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Abstract:

Government intervention must be taken in the building industry in order to improve occupational safety and health in Tunisia. The objective of this research is to measure the value of mortality risk reductions for fatal injury in the Tunisian building and manufacturing industries. We use a random sample of 7978 employees working in the private sector for the year 2002. These data are taken from the *Caisse nationale de la sécurité sociale*. The results show a positive and significant fatal risk premium in the building and the manufacturing industries. The implied value of mortality risk is higher for the building industry (689,280.5 dinars) than the manufacturing industry (448,663.32 dinars). Compared to similar countries, the value of mortality risk estimates is relatively small. This result can provide useful information for policymakers about the type of industry (building industry) in which intervention must be taken in order to improve occupational safety and health in Tunisia.

Keywords: Occupational safety, fatal injury, Safety

JEL classification codes: J17; J28; J31

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1. Introduction

Although numerous value of mortality risk (VMR) studies have been conducted in the United States and other developed countries, there are few studies directly conducted in the developing countries. In order to obtain a VMR estimate in a developing country, three types of efforts have been made: scaling, meta analysis and direct estimation (Bowland and Beghin, 2001). The scaling approach adopts valuation estimates made in developed countries with calibrations based on income differences. Nevertheless, the scaling approach is often problematic because other factors such as regional economic and demographic characteristics and cultures can affect VMR (Mead and Brajer, 2006). In addition, income elasticity is not constant. Alberini and Krupnick (2000) indicated that in most of the cases, the VMR's income elasticity is higher for poorer people than for the richest ones.

The meta-analysis approach uses existing studies conducted in the industrialized countries to derive a VMR prediction function for developing countries, taking into considerations the differences in risk, income, human capital levels as well as the demographic indicators of a country.

Obviously, it is preferable to conduct VMR studies directly from a country itself. Several empirical studies have been made in recent years to estimate the value of a statistical life, but most of them deal with the developed countries (Viscusi, 1993; Viscusi and Aldy, 2003). The studies on this aspect are rare when it comes to the developing countries (Ben khalifa et al., 2013) mainly because of data constraints.

To our knowledge, no study has estimated the value of mortality risk reductions in the Tunisian context. The objective of this research is to measure the value of mortality risk reductions for fatal injury in the Tunisian building and manufacturing industries. We use the hedonistic approach based on the estimation of wage premiums for risk. Our estimates show that the implied value of statistical life in the manufacturing industry is smaller than in the building one.

The second section discusses the theoretical model. The description of the data and the empirical results are presented in the third and the fourth sections, respectively. The last section concludes.

2. The theoretical model[1]

To measure to measure the value of mortality risk reductions, several methods have been proposed in the economic literature to estimate the implicit prices for the reduction of risks to life and health. These mentioned methods include the approach of the cost of disease, the human capital approach and the willingness to pay approach. However, the latter approach is considered as the most appropriate method. Willingness to pay is usually measured by analyzing the prices paid for the prevention and risk of death. However, these prices are not directly observed.

There are two main methods to measure the willingness to pay for risk reduction. The first, the contingent valuation method which is based on data generated by questionnaire (Alberini et al, 1997). In this approach, individuals are asked directly how much they would be willing to pay to reduce the risk of death at work. The second method is the hedonic approach based on the wage premiums. The latter approach is more popular because of the availability of data.

The hedonic wage model requires data on workers' wages, job risks and other characteristics. The wage that the worker is willing to accept reflects the utility expected from the job characteristics. A worker's indifference curve shows his tradeoffs between the wage

[1] This section is inspired by Bellavance et al. (2009).

rate and the risk of death in the workplace, as described above. Since workplace safety influences firm productivity and costs, the isoprofit curve measures the tradeoffs between job risk and wages. The hedonic wage function is the envelope of mutual tangencies between firm isoprofit curves and employee indifference curves.

Thus, the reduced form of the hedonic wage function can be specified as follows:

$$\text{Ln}\ W_i = g\ X_{Ii}, X_{Ji} + \mu_i, \tag{1}$$

where ln W_i = the natural logarithm of the ith individual worker's wage rate, X_{Ii} = ith individual worker's characteristics[2], X_{Ji} = ith individual worker's job characteristics[3] including RISK (mortality rate measured at the firm level), and u_i = random error term.

It is arguable that, in the individual's choice of job riskiness, safety should be considered as a normal good. Consistent with this notion is that individuals with greater human capital and earning potential will experience an income effect and select jobs with less risk. If disturbances reflect unobserved heterogeneity among individuals, then those with unobserved characteristics which enable them to earn higher wages will also lead them to find safer jobs. Therefore, the endogeneity of job risk implies that ordinary least squares estimates of the wage equation may be biased and this should be corrected. Thus, we consider RISK as an endogenous variable (Garen, 1988), and we use the method of instrumental variables. Hausman tests performed with our dataset rejected the exogeneity of the RISK variable which justifies our method econometric choice.

2 These include EDUCATION, EXPERIENCE, GENDER, AGE, PERMANENCE STATUS, MARITAL STATUS, and UNION STATUS.
3 These also include INDUSTRIES (manufacturing, building, other industries are default) and LOCATION (shore, interior, South-West, Tunis area is default).

3. Data source

We use a random sample of 7978 employees working in the private sector for the year 2002. These data are taken from the *Caisse nationale de la sécurité sociale*. Definitions and descriptive statistics of the variables are presented in Table 1.

The dependent variable used in this study is the natural logarithm of the monthly average wage rate. Table 1 discloses that fatality rates are higher in the building industry than in the manufacturing sector. The fatal injury variable should affect positively the wages based on the theoretical foundations of the compensating wage differentials.

We use controls variables (STATUS, EXPERIENCE, AGE, GENDER, MARITAL STATUS and EDUCATION) that serve as control of the labor supply. EDUCATION and EXPERIENCE variables are used to account for the effect of human capital on wage disparities. We expect that wage increases with the level of education so that workers with a high level of education will have higher wages.

Table 1: Descriptive statistics of the sample

Dependant variable	**Definition**	**Mean**			**Standard deviation**
		All workers	**Manufacturing**	**Building**	
Log (WAGE)	Logarithm of the monthly average wage rate	5.75	5.75	5.76	0.19
Independents variables					
RISK	The fatal injuries per 1000 workers	8.77	7.79	11.88	0.33
SHORE	Dummy for Shore location	0.58	0.636	0.53	0.49
INTERIOR	Dummy for Interior location	0.086	0.068	0.111	0.28
SOUTH-WEST	Dummy for South-west location	0.018	0.013	0.032	0.13
MANUFACTURING	Dummy for manufacturing industry	0.51	1	0	0.49
BUILDING	Dummy for building industry	0.116	0	1	0.32
MARITAL STATUS	Dummy for married worker	0.64	0.64	0.626	0.47
EDUCATION	The number of educated years	7.18	7.12	7.21	2.41
PERMANENCE STATUS	Dummy for a permanent status worker	0.43	0.458	0.387	0.49
EXPERIENCE	Number of years of experience	4.81	4.94	4.24	6.64
AGE	Worker age	38.53	37.68	37.61	9.83
GENDER	Dummy for men	0.91	0.90	0.92	0.27
UNION	Dummy for unionized worker	0.18	0.184	0.202	0.38

Similarly, the experience variable should vary positively with wages because the "learning by doing"[4] is an important explanation of the increase in the productivity associated with higher wages. We expect that a married, experienced male worker should have a higher wage.

We also control for industries and location areas to take account of the characteristics of the labor demand. Three dummies variables for the

location area (SHORE, INTERIOR and SOUTH-WEST) were introduced.

Finally, the union role is defending the interests of workers and the requirements of good working conditions. Thus, UNION variable should positively influence the perceived wage premium.

4. Empirical results

Estimation of the risk premium is generally based on the canonical hedonic wage model. The hedonic wage equation (1) can be written in more detail by:

$$\begin{aligned} \text{Ln WAGE} &= \beta_0 + \beta_1 \text{RISK} + \beta_2 \text{PERMANENCE STATUS} + \beta_3 \text{UNION} + \beta_4 \text{EXPERIENCE} + \\ &\beta_5 \text{MARITAL STATUS} + \beta_6 \text{EDUCATION} + \beta_7 \text{AGE} + \beta_8 \text{GENDER} + \sum_{i=9}^{11} \beta_i \times \text{LOCATION}_i + \\ &\beta_{12} \text{MANUFACTURING} + \beta_{13} \text{BUILDING} \end{aligned} \quad (2)$$

Equation (2) has been estimated by the method of instrumental variables to avoid the problem of a selectivity biais arising if richer people choose safer jobs. Accordingly, we consider RISK as an endogenous variable. The endogeneity of job risk implies that ordinary least squares estimates of the wage equation may be biased and this should be corrected. Estimated results are reported in Table 2. The explanatory power of the regressions is fairly good. The coefficients are stable, positive and significant, and the control variables are most significant with the expected sign. The determination coefficient is between 0.36 and 0.44.

[4] It means that running repeatedly a task or a set of tasks, the assets will be faster and more productive.

The results show that in the BUILDING industry, workers are more compensated for job risk than in the other industries. The risk coefficient varies from 0.119 (MANUFACTURING) to 0.181 (BUILDING).

The three models show that married, experienced, well educated, male and unionized workers with permanent status and located in the area of the southwest require a higher wage premium for risky job. Thus, the risk of accidents affects significantly the increase of wage. Consequently, the compensating wage differentials theory is empirically confirmed in the case of Tunisia which implies the existence of risk premium for hazardous work. Delire and Levy (2004) support our results; workers prefer high wages for high risk jobs. However, for Sandy and Elliott (2005), the hypothesis of the existence of wage premium is rejected.

Estimated coefficients risks are used to estimate the value of mortality risk. According to the first model, the effect of a unit increase in fatality risk on the worker's gain is 0.135. Evaluate the wage premium to the average wage of 314.19 dinars provides an estimate of the willingness to pay to avoid a fatal accident of 53.35 dinars. A unit increase in fatal accidents increases actually the risk of annual deaths by 1/1000. Multiplying by 12 to annualize the figure and by 1000 to reflect the scale of the variable "fatality risk", the result of estimating the value of mortality risk is 508,988.27 dinars. As a result, the value of mortality risk in Tunisia is between 448,663.32 and 689,280.5 dinars.

Table 2: Estimation of equation 7 by instrumental variables

VARIABLES	All workers	Manufacturing industry	Building industry
RISK	0.135*** (0.0218)	0.119*** (0.0268)	0.181*** (0.0336)
UNION	0.255*** (0.00882)	0.247*** (0.00977)	0.263*** (0.0148)
MARITAL STATUS	0.0776*** (0.00722)	0.0609*** (0.00791)	0.0946*** (0.0123)
AGE	0.14 (0.043)	0.13 (0.05)	0.15 (0.047)
GENDER	0.479*** (0.0124)	0.510*** (0.0133)	0.438*** (0.0218)
EXPERIENCE	0.112*** (0.00745)	0.0817*** (0.00815)	0.143*** (0.0127)
PERMANENCE STATUS	0.0885*** (0.00979)	0.103*** (0.0106)	0.0707*** (0.0169)
EDUCATION	0.994*** (0.0251)	0.953*** (0.0309)	1.019*** (0.0385)
SHORE	0.00578 (0.00773)	-0.00137 (0.00864)	0.0131 (0.0129)
INTERIOR	0.0534*** (0.0133)	0.00781 (0.0162)	0.0845*** (0.0206)
SOUTH-WEST	0.227*** (0.0262)	0.224*** (0.0333)	0.233*** (0.0396)
BUILDING	0.0612*** (0.0045)	- -	- -
MANUFACTURING	0.0421*** (0.00693)	- -	- -
CONSTANT	5.268*** (0.0145)	5.313** (0.0157)	5.274** (0.0239)
OBSERVATIONS	7978	4103	926
R-SQUARED	0.367	0.44	0.41
HAUSMAN EXOGENEITY TEST	1670***	998.41***	893***
VMRL	508,988.27	448,663.32	689,280.5

Standard deviation in parentheses, VMR: Value of Mortality Risk

** P-value < 0.01, ** P-value < 0.05, * P-value < 0.10

The value of mortality risk in the MANUFACTURING industry is almost two thirds of the VMR for workers in the BUILDING industry. To compare our results with those in developed countries, we convert our estimates, 689,280.5 dinars (BUILDING industry), in dollars, the VMR is about $ 492,343. As expected, these VMR are lower than the estimates conducted in developed countries. In fact, Cropper and Freeman (1991) investigated 17 studies, and argue that the value of a statistical life is between $ 1.9 million and $ 6.4 million (in US dollars 1990). Viscusi (1993) and Viscusi and Aldy (2002) find that recent estimates of the value of mortality risk are clustered in the range of 3-7 million (US $ 1990).

In addition, Blomquist (2004) identified several studies that have determined the value of mortality risk in the United States during the period 1990-2002. This value is between 1.7 million and 7.2 million (US $ 2000). In Taiwan the value of mortality risk ranges between 2.61 million and 7.18 million dollars (Hamitt and Liu, 2003).

Similarly, the value of mortality risk in Tunisia is lower than the value of mortality risk in developing countries like India, 0.8 million (Madheswaran, 2007). The value of mortality risk in Thailand is of the order of $ 1.48 million (Vassanadumrongdee and Matsuoka, 2005). However, the value of mortality risk in Iran is relatively low, 66,750 USD (Brajer and Rahmatian, 2004).

5. Conclusion

This paper estimates the value of mortality risk reductions the Tunisian building and manufacturing industries. Our results show positive and significant fatal risk premiums in the building and manufacturing industries. In addition, in the building industry, workers are more compensated for job risk than in the other industries. Furthermore, as expected, the implied values of value of mortality risk in Tunisia are relatively smaller than those in the developed countries.

Therefore, the safety incentives created by market mechanisms are working. However, due to the lack of perfect information about risks, or to other market frictions limiting workers' mobility, it is likely that government intervention is useful in industry with higher job risk to complement market mechanisms in order to improve health and safety in the workplace. These results can provide useful information for policymakers about the type of industry in which intervention must be taken in order to improve the occupational safety and health in Tunisia.

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