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The Economic Evaluation of Job Safety
A Methodological Survey and Some Estimates for Austria

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ZUSAMMENFASSUNG

Gesetzliche Regelungen und direkte staatliche Eingriffe im Bereich der Arbeitswelt, des Verkehrs oder der Umwelt haben in einem großen Ausmaß die Vermeidung oder Reduzierung von Krankheits- und Unfallsrisken zum Ziel. Nicht selten verläuft die öffentliche Diskussion über die Beurteilung dieser Maßnahmen im außerökonomischen Raum unter (bewußtem oder unbewußtem) Verzicht auf die Offenlegung der Kosten-Nutzen-Aspekte. Doch gerade die Umweltproblematik demonstriert deutlich die Aktualität der Frage, anhand welcher Kriterien die politischen Entscheidungsträger derartige Maßnahmen bewerten sollen.

In dieser Arbeit wird die Frage der Bewertung von Sicherheitsmaßnahmen aus der Sicht des Arbeitsmarktes aufgegriffen. Nach einer theoretischen Einleitung gibt sie einen Überblick über verschiedene methodische Konzepte zur Quantifizierung des Nutzens von Maßnahmen der Arbeitsplatzsicherheit. Im empirischen Teil wird auf der Basis von Arbeitsmarktdaten aus dem Mikrozensus 1981 und nach Wirtschaftszweigen gegliederten Unfallstatistiken öffentlicher Versicherungsanstalten die implizite Bewertung des Arbeitsplatzrisikos geschätzt. Hiefür wird die sogenannte "hedonic price" - Methode angewandt, d.h. die impliziten Preise von Arbeitnehmer- und Arbeitsplatzcharakteristika werden aus beobachteten Daten am Arbeitsmarkt mithilfe von Regressionsschätzungen ermittelt.

Aus den Koeffizienten der Risikovariablen kann über den Betrag Aufschluß gewonnen werden, den die Gesellschaft für die Bereitstellung von Sicherheitsmaßnahmen zur Verminderung des Unfallrisikos zu zahlen bereit ist. Die Ergebnisse weisen darauf hin, daß

auch in Österreich, trotz der in der politischen Diskussion dominierenden Auffassung, erhöhtes Arbeitsplatzrisiko sei nicht durch monetäre Entschädigungen abzugelten, eine implizite Beziehung zwischen Lohnhöhe und Arbeitsplatzrisiko besteht. Weiters zeigt sich, daß eine Bewertung von Sicherheitsmaßnahmen anhand des gesamtwirtschaftlichen Einkommensentganges aufgrund des Produktionsausfalles, der durch die Nichtbereitstellung dieser Sicherheitsvorkehrungen entstünde, die gesellschaftliche Bewertung dieser Maßnahmen schwerwiegend unterschätzt.

1. INTRODUCTION

In Austria, job safety is controlled by a set of rules and organizations (work inspectorate, "Arbeitsinspektionsgesetz", "Arbeitnehmerschutzgesetz", "Allgemeine Dienstnehmerschutzveror dnung", etc. A list of all relevant regulations is periodically published in "Amtliche Nachrichten des Bundesministeriums für soziale Verwaltung und des Bundesministeriums für Gesundheit und Umweltschutz"). These regulations are the result of political decisions and according to the Austrian system of social partnership discussed and previously decided upon by the representatives of employers and employees.

Since there is a trade-off between the amount of money invested into job safety and the number of work related accidents and deaths, a socially and economically important value judgement is inherent in job safety regulations: How much is a reduced number of (fatal) accidents worth? Are they worth the costs? Should more or fewer resources be devoted to job safety programs in Austria? While the cost of job safety programs can be stated in terms of money with comparative ease, estimating the social benefits of these programs is a more difficult problem. It raises the questions of what the benefits of job safety are, and how to aggregate the benefits of individuals up to a measure of social benefits. The direct cost approach tackles this issue by considering the increase in value added which is directly attributable to a reduction in the number of accidents as a measure of the benefits. However, as discussed more fully in the following section, this method neglects the utility workers gain from reductions in risk and, therefore, may seriously understate society's willingness to pay for job safety programs. A more appropriate way of estimating the benefits of job safety is to consider the trade-off between wages and risk that has been established by agents in the labor market. This trade-off indicates how much extra money has to be paid to attract workers to a more risky job, and is referred to as the marginal value of safety.

This marginal value of safety concept is much broader and applies to many more situations than the labor market and job safety. The same question, namely how much society is willing to pay for a marginal reduction of risk, can be asked in connection with policy regulations concerning transportation or the environment. Is society willing to accept the costs of speed limits for a reduction of risk due to accidents and pollution ? Are people willing to pay higher prices of vegetables for more protection by stricter regulations concerning the use of pesticides ? Will they trade less air pollution from power plants for a higher price of electricity ? The growing interest in environmental issues during recent years demonstrates at least to some extent an urgent need of policy makers for an estimate of the marginal value of safety. However, in many cases this estimation cannot be worked out directly, since there is no market coordinating the valuations of the individuals. Thus, estimates derived from the labor market may provide guidance also in those cases, where the general concept of the marginal value of safety is applicable, but no market data are available.

The so called hedonic price method, which looks at the implicit price of risk, will be applied to data for the Austrian labor market in section three of this paper. Section two gives a brief survey of various methods for the estimation of the benefits of job safety regulations or policy actions in general and discusses some of the results of similar studies. The concluding section compares these results with the estimates for Austria.

2. A SURVEY OF METHODOLOGY [1]

Two approaches are available for estimating the marginal value of safety for Austria: (1) the contingent valuation method and (2) the hedonic price method. The contingent valuation method is implemented by taking a survey in which individual respondents are directly asked for their marginal value of safety (in AS). This magnitude can be solicited in one of two ways. First, the respondent could be asked for his willingness to pay for a small reduction in job related risks of fatal accidents. Second, he could be asked to state the extra compensation required to induce him to willingly accept an otherwise identical job with slightly greater risk of fatal accidents. As demonstrated in Gegax, Gerking, and Schulze (1985), the latter of these two approaches may lead to an upward biased estimate of the marginal value of safety; a result that is consistent with other contingent valuation studies of environmental hazards (see Cummings, Brookshine, and Schulze, 1986). At this time, however, no contingent valuation survey has been undertaken in Austria. The hedonic price method is used exclusively in this study. Additionally, the hedonic price method generally is regarded as the more accurate of the two methods by those making environmental benefit assessments.

The hedonic price method, as applied to estimating the marginal value of safety from labor market data, usually is implemented by estimating the wage determination model shown in equation (1).

$$WAGE_i = f\ (H_i, P_i, W_i, RISK_i) \qquad (1)$$

where $WAGE_i$ denotes the wage paid to the i-th worker, H_i denotes a vector of human capital variables, P_i denotes a vector of personal characteristics, W_i denotes a vector of work environment variables, and $RISK_i$ denotes a measure of the probability of a fatal accident while at work. Under the assumption of perfectly competitive markets and perfect labor mobility, this equation is interpreted as a reduced form market clearing hedonic wage equation. This relation is the double envelope of workers indifference curves and firms iso-profit curves (Rosen 1974 and Smith 1979). As a consequence, the slope of the curve in the wage risk plane, $\partial WAGE/\partial RISK$, is equal to the workers marginal rate of substitution between wages and risks of fatal accidents. This partial derivative is expected to be positive and its magnitude reflects the market determined compensation that a worker would receive for accepting a small increase in risk of death on the job. Thus, it is used as the basis for estimating the marginal value of safety.

The hedonic wage approach (and the contingent valuation method for that matter) to estimating the marginal value of safety represents a departure from the so-called human capital approach. That latter method values reductions in safety according to the discounted present value of lost earnings due to increased deaths. The advantage of the human capital approach is its actuarial focus; however, this method contains an implicit and questionable judgement that safety can be valued in terms of gains and losses in value added. In other words, this method would assign a zero marginal value of safety to a retiree from the labor force, even though retirees certainly would pay a positive sum in order to reduce the risk of death they face. The hedonic wage approach, on the other hand, contains no such judgement. Instead, this method focuses on bargains made between employers and employees throughout the economy and allows for the direct disutility workers may experience as risk of death on the job rises. As a consequence, the estimate of ∂ WAGE/∂ RISK derived from equation (1) can be interpreted as the marginal willingness to pay to avoid risk. Of course, extrapolation outside the sample always is dangerous; nevertheless, this marginal willingness to pay figure can be applied to risks faced by labor force retirees with greater confidence than can the zero value obtained from the human capital method.

Despite its superior conceptual properties, the hedonic wage approach, when applied to data from the United States and the United Kingdom, has yielded vastly different estimates of the marginal value of safety. For example, the pioneering study by Thaler and Rosen (1975) found a value of approximately $200,000 (in 1967 dollars) while other studies have estimated the marginal value of safety to be more than $3,000,000 (in 1977 dollars) (Olson 1981). This range of estimates, together with their potential significance in formulating public policy, has triggered a lively debate over which estimates are best supported and how the differences between them can be explained. Marin and Psacharopoulos (1982) have compared the results of previous hedonic wage and risk studies and found two factors which simultaneously bear on both of these issues.

First, some studies, including those by Brown (1980), Thaler and Rosen (1975) and Arnould and Nichols (1983) have used data measuring total excess death rates classified by occupation (i.e. total death rates less those expected on the basis of the workers socio-economic and demographic characteristics) ; while other investigators such as Viscusi (1979) and Olson (1981) have used data on fatal accidents at work classified by industry. Estimates of willingness to pay to avoid risk are consistently five to ten times larger in studies that use industry as compared with occupational risk data. According to Marin and Psacharopoulos, this situation suggests the possibility that in risky industries, the entire wage structure may be affected so that workers on relatively safe jobs may earn more than they would if employed in another industry. Therefore, the use of industry risk data may result in an overestimate of the marginal value of safty. Another possibility is that the use of data measuring total excess death rates may result in an underestimate of the marginal value of safety because many causes of death (cancers, for example) are difficult to relate to specific work environment characteristics and their risks may not be fully perceived. Gegax, Gerking and Schulze (1985) discuss this issue of perception in greater detail. Moreover, members of certain occupations may be subject to disproportionately greater risks of death from non-work related causes. Therefore, studies which make use of accidental death, rather than total excess death rate data may be on the most solid ground.

Second, nearly all of the empirical hedonic wage-risk studies carried out to date have used highly restricted non-random samples. Thaler and Rosen, for example, considered only workers in the most dangerous occupations and Viscusi's results are based on a sample of blue collar workers. The effect of this factor on the marginal value of safety estimates is difficult to assess.

At first, it would appear that hedonic wage estimates of the marginal value of safety would be superior if they were based on as broad a sample as possible. A large national random sample might be regarded as ideal. Appearances, however, can be deceiving because some types of workers may face little or no risk of a fatal accident on the job. For these workers risk would not enter the production function for their job, implying that no hedonic wage-risk gradient exists. As a consequence, it actually may be more desirable to focus the analysis on a subset of workers who are known to face some positive and perceptible risk levels. The empirical work reported in the following section, therefore, focuses on Austrian blue collar workers.

III. EMPIRICAL RESULTS FOR AUSTRIA

In Austria, maintenance of job safety is mainly a task of the work inspectorate. Unlike the situation in the U.S., for example, there exists only a weak economic incentive towards job safety. Since compensation payments for injuries on the job are usually covered by social insurance, the financial risk due to work related accidents is rather limited for the employer (see Koziol, 1984). Moreover, the amount of compensation is restricted to direct costs. Thus, the employee (or his family) is entitled only to compensation for medical care, rehabilitation or funeral cost.

As far as the relation between risk and wages is concerned, the consequences may be twofold:

- If the organizations in charge of the control of risk on the job are able to reduce risk on all jobs to the same level, the interindustry differences in risk will vanish as well as any risk-premium included in the wage.

- If they are unable to do so, workers facing extra risk on their job may receive higher wage-differentials than workers in a country with regulations allowing for more extensive compensation. Workers demand higher extra wages to substitute for the lower compensation they will receive (or their families in the case of a fatal accident), and employers can afford it since lower compensation payments yield higher expected profits.

As can be conjectured (and will be shown later in the paper), the differences in risk cannot be eliminated completely. Thus, we expect the implicit price of risk as it is established in the Austrian labor market to be rather high compared to other countries. One reason lies in the low compensation payments, which can be obtained for job related accidents in Austria. [2]

The empirical analysis applies the hedonic wage equation, which was sketched in (1). It uses a data set drawn from the 1981 Microcensus file of the Austrian Central Bureau of Statistics (ÖStZ). Risk measures are derived from hitherto unpublished figures on total and fatal accidents on the job by industry from three public insurance companies.

The 1981 Microcensus is a supplementary survey to the 1981 Population Census and comprises about 70.000 individuals. For the present analysis only a small subset of about 4200 individuals is used. One of the selection criteria is the availability of information on all relevant characteristics. A further reduction of the data set results from the exclusion of white collar workers, civil servants, and workers in agriculture. The exclusion of white collar workers and civil servants is justified by the fact that no hedonic gradient for these workers may exist. Agricultural workers can be regarded as outliers in the sample since the earnings level is one of the lowest, possibly because of non-monetary income components, whereas the risk of accidents is the highest at all. Thus, this group was excluded on empirical grounds.

The dependent variable used in the regression analysis is (the logarithm of) the average monthly net earnings. Explanatory variables which control for differences in worker and workplace characteristics are a vector of dummies indicating highest educational attainment, hours actually worked per week, a proxy for work experience, a dummy variable indicating whether the person is female and a dummy variable indicating whether the person is skilled for the workplace presently held.

Risk measures were derived from social insurance data. Two companies ("Allgemeine Unfallversicherungs Anstalt", "Versicherungsanstalt der österreichischen Eisenbahnen") made information on the total number of insured employees, number of job related accidents, and number of fatal accidents by 26 industries available to us for the years 1977 to 1984. Unfortunately, there are no appropriate data by occupation. From the "Versicherungsanstalt öffentlich Bediensteter" only the number of job related accidents was available by industry. The other two figures could be received in sum only. They had to be ascribed to industries by their shares of accidents. However, this company insures less than ten percent of Austrian workers.

To reduce the stochastic element in our risk measures, the average numbers over the eight year period 1977-84 rather than figures for a single year were used. It can be seen from the results presented in table 1 that there is a marked difference of risk across industries. Workers in construction or mining are about 40 times more threatened to die on the job than workers in the clothing industry. Almost fifteen out of one-hundred construction workers are injured by job related accidents every year. This figure is nearly twenty times higher than the corresponding one in banking.

From the two indicators presented in table 1, fatal accidents per 1000 workers is the preferable one for measuring work related risk. It is based on the clearly observable event, whether or not a person was killed in a job related accident. The figures on accidents per 1000 workers, on the other hand, result from the aggregation of various types of injuries. However, to obtain results comparable to a direct cost study for Austria, worked out on the basis of the total number of work related accidents, (Kunz, 1984, Kunz, without year) the empirical analysis was carried out with the second risk indicator as well.

A problem when using regression methods to estimate equation (1) is the choice of the functional form since on theoretical grounds there is no clearly superior solution. However, experiments with a Box-Cox-transformation by Gegax, Gerking and Schulze (1985) show that the results are not very sensitive to the choice of functional form. For this reason and its slightly superior theoretical justification the familiar semilog-linear form is chosen.

Table 1: Number of Accidents per 1000 Workers in AustrianIndustriesper Year (Average and Standard Deviationof Period 1977-1984)*)

	Total	Fatal
Agriculture, Forestry (1)	95.57 (5.00)	0.517 (0.122)
Electricty, Gas, Water (4)	54,23 (2.56)	0.157 (0.070)
Mining, Quarrying (2)	81.41 (3.49)	0.367 (0.114)
Manufacturing of Food, Beverages, Tabacco (31)	75.54 (3.59)	0.087 (0.020)
Manufacturing of Textiles (321)	40.73 (2.12)	0.024 (0.022)
Manufacturing of Weaving Apparel, Footwear (322, 324)	23.88 (1.84)	0.010 (0.013)
Manufacturing of Leather (323)	35.81 (3.97)	0.099 (0.104)
Manufacturing of Wood (33)	99.09 (2.47)	0.105 (0.034)
Manufacturing of Paper (341)	101.32 (6.58)	0.083 (0.049)
Printing, Publishing (342)	38.66 (2.38)	0.040 (0.030)
Manufacturing of Chemicals (35)	69.04 (3.38)	0.076 (0.129)
Manufacturing of Non-Metal Minerals (36)	107.98 (5.19)	0.154 (0.055)
Basic Metal Industry and Manufacturing of Fabricated Metal Products (37,38)	110.68 (6.46)	0.071 (0.014)
Construction (5)	149.09 (2.68)	0.358 (0.043)
Trade, Storage (61,62)	32.86 (1.23)	0.056 (0.012)
Hotels, Restaurants (63)	37.35 (2.08)	0.020 (0.016)
Transport, Communication (7)	46.13 (1.77)	0.208 (0.038)
Financing, Insurance (81,82)	8.022 (0.31)	0.037 (0.027)
Business Services (83)	15.83 (1.58)	0.055 (0.024)
Sanitary Services (92)	32.81 (2.71)	0.058 (0.025)
Cultural Services (94)	35.36 (2.47)	0.074 (0.065)
Health Services, Welfare Institutions (933, 934)	47.92 (1.77)	0.027 (0.010)
Educational Services, Research Institutes (931,932)	22.67 (1.66)	0.039 (0.021)
Public Administration (91, 935)	19.04 (0.42)	0.056 (0.007)
Household Services (953)	14.81 (0.51)	0.009 (0.18))

*) Number after the industry descriptor represents the ISIC-Code.

Source : Data kindly made available by "Allgemeine Unfallversicherungsanstalt", "Versicherungsanstalt der österreichischen Eisenbahnen" and "Versicherungsanstalt öffentlicher Bediensteter"

Another problem is the stochastic nature of our risk variable. It is well known that the parameter of a variable which is measured with error is biased toward zero when estimated by OLS. The bias is related to the variances of the unmeasured true variable and the error component. By using the pooled variance of the time variances of risk by industries (see table 1) as an estimator of the variance of the measurement error, maximum likelihood estimators can be derived (see Dhrymes 1978, p. 242 ss). Actually, for the empirical analysis presented below the maximum likelihood estimates were calculated as well. But since the differences in results turned out to be of minor importance, only the OLS-estimates are reported.

Basically two specifications of the reduced form hedonic wage equation can be found in the literature. They differ in the way the risk variable enters the equation and usually yield markedly different results. The first is a semilog-linear function with the risk variable entering linearly. The second adds a quadratic term of the risk measure, allowing for increasing or diminishing returns on safety.

The results of our regression analysis when using fatal accidents per 1000 workers as risk measure are summarized in table 2. All coefficients have the sign usually expected in human capital related analysis[3]. In particular, the coefficients of the risk variables are all significantly different from zero. Using the second specification, both, the risk and the risk-square coefficient prove to be highly significant, indicating that the relationship between wages and risk is nonlinear. Moreover, the

Table 2: Regression Results of Equation (1) Using Fatal Accidents as Measure of Risk (t-values in parenthesis)

	(1)	(2)
INTERCEPT	7.137	6.994
	(15.82)	(15.50)
SEX	-1.521	-1.385
	(-3.29)	(-3.00)
SCHOOL1	.0469	.0477
	(3.76)	(3.83)
SCHOOL2	.1375	.1393
	(3.66)	(3.72)
SCHOOL2 * SEX	-.1250	-.123
	(-2.28)	(-2.25)
EXPER	.0214	.0212
	(10.43)	(10.38)
EXPER * SEX	-.00922	-.0094
	(-2.80)	(-2.87)
EXPER2	-.00038	-.00038
	(-8.64)	(-8.56)
EXPER2 * SEX	.00016	.00017
	(2.32)	(2.37)
WTIME	.4084	.4293
	(3.35)	(3.52)
WTIME * SEX	.3427	.3197
	(2.75)	(2.57)
SKILL	.0970	.0983
	(7.71)	(7.83)
RISK	.2282	1.2894
	(5.28)	(5.78)
RISK * SEX	.4518	———
	(2.99)	
RISK2	———	-2.4906
		(-4.67)
R**2	.52	.52
N	4225	4225

Notes: SEX = 1 for female, 0 for male. SCHOOL1 is a dummy variable assuming a value of 1 when the respondent had a degree from an occupational training school (Lehrabschlußprüfung). SCHOOL2 assumes a value of 1, whenever the respondent had a higher educational level than compulsory secondary general school. EXPER is a proxy for work experience and was computed as age minus years of schooling minus 6. EXPER2 is the squared EXPER-variable. WTIME is the log of the respondents weekly working time. SKILL is a dummy indicating whether the respondent was skilled for the work place he occupied at the time of the survey. Interaction variables for schooling, experience, working time and risk with sex were used to allow for the differential effect of these factors on men and women.

negative coefficient of the risk-square variable implies a much lower marginal value of safety for risky industries than for less risky ones. This suggests that the labor market can be viewed as providing a selection mechanism which sorts individuals with high risk aversion to the safer industries and vice versa (see Thaler and Rosen 1975, Olson 1981, Sider 1985).

It could be suspected that our estimated equation lacks variables concerning workplace productivity and general working conditions. We tried two productivity measures, namely capital coefficient and capital intensity, but both turned out to be insignificant. Omitting factors of working conditions is even more dangerous as there might exist some positive correlation between accidental risk and bad working conditions. Under these circumstances our estimates of the risk coefficient would be biased upward. However, in a study done by Christl (1985) for Austria it is found that most of the variables measuring working conditions have an insignificant effect on wages and some of them even the wrong sign. Nevertheless, our risk coefficient might reflect the some influence of general working conditions as well[4]. But this is true for most of the other studies with which we compare our estimates.

The regression results can be used to compute the implicit price of safety. By virtue of our semilog-linear specification the coefficient of the risk variable, say b, represents the partial derivative of the logarithm of the monthly income, log Y, with respect to the risk variable, RISK. Treating the other variables as paramters we can write:

$$b := \frac{d\log Y}{dRISK} = \frac{1}{Y} \cdot \frac{dY}{dRISK} ,$$

whereby follows:

$$dY = Y.b.dRISK \quad .$$

Multiplying through with the number of workers N and taking into account that we have defined the risk variable as the number of accidents, ACC, per 1000 workers per year (RISK = 1000.ACC/N) it follows:

$$dY.N = Y.b.dRISK.N = Y.b.1000.dACC \qquad (2) \quad .$$

A similar equation can be derived for the nonlinear specification:

$$dY.N = Y.(b_1 + 2b_2.RISK).1000.dACC \qquad (3) \quad ,$$

the only difference occuring from the somewhat more complicated derivative of income with respect to risk. Since dY is the differential in monthly income a worker is prepared to accept in exchange of a reduction in the number of accidents by 1, the expression on the left hand side represents the total sum of benefits accruing to society (measured in income per month) when the number of accidents per year is reduced by 1.

These figures can be calculated from the right-hand sides of (2) and (3). In order to make our figures comparable to those of other studies we converted them to a yearly basis by inserting income per year rather than per month, i.e. we multiplied the income figures by 14. For the linear specification the average income in the sample of 101.000 AS per year (7.215 * 14) was inserted and yielded a result of 33 million AS. For the quadratic specification the corresponding figure is usually computed by inserting average income and average risk into equation (3) (see for example Olson, 1981). This is quite unsatisfactory, since even when taking the geometric mean of income we are off the regression function at this point due to the inclusion of the quadratic risk term. A more appropriate way is to apply the sample enumeration method, i.e. to evaluate equation (3) for every individual in the sample and take the average therefrom. Using this procedure we arrive at an amount of 55 million AS[5].

Similar to the results of other studies this is considerably higher than the figure from the linear function. The reason lies in the skewed distribution of risk in the sample. More than 70 % of the workers face a risk of fatal accident below the mean. Thus, the majority of workers place a higher value on safety than the average worker. As a consequence the linear specification which implicitly assumes the same marginal value of safety throughout the sample underestimates the average value.

Table 3: Regression Results of Equation (1) Using Total Accidents as Measure of Risk (t-values in parenthesis)

	(1)	(2)
INTERCEPT	6.905	6.861
	(15.82)	(15.19)
SEX	-1.239	-1.198
	(-2.67)	(-2.59)
SCHOOL1	.0475	.0477
	(3.82)	(3.83)
SCHOOL2	.1381	.1395
	(3.72)	(3.73)
SCHOOL2 * SEX	-.1321	-.1306
	(-2.41)	(-2.39)
EXPER	.0217	.0219
	(10.66)	(10.72)
EXPER * SEX	-.00997	-.0105
	(-3.03)	(-3.20)
EXPER2	-.00038	-.00038
	(-8.81)	(-8.84)
EXPER2 * SEX	.00018	.00019
	(2.56)	(2.70)
WTIME	.4549	.4547
	(3.73)	(3.73)
WTIME * SEX	.2787	.2699
	(2.23)	(2.16)
SKILL	.0905	.0911
	(7.21)	(7.26)
RISK	.00097	.0023
	(8.19)	(4.83)
RISK2	——	-.000008
		(-2.92)
R**2	.52	.52
N	4225	4225

Notes: See table 2

Using total accidents per 1000 workers as risk measure the marginal value of safety can be interpreted as the amount of money society is willing to pay for the prevention of one average work-accident. Again the regression results yield statistically significant risk coefficients[6] (see table 3). This yields a marginal value of safety of about 95.000 AS for the first specification and 89.000 AS[7] for the second.

IV. SUMMARY AND CONCLUSIONS

To summarize our results the Austrian situation is characterized by 2 facts:

- Despite an elaborated set of safety regulations there remains a substantial heterogeneity of work places with regard to the risk of accident. Using data of accidents per worker across different industries it is found that the probability of a fatal accident is more than fourty times higher in "high risk" industries compared with "low risk" industries.

- Although the political discussion concerning job safety is dominated by the value judgement that a human life cannot be evaluated in terms of money such an evaluation is implicit to the Austrian labor market. Applying the hedonic price method we could find fairly reasonable values for the implicit price of job-safety. The significant negative quadratic risk term shows that the labor market allocates less risk averse individuals into riskier industries.

That latter result has the somewhat surprising policy implication that a reduction of risk in a low-risk industry has a more beneficial effect than in a high-risk industry. This follows from the fact that the relative increase in wages becomes smaller as the probability of risk grows.

When compared to the results of the other studies (see section 2) our estimate of 55 mill. AS for the marginal value of safety turns out to be one of the highest. This is partly due to the use of risk data classified by industry. Nevertheless, it supports our hypothesis that the regulations concerning compensation payments in Austria will bring forward a higher implicit price of risk in the labour market.

Finally, we want to compare our figures with the results of a study for Austria undertaken by the "Allgemeine Unfallversicherungsanstalt" (see Kunz, 1984; Kunz, without year). By applying the direct cost approach, which corresponds roughly to the summation of the costs necessary to cure the injured person and the forgone value added of the firm due to lost working days, this study arrives at figures of 25.000 to 40.000 AS per accident for the whole economy in 1982 and of 14.000 to 20.000 per accident counting only costs occurring to the firm. As can be seen, our estimates are about three times higher when using total accidents as risk measure which seems to be roughly comparable with the accident data used by Kunz. This indicates that for Austria, too, the direct cost approach seriously underestimates the social costs of accidents by neglecting the willingness-to-pay of individuals for a reduced risk. Kunz arrives at the conclusion that the benefits of preventing an accident (measured in direct costs of accidents) are nearly twice as high as the respective costs. Since the benefit measures derived from our analysis are much higher than those of Kunz, we can even enforce his conclusion that at present job safety regulations seem to be too weak in Austria.

The model applied in the paper implicitly assumes a neoclassical labor market with the usual restrictive assumptions like atomistic market structures, full information, perfect mobility and optimizing behaviour. We are fully aware of the fact that labor markets are not that simple. They are segmented and there is an unequal distribution of bargaining power between employers and employees, especially in a period of economic recession where our data are from. Consequently we do not intend to plea for a substitution of Austrian job safety regulations by a 'free market', but for economic incentives supporting job safety regulations. However, as far as the marginal value of safety measure is concerned, the market imperfections mentioned above tend to lower the risk premium payed to workers. Thus, the 55 mill. AS resulting from the estimation might even underestimate the true marginal value of safety[8].

As mentioned in section 1 the marginal value of safety concept applies to many more situations than the labor market, in particular to situations where there is no market at all. If the results from the labor market apply generally, an environmental policy, for example, which tries to equate the cost of safety measures with the expected cost prevented, will underestimate the benefits to the Austrian society. It will bring about much to weak regulations and earn broad dissent in the population. Willingness-to-pay measures might be a better guideline for environmental policy than aggregated direct cost even when they are derived from the labor market.

NOTES

1) An interesting alternative to assesing the relationship between risk and wages from individual survey data discussed in the following is to use aggregate time series data and estimate a production model with risk as a separate input factor. This procedure is not covered in the survey below (see e.g. Sider 1985)

2) Since some studies indicate that unionized workers receive a higher risk-premium (Thaler and Rosen, 1975, Olson, 1981) alternatively it could be argued that the higher degree of unionization in Austria leads to a higher overall value of the implicit price of risk. Generally speaking the estimates depend on the legal and institutional organisation of the labor market in a country, since they are derived from a double envelope of worker indifference curves and firm iso-profit curves.

3) The specification displayed in table 2 is condensed from a more general one containing a more detailed set of educational dummy variables and allowing for parameter differences between men and women for all variables. However, the estimates for all educational levels above medium level secondary school turned out to be statistically identical with that of SCHOOL2. So we can aggregate them up to just one category. Elimination of insignificant interactions between SEX and other variables yields the specification reported in table 2.

4) The existence of various kinds of bonus paymants compensating for bad working conditions does not necessarily mean that wages are higher for those jobs. It is perfectly conceivable that the wage level for those jobs is so much lower that bonus payments only bring it up to the general wage level. At least this interpretation is compatible with the results of Christl (1985).

5) Estimation at the average yields a value of nearly 66 mill AS. At leastin our data set application of thissimplemethod introduces a considerable bias in the marginal value of safety.

6) This contrasts with the results of Christl (1985). In this study a compensating differences model is estimated and one of the variables included is a measure of perceived risk at work. This variable turns out to be significant only for women.

7) Note that in this case the nonlinear specification yields a lower figure than the linear. This results from a left-skewed distribution of total accidents per 1000 workers.

8) Of course, there is no need to interprete our empirical results in this restricted sense. Alternatively, one could derive the estimated wage-risk-relationship from a bargaining type model with unions and industry representatives negotiating the wage structure. As an anonymous referee pointed out, if worker representatives are better informed about risks than workers the observed wage-risk-relationship could be even more close to the equilibrium position. This could be another reason for the high estimate of the marginal value of safety for Austria.

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