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Value of Statistical Life in India: A Hedonic Wage Approach

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VALUE OF STATISTICAL LIFE IN INDIA: A HEDONIC WAGE APPROACH

Agamoni Majumder* **and S Madheswaran****

Abstract

Conducting benefit-cost analysis of health and safety regulations requires placing a dollar value on reductions in health risks, including risk of death. These values, estimated from observed labour market data and converted to Values of a Statistical Life (VSL), are used to value reductions in risk of death achieved by industrial safety programmes or environmental health programmes. In this context, this study examines whether workers are paid compensation for their job risk and hence estimates their Value of Statistical Life (VSL) that will reflect job risk preferences of workers in India. The theory of compensating wage differential forms the basis for estimating mortality risks in this study. Using hedonic wage approach, the VSL estimated in this study is INR 44.69 million ($ 0.64 million) and the estimated Value of Statistical Injury (VSI) is INR 1.67 million ($0.02 million). Workers who perceive their job to be hazardous earn a wage premium of Rs 4,358 ($ 68) annually. This paper also examines the implications of using Benefit Transfer Methodology (BTM)and found that it understates the VSL estimate of India. The policy options are highlighted based on the empirical estimates.

Introduction

A competitive labour market is characterised by a single wage rate if all the jobs and all the workers were homogeneous. In reality, however, jobs and workers are heterogeneous and therefore uniform wage doesn't exist (Borjas, 2013). Different jobs have different characteristics such as the riskiness of a job, the pleasantness of work, the difficulty of the job, etc (Smith, 1776). Therefore, difference in the wages arise due to difference in job characteristics. Riskiness or hazard level of a job is one of the prime factors which causes differences in wages. In the United States, job-related mortality risks are often valued using Compensating Wage Differentials (CWD) that is observed in the labour market. CWD measures the amount that a worker needs to be paid for accepting a small increase in his fatality risk or the amount that the worker would pay to secure a small reduction in his risk of death (Majumder and Madheswaran, 2017). These wage premiums can be obtained from the labour market data and converted to Values of Statistical Life (VSL), a number that summarizes the amount that individuals are willing to pay collectively in the hope of saving one's life. VSL measures the risk-money trade-off for tiny amount of fatal risks (Viscusi 2003).

The application of VSL in policymaking and evaluation is extensive in developed countries compared to developing countries. In fact, the VSL estimates for developing countries are not adequate and therefore, policymakers employ various methods like human capital approach and benefit transfer method (BTM) to estimate VSL. These traditional methods have serious shortcomings which produce inaccurate estimates of VSL. For example, human capital approach that uses foregone income to value

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improvements in life expectancy often undervalue people's actual WTP for small reduction in fatality risk and thereby yield inaccurate estimates of VSL (Nathalie *et al,* 1999). Therefore, it is very crucial to conduct separate studies on VSL in developing countries. In this context, our study attempts at estimating the Value of Statistical Life and Injury for Indian labour market using the hedonic wage approach. Besides, this study shows the implication of using benefit transfer method for estimation of VSL for India.

India is one of the fastest growing developing economies that has witnessed various changes in the labour market characteristics in the past few years. There have been increased use of chemicals exposing worker to physical, chemical and biological substances with undiscovered risks, increase in operation of hazardous industries and prevalence of high levels of job-related stress that pose severe health hazards and environmental risks. Although the Government of India has enacted regulations to ensure safe and healthy working conditions, lacunae still exist in policy making which requires formulation of new and effective policies that cover the areas yet untouched by regulatory lenses. These regulations need to be revised in accordance with the changes in the labour market. VSL estimates provide a reference point for assessing the benefits associated with risk reduction policies for the Government. Accordingly, this study will be useful for framing a wide range of health, safety and environmental policies and also aid in evaluating environmental health projects in India (National Policy on Safety, Health and Environment at Work Place 2009).

The rest of the paper is organized as follows: The first section provides a concise review of VSL studies undertaken in India. The focus of the second section is on the theoretical framework of the study. This section outlines the methodology used to estimate the compensating wage differentials and VSL. Subsequent sections discuss the study location, sources of data and the sampling procedure followed. The analysis of the secondary data and the functional form analysis using Box-Cox transformation are presented in separate sections. The next section presents the empirical results and discussion on the findings of the study. The implication of using Benefit Transfer Methodology for estimating VSL for India is discussed in the following section. Finally, the general conclusion and implications of the study are presented.

Review of VSL Studies Based on Indian Labour Market

In 1996-1997, a pioneer study on VSL in India was undertaken by Shanmugam based on a primary survey of 522 blue-collar workers in manufacturing industries of Madras district during 1990. The estimated VSL in his study ranged between INR 14 million and INR 19 million while the Value of Statistical Injury (VSI) ranged between INR 2,014 and INR 7,632. Further, in 1999, Nathalie *et al* estimated that the VSL for India that lied between INR 6.4 million and INR 15 million. This study obtained industry-wise fatal and non-fatal injury rates from various volumes of the Indian Labour Yearbook and the data on wage was obtained from the fourth round of Occupational Wage Survey conducted by Indian Labour Bureau. This is the only study in India which yielded VSL estimates that are completely based on secondary data. Besides, it made a comparative analysis by estimating VSL with Benefit Transfer Method (BTM) and showed that using Hedonic Wage Method yields a better result compared to the BTM. In 2001, Shanmugam used the data from his previous studies and estimated the

VSL by correcting for the selectivity bias and found the VSL estimate to be INR 56 million which is much higher than what he estimated in his earlier studies. Madheswaran (2004, 2007) conducted another VSL study in India based on primary survey of 550 workers in Chennai and 463 workers in Mumbai during 1999-2000. He obtained a VSL estimate of INR 15.4 million for Chennai and INR 14.8 million for Mumbai. The VSI was found to be INR 6,470 and INR 9,000 for Chennai and Mumbai respectively. However, this study did not correct for the selectivity bias. Shanmugam (2010) estimated the discount rate for health benefits. The real discount rate that he obtained from his study varies across regions and range between 2.4 percent and 5.1 percent. His estimates of discount rate were similar to the interest rates prevailing in the financial market during the study period. From this study, he estimated the VSL to be INR 20 million which is again higher than the estimates of his earlier studies. The recent study in India was undertaken by Shanmugam and Madheswaran in 2011. Their study is based on the primary data collected by Shanmugam in 1990 and they obtained a VSL of INR 10.28 million and a VSI of INR 4,876. This study accounted for several issues like the selectivity bias, the effect of insurance and wealth on wage and VSL of the workers.

Given the review of literature, it is observed that most of the VSL studies undertaken in India are based on primary data that was collected during the 1990s and early 2000 from the highly industrialized states of Maharashtra and Tamil Nadu. Over the past few years, Indian labour market has undergone various changes in terms of characteristics of work, handling of hazardous substances and exposure of workers to chemical and other hazardous substances. The potential of many such occupational hazards are yet unknown to us. Previously, Maharashtra and Tamil Nadu were two of the most industrialized states where occupational accidents and fatalities were considerably high. However, over the past few years, it has been observed that the prevalence of fatal industrial accidents and injuries are the highest in Gujarat (National Crime Records Bureau, 2010-14). This change in the pattern of job risk and fatal industrial occurrences needs to be enquired upon. Besides, the previous studies conducted a preliminary estimation of the effect of insurance and compensation benefit of workers on VSL. At this juncture, it is appropriate to conduct a study on job risk preferences of workers. Thus, the this paper intends to study whether workers are compensated for undertaking risky jobs and thereby estimate the Value of Statistical Life and Injury of workers.

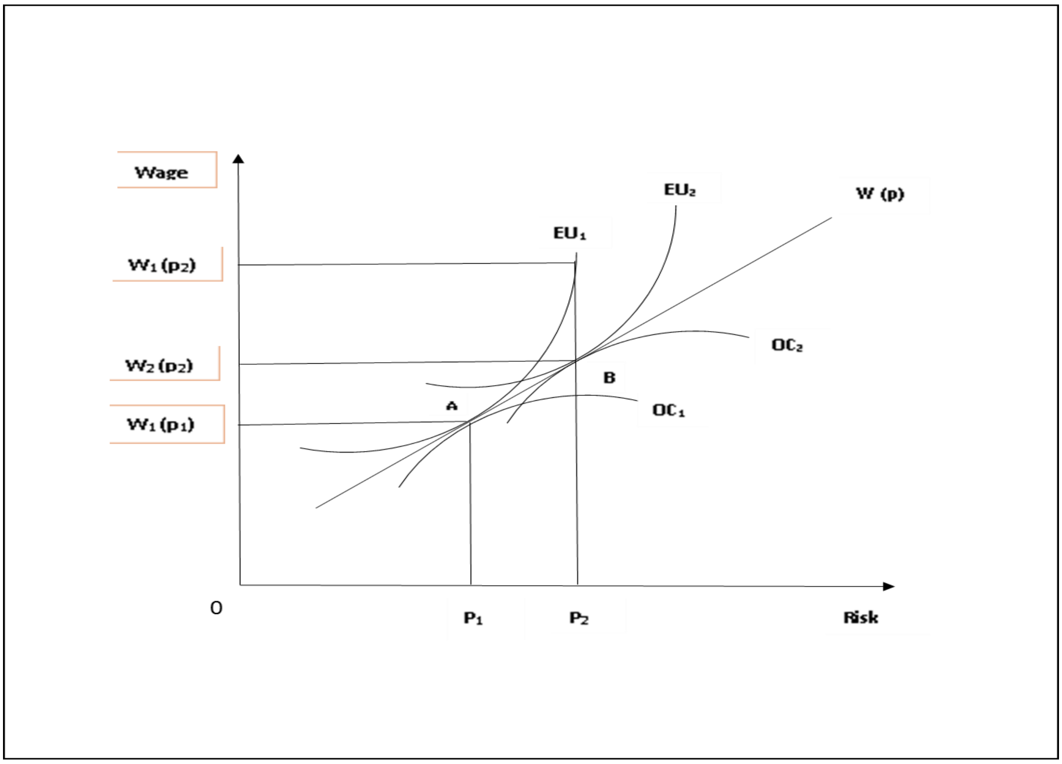
Theoretical Framework

This study is built on the theory of compensating wage differential. Adam Smith introduced the concept of compensating wage differential in 1776. He listed five principles for compensating non-pecuniary attributes of job: amenities and hardships of job, education and training expenses, stability or instability of job, degree of trust required, and prospects and uncertainty of success. Richard Thaler and Sherwin Rosen developed the modern theory of compensating wage differentials in 1976. The methodology used under this new approach is derived from the hedonic wage literature, which focuses on 'hedonic' or 'quality-adjusted' wages. Thaler and Rosen observed that the transactions in labour market can be considered as tied sales. Workers not only sell their labour, but also buy certain non-monetary job characteristics at the same time. Similarly, the firms purchase labour and sell non-monetary job characteristics like job risk to workers as well. Thus, firms can be viewed as joint producers in the sense that some output is sold to consumers in products market while other output is sold to workers in conjunction with labour-service rentals. The labour market provides some mechanism through which the implicit trading in risk occurs where the extent of risk differs from one job to another. The workers however need to be persuaded to take up risky jobs through a set of compensating wage differences included in their wage rate. In the hedonic approach, wage acts as the key source of information on work-related health and fatality risk. The wage-risk trade-off is obtained from the labour market and used in estimation of VSL.

Given the discussion on the theory of CWD, it will be interesting to study how the wage-risk trade-off is obtained from the equilibrium in the labour market. This can be explained with the help of an example where there are two firms (firm 1 and firm 2) and two workers (worker 1 and worker 2). Firms show their Willingness to Pay (WTP) the workers for undertaking risks. This is shown by the wage offer curves of the firms labelled as "OC" in the figure 1. Offer curves are also called the iso-profit curve because all the points along this curve have a constant level of profit. Providing safe working condition is quite costly for a firm and also affects its profit level. As the firm has to hold the profit level constant, the only way it can offer a safe work environment to its workers is by reducing the wage of the workers (Borjas, 2013). Thus, it is evident that different firms would have different offer curves because few firms will find it easy to offer safe working environment while others will find it difficult. On the other hand, different workers will have different risk preferences. The expected utility curves (EU) or the indifference curves show the risk preferences of the workers. As observed from the Figure 1, worker 1 has a steeper EU curve which implies that he is risk averse and therefore he prefers to work in a safe environment. In contrast, worker 2 has a flatter EU curve therefore doesn't mind taking up risky jobs.

The aim of the workers is to maximize their utility by selecting the wage-risk offer that places them on the highest possible EU curve. As per the Figure 1, worker 1 who dislikes risk maximizes his utility at point A and worker 2 who doesn't mind taking up risks maximizes his utility at point B. Thus, equilibrium wage-risk choice for a labour is given by the tangency point between the firm's wage offer curve (OC) and the worker's expected utility (EU) curve. Hence, a non-random sorting takes place in the labour market where, **"safe firms are matched with safety-loving workers, and risky firms are matched with workers who are less risk averse"** (Borjas, 2013). The **hedonic wage function "**w (p)" is generated by joining all the equilibrium wage-risk combination of the workers in a hedonic labour market. The hedonic wage function sums up the relationship between the wages that workers are paid and the job characteristics. W (p) also reveals the average rates of wage-risk tradeoff across workers.

Figure1: Equilibrium Wage-risk Choice Determination in Labour Market



Source: Borjas (2013)

The equilibrium in the hedonic labour market can be shown mathematically as well. In this respect, two utility functions are considered. The first utility function corresponds to good health state with utility "u (w)" and the second one corresponds to ill health (due to injury) with utility "v (w)". Good health is preferred to ill health. Therefore,

u (w) > v (w).

It is assumed that workers prefer higher wage, so the marginal utility of income is positive, i.e.

U′ (w) > 0 and **v′ (w) > 0,**

The Expected Utility (EU) function of workers is given as follows:

Z = (1-p) × u (w) +p × v (w)

The expected utility function is nothing but the summation of the probability of each state multiplied by the utility derived under each state.

As mentioned earlier, the worker aims at maximizing the expected utility given risk, i.e.

$\boldsymbol{max_p Z}$ **= (1-p) × u (w) + p × v (w)**

Therefore, the optimal wage-risk choice is determined by solving the first order conditions for maximizing the expected utility. The resulting choice is given by the following equation:

$$\frac{dw}{dp} = -\frac{Zp}{Zw} = \frac{u(w) - v(w)}{(1-p)u'(w) + pv'(w)} > \mathbf{0}$$

This equation shows that the change in wage due to the change in the risk level is equal to the difference between the utilities under each state divided by the summation of the marginal utilities under each state. **"dw/dp"** represents the slope of the hedonic wage function w (p). An upward rising hedonic wage locus implies that as the worker undertakes more and more risk, his wage should also increase.

The above exercise shows how the wage-risk trade-off is obtaied from the labour market. The next few paragraphs show how this trade-off is utilized to estimate the hedonic wage equation.

Under the hedonic wage approach, Jacob Mincer's earning function is modified to obtain the hedonic wage function which shows that a worker's wage is a function of his productivity (or worker's individual attributes) and the non-pecuniary job attributes. Hence, the hedonic wage equation is written as follows:

$$\boldsymbol{LnW_i = \alpha + \beta_1 p_i + \beta_2 q_i + \sum_k \gamma_k X_{ki} + \epsilon_i} \qquad \text{.......................} \ \mathbf{(1)}$$

Here, $\mathbf{W_i}$ is the worker's after-tax hourly wage, α is the constant term, $\mathbf{X_{ki}}$ is the vector of worker's personal characteristics such as their age, education level, experience, etc., and job characteristics such as hours of work, number of holidays given per month, work conditions, etc., $\mathbf{p_i}$ is the work related fatal injury risk, $\mathbf{q_i}$ is the work-related non-fatal injury risk and $\mathbf{€_i}$ is the random error term. $\boldsymbol{\beta_1}$, $\boldsymbol{\beta_2}$ and $\boldsymbol{\gamma_k}$ are the parameters that are required to be estimated using regression analysis. This hedonic wage equation yields the wage-risk trade-off of the workers which is used to estimate their VSL.

Estimation of VSL

The Factories Act says that a worker can work up to 9 hours a day. A worker is also entitled to 12 paid leaves in the following year if he works for 240 days in the present calendar year. In this study, workers get at least 12 days of paid leave in a year. Therefore, it is assumed that, workers in the sample work for 240 days on an average. Multiplying 240 days by 9 hours per day, the total annual work hours come to 2160 hours.

Given the estimated wage-risk trade-off, $(\widehat{\boldsymbol{\beta_1}})$ obtained from equation (1), the average probability of death which is usually measured per one lakh workers and by assuming that workers work for 2160 hours annually, the VSL at mean hourly wage level**,** $(\overline{\boldsymbol{w}})$ is estimated in the following way:

$$\boldsymbol{VSL = \widehat{\beta_1} \times (\overline{w}) \times 2160 \times 100,000} \qquad \text{..............................} \ \mathbf{(2)}$$

Similarly, given the estimated wage-risk trade-off, $(\widehat{\boldsymbol{\beta_2}})$ obtained from equation (1), the average probability of injury which is usually measured per one thousand workers and by assuming that workers work for 2160 hours annually, the Value of Statistical Injury (VSI) at mean hourly wage level, $(\overline{\boldsymbol{w}})$ is estimated in the following way:

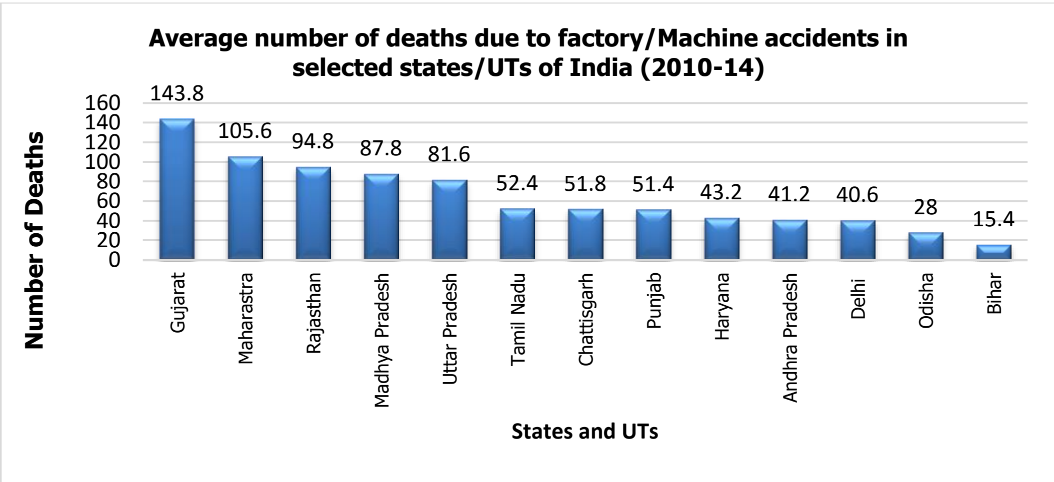
$$\boldsymbol{VSI = \widehat{\beta_2} \times (\overline{w}) \times 2160 \times 1000} \qquad \text{..............................} \ \mathbf{(2')}$$

In order to estimate the basic Value of Statistical Life and Injury, the CWD has to be obtained from labour market data with the help of Hedonic Wage Approach. This approach use wages to obtain information on work related health and death risks. The estimated wage premiums are then converted to VSL.

Data and Variables

Gujarat has been selected as the study location. It is one of the highly industrialized states in India. There are many industrial clusters like Gujarat Industrial Development Corporation (GIDC), which consists of large variety of industries like textile, pharmaceuticals, chemical, steel, food products, etc. Many of these industries engage workers in risky jobs. Besides, it has been observed in the recent past (i.e. during 2010-14), that majority of deaths from factory/machine accidents have taken place in the state of Gujarat.

Figure 1: State-wise Average Number of Fatal-industrial Injuries in India during 2010 to 2014



Source: National Crime Records Bureau, Ministry of Home Affairs, Government of India.

Figure 1 shows five years (2010 to 2014) average of the total number of deaths due to factory accidents in each state. The industry-wise data on factory accidents is not available for each state and therefore, per-industry average number of deaths due to factory accidents could not be estimated. However, the above exercise provides some insight into the number of deaths occurring due to factory accidents in Indian states.

This study combines primary and secondary data on variables. One of the most important variables in this study are the job risk variables. Job risks can be of two types, namely, objective job risk and subjective job risk. Objective job risk pertains to a certain industry or occupation which is generally reported by various government agencies in a country[1]. Thus, the secondary data provides information on objective job risk. On the other hand, the subjective job risks pertain to the individual perception of

[1] The government/ government agencies report the number of death and injuries occurring in various industries (by two- or three-digit industrial classification code) during a particular period of time (say, in a year). Given this information and the total employment during that period, the fatal and non-fatal risk associated with a particular industry or occupation is obtained. In USA, Department of Labour, Bureau of Labour Statistics (BLS) collects and compiles mortality and injury risk data.

the workers about the riskiness of their job. This data may be obtained through a primary survey (Majumder and Madheswaran 2016). In this study, the data on objective job risks, i.e. the industry-wise data on number of deaths and injury to workers on an annual basis, has been obtained from the office of Industrial Safety & Health, Ahmedabad. From this secondary data, the average probability of death per one lakh male blue-collar workers and average probability of injury per 1,000 workers in various manufacturing industries of Ahmedabad are estimated. A certain number of industries were selected. On the other hand, data on wage of the workers, subjective job risk, family demographics, working conditions, etc have been obtained through primary survey across four industrial divisions of Ahmedabad district from October 2016 to February 2017. All these variables are listed in Table 2.

A multi-stage random sampling technique has been followed to collect the primary data. Firstly, the region of study was chosen. Ahmedabad district of Gujarat has been selected as the field of study since it has the highest number of registered factories. The factories included in the primary survey are distributed in four divisions of Ahmedabad district. Once the study area was selected, the next step involved selection of workers based on the nature of their work. Therefore, blue-collar male workers in manufacturing industries were selected on the basis of the records of the office of Industrial Safety & Health, which showed that only male workers in blue-collar jobs have incurred employment injuries (both fatal and non-fatal) from 2010 to 2014. Female workers are less likely to incur any accidents since they are not assigned to risky jobs. Besides, the records do not show any major employment injury for women workers in manufacturing industries. The workers in other industries (like service sector workers, workers in coal mines, railways, etc.) that do not come under Factories Act are not considered here. After the selection of the blue-collar workers in the manufacturing industry, these workers were stratified into 13 groups according to the National Industrial Classification (NIC) Codes of 2004.

About 1percent of the sample from each industry group was chosen that amounts to about 438. However, there were certain questionnaires which had inadequate information and they had to be removed from the analysis. Therefore, the final sample size came out to be 430 for the present study. The factories were chosen randomly from all the four divisions of Ahmedabad district. The details and the address of the factories were obtained from the office of the Industrial Safety & Health, Ahmedabad. Interview method was adopted to collect required information from the workers using a pre-tested questionnaire. On an average, five to six workers in each factory were interviewed. Table 2 provides the descriptive statistics on variables collected from primary survey.

Table 2: Descriptive Statistics of Variables Obtained from Primary Data

Variable	Description	Mean & Standard Deviation	Expected sign
Dependent variable			
HOURLY WAGE	After-tax hourly wage of workers	42.96 (12.72)	NA
Independent variables			
• Risk Variables			
FATAL	Annual average probability of death per one lakh workers	19.26 (10.30)	Positive

INJURY	Annual average probability of injury per one thousand workers	1.97 (2.21)	Positive
ENV DANGER	Indicator of job hazard perception. 1= If worker's job exposes him to environmental problems and unhealthy conditions, 0= if he feels that his job doesn't expose him to environmental problems.	0.6116 (0.48)	Positive
• Personal characteristics of worker			
EXPERIENCE	Work experience in years	17.85 (11.15)	Positive
PRIMARY	1= If the worker has completed primary education, 0 = otherwise	0.22 (0.41)	Positive
SECONDARY	1 = If the worker has completed secondary education, 0 = otherwise	0.29 (0.45)	Positive
HS	1 = If the worker has completed higher secondary education, 0 = otherwise	0.31 (0.46)	Positive
GRADUATE	1 = If the worker is a graduate or has a college degree, 0 = otherwise	0.06 (0.23)	Positive
SC	1= if the worker belongs to the SC (Schedule Caste) Category, 0= if the worker belongs to other social class.	0.16 (0.37)	NA
MIGRANT	1= if the worker is a migrant, 0= if the worker's native is Gujarat	0.56 (0.49)	NA
• Job characteristics			
JOB TYPE	1= if worker's job is permanent, 0= if worker works on a contractual/ temporary basis	0.739 (0.43)	Positive
TRAINING	1= if worker obtained job training in the factory where he works, 0= if worker completed job training elsewhere	0.425 (0.49)	Positive
SIZE	1= if number of workers in the factory is less than or equal to 500, 0= if number of workers is greater than 500	0.623 (0.48)	Negative
UNION	1 =If worker is a union member, 0= if he is not union member	0.07 (0.26)	Positive
PHW	1= If worker's job requires physical hard work,0= doesn't require hard work	0.45 (0.49)	Negative
SECU	1= if the worker's job is secured, 0= otherwise	0.60 (0.48)	Positive
MENT	1= If worker's job requires mental work, 0= doesn't requires mental work	0.47 (0.50)	Positive
FAST	1= If worker's job requires him to work fast, 0= otherwise	0.23 (0.42)	Negative
CONTRACTOR	1 = If worker is a job contractor, 0 = otherwise	0.034 (0.18)	Positive
SUPER	1 =If the worker is a supervisor, 0= otherwise	0.07 (0.26)	Positive
FITTER	1= If the worker does fitter work, 0= otherwise	0.14 (0.35)	Positive
TECH	1= If the worker does technical work, 0= otherwise	0.06 (0.24)	Positive
ASSIST	1= If the worker is an assistant/Helper, 0= otherwise	0.12 (0.33)	Negative
DIV 1	1= If the worker belongs to a factory located in Division 1 of Ahmedabad district, 0 =otherwise	0.26 (0.44)	NA
DIV 2	1= If the worker belongs to a factory located in Division 2 of Ahmedabad district, 0 =otherwise	0.20 (0.40)	
DIV 3	1= If the worker belongs to a factory located in Division 3 of Ahmedabad district, 0 =otherwise	0.33 (0.47)	

Source: Author's calculation based on primary data collected from factory workers at Ahmedabad

The dependent variable of study is the **WAGE** variable. Information on wage has been collected from the workers and cross-checked with their salary slip or the salary record of workers kept with the factories (whichever was available). The hourly wage has been estimated on the basis of the monthly and daily wage reported by the workers. In this paper, hourly wage refers to the after tax hourly wage of the workers. It is observed from the Table 2, that the mean hourly wage of the workers is Rs 42.96.

The variables FATAL and INJURY corresponds to the annual average probability of death per one lakh workers and annual average probability of injury per one thousand workers respectively. On the other hand, the risk variable ENVDANGER measures the objective perception of job risk of the worker. About 61 percent of workers in the sample perceive their job to be risky and expose them to unhealthy conditions. This variable is a dummy variable which pertains to whether a worker's job exposes him to any environmental problems or unhealthy conditions. This variable is used as an alternative job risk measure in order to examine how the workers' subjective decisions compare with objective measures. Therefore, VSL and VSI estimates are obtained on the basis of two risk variables, i.e., FATAL and INJURY, and not from ENVDANGER.

The risk measures that are obtained from Table 1 are matched to the workers in the sample using NIC code. However, a measurement problem may arise while matching the workers to the risk measures which is quite common in this type of studies since all the workers in a particular industry do not face the same level of risk. In case of white-collar workers, this problem is more serious because they encounter a different and much safer work conditions (Garen, 1988). This study concerns only blue-collar workers and therefore, measurement problem may not be as serious as in other studies. Besides, a subjective measure of risk, i.e. ENVDANGER, has been introduced in this study to mitigate this problem.

As mentioned at the beginning of this section, the data on personal and work characteristics has been obtained from the primary survey of workers from four industrial divisions of Ahmedabad district of Gujarat. Tables 3 and 4 provide division-wise information on the personal and work characteristics of workers in the sample.

Table 3: Division-wise Information on personal Characteristics of Workers in the Sample

Division	Illiterate	Primary	Secondary	Higher secondary	Graduate	SC	Migrant
	(figures are in percentage)						
DIVISION 1	10	29	27	28	6	21	48
DIVISION 2	10	23	21	38	8	16	58
DIVISION 3	11	20	36	29	4	14	62
DIVISION 4	20	17	26	32	4	17	18
For full sample	12	22	29	31	6	16	46

Source: Author's calculation based on primary data collected from factory workers at Ahmedabad

Table 3 shows the variables of personal characteristics of workers like their education level, caste indicator and state of origin. About 12 percent of workers in the whole sample are illiterate and majority of these workers belong to division 4. Majority of the workers in the sample have completed their higher secondary education. On the other hand, the proportion of graduates in the sample is the lowest. SC is a dummy variable showing whether the worker belongs to a Scheduled Caste. In division 1, about 21 percent of the workers belong to the Scheduled Castes while in division 3, only 14 percent of workers belong to this social class. About 46 percent of the workers in the whole sample are migrant workers or workers from other states. While division 3 comprises the highest proportion of migrant workers, division 4 has the lowest.

Table 4: Division-wise Information on job Characteristics of Workers in the Sample

Division	Physical Hard Work	Over Time	Job Security	Mental Work	Carefulness	Fast
	(figures are in percentage)					
DIVISION 1	53	68	56	48	84	19
DIVISION 2	44	72	55	53	88	20
DIVISION 3	33	87	71	51	83	30
DIVISION 4	55	81	57	37	89	24
For full sample	45	77	61	48	85	24

Source: Author's calculation based on primary data collected from factory workers at Ahmedabad

Table 4 shows the job characteristics of workers across the four industrial divisions. All the variables listed in this table are dummies for the nature of job. Majority of workers in the whole sample and across all divisions said that their job requires them to be careful and avoid making any mistakes which may lead to accidents. About 77 percent of workers in the whole sample have to work over-time or engage in extra hours of work; 61 percent of workers have secure jobs. In division 3, 71 percent of workers have secure jobs. On the other hand, 45 percent of workers in the sample have to undertake hard physical works in their job. More than half of the workers in division 1 had to undergo hard physical work. Only 24 percent of the workers in the total sample need to work fast or engage in a job where speed of work is an important factor.

Analysis of Secondary Data

Five years' data (2010-2014) on the number of fatal and non-fatal injury has been collected and the average probability of death per one lakh workers and average probability of injury per 1,000 workers are calculated using the following formulas. The risk of death and injury may vary considerably over a year if any catastrophe occurs leading to multiple causalities. Therefore, in order to reduce the effect of random fluctuations, a five years' average data has been used for the calculation of the probabilities.

Average probability of death per one lakh workers

$$= \frac{\boldsymbol{Total\ number\ of\ fatal\ injuries\ for\ a\ NIC}}{\boldsymbol{Total\ number\ of\ blue\ collar\ workers\ for\ a\ NIC}} \times (\mathbf{1,00,000})$$

Similarly, the average probability of injury per 1,000 workers has been calculated by the following formula:

Average probability of injury per one thousand workers

$$= \frac{\boldsymbol{Total\ number\ of\ non\ fatal\ injuries\ for\ a\ NIC}}{\boldsymbol{Total\ number\ of\ bluecollar\ workers\ for\ a\ NIC}} \times (\mathbf{1,000})$$

The total number of fatal and non-fatal injuries corresponds to both male and female workers. Data on fatal and non-fatal injuries is not separately available for male and female workers. However, according to officials of the Industrial Safety & Health, Gujarat, female workers do not face significant fatal and non-fatal injuries since they're assigned safer works. Even during the primary survey it has been observed that women are not assigned any hazardous work. None of the factories that were visited reported any death or injury of female staff in past five years. So it can be considered that the total number of fatal injuries used in estimation of the average probabilities mainly pertain to male workers. The average probabilities of death and injury for 13 types of manufacturing are shown in Table 5.

Table 5: Annual Average Probability of Death and Injury for Male Blue-collar Workers in Manufacturing Industries of Ahmedabad.

Sr. No.	NIC	Industry	Average probability of death (p)	Average probability of injury (q)	No. in sample
1	15	Mfg. of Food Products and Beverages	7.49	0.74	35
2	17	Mfg. of Textile	9.17	2.29	56
3	20	Mfg. of Wood and Products Wood and Cork	22.96	0.37	19
4	21	Mfg. of Paper and Paper Products	43.71	0.95	32
5	23	Mfg. of Cock Refined Petro Products and N. Fuel	19.62	9.47	29
6	24	Mfg. of Chemicals and Chemical Products	15.4	2.69	41
7	25	Mfg. of Rubber and Plastics Products	10.21	0.91	17
8	26	Mfg. of Other Non- Metallic Mineral Products	18.31	0.47	29
9	27	Mfg. of Basic Metals	16.51	0.82	43
10	28	Mfg. of Fabricated Metal Products	12.91	0.48	37
11	29	Mfg. of Machinery and Equipment	34.41	1.4	50
12	31	Mfg. of Electrical Machinery and Apparatus	17.01	1.48	16
13	35	Mfg. of Transport Equipment	22.38	3.55	26
For the full sample			19.23	1.970	**430**

Source: Author's calculation using secondary information from the Industrial Safety & Health Office, Ahmedabad.

From Table 1, it can be observed that the workers in manufacturing of paper and paper products (NIC 21) face the highest average probability of death while those engaged in manufacturing of food and food products (NIC 15) face the lowest risk of death among all the industries that are listed here. Workers in manufacturing of wood and wood products (NIC 20) face least average probability of injury while those in manufacturing of coke and refined petroleum products (NIC 23) face the highest probability of injury among all the industries. The mean probability of death and injury for all the 13 industries taken together are 19.23 per one lakh workers and 1.97 per 1,000 workers, respectively.

Flexible Functional form Analysis

Estimation of hedonic wage equation is not straight forward. A crucial issue with estimation of hedonic wage equation is choosing appropriate functional form. In this section, the following issue along with its remedial approaches are discussed. The matter of selecting an appropriate functional form has always been a debatable issue with any econometric model. In the beginning, researchers used linear or a semi-logarithmic specification for estimation of hedonic wage regression. Theory doesn't suggest the use of any particular specification, therefore researchers tried to solve this problem econometrically (Shanmugam and Madheswaran, 2011). Moore and Viscusi in 1988 used Box-Cox transformation to obtain a flexible functional form for estimating the wage regression. Most of the studies follow this approach and they use semi-logarithm specification for estimation of wage equation. In this study, Box-Cox transformation is used to determine the suitable specification for estimation of the hedonic wage equation. Maximum Likelihood Estimation (MLE) is used to estimate the following Box-Cox transformation wage equation (3)

$$\frac{w_i^{\lambda}-1}{\lambda} = \alpha + \beta_1 p_i + \beta_2 q_i + \sum_k \gamma_k X_{ki} + \epsilon_i \qquad \text{................................ (3)}$$

Here, it is assumed that, λ takes on a value such that the model is normally distributed, is homoscedastic and linear in regression. The parameter λ has to be estimated such that it maximises the log-likelihood function. The value of λ lies between -1 and +1. If λ →-1, then an inverse form is suitable, if λ→0, then a semi-logarithmic form is suitable, if λ→1 then a linear form is suitable. Table 6 shows the Box-Cox non-linear regression estimates of the wage function. The mean square error (ESS) indicates that the semi-logarithmic form is the most suitable form for estimation of hedonic wage equation.

Table 6: Box-Cox Transformation for Hedonic Wage Equation

Variables	λ = -1 (Inverse)	λ = 0 (Semi-log)	λ = 1 (Linear)
Constant	0.0364* (25.17)	3.2695* (57.33)	23.5638* (9.37)
FATAL	-0.000093* (3.64)	0.004816* (4.73)	0.246088* (5.48)
INJURY	-0.000437* (3.60)	0.01800* (3.75)	0.767003* (3.63)
EXP	-0.000301* (3.68)	0.01117* (3.46)	0.45428* (3.19)
EXP^2	-0.000004* (2.27)	-0.000140*(1.99)	-0.005361** (1.72)
PRIMARY	-0.003741* (3.95)	0.13106* (3.51)	4.76375* (2.89)
SECONDARY	-0.003313* (3.62)	0.11471* (3.17)	4.1788* (2.62)
HS	-0.00453* (5.03)	0.2085* (4.34)	6.8368* (4.36)
GRADUATE	-0.00427* (3.28)	0.17083* (3.33)	7.3403* (3.24)
MIGRANT	0.00114* (2.13)	-0.05506* (2.60)	-2.68729* (2.88)
SC	0.00188* (2.83)	-0.06507* (2.48)	-2.4767* (2.14)
UNION	-0.00179***(1.72)	0.050272 (1.22)	1.22989 (0.68)
SIZE	0.00091 (1.60)	-0.02599 (1.15)	-0.502732 (0.51)
JOB TYPE	0.001302* (2.01)	-0.05177* (2.03)	-2.3174* (2.06)
TRAINING	0.000749 (1.38)	-0.03105 (1.45)	-1.3681 (1.45)
PHW	0.00091*** (1.68)	-0.041462** (1.93)	-1.8952* (2.01)
SECU	0.000252 (0.41)	-0.01594 (0.66)	-0.954515 (0.89)
MENT	-0.000956** (1.85)	0.03714** (1.82)	1.61114** (1.79)
FAST	0.001451* (2.47)	-0.05724* (2.47)	-2.3985* (2.35)
CONTRACTOR	-0.004932* (3.33)	0.294437* (5.04)	17.4226* (6.76)
SUPERVISOR	-0.00269* (2.77)	0.13332* (3.47)	6.90757 * (4.08)
FITTER	-0.00194* (2.64)	0.09664* (3.33)	4.91511* (3.84)
TECHNICIAN	-0.00156 (1.53)	0.078362** (1.94)	4.06473* (2.29)
ASSISTANT	0.00320* (4.06)	-0.10924* (3.51)	-3.83979* (2.80)
DIV1	-.00646* (8.44)	0.24664* (8.17)	9.97315* (7.49)
DIV 2	-.00351* (4.39)	0.13442* (4.26)	5.526414* (3.97)
DIV 3	-.00521* (6.86)	0.20353* (6.79)	8.37558* (6.34)
R^2	0.5378	0.5581	0.5623
F	17.90	19.43	19.77
N	427	427	427
ESS	**33047.2**	**29975.73**	**29980.24**

* 1 % level of significance, ** 5 % level of significance, *** 10 % level of significance

Note: Absolute t values are given in parentheses

Source: Author's estimation based on primary data collected from factory workers at Ahmedabad

The semi-logarithmic wage equation is given as follows:

$$LOG\ WAGE = \alpha + \beta_1 FATAL + \beta_2 INJURY + \sum_k \gamma_k X_{ki} + \epsilon_i \text{ ....} \quad \mathbf{(3)}$$

Here, X_{ki} include factors like human capital variables (education level of the worker), variables pertaining to the firm characteristics (size of workers, private sector firm, etcetera.), and personal characteristics of workers (experience, origin, social class, occupation of the worker, etcetera).

Estimation of Hedonic Wage Equation and Discussion on Results

Table 7 provides the estimates of the semi-logarithmic hedonic wage equation. There are two specifications under which the estimation is done. The first specification in column (1), presents the basic OLS estimate of the semi-logarithmic wage equation and it includes two risk variables .i.e. FATAL and INJURY along with other determinants of wage. The second specification includes only ENVDANGER as the risk variable along with other independent variables.

Table 7: Results of Estimation of Hedonic Wage Equation

VARIABLES	(1)	(2)
Constant	3.2695* (57.33)	3.3608* (60.30)
FATAL	0.004816* (4.73)	
INJURY	0.01800* (3.75)	
ENV DANGER		0.04696* (2.25)
EXP	0.01117* (3.46)	0.011712* (3.51)
EXP^2	-0.000140*(1.99)	-0.00015* (2.13)
PRIMARY	0.13106* (3.51)	0.14711* (3.82)
SECONDARY	0.11471* (3.17)	0.12685* (3.40)
HS	0.2085* (4.34)	0.17456* (4.75)
GRADUATE	0.17083* (3.33)	0.18699* (3.53)
SC	-0.05506* (2.60)	-0.07633 (2.82)
MIGRANT	-0.06507* (2.48)	-0.059461* (2.73)
UNION	0.050272 (1.22)	0.088922* (2.12)
SIZE	-0.02599 (1.15)	-0.032039 (1.38)
JOBTYPE	-0.05177* (2.03)	-0.067433* (2.57)
TRAINING	-0.03105 (1.45)	-0.038959** (1.77)
PHW	-0.041462** (1.93)	-0.053752* (2.43)
SECU	-0.01594 (0.66)	0.015872 (0.65)
MENT	0.03714** (1.82)	0.048516* (2.32)
FAST	-0.05724* (2.47)	-0.06447* (2.69)
CONTRACTOR	0.294437* (5.04)	0.334490* (5.59)
SUPERVISOR	0.13332* (3.47)	0.137286* (3.46)
FITTER	0.09664* (3.33)	0.103168* (3.43)
TECH	0.078362** (1.94)	0.091750* (2.21)
ASSIST	-0.10924* (3.51)	-0.109878* (3.42)
DIV 1	0.24664* (8.17)	0.251773* (8.09)
DIV 2	0.13442* (4.26)	0.121779* (3.74)
DIV 3	0.20353* (6.79)	0.193217* (6.45)
N	427	427
R- squared	0.5581	0.5262
F-Statistics	19.43	17.81
VSL (in INR)	4,46,91,254 (44.69 million)	
VSI (in INR)	16,70,285 (1.67million)	
Value of Danger (in INR)		4,358

* 1 % level of significance, ** 5 % level of significance, *** 10 % level of significance

Note: Absolute t values are given in parentheses

Source: Author's estimation based on primary data collected from factory workers at Ahmedabad

As predicted by the theoretical model, the result in specification (1) shows that risk variables have positive and significant influence on the wage of the individual. This result implies that in case of Indian labour market, workers do get compensated for the fatal and the non-fatal risks that they face in their work. The VSL and VSI estimated from specification (1) is INR 44.69 million ($ 0.64million) and INR 1.67 million ($ 0.02 million) respectively. The second specification under column (2) includes only ENVDANGER as the risk variable and other determinants of wage. The self-assessed job risk variable is observed to positively and significantly influence individual's earning. As observed in specification (2), the workers who perceive their job to be risky earn an annual premium of INR 4,358 compared to others who don't perceive their jobs to be risky. This value is obtained by multiplying the annual work hours and the mean hourly wage to the coefficient of the danger variable. The value of danger is considerably low when compared to the VSI. This is due to the fact that most workers are unaware of the riskiness of their job.

A worker's experience has a positive and significant influence on his wage. The earnings of a worker increases with his experience up to a certain level after which it starts to decline. Therefore, the EXP^2 variable has a negative and significant relation with the worker's wage. The education variable behaves as predicted for both specification (1) and (2). The dummy for social class of the worker shows whether he belongs to schedule caste or not has significantly negative influence on their wages. This implies that on an average, a worker belonging to a schedule caste earn lower wages in risky jobs compared to workers belonging to other social classes. Similarly, a migrant worker earns significantly lesser in risky jobs compared to the local workers.

Union status of a worker is observed to have a positive effect on his wage implying that workers who are members of labour union tend to earn higher wages. However, the union variable is insignificant for the first specification. On the other hand, for specification (2), union status has a positive as well as significant influence on worker's wage. The size of the workers in a factory does not have any significant influence on the wage for both the specifications. A contractual worker or a worker engaged in temporary job earns significantly less compared to a worker engaged in permanent job. Workers who received on the job training in the same factory where they work presently are observed to earn less compared to others who have completed their training before joining their present job. Although, this variable is not significant for specification (1), it is significant for specification (2) at 5 percent level. For specification (1), it is observed that jobs which necessitate a worker to work hard physically and engage in mental work earn significantly more than other workers. On the other hand, for the second specification, workers earn significantly lower for doing physical work and more for engaging in mental work. This implies that those workers who engage in physical work and perceive their job to be risky earns lower while the opposite is true for workers who does mental work. Workers in those jobs which require them to work fast earn significantly lesser. Job security seems to have no significant effect on wage for both the specifications.

Coming to the job designations, contractors, supervisors, fitters and technicians are paid significantly more compared to all the other job designations while an assistant earns significantly lesser than other job designations. For both the specifications, workers in industrial divisions 1, 2 and 3 earn significantly higher wage compared to workers in the base category which is division 4.

Implications of Using Benefit Transfer Methodology (BTM) for Estimation of VSL

In the introduction section, it has been mentioned that BTM can be used as an alternative to estimate VSL of developing countries without conducting individual VSL study in such countries. However, this methodology has been found to yield biased estimates of VSL for developing countries. This section briefly explains the BTM and examines whether this method yields biased VSL estimates for India.

Under the BTM, VSL estimates are transferred from a developed country to a developing country using a simple formula. If there is a developing country, say A, and a developed country, say B, then the VSL estimate of country B can be transferred to country A using the formula,

$$\frac{VSL^A}{Y^A} = \frac{VSL^B}{Y^B} \qquad \text{.................} \ \mathbf{(4)}$$

Therefore, from (7),

$$VSL^A = \frac{VSL^B}{Y^B} \times Y^A$$

Here, Y denotes the foregone earnings of each country. Equation (4) shows that the ratio of the VSL to the foregone earnings of both the countries is equal. It has to be noted that there are two strong assumptions under which BTM is valid. Firstly, BTM assumes that the risk preferences of individuals in the two concerned countries are equal. Secondly, it assumes that the income elasticity of VSL is equal to unity for both the countries. However, for developing countries, the income elasticity is less than unity. Therefore, transferring VSL estimates from developed countries to developing countries based on these assumptions will yield biased VSL estimate for the developing country.

If BTM is applied and the VSL for India is transferred from a developed nation like USA then we find that the VSL estimate of India is underestimated. The information on foregone earnings is obtained from World Bank and the VSL for USA is obtained from USEPA. Value of foregone earnings of India is \$ 2047.64 (2016 US dollar) and the ratio of the VSL to foregone earnings in the USA is approximately \$ 154.53. Therefore, the predicted VSL for India is estimated to be approximately Rs 21.39 million (\$ 0.31 million). Thus, VSL obtained using BTM approach clearly underestimates the VSL estimates obtained from this study.

Conclusion

This paper presents a hedonic wage study to estimate the value of statistical life and injury for industrial workers in Ahmedabad, India. The study utilises secondary as well as primary information to estimate the VSL. While data on objective job risks are obtained from office of Industrial Safety and Health, Ahmedabad, the information on all the other variables are obtained from primary survey. The information on worker's personal attributes and job characteristics have been collected from 430 male blue-collar workers in 13 selected manufacturing industries of Ahmedabad. The Value of Statistical Life is estimated to be INR 44.69 million (\$ 0.64 million) while the VSI is estimated to be INR 1.67 million (\$0.02 million). These estimates are similar to the values obtained from previous VSL studies on Indian labour market. Thus, this study demonstrates that the workers are compensated for occupational risks.

Since there are only a few VSL studies in developing countries, the present study is an addition to such VSL literature. This study not only provides an updated estimate of VSL for Indian labour market but has also revised the estimation method. The estimation of VSL in this study is done using a slightly different formula compared to previous studies in India. The earlier VSL studies assumed that workers work for 2000 hours annually; however, proper justification for this assumption was not provided. The present study uses a revised value for work hours which is 2160 annual hours of work for estimation of VSL and VSI and a justification for using this value is provided in the paper.

However, this study has certain limitations. Availability of secondary data on job risk by worker's occupation and age is an issue in developing countries. Such data would enable researchers to undertake detailed analysis of the relationship between worker's age and VSL. Since this type of data was unavailable, the influence of worker's age on his VSL could not be examined and hence the estimates of this study may be biased. Certain issues with estimation of VSL such as selectivity bias arising out of heterogeneity in worker characteristics and endogeneity of job risk on wages have not been considered in this study. The impact of insurance benefit on worker's VSL and discount rates for long-term health-related job risks have not been included in this study which may yield biased estimates. Some of these issues will be addressed in future studies.

Health and occupational safety is a very important area but mostly overlooked in developing countries. Even if these regulations are present, they are not well implemented. The estimates of VSL can aid in framing and evaluation of various safety and health policies by the government, international agencies and policymakers in developing countries. VSL can be used for cost-benefit analysis to identify those policies that are economically efficient. Generally, government agencies would prefer to impose those policies for which the benefits exceed the cost. However, since such policies are made in the political domain, policies influencing life and health are likely to reflect the incentives and political power of the policy makers. Thus, VSL can be considered a political variable which can be influenced by those who have political power.

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