853	282.8
Modeling inefficiency								
Year of sick leave (reference: 2005)								
2006	−0.146	−28.2	−0.146	−28.3	−0.145	−28.1	−0.146	−28.0
2007	−0.023	−4.5	−0.024	−4.6	−0.018	−3.5	−0.023	−4.3
2008	−0.255	−46.4	−0.255	−46.5	−0.247	−45.1	−0.257	−46.5
2009	0.104	19.2	0.104	19.2	0.114	21.1	0.095	17.4
2010	0.150	27.0	0.150	27.1	0.161	29.0	0.135	24.3
2011	0.186	32.6	0.187	32.8	0.195	34.1	0.165	28.8
2012	0.158	25,0	0.159	25.2	0.165	26.2	0.128	20.3
2013	0.278	46.8	0.281	47.3	0.288	48.5	0.240	40.4
Nationality (reference: Spanish)								
Developed	−0.152	−9.7	−0.147	−10.1	−0.162	−11.1	−0.138	−9.4
Undeveloped	−0.288	−47.0	−0.285	−50.4	−0.298	−52.7	−0.280	−48.7
Open-ended contract	0.030	9.3	0.031	9.6	0.030	9.5	−0.016	−4.7
Compensation	0.005	44.7	0.005	45.2	0.004	34.4	0.003	30.4
Male	−0.217	−57.4	0.046	8.2			−0.196	−51.8
Difficult to diagnose	0.163	37.5	0.176	40.6			0.168	38.9
Age							0.018	89.7
Tenure							1.0E−04	5.0
Constant	−1.143	−45.2	−1.348	−52.7	−1.169	−46.5	−1.782	−67.5

[a] When modeling inefficiency, 8 variables have been included to control for worker occupation, 3 to control for sector of activity and 16 to control for the regions in Spain

representing an expenditure of over 3000 million constant 2011 Euros.

The last part of this paper presents some extensions related to the methodological proposal. The main aim of this last section is to provide the reader with an example of the potential uses of the technique. Simultaneously, it may be also useful for the policy makers. We detect that those injuries whose recovery period depends more on the worker's behavior are the ones exhibiting a higher relative weight of the "economic days off" in the total duration. Otherwise, we also find that longer durations and higher costs correspond to high level occupations. Finally, an appealing result is that duration moral hazard appears to have increased during the Great Recession. As the literature has pointed out, the interaction between UI and workplace accident insurance might be behind this empirical regularity.

All in all, our estimates seem to show quite reasonable and sensible results according to previous literature reports. In addition, the robustness checks performed show a high stability of our cost calculation. We strongly believe that our technique is able to measure absenteeism more accurately and, consequently, the economic costs are better assessed. We also think that this method opens an interesting path for future research. European countries, with similar health insurance systems, could be good candidates to apply this technique.

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