WPS-2078

Valuing Mortality Reductions in India
A Study of Compensating Wage Differentials

by Nathalie B. Simon, Maureen L. Cropper
Anna Alberini, and Seema Arora

January 1999

Nathalie B. Simon is an economist at USEPA. Maureen L. Cropper is a principal economist at the World Bank (DECRG). Anna Alberini is an assistant professor at the University of Colorado and Seema Arora is an assistant professor at Vanderbilt University.

Valuing Mortality Reductions in India
A Study of Compensating Wage Differentials

by Nathalie B. Simon, Maureen L. Cropper
Anna Alberini, and Seema Arora

I. Introduction

Conducting benefit-cost analyses of health and safety regulations requires placing a dollar value on reductions in health risks, including risk of death. In the United States, mortality risks are often valued using compensating wage differentials (Viscusi, 1992 and 1993; Viscusi and Moore, 1989; Moore and Viscusi, 1988). These differentials measure what a worker would have to be paid to accept a small increase in his risk of dying, or, equivalently, what the worker would pay to achieve a small reduction in his risk of death. These values, estimated from observed labor market data and converted to Values of a Statistical Life (VSL), are used to value reductions in risk of death achieved by industrial safety programs or environmental health programs (USEPA, 1997; Bayless, 1982).[1]

Although there is an extensive literature on compensating wage differentials in the U.S., very few studies of compensating wage differentials exist in developing countries. In the absence of these studies, policy makers often value improvements in life

[1] The Value of a Statistical Life is the value of a risk reduction divided by the size of the risk reduction:

$$VSL = \frac{Value..of..\Delta r}{\Delta r}$$

expectancy using foregone earnings. That is, the value of an improvement in life expectancy is measured by the income that would be earned during the individual's additional productive lifetime. It is well known that valuing mortality risks using earnings--the so-called human capital approach--is likely to understate what people themselves would pay for small risk changes. Indeed, U.S. data suggest that the amount people would pay for risk reductions based on compensating wage differentials is from 8 to 23 times the value of the risk reductions as estimated by the human capital approach (Viscusi, 1993).

One way to estimate a VSL for developing countries without conducting original studies is to extrapolate VSL estimates to these countries from the U.S. For example, one could inflate the foregone earnings of an Indian worker by the ratio of the VSL to foregone earnings computed from a study in the U.S. This assumes, however, identical attitudes toward risk in the two countries and an income elasticity of willingness to pay (WTP) for risk reductions equal to one.[2] Without independent studies of the VSL in developing countries, such assumptions are difficult to justify.

We attempt to shed light on this issue by conducting a compensating wage study in one developing country—India—to obtain estimates of the VSL that reflect Indian risk preferences. We then compare the ratio of the VSL to the present value of foregone earnings in India with ratios obtained in similar studies conducted in the U.S. and

[2] These points are discussed more fully in Section II.

elsewhere. This allows us to evaluate the benefits-transfer methodology discussed above, using India as an example.

The remainder of the paper proceeds as follows. In section II, we discuss the theory of compensating wage differentials and the theoretical basis for the benefits-transfer methodology discussed above. Section III reviews selected studies in the compensating wage literature, including those for developing countries. Section IV describes the methodology and data we use to estimate the Indian compensating wage differentials. Section V presents our results, compares them to those obtained in the U.S. and examines the implications for benefits transfer. Section VI concludes.

II. Compensating Wage Differentials and Benefits-Transfer

A. An Hedonic Model of the Labor Market

The basic idea behind compensating wage differentials is that jobs can be characterized by various attributes, including risk of accidental death. Workers are described by the amount they require as compensation for different risk levels, while firms are characterized by the amounts they are willing to offer workers to accept different risk levels. The matching of wage offers and acceptances determines the hedonic wage equation, which describes the compensation received for bearing risk in market equilibrium.

One way to express the individual's willingness to substitute risk for income in the labor market is to ask how much compensation he would require to work at various risk levels, holding utility constant. This compensation is the amount *C* that is given implicitly by

$$(1-p)(1-r)U(C+I)=k \tag{1}$$

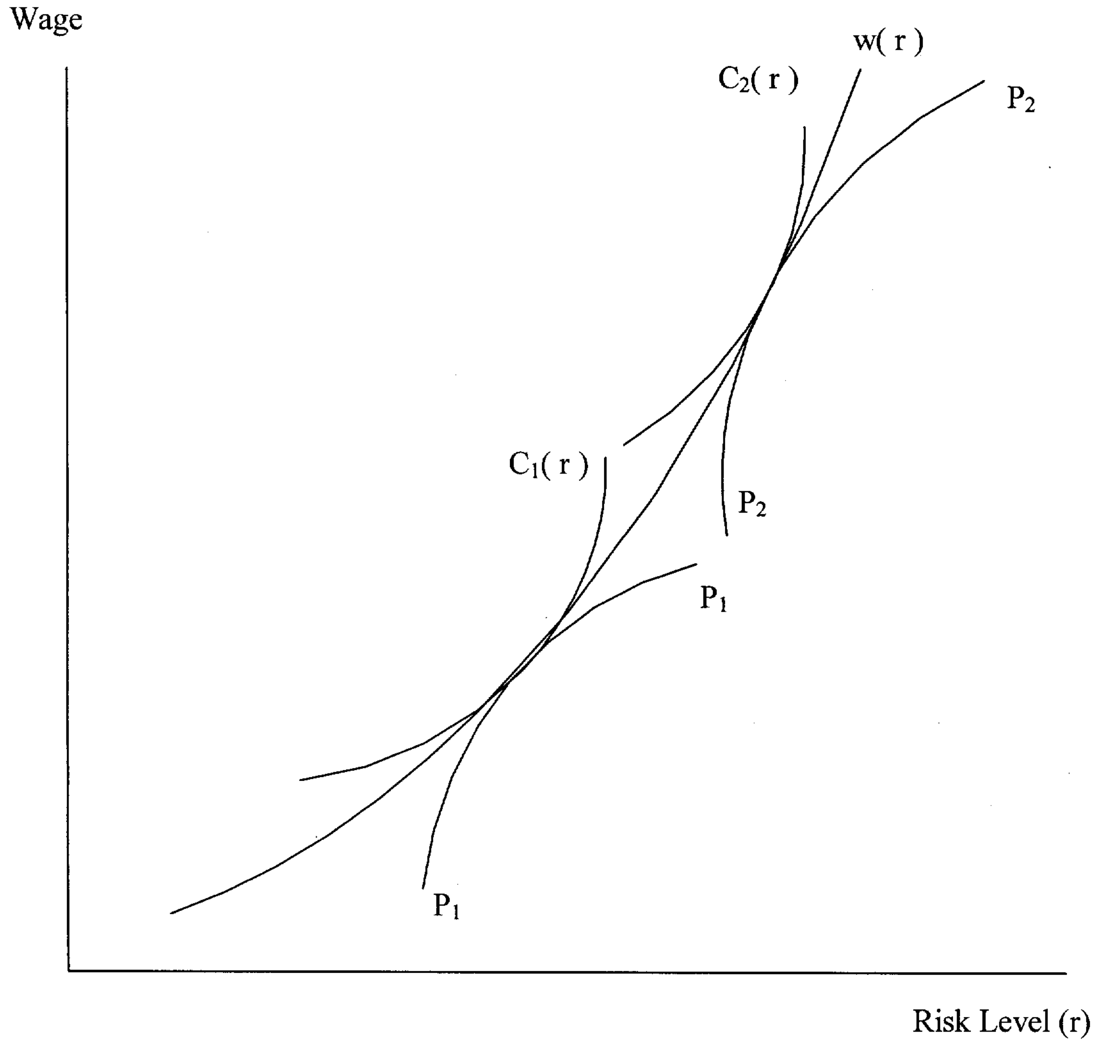
where r is the risk of death on the job, p is the risk of dying from all other causes and *I* represents non-wage income. The compensation function *C(r)* is pictured in Figure 1 for different workers. The worker's choice of risk level, *r*, occurs where a marginal change in required compensation, C'(r), equals a marginal change in the wage offered in market equilibrium, w'(r), or, equivalently, where the compensation function is tangent to the hedonic wage equation, w(r).

From the firm's perspective, wage offers that keep profits constant at various risk levels are given by offer curves PP in Figure 1. Equilibrium in the labor market is given by the locus of tangency points between various required compensation and offer curves. This locus is the hedonic wage function, and its derivative with respect to risk of death measures the value of a small change in risk to the worker:

$$\frac{dw}{dr}=\frac{(1-p)U(w+I)}{(1-p)(1-r)U'(w+I)}\equiv VSL \tag{2}$$

The rate at which a worker is willing to substitute income for risk is his expected utility if he survives risk of death on the job, (1-p)U'(w+I), divided by his expected marginal utility of income, (1-p)(1-r)U'(w+I). VSL, as we label the relationship, is increasing in risk, indicating that, ceteris paribus, individuals facing higher baseline risk should be willing to pay more for a change in risk of a given magnitude. Representing

Figure 1: Equilibrium in an Hedonic Labor Market



income by $Y \equiv w + I$, we examine the relationship between the value of a risk change (VSL) and (foregone) income, which forms the basis for benefits transfer.

B. Benefits-Transfer Using Ratios of VSL to Foregone Earnings

If we assume that individuals in two different countries, say A and B, have the same preferences (i.e., have the same utility function), then we can assume that, ceteris paribus, the ratio of VSL to foregone earnings is the same in both A and B, or:

$$\frac{VSL^A}{Y^A} = \frac{VSL^B}{Y^B} \tag{3}$$

where Y equals the present value of foregone earnings. In this case, transferring estimates of VSL from country A to country B is a simple matter. One can either multiply Y^B by the ratio (VSL^A/Y^A) or multiply VSL^A by the ratio (Y^B/Y^A).[3]

This benefits transfer methodology is valid, however, only if the ratio (VSL/Y) is independent of income. This is equivalent to assuming that the VSL increases in strict proportion to income, i.e., that the income elasticity of the VSL is equal to 1. If, on the other hand, the VSL increases less than in proportion to income (if the income elasticity is less than one), transferring VSL estimates from a richer to a poorer country will under-estimate the VSL for the poorer country.

Of course, the above discussion assumes that individuals' preferences, and hence the utility functions faced by individuals in both countries, are identical. If they were to

[3] The former method, multiplying VSL^B by the ratio of VSL^A/Y^A, avoids the use of exchange rates and thus provides more stable estimates.

vary across countries, conditions for benefits transfer would become even more restrictive. This underscores the importance of conducting compensating wage studies to estimate the VSL in developing countries.

III. Review of Labor Market Studies

A. Compensating Wage Studies in Developed Countries

Although the notion that workers will be compensated for unpleasant conditions in the workplace dates back to at least Adam Smith (1776), the modern theory of compensating wage differentials is usually attributed to Richard Thaler and Sherwin Rosen (1976). Thaler and Rosen suggested that the labor market could be viewed as an example of an hedonic market—a market in which the price of a product (in this case, a job) varies with its attributes.

In the two decades since Thaler and Rosen's pioneering work, there have been literally dozens of studies that have estimated hedonic wage equations. Hedonic wage equations have been estimated for various segments of the U.S. labor market, including unionized industries, blue-collar workers, and males. Similar studies have been conducted in the United Kingdom (Marin and Psacharopoulous, 1982), Australia, Japan (Knieser and Leeth, 1991), and Canada (Cousineau et al., 1992).

While the earliest of these studies used average wage data across industries (Smith, 1974), later contributions focused on data for the individual worker. In a typical study the wage received by worker i is explained as a function of his productivity (measured by education, experience, job tenure) and job attributes. Whenever possible, the data are measured for the individual; however, risk of accidental death or injury is usually measured for the industry in which the individual works.[4] Typically, the risk data used in these studies are reported for two-digit industrial classifications, although recent studies in the U.S. use risk data reported at the one-digit industry level by state (Viscusi and Moore, 1989; Moore and Viscusi, 1988, 1990a and 1990b; Knieser and Leeth, 1991).

In addition to including risk of accidental death, it is important that the hedonic wage equation include job attributes that might be correlated with risk of death on the job. This includes risk of non-fatal injury, as well as dummy variables for the worker's occupation and the industry, to capture non-pecuniary job attributes that are difficult to measure directly.

Several studies have shown, however, that, even after controlling for individual and job characteristics including risk of death and injury, equally skilled workers are able to command higher wages in some industries than in others (Krueger and Summers, 1988; Katz, 1986). The explanation generally offered for these persistent inter-industry differentials is that some firms are simply willing to pay higher wages—perhaps to avoid strikes, labor turn-over, etc.—and find that paying these higher wages is consistent with maximizing profit. This underscores the importance of controlling for inter-industry wage differentials in measuring the premium attached to fatal and nonfatal job risks.

[4] Several studies (Gegax, De Haan, and Schulze, 1991; Gerking and De Haan, and Schulze, 1988; Shanmugam, 1997) have used the individual's *subjective* estimate of his or her own risk as the measure of risk. The correlation between perceived and actual risk, however, was generally low in spite of the fact that risk so defined was a significant predictor of wage.

B. Compensating Wage Studies in Developing Countries

In spite of the large number of compensating wage studies completed in developed countries, very few have been completed in developing countries. However, in a recent study for Taiwan, a newly industrialized economy, Liu et al. (1997) find evidence of compensating wage differentials using data from labor market surveys for years 1982 to 1986. The implied VSL stemming from their work ranges between US $413,000 and US $461,000 with a ratio of VSL to the present value of foregone earnings between 7 and 8.

Only one other study that we know of has been conducted in a developing country—Shanmugam's work in India (1997). Unlike our study, however, Shanmugam's study focuses on a single metropolitan area in India--the Madras District in the state of Tamil Nadu--rather than looking at the country as a whole. Using 522 observations collected from blue-collar, male workers including wage, worker characteristics and perceptions of job risk, Shanmugam finds evidence of compensating wage differentials using injury data collected at the two-digit level (Indian Industrial Classification) as the risk measure. The implied value of a statistical life comes to Rs. 12.084 million, or approximately US $400,000.

Looking at the ratio of VSL to the present value of foregone earnings, however, Shanmugam's figures seem exceptionally high. The ratio of his VSL to foregone earnings is 73, 10 times higher than that obtained by Liu et al. for Taiwan and between 5 to 13 times higher than that obtained by Moore and Viscusi for the U.S. (1988). It could be that by focusing on only one metropolitan area, his estimate of VSL, and hence the ratio of VSL to foregone earnings, is not representative of that for the country as a whole. We remedy this in our study by using labor market data for the entire country.

IV. Methodology

We estimate an hedonic wage equation for Indian manufacturing industry using grouped data for 1,454 occupation/industry cells. The hedonic wage equation takes the following form,

$$\ln w_{ij} = \alpha_0 + \alpha_j r_j + \sum_{i=1}^{I} \phi_i D_i + \beta' \boldsymbol{X}_{ij} + \Gamma' \boldsymbol{Z}_j \tag{4}$$

where w_{ij} represents the average daily wage in occupation i and industry j, r_j is the risk of fatal injury in industry j, and the $\{D_i\}$ are occupation dummies. The vector $\boldsymbol{X}_{ij}$ includes characteristics that vary by occupation and industry, such as the proportion of men in the occupation/industry cell, while $\mathbf{Z}_j$ includes industry-specific data such as average firm size, region in which the industry is concentrated, and risk of non-fatal injury. Since we use grouped data, we estimate the model using weighted least squares, where the weights are the number of workers in a given occupation-industry cell. The data used to estimate the above equation are described in more detail below.

A. Data Description

Data on the average daily wage earned by workers in occupation i and industry j are from the Occupational Wage Survey (OWS), conducted by the Indian Labour Bureau. The OWS is administered periodically to a random sample of registered factories in selected industries.[5] Industries are included in the OWS if they belong to the organized (i.e. unionized) sector, employ a "large" number of individuals and if they are considered to be "important" to the Indian Industrial Economy (OWS, 1994). Given that unions play a potentially large role in informing their members of job-related risks, it makes sense to focus on this sector of the Indian labor force. The Fourth Round of the OWS, conducted between 1985 and 1991, provides the most recent, completed survey available. It compiles information for a total of 53 three-digit industries, listed in Table 1. While the OWS provides information for some plantation industries and mining, we limit the analysis to manufacturing only.

The OWS reports the average daily wage for full-time, manual workers, by occupation, for the industries listed in Table 1.[6] In addition to wage information, the OWS provides other pertinent information at the occupation level within each industry, including a detailed description of the work performed, the number of workers employed, the proportion of men, the number of time-rated (vs. piece-rated) workers, cost-of-living allowance, over-time allowance and shift allowance. Table 2 lists the occupations that occur most frequently in the data. The OWS also provides some information for each

---

[5] All factories employing 20 or more persons (10 or more if power is used) are required to register with the relevant state government. In addition, each state has the authority to extend the registration requirement to any factory regardless of size provided that, if the operation is family-owned, at least one employee is hired from outside the family.

[6] Because the OWS data took several years to collect, all wage and other monetary data are reported in constant (1990) rupees.

Table 1: Manufacturing Industries
Included in Fourth Round of the Occupational Wage Survey

2-digit IIC	3-digit IIC	Industry Name
20&21: Food and Food Products	201	Manufacture of Milk and Ice Cream Powder, Condensed and Bottled Milk, and Baby Milk Foods
	206	Manufacture and Refining of Sugar (Vacuum Pan Sugar Factories)
	207	Manufacture of Khandsari Sugar
	210	Manufacture of Hydrogenated Oils, Vanaspati Ghee, etc.
	212	Tea Processing
	214	Cashewnut Shelling, Processing and Packing
22: Beverages, Tobacco and Related Products	224	Soft Drinks and Carbonated Water Industries
	227	Manufacture of Cigarette and Cigarette Tobacco
23: Cotton Textiles	231	Cotton Spinning, Weaving, Finishing
24: Wool, Silk and Man-Made Fibre Textiles	241	Wool Spinning, Weaving and Finishing in Mills
	245	Spinning, Weaving and Finishing of Silk Textiles
	247	Spinning, Weaving & Finishing of Other Textiles, Synthetic Fibres
25: Jute	251	Jute and Mesta Spinning and Weaving
26: Textile Products	264	Manufacture of All Types of Textile Garments including Wearing Apparel
28: Paper & Paper Products & Printing, Publishing, etc.	280	Manufacture of Paper, Newsprint and Packing Paper (Machine Made)
	284/285	Printing and Publishing of Newspapers, Periodicals, Books, Journals, Maps, etc.
29: Leather and Leather Products	291	Manufacture of Footwear (excl. Repair) Except Vulcanized, Moulded Rubber, Plastic Footwear
30: Basic Chemicals &Chemical Products	300	Manufacture of Tyres and Tubes
	304	Petroleum Refineries
31: Rubber, Plastic, Petroleum and Coal Products	310	Manufacture of Basic Industrial Organic, Inorganic Chemicals and Gases
	311	Manufacture of Fertilizers (Inorganic, Organic and Mixed)
	313	Manufacture of Drugs and Medicines
	314	Manufacture of Toilet Soap, Washing Soap and Soap Powder
	317	Manufacture of Matches
32: Non-Metallic Mineral Products	321	Manufacture of Glass and Glass Products
	324	Manufacture of Cement
33: Basic Metal and Alloys	330	Iron and Steel Industries
	331	Manufacture of Castings and Forgings (Ferrous)
35/36: Machinery and Equipment Other than Transport Equipment	335	Aluminum Manufacturing Industries
	350	Manufacture of Agricultural Machinery and Equipment and Parts
	352	Manufacture of Prime Movers, Boilers and Steam Generating Plants and Parts
	353	Manufacture of Textile Machinery and Jute Machinery
	355	Manufacture of Refrigerators and Air Conditioners
	357	Manufacture of Machine Tools, their Parts and Accessories
	360	Manufacture of Electrical Industrial Machinery and Apparatus and Parts
	363	Manufacture of Electrical Apparatus, Appliances and Other Parts Excl. Repair
	364	Manufacture of Television Sets and Teleprinters
	366	Manufacture of Electronic Computers, Components and Control Instruments and Accessories
37: Transport Equipment and Parts	370	Ship Building and Repairing
	371/372	Manufacture of Locomotives, Railway Wagons and Coaches and Parts
	374	Manufacture of Motor Vehicles and Parts
	375	Manufacture of Motorcycles and Scooters and Parts
	376	Manufacture of Bicycles, Cycle Rickshaws and Parts
	377	Manufacture of Aircrafts and Parts
38: Other	382	Manufacture of Watches and Clocks

IIC=Indian Industrial Classification

Table 2: Occupations Appearing in 10 or more OWS Industries

Occupation Name	Number of Industries
Watchman	45
Helper	44
Sweeper	43
Coolie	41
Driver	41
Electrician	41
Fitter	41
Supervisor	40
Carpenter	32
Checker	31
Welder	30
Packer	29
Foreman	28
Machine Operator	28
Turner	28
Mechanic	26
Painter	21
Blacksmith	19
Maistry	18
Grinder	17
Oilman	16
Boiler Attendant	15
Driller	15
Moulder	13
Pressman	13
Fireman	12
Mason	12
Mate	12
Assembler	11
Charge Hand	11
Furnace Man	11
Loader/Unloader	11
Wire Man	11
Crane Driver	10

three-digit industry, including average firm size and the concentration of the industry within geographic regions.

We supplement the OWS data with data collected and reported in the Annual Survey of Industries (ASI). These data include value added per worker, number of employees in government-operated (vs. privately-owned) factories and the turnover rate in each industry. These data are reported at the two-digit industry level, except for value added per worker, which is reported at the three-digit level. To measure on-the-job risk, we use the rate of fatal injuries in the industry and the rate of non-fatal injuries in the industry, obtained from various volumes of the *Indian Labour Yearbook.* Descriptive statistics and definitions for all of the variables used are provided in Table 3. The average annual wage rate for Indian manufacturing workers is Rs. 20,054 (1990 Rupees).[7] In general, risk of death on the job is somewhat higher in India than in the U.S. In India, approximately 15 workers per 100,000 die on the job compared to only 8 per 100,000 in the U.S. (Moore and Viscusi, 1988).[8]

B. Regression Analysis

Using the data described above, we estimated several different specifications of the hedonic wage equation. These vary in the number of explanatory variables included in the model, and in the definition of the risk variables.

---

[7] The average annual wage was calculated assuming a 300-day work-year.

[8] Indian job-related fatality rates are reported per 10,000 man-days. Rates per 100,000 worker are calculated assuming a 300-day work-year.

Table 3: Descriptive Statistics

Variable Name	Variable Definition	Level of Observation	Mean	Standard Deviation
Wage	Annual Wage* (1990 Rupees)	3-digit industry/ occupation	20054.01	8815.48
Fatal	Number of fatal injuries/ 100,000 workers, from previous period	2-digit industry	0.149	0.086
Nonfatal	Number of non-fatal injuries/ 100,000 workers, from previous period	2-digit industry	38.942	42.493
Workers	Number of workers in occupation	3-digit industry/ occupation	3505.37	9827.39
Time	Proportion of time-rated workers	3-digit industry/ occupation	89.258	28.461
Overtime	=1 if overtime is paid	3-digit industry/ occupation	0.711	0.453
Shift	=1 if shift allowance paid	3-digit industry/ occupation	0.569	0.495
Icode25	=1 if iic=25 (Jute textiles)	2-digit industry	0.030	0.169
Icode29	=1 if iic=29 (Leather & Fur)	2-digit industry	0.015	0.122
Icode30	=1 if iic=30 (Plastic & Petroleum)	2-digit industry	0.085	0.278
Icode36	=1 if iic=36 (Electric Machinery)	2-digit industry	0.119	0.324
Icode37	=1 if iic=37 (Transport Equipment)	2-digit industry	0.140	0.347
Men	proportion of men	3-digit industry/ occupation	96.083	13.462
Unitsize	average unit size ('00s)	3-digit industry	2.289	4.609
Value	average value added per 1000 workers, in 1990 Rupees	3-digit industry	57.190	64.231
South	=1 if share of workers in south > 40 %	3-digit industry	0.117	0.321
Nwest	=1 if share of workers in northwest > 40%	3-digit industry	0.021	0.142
East	=1 if share of workers in east > 40 %	3-digit industry	0.075	0.263
West	=1 if share of workers in west > 40 %	3-digit industry	0.147	0.354
Public	Proportion of workers in government-operated industries	2-digit industry	0.274	0.146
Dispute	average length of industrial disputes per 1,000 mandays	2-digit industry	1.488	2.320
Quit	average turnover rate	2-digit industry	30.289	11.174

Notes: *Annual wage includes basic wage, dearness allowance, shift allowance, overtime, housing allowance if applicable.

The core model controls for occupation, the proportion of men and the proportion of time-rated workers employed in an occupation/industry cell. It also includes indicator variables to control for shift allowances and overtime allowances, and includes average value added per worker. The 455 occupation dummies control for differences in required skill and education levels for each job. The proportion of men attempts to control for wage differentials between male and female workers: Occupations employing a higher proportion of men presumably will pay higher wages all else equal. The presence of shift allowances and overtime allowances are used as indicators of the pleasantness of the job. If shift allowances and overtime allowances are paid, this may indicate that the job requires long hours of work at less convenient and desirable times of the day. The average value added per worker, on the other hand, acts as a proxy for worker productivity. The model also controls for the average size of establishments in the industry.

The second model, in addition to the variables listed above, controls for the region in which the industry is concentrated, to account for any differences in cost of living or other geographical factors that could influence wages.[9] The indicator variable for a region equals one if 40 percent or more of the workers employed in an industry are located in the region in question.

The third and final specification incorporates several other variables reported at the two-digit industrial classification level including the proportion of workers employed

---

[9] The regions were defined according to specifications provided in Hanson and Lieberman's *India:Poverty, Employment and Social Services*, 1989.

in government-operated factories (vs. privately owned and operated), the average length of industrial disputes in man-days, and the average turnover rate in the industry. While one would expect that workers employed in government-operated factories enjoy more job security, workers employed in such firms may in return earn lower wages than those employed in private companies for the same work. The average length of labor disputes in an industry acts as an imperfect proxy for the strength of the unions. Reliable information on union membership was not available. Finally, we added the average turnover rate to the model to control for the fact that new hires at a factory are likely to earn less than workers with more tenure. The higher the rate of turnover, the lower the average tenure and the lower the average wage.

In each of the specifications described above, we have attempted to control for inter-industry differentials by incorporating several industry dummy variables. However, given that the injury data are available only at the two-digit level and that the scope of this analysis extends to manufacturing industries only, it is impossible to control for all industries.

In order to select dummy variables for the most influential industries, we first regressed the wage on the full set of industry dummy variables as well as other occupation characteristics, using weighted least squares. Those industry dummies that were significant at the 99.9 percent level were then incorporated into the hedonic wage equation. The results for this initial regression are reported in Table 4.

The three specifications of the hedonic wage equation described above were estimated for each of two measures of fatal and non-fatal injury risk. The first uses the

Table 4: WLS+ Regression Results for Selection of Industry Dummies
(Dependent Variable: Log Wage; Occupation Dummies Absorbed)

Variable Name	Coefficient	St. Error	Pr > |T|
FOOD PRODUCTS	-0.004	0.099	0.9709
TOBACCO & TOBACCO PRODUCTS	0.354**	0.159	0.0260
COTTON TEXTILES	0.211**	0.104	0.0424
WOOL, SILK & SYNTHETIC TEXTILES	0.255**	0.097	0.0088
JUTE, HEMP & MESTA TEXTILES	8.380**	1.908	0.0001
TEXTILE PRODUCTS	-0.094	0.111	0.3977
PAPER & PAPER PRODUCTS	0.216**	0.104	0.0381
LEATHER & FUR PRODUCTS	0.446**	0.122	0.0003
RUBBER, PLASTIC, PETROLEUM & COAL	0.442**	0.096	0.0001
CHEMICAL & CHEMICAL PRODUCTS	0.223	0.125	0.0754
NON-METALLIC MINERAL PRODUCTS	0.255**	0.103	0.0132
BASIC METAL & ALLOYS INDUSTRIES	0.160	0.095	0.0927
MACHINERY & MACHINE TOOLS	0.139	0.101	0.1685
ELECTRICAL MACHINERY & APPLIANCES	0.421**	0.094	0.0001
TRANSPORT EQUIPMENT & PARTS	0.406**	0.094	0.0001
MEN	0.005**	0.001	0.0001
UNITSIZE	0.1412**	0.028	0.0001
UNITSIZE*UNITSIZE	-0.016**	0.004	0.0001
AVGVALD	0.003**	0.0004	0.0001
CONSTANT	8.724**	0.116	0.0001

Notes: +Weight=number of workers employed in occupation-industry cell.
** Indicates significance at 95% level of confidence.

fatal and non-fatal injury rates in the year preceding the collection of wage data in the OWS. The second uses the average of the injury rates from the five years preceding the OWS.

V. Discussion

A. Regression Results

The results for all six model specifications are provided in Table 5. The signs of the coefficients of most variables generally agree with what has been reported in the literature. In all six specifications, occupations with a higher proportion of men pay more than those employing more women. Workers in large firms earn more than those working in small firms, but at a decreasing rate. Workers are also rewarded for higher productivity as evidenced by the positive (and statistically significant) coefficient on the value-added variable. Wages are higher in occupations that offer shift allowances and/or overtime allowances, perhaps to compensate workers for unpleasant working conditions. Region also seems to play a significant role in determining the wage although not as we had first anticipated. The region concentration variables were introduced into the equation primarily to account for cost-of-living differences across the country. Instead, it appears that they are capturing a different phenomenon. By construction, the regional concentration variable equals one if 40 percent or more of the employees in the industry are located in the region in question. The negative coefficients we obtained for *every* region suggest that, when an industry is concentrated in a region, firms in the industry

Table 5: WLS+ Regression Results for Six Model Specifications

(Dependent Variable: Log Annual Wage; Standard Errors in Parentheses)

Variable Name	Risk From Previous Year			Five-year Average Risk		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Constant	8.410** (0.634)	8.468** (0.568)	8.269** (0.574)	8.480** (0.640)	8.563** (0.581)	8.262** (0.579)
Fatal	0.430** (0.1300)	0.684** (0.124)	0.747** (0.145)	0.318 (0.275)	0.324 (0.255)	0.601* (0.330)
Nonfatal	0.0023** (0.0004)	0.002** (0.0004)	0.004** (0.001)	0.002** (0.0004)	0.001** (0.0004)	0.006** (0.001)
Time	0.001** (0.0005)	-0.0004 (0.0004)	-0.001 (0.0004)	0.001** (0.0005)	-0.0003 (0.0005)	-0.001 (0.0005)
Overtime	0.105** (0.024)	0.059** (0.025)	0.063** (0.025)	0.084** (0.025)	0.066** (0.026)	0.071** (0.025)
Shift	0.033 (0.022)	0.044** (0.020)	0.040** (0.020)	0.045** (0.022)	0.049** (0.021)	0.044** (0.021)
Icode25 (Jute)	6.861** (1.535)	9.312** (1.485)	10.311** (1.705)	4.928** (1.514)	6.928** (1.522)	9.503** (1.709)
Icode29 (Leather)	0.385** (0.083)	0.356** (0.076)	0.326** (0.079)	0.361** (0.086)	0.316** (0.079)	0.314** (0.079)
Icode30 (Rubber)	0.268** (0.034)	0.361** (0.033)	0.394** (0.038)	0.246** (0.034)	0.326** (0.034)	0.392** (0.039)
Icode36 (Elec. Mach.)	0.329** (0.037)	0.393** (0.035)	0.429** (0.038)	0.282** (0.038)	0.307** (0.037)	0.362** (0.040)
Icode37 (Transport)	0.264** (0.026)	0.358** (0.025)	0.378** (0.059)	0.248** (0.036)	0.333** (0.032)	0.242** (0.085)
Men	0.006** (0.001)	0.007** (0.001)	0.008** (0.001)	0.006** (0.001)	0.008** (0.001)	0.007** (0.001)
Unitsize	0.118** (0.021)	0.135** (0.020)	0.149** (0.025)	0.081** (0.020)	0.090** (0.021)	0.126** (0.025)
(Unitsize)^2	-0.014** (0.003)	-0.018** (0.003)	-0.020** (0.003)	-0.010** (0.003)	-0.013** (0.003)	-0.017** (0.003)
Value	0.004** (0.0003)	0.003** (0.0003)	0.002** (0.0003)	0.004** (0.0003)	0.003** (0.0003)	0.003** (0.0003)
South	--	-0.171** (0.030)	-0.202** (0.031)	--	-0.137** (0.030)	-0.180** (0.031)
Nwest	--	-0.736** (0.052)	-0.757** (0.052)	--	-0.734** (0.053)	-0.751** (0.053)
East	--	-0.169** (0.034)	-0.275** (0.045)	--	-0.089** (0.033)	-0.214** (0.045)
West	--	-0.034 (0.023)	-0.047 (0.026)	--	-0.025 (0.024)	-0.033 (0.026)
Public	--	--	-0.223 (0.134)	--	--	-0.162 (0.150)
Dispute	--	--	-0.022 (0.014)	--	--	-0.077** (0.020)
Quit	--	--	0.001 (0.001)	--	--	0.001 (0.002)

Notes: +Weight=number of workers in occupation-industry cell.
**Indicates significance at the 95% level of confidence and * at the 90% level.
Coefficients for Occupation Dummies omitted.

have monopsony power or are selecting locations strategically to take advantage of low labor costs.

As expected, government ownership of firms reduces wages, as do longer labor disputes. The effect of the average turnover rate, on the other hand, is positive, an unexpected sign, although not statistically significant. Judging from the significance of the industry dummy variables, inter-industry wage differentials appear to be an important determinant of wages as well.

Finally, turning to the effects of the fatal and non-fatal injury rates, risk of injury and risk of death on the job positively influence the wage. This holds true in all specifications of the model; however, only the coefficients using the previous period's injury and mortality rates as the risk measures produce statistically significant results. This lack of statistical significance is not surprising, however, since averaging the risk variables over five years reduces the variation in the risk measure across industries and thus increases the standard errors of the risk coefficients. The fact that the magnitudes of the coefficients are similar across definitions of risk, however, is indicative of the robustness of the results.

B. Value of Life Estimates

Since the compensating wage differentials obtained from studies like this are used to value improvements in risk of death and/or injury, it is interesting to convert these estimates to Values of a Statistical Life (VSL) and Values of a Statistical Injury (VSI) for comparison to other studies. According to our models, the VSL, when evaluated at the mean wage, ranges between Rs. 6,417,341 and Rs. 15,040,642 (1990 Rupees).[10] The VSI, on the other hand, ranges between Rs. 20,054 and Rs. 120,325 (1990 Rupees). At current exchange rates ($1 US = 42 Rs.) the VSL for India ranges between US $153,000 and US $358,000, while the VSI ranges between US $477 and US $2,870.

In judging whether these results are reasonable, it is important that the Indian VSL values be compared to foregone earnings. For the workers in our sample, the present value of foregone earnings is Rs. 313,000. This implies a ratio of VSL to foregone earnings of 20 to 48—much higher than the range implied by Moore and Viscusi (1988) of 8 to 23 for theU.S.

Two factors could explain this result. One is that Indian workers are more risk averse than U.S. workers. A number of studies examine consumption-saving decisions and the degree of risk aversion for the U.S. population. The values of the relative risk aversion index (ρ) that have emerged from this literature range between 1 and 7 (Laibson, 1998 and Heal, 1998). In contrast, very few studies examine the issue of risk aversion in developing countries. One study does provide some estimates of risk aversion for India, although in a much different context. Binswanger (1980) empirically estimates risk aversion among farmers in India from data on their investment decisions. His value of ρ, equal to 1.5, does not, however, adequately explain the discrepancy in the ratios.

---

[10] The VSL estimates are calculated by multiplying the coefficient on risk of fatality by the annual wage rate. This is then multiplied by 10,000 (the denominator of our risk measure).

An alternate and more satisfying explanation is that the income elasticity of the VSL is less than one, implying that VSL/Y rises as income falls. Empirical estimates of WTP to avoid *illness* suggest that the income elasticity of WTP to avoid illness is well below 1.[11]

C. Implications for Benefits Transfer

The fact that the ratio of VSL to income is higher in India that in the U.S. suggests that traditional approaches for transferring VSL estimates from the U.S. to India are likely to underestimate the VSL in India. If, following equation (3), one multiplies foregone earnings for India (Rs. 313,000) by the ratio of the VSL to foregone earnings in the U.S. (8.63-25.2), the predicted VSL for India ranges from approximately 2.7 to 7.9 million rupees, much smaller than our estimates of 6.4 to 15 million rupees.

VI. Conclusions

The estimates of compensating wage differentials that we obtain from the OWS imply a Value of a Statistical Life (VSL) in India of 6.4 to 15 million rupees (1990 rupees.). This number is between 20 and 48 times forgone earnings—the human capital measure of the value of reducing risk of death. While the ratio of the VSL to foregone earnings implied by our study is large by comparison with studies in the U.S., it is much

[11] For example, Loehman and De (1982) find an income elasticity ranging between 0.26 and 0.60 in their study of the willingness to pay among respondents in Tampa, Florida to avoid respiratory symptoms associated with air pollution. Alberini et al. (1997) find an income elasticity of WTP to avoid illness of 0.45 in a similar study conducted in Taiwan.

smaller than the ratio implied by Shanmugam's study of compensating wage differentials in the Indian labor market, which implies a ratio of 73!

While we believe that our estimates of compensating wage differentials are robust, there remains the important question of whether these estimates should be used to value risk reductions achieved by public health and safety programs in India. To use these estimates one must believe, as the theory in section II implies, that a worker's willingness to accept compensation (WTA) for a small risk increase equals what he would pay (WTP) to avoid the same risk decrease. One must also believe that the worker's preferences are representative of those of the randomly chosen Indian citizen.

There are researchers who question the notion that compensating wage differentials in the labor market measure what citizens would be willing to pay, out of their own pocket, for risk reductions. Garber and Phelps (1977), for example, appeal to the fact that, when the risk-reducing intervention is of a public good nature (e.g., reducing ambient air pollution) it may be a poor substitute for private goods. Under these circumstances, as Hanemann (1991) has shown, willingness to accept compensation (for a risk increase) can be orders of magnitude larger than willingness to pay (for a risk decrease).

In addition, preliminary results of pre-tests of a survey instrument to estimate WTP for risk reductions by Krupnick et al. (1998) support Garber and Phelps' conclusion. In pre-tests of their questionnaire in the U.S. and Japan, Krupnick et al. find the amount that people will pay for a medical intervention to reduce their risk of dying over the next ten years is substantially less than wage differentials for comparable risk reductions in the labor market.

Given these findings, we believe that policymakers should exercise caution in utilizing any compensating wage estimates, including those presented here, to value reductions in risk of death associated with public health and safety programs. These values, however, may be viewed as upper bound estimates of WTP for risk reductions, just as foregone earnings may be viewed as lower bound estimates of the value of risk reductions.

REFERENCES

Alberini, Anna, Maureen Cropper, Tsu-Tan Fu, Alan Krupnick, Jin-Tan Liu, Daigee Shaw and Winston Harrington (1997), "Valuing Health Effects of Air Pollution in Developing Countries: The Case of Taiwan," *Journal of Environmental Economics and Management*, 34, 107-126.

Bayless, Mark (1982), "Measuring the Benefits of Air Quality Improvements: A Hedonic Salary Approach," *Journal of Environmental Economics and Management*, 9, 81-99.

Binswanger, Hans (1980), "Attitudes Toward Risk: Experimental Measurement in Rural India," *American Journal of Agricultural Economics*, 62, 395-407.

Cousineau, Jean-Michel, Robert Lacroix and Anne-Marie Girard (1992), "Occupational Hazard and Wage Compensating Differentials," *The Review of Economics and Statistics*, 74(1), 166-169.

Garber, Alan and Charles Phelps (1997), "Economic Foundations of Cost-Effectiveness Analysis," *Journal of Health Economics*, 16(1), 1-31.

Hanemann, W. Michael (1991), "Willingness to Pay and Willingness to Accept: How Much Can They Differ?" *American Economic Review*, 81, 635-47.

Hanson, James A. and Samuel S. Lieberman (1989), *India: Poverty, Employment, and Social Services.* Washington, DC: The World Bank.

Heal, Geoffrey (1998), personal communication with Maureen Cropper.

Katz, Lawrence (1986), "Efficiency Wage Theories: A Partial Evaluation," in Stanley Fischer (ed.), *NBER Macroeconomics Annual 1986*. Cambridge: MIT Press, 235-76.

Knieser, Thomas, and John D. Leeth (1991), "Compensating Wage Differentials for Fatal Injury Risk in Australia, Japan, and the United States," *Journal of Risk and Uncertainty*, 4(1), 75-90.

Krueger, Alan B., and Lawrence H. Summers (1988), "Efficiency Wages and the Inter-Industry Wage Structure," *Econometrica*, 56(2), 259-293.

Krupnick, Alan, Anna Alberini, Robert Belli, Maureen Cropper and Nathalie Simon (1998), "New Directions in Mortality Risk Valuation and Stated Preference Methods: Preliminary Results, " *Proceedings of PSAM 4: The International Conference of Probabilistic Safety Assessment and Management, New York, NY*

Laibson, David (1998), personal communication with Maureen Cropper.

Liu, Jin-Tan, James K. Hammitt, and Jin-Long Liu (1997), "Estimated Hedonic Wage Function and the Value of Life in a Developing Country," *Economics Letters*, 57, 353-358.

Loehman, Edna, and Vo Hu De (1982), "Application of Stochastic Choice Modeling to Policy Analysis of Public Goods: A Case Study of Air Quality Improvements," *The Review of Economics and Statistics*, 64(3), 474-480.

Moore, Michael J., and W. Kip Viscusi (1990a), "Discounting Environmental Health Risks: New Evidence and Policy Implications," *Journal of Environmental Economics and Management*, 18(2) Part 2, S51-62.

______ (1990b), "Models for Estimating Discount Rates for Long-Term Health Risks Using Labor Market Data," *Journal of Risk and Uncertainty*, 3(4), 381-401.

______ (1988), "Doubling the Estimated Value of Life: Results Using New Occupational Fatality Data," *Journal of Policy Analysis and Management,* 7(3), 476-490.

Shanmugam, K. R. (1997), "Compensating Wage Differentials for Work Related Fatal and Injury Accidents," *The Indian Journal of Labour Economics*, 40(2).

Smith, Adam (1776), *The Wealth of Nations*. New York: Modern Library, 1937.

Smith, Robert S. (1974), "The Feasibility of an Injury Tax Approach to Occupational Safety," *Law of Contemporary Problems*, 38(4), 730-44.

Thaler, Richard, and Sherwin Rosen (1976), "The Value of Saving a Life: Evidence From the Market," in Nestor E. Terleckyj (ed.), *Household Production and Consumption*. Cambridge: NBER.

USEPA, *The Benefits and Costs of the Clean Air Act, 1970 to 1990*, report prepared for Congress, 1997.

Viscusi, W. Kip (1993), "The Value of Risks to Life and Health," *Journal of Economic Literature*, 31, 1912-46.

______ (1992), *Fatal Tradeoffs: Public and Private Responsibilities for Risk.* New York: Oxford University Press.

Viscusi, W. Kip, and Michael J. Moore (1988), "Rates of Time Preference and Valuations of the Duration of Life," *Journal of Public Economics*, 38(3) 297-317.