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Abstract

This study contributes to the literature by estimating discount rate for environmental health benefits and value of statistical life of workers in India. The discount rate is imputed from wage-risk trade-offs in which workers decide whether to accept a risky job with higher wages. The estimated real discount rate ranges between 2.7 and 3 percent, which is closer to the financial market rate for the study period and consistent with earlier studies from developed nations. The estimated value of life is Rs. 20 (US $ 1.107) million. The results of the study can aid policymakers, international agencies and other researchers in evaluating health projects in India and other developing countries.

Keywords: *Expected length of life, value of statistical life, time preference rate*

JEL Codes: *J17, J28, and J31*

INTRODUCTION

Economic analyses of life saving policies require appropriate discount rate for comparing long-term health benefits. It is, in general, argued that the society's risk less rate of time preference can serve as the discount rate for all benefit components if capital markets are perfect. The issue becomes more complex if capital markets are imperfect and particularly for health benefits because human health/life can not be traded explicitly in an inter-temporal market (Moore and Viscusi, 1990). In this context, the debate is whether one can use the same discounting rate that is used for evaluating other benefit components or one can find a different rate for health benefits.

Many studies have attempted to resolve this issue empirically by estimating the discount rate for health impacts and then compared the estimated rate with market rate of interest for trading financial resources (eg., Atmadja, 2008; Kula, 2004; Van der Pol and Cairns, 2001; and Viscusi and Moore, 1989). These studies are broadly grouped in to: stated preference studies and revealed preference studies. In the former, individuals are asked to evaluate the stylized inter temporal prospects involving real or hypothetical outcomes such as health and life years, while in the latter rates are computed from economic decisions that people make in their ordinary life (see Frederick et al., 2002 for an excellent survey).

Early studies in the revealed preference category examined the consumer's trade-off between the immediate purchase price of electrical appliances and the long-term costs of running them. Estimated rates in these studies vastly exceeded the market rates and varied widely across product categories. Another set of studies, called labor market studies have estimated the discount rates from wage risk trade-offs. They have used three alternate but equally plausible models: discounted expected life years (DELY) model (Moore and Viscusi, 1988), Markov decision (MD) model (Viscusi and Moore, 1989) and life cycle (LC) model (Moore and Viscusi, 1990). The estimated rates in these studies, ranging 2 and 17 per cent, have a more plausible range than consumers' implicit discount range from 17 to 300 per cent for appliance energy efficiency.

Following this tradition, this study attempts to estimate the value of life and the implicit time preference rate that the Indian workers reveal through their willingness to incur the job related fatal risks. It contributes to the discounting literature primarily in two ways. Firstly, the labor market studies using LC model are practically non existent in developing countries and other developed countries except USA. This is the first study in the developing country context utilizing the LC model. Secondly, in the Indian context a few stated preference studies such as Pender (1996) and Atmadja (2008) provide the estimates of discount rate, ranging between 10-70 per cent. A few revealed preference studies such as Kula (2004) and Shanmugam (2006) also provide the estimates of discount rate. This study enables us to check the robustness of the results of past studies, particularly Shanmugam (2006) which uses the DELY model.

The rest of this study proceeds as follows. A brief review of literature is given in the next section. Then we explain the methodology, the data and variables used in the study. Empirical results are presented and discussed in the subsequent section. In the final section, the general conclusions and implications of the study are given.

A BRIEF REVIEW OF LITERATURE

The discount rate is one of the most critical parameters in the benefit-cost analysis. It measures the relative values of various benefits/costs that occur at different points in time and is not surprising therefore that so much controversy has centered on this over the years. In the most theoretical debates about the social discount rate, the background appears to be a Samuelson-Bergson type of social welfare function: SW = f (U_1, U_2, …….U_n), where SW is social welfare that depends upon the(income related) utilities of individuals in the society, U. The change in the society welfare is affected by the changes in individuals' income, Y_i. The total utility function increases as income/consumption increases while marginal utility function decreases as income/consumption increases with constant elasticity. This diminishing marginal utility (DMU) of income/consumption is the main reason for giving greater weigh to present consumption opposed to future consumption (Kula, 2004).

Many models, developed to compute the social rate of time preference (S) including the one employed by Sharma et al., (1991) for India, contain the notion of DMU. Based upon this, the linear formula for S can be expressed as: $S = m + \varepsilon g$, where m is a pure time discount rate, g is the growth rate of per capita real consumption and ε is the negative of the elasticity of marginal utility of consumption (see Markandya and Pearce, 1988 for a lucid derivation of S). If the consumption grows, S will rise above the private discount rate, m. With no growth in per capita consumption, $S = m$. S can be positive even if the consumption is falling as long as $m > |\varepsilon g|$.

The opportunity cost of capital or social return on investment (ρ) can be obtained by looking at the rate of return on the best investment of similar risk that is displaced as a result of undertaking the project in question. It requires an investment to yield a return at least as high as that on the alternative use of funds. This is the basic rationale for a discount based on the opportunity cost. Due to a shortage of capital, such rates are usually very high in developing countries.[1]

[1] A criticism leveled against the opportunity cost discounting is that it implies a reinvestment of benefits at the opportunity cost rate and quite often this is invalid. Therefore, many past studies have applied the weighted discount rate procedure as advocated in Marglin (1967).

If the market is perfect, the social discount rate is simply the market interest that reflects equally the consumer and the producer rates of time preference. If capital market is imperfect the issue becomes more complex, particularly for health benefits because life and health can not traded explicitly in an inter-temporal market.[2] Therefore, as indicated above, various studies have attempted to empirically measure the time preference rate of individual that can be captured by a single discount rate and then compared the estimated rate with the market rate. Broadly these studies are grouped into (i) revealed preference studies and (ii) stated preference studies.

(i) Revealed Preference Studies

In the revealed preference studies, discount rates are estimated by identifying the real-world behaviors that involve tradeoffs between the near future and more distant future. Early studies in this category have examined the consumer's choices among different models of electrical appliances that presented purchasers with a trade-off between the immediate purchase price and the long-term costs of running them. In these studies, the rates implied by consumers' choices vastly exceeded market interest rates and varied widely across product categories (for example, 17-20 percent for air conditioners (Hausman, 1979) and 45-300 per cent for refrigerators (Gately, 1980)).

Later studies have estimated the discount rates from wage risk trade-offs, in which workers decide whether to accept a risky job with a higher wage. These studies employ DELY, LC and MD models. The hedonic wage (HW) approach that rests on Adam Smith's proposition that "risky jobs command compensating wage differentials" forms the basis of these models. In the HW approach, jobs are characterized by various attributes such as levels of risk of accidental death/injury.

[2] In this context, many suggest the use of a risk free consumer lending (treasury bill) as a proxy for S. Some others argue for the adjustment of discount rate (i.e., low rate).

Workers are described by the amount they are willing to accept for different risk levels and employers are characterized by the amount they are willing to offer workers to accept risk levels. An acceptable match occurs when preferred choices of both workers and employers are consistent. Thus, the actual wage embodies a series of hedonic prices for various attributes including accidental risks.

Controlling for other aspects of the job would provide an estimate of the wage premium that workers receive for job risks. Summing this measure across workers can provide and estimated hedonic (i.e. quality-adjusted) value of life/injury. A large number of studies emerged in the literature to provide the estimates of value of life/injury for many countries (see Viscusi (1993) and Viscusi and Aldy (2003) for survey).

Earlier HW studies ignored both discounting and differing duration of life at risk for employees at different ages, as employment risks have been viewed using empirical simplification of a single period model. However, the DELY model includes the expected discounted life year lost (ELYL) variable (instead of job risk) in the standard hedonic model to estimate the impact of changes in expected remaining lifetime on wages. Although this model is simple to estimate, its structure has no formal theoretical basis. However, the MD and LC models have theoretical basis.[3]

Using the DELY approach and the MD approach, Moore and Viscusi (1988) and Moore and Viscusi (1990) found that the estimated the rate of time preference was 10-12 per cent and 11 per cent for US workers respectively. Employing the LC approach, Viscusi and Moore

[3] In the MD model, worker selects the optimal job risks from the wage offer curve where this risk affects the probability of death in each period. In selecting their optimal occupational risks, workers determine their life expectancy. The LC model is explained briefly in methodology section.

(1989) found that the real discount rate for US workers was 2 per cent. Thus, in the labor market studies, the estimated discount rates range from about 2 to 12 per cent.

In the Indian context, Shanmugam (2006) estimated the implicit discount rate (ranging 7.6 – 9.7 per cent) for workers using the DELY approach. Using the consumption approach, Kula (2004) provides the estimates of (i) ε, the elasticity of marginal utility of consumption (using time series data (1965 and 1995) on per capita spending on food, per capita income and prices of food and non-food), (ii) the growth rate of real per capita consumption (g) and (iii) m, the mortality based (pure) time discount rate (it is simply the average death rate for the study period) in India as 1.64 per cent, 2.4 per cent and 1.3 per cent respectively. With these, the social discount rate ($S=m+\varepsilon g$) in India is computed at 5.2 per cent.

(ii) Stated Preference Studies

The stated preference studies adopt four types of experimental elicitation procedures, namely choice tasks, matching tasks, pricing tasks and rating tasks. In a choice task, the individuals are asked to choose between a smaller, more immediate reward and larger, more delayed reward. In the matching tasks, respondents fill in the blank to equate two inter temporal options (e.g. $10 now = $ 12 in one year). In the pricing tasks, each respondent will specify a willingness to pay to obtain (or avoid) an outcome occurring at a particular time. In the case of rating tasks, each respondent evaluates an outcome occurring at a particular time by rating its attractiveness or aversiveness. Interestingly, these studies have used real rewards including money, rice and corn and/or hypothetical rewards: monetary gains and losses, and aversive health conditions. Although there is no theoretical basis for preferring one method to the other, evidence indicates that they yield very different discount rates: negative to infinity (Frederick et al., 2002).

METHODOLOGY

This study utilizes the LC model developed in Moore and Viscusi (1990), which specifies the expected discounted lifetime utility of a worker with T years of remaining life who discounts future utilities at r and selects a job with risk p as[4]:

$$V = \int_0^{T(p)} U^1(Y(p))\, e^{-rt}\, dt \quad (1)$$

The worker's problem is then to choose p in order to maximize his/her expected discounted lifetime utility V. From the first order condition for a maximum, the following equation can be derived:

$$\partial Y/\partial p = -r\,(\partial T/\partial p)\,(U(.)/U_Y)\,[e^{rT(p)} - 1]^{-1} \quad (2)$$

In (2) the left side is the worker's marginal rate of substitution between the current period wages and job risk that depends upon the expected remaining time (T), the discount rate (r) and the effect of risk on longevity ($\partial T/\partial p$). Taking logarithms on both sides of the equation (2) yields:

$$\ln\,(\partial Y/\partial p) = \alpha_i - rT + \varepsilon \quad (3)$$

where ε captures errors in the approximation: $\ln\,(e^{rT}-1)^{-1} \approx -rT$ and the term, α_i (= $\ln\,(-r*\partial T/\partial p*U/U_Y)$ can be approximated by a vector Z that incorporates proxies for differences in tastes. The estimated r will give a direct estimate of the worker's rate of time preference.

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[4] The model assumes that the worker's state-dependent/time separable preferences is $U^j\,(Y^j)$, where Y^j is income in state j=1,2 (in no accident state 1, worker i is healthy and earns a wage Y_i that increases with p and in risky/accidental state 2, worker dies and earns no wage) and the worker's time horizon equals his/her expected remaining lifetime, T that depends on p with longevity a decreasing function of p (i.e., $T_p < 0$).

The empirical strategy involves two steps: in the first stage the following wage equation is specified and estimated using the Non linear Least Square (NLS) method:

$$\ln Y_i = \Sigma_k (\alpha_k R_{ik} p_i + \beta_k R_{ik} p_i^2) + \Sigma_m \gamma_m X_m + u_i. \qquad (4)$$

In (4), R_{ik} is a dummy indicator of the region of residence of worker i. p, the risk term, is entered its linear as well as its quadratic terms and both interacted with regional dummies so that variations in the implicit price of risk arise due to differences in regions and risks. X_m (other determinants of wages) includes job experience, education levels, firm size, and dummy indicators for backward community, supervisory and union status and other non-pecuniary job attributes-whether job provides good security or it has irregular work hours or it requires on the job decision-making. From the estimates of (4), the implicit price for worker i residing at k region ($\partial Y_i/\partial p_i$) can be computed and used as the dependent variable in the implicit price equation that is specified in the second stage as:[5]

$$\partial Y_i/\partial p_i = Z_i \varphi - r^* T_i + \varepsilon_i \qquad (5)$$

In (5), Z is a vector of variables (dummy indicators for education levels, union status, backward community, private employment and owing a house). As the Ordinary Least Square (OLS) may provide biased estimates due to the endogeneity of T, the Two-Stage Least Squares (TSLS) method is used. Then, the discount rate r is computed using the following expression:

$$R=[\partial \ln(Y_i/\partial p_i)/\partial T] =[1/(\partial Y_i/\partial p_i)] \text{ x } [\partial(\partial Y_i/\partial p_i)/\partial T] = r^*[1/(\partial Y_i/\partial p_i)] \quad (6)$$

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[5] Since observations with negative implicit price are lost in the log transformation, the wage risk trade-off $\partial Y_i/\partial p_i$ is used in (2).

DATA AND VARIABLES

This study utilizes the primary data collected by means of a survey conducted in 1990. The survey used the multi-stage random sampling technique to draw the sample observations. First, Madras (later renamed as Chennai) district of Tamil Nadu, a state in southern India was chosen as the study area. In the second stage, the blue-collar male employees in manufacturing industries were considered since they alone faced employment related death risks in the study area from 1987 to 1990. Then, these workers were stratified into 17 groups using their industrial codes at the 2-digit National Industrial Classification (NIC) level. Fixing 1 per cent from each stratum, the total sample size was fixed at 522. Then, 522 workers were drawn randomly for the interview. A maximum sample of four workers from each randomly selected factory was drawn.

The collected data set consists of information on workers' personal as well as enterprise characteristics, including the worker's subjective risk assessment of whether his employment exposes him to dangerous or unhealthy conditions (DANGER). This binary variable takes a value of one if he feels that his job involves risks. The source of data pertaining to job risk is the Administrative Report of the Chief Inspector of Factories, Madras. For the administrative purpose, Chennai district is divided into four divisions/regions (Shanmugam, 1996/7).[6] The sample workers are distributed in all four regions. The administrative report of each division provides data pertaining to the total number of male workers and the number of death and injury accidental cases among them on an annual basis at the 2-digit NIC level.

[6] The first division consists of Mannady, Royapuram, Washermanpet, Basin Bridge and Mint areas. The second division covers Mount, Arumbakkam, and Chindadiripet areas. In the third division, Adyar, Triplicane, Saidapet, Vadapalani and Kodampauk areas are covered. Areas like Guindy, Meenampakkam, and Tiruvanmiyur come under the fourth division. For more details, see Shanmugam (1995).

These risks may vary substantially over the years and can be particularly high when there is a major catastrophe resulting in multiple deaths. Therefore, the average probabilities of fatal risk per 1 lakh workers (p=Risk Measure 1)) over the years 1987-90 were computed and matched to the sample workers, using their industrial codes and job location. Information on the worker's age and sex and remaining life data from life expectancy tables (for males in Chennai District) are used to calculate the remaining life of sample workers (T).

A well-known problem with the use of industry data to measure individual risk is that workers in the same industry may face different risks in different jobs. Therefore, to introduce individual job specific variations in the risk levels, the p is allowed to interact with DANGER in an alternate specification (Risk Measure 2). Table 1 shows means and standard deviations of the study variables. [7]

EMPIRICAL RESULTS

a. The Market Wage Equation Results

Table 2 presents the NLS estimation results of wage equation. The dependent variable is the natural logarithm of hourly wages after taxes (this is computed by assuming 2000 hours worked per year). First, consider the results of the wage equation shown in column 1 of table 2 that uses the fatal risk variable p (Risk Measure 1). Signs and magnitudes of the parameters of almost all variables are largely as expected. Educational dummies are positive and are statistically significant at 1 per cent level. Wages increases with job experience and firm size. The union differential is approximately 32 per cent. Workers belong to backward community (caste) tend to earn more, indicating that they are more

[7] Although the data refers to 1990, its representation is still valid as there are not much change in the nature of jobs and safety regulations in the study area. A recent study by Madheswaran (2004), which uses the data collected from the same sample area, shows that the average fatal risk is 11.35 per 100000 workers.

productive in blue-collar risky occupations. Supervisors earn more, but this result is not strongly supported by t value.

Table 1: Descriptive Statistics of the Study Variables

Variables	Mean (S.D.)	Variables	Mean (S.D.)
Life years lost (in years)	25.058 (6.687)	Supervisor Status (Yes=1, No=0)	0.2701 (0.444)
After tax hourly wage rate (in Rs.)	5.3026 (2.248)	Job security (Yes=1, No=0)	0.6226 (0.485)
Fatal risk per 1 lakh workers (p)	10.441 (9.257)	Decision making (Yes=1, No=0)	0.4617 (0.499)
Indicator for high school education	0.2625 (0.440)	Irregular job hours (Yes=1, No=0)	0.4080 (0.491)
Indicator for HSc education	0.3985 (0.490)	Estimated wage risk trade off	0.1035 (0.082)
Indicator for college degree	0.0766 (0.266)	Indicator for region 1	0.1303 (0.337)
Job experience (in years)	13.952 (7.035)	Indicator for region 2	0.433 (0.496)
Indicator for backward caste	0.6456 (0.478)	Indicator for region 3	0.2989 (0.458)
Indicator for union status	0.5249 (0.499)	Indicator for region 4	0.1379 (0.345)
Firm size	90.964 (273.7)	Indicator for own house	0.4348 (0.496)
Indicator for private job	0.8697 (0.337)	Sample Size	522

Note: The mean value of (fatal risk x Danger) variable is 9.7304 and that of the estimated wage risk trade corresponding this variable is 0.1028.

Workers in the job providing good security receive somewhat more, which is unexpected. However, the higher wages of employees with job security is quite consistent with a greater security associated with upper blue-collar positions. Thus, this variable may be capturing the relative ranking of the worker's job rather than any particular job attribute that is not appropriately compensated. Workers who make on the job decisions and workers having irregular work hours receive more.

The results of primary interest are the estimated effects of the region-job risk interaction variables as they are used to compute the implicit prices. In terms of total effects, they perform well. The linear risk effect is positive and statistically significant at 5 per cent level in all regions, except in fourth region where it is significant only at 10 per cent level. The region-risk squared term is negative and significant in regions 1 and 3, indicating that wage-risk locus is concave. However, this term is not significant in regions 2 and 4.

Evaluating the coefficients of risk variables at the mean wage level and job risk level and multiplying the resulting value by 2000 hours to annualize the figure and by 1 lakh to reflect the scale of the risk variable would yield a trade-off of Rs. 17.89 million per statistical life in region 1. Using the conversion rate provided by the Reserve Bank of India of US $ 1 = Rs. 18.07 in 1990, this amount equals US $ 0.99 million. The life values estimated for regions 2, 3 and 4 are Rs. 19.98 (US $ 1.106) million, Rs. 26.3 (US $ 1.455) million and Rs. 30.2 (US $ 1.67) million respectively. The average value of life for the sample worker is approximately equal to Rs. 20 (US $ 1.107) million. Thus, a significant compensation for job risk is observed in all regions.

Table 2: Non-linear Least Square Estimates of the Market Wage Equation

Variables	Risk Measure 1 (=p)	Risk Measure 2 (=p*DANGER)
	(1)	(2)
Region1 x Job Risk	0.0617 (5.735)	0.0620 (5.765)
Region1 x Job Risk^2	-0.0015 (3.440)	-0.0016 (3.522)
Region 2 x Job Risk	0.0146 (2.072)	0.0196 (2.703)
Region 2 x Job Risk^2	0.0002 (0.509)	0.0000 (0.036)
Region 3 x Job Risk	0.0421 (5.292)	0.0440 (5.330)
Region 3 x Job Risk^2	-0.0008 (2.394)	-0.0009 (2.417)
Region 4 x Job Risk	0.0350 (1.864)	0.0335 (1.807)
Region 4 x Job Risk^2	-0.0006 (0.575)	-0.0005 (0.499)
High School Education	0.3248 (9.383)	0.3335 (9.862)
Higher Secondary Education	0.3815 (11.208)	0.3931 (11.822)
College Education	0.5159 (8.916)	0.5168 (9.088)
Job Experience	0.0343 (16.541)	0.0349 (17.202)
Backward Community	0.2231 (8.062)	0.2219 (8.114)
Union Status	0.2765 (8.677)	0.2607 (8.278)
Firm Size	0.0001 (2.453)	0.0001 (2.120)
Supervisory Status	0.0163 (0.393)	0.0224 (0.545)
Job Security	0.1871 (6.085)	0.2099 (6.893)
Decision-making	0.1799 (4.812)	0.1541 (4.172)
Irregular Work Hours	0.1049 (3.594)	0.0944 (3.259)
R^2 [Adjusted R^2]	0.4678 [0.4488]	0.4798 [0.4612]

Figures in parentheses are absolute t values.

A more or less similar results obtained in column 2 of table 2 where the risk measure 2 (i.e., p x DANGER) is utilized. The value a statistical life is estimated as Rs. 14.9 million, Rs. 20.9 million, Rs. 26.2 million and Rs. 30.2 million in Region1, Region 2, Region 3 and Region 4 respectively. Given that mean values of fatal risk are 15.1, 10.4, 9.9 and 7.2 in respective regions, we can infer that on an average although workers in regions 1 and 2 face more risks than their counterparts in other regions, they demand less compensation for facing risks and so they are more risk-lover.

b. Implicit Price Equation Results

Table 3 displays the TSLS estimation results of (5). The dependent variable ($\partial Y_i/\partial p_i$) in columns 1 and 2 are derived from results in column 1 (risk measure 1) and in column 2 of table 2 (risk measure 2) respectively. In both columns, dummy indicators for education levels influence the implicit price variable positively, but the results are not supported by t values (even at 10 per cent level). Although the union status variable has a positive impact in both columns, its impact is significant at 5 per cent level in column 2. However, it is significant at 10 per cent level in column 1. Since the proportions of union workers in the respective regions are 0.34, 0.55, 0.49 and 0.71 and union dummy has positive coefficient, we can infer that unions are strong enough to bargain to get higher wage premiums for job risks. Although the backward community influences the wage premium positively in both columns, it is significant at 10 percent level only in column 2. The parameter associated with dummy indicator for own home is positive in both columns, but it is significant at 5 per cent in column 2 and at 10 per cent in column 1. The private job indicator has a significant positive impact in both columns.

Table 3: Two Stage Least Square Estimates of Implicit Price Equation

Variables	**Risk Measure 1**	**Risk Measure 2**
	(1)	**(2)**
Constant	0.1284 (6.786)	0.1224 (6.022)
Life Years Lost (-r*)	-0.0030 (4.760)	-0.0028 (4.031)
Discount rate –r	***0.0290***	***0.0272***
High School Education	0.0010 (0.099)	-0.0024 (0.218)
Higher Secondary Education	0.0066 (0.738)	0.0000 (0.005)
College Education	0.0014 (0.099)	-0.0063 (0.403)
Union Status	0.0139 (1.882)	0.0177 (2.235)
Backward Community	0.0104 (1.406)	0.0140 (1.770)
Indicator for Own House	0.0130 (1.810)	0.0169 (2.197)
Private Job	0.0297 (2.813)	0.0260 (2.290)
R^2	0.0845	0.0757

(Absolute t values are in parentheses)

As expected, the effect of life years lost (longevity) variable is negative and statistically significant at 1 per cent level in both columns, providing a strong support for the life cycle model of inter temporal choice. The estimated real discount rate using (6) is approximately equal to 3.0 per cent in column 1 and 2.7 per cent in column 2 of table 3. Therefore, we can reject both extreme alternative hypotheses that the Indian workers exhibit a zero rate and an infinite rate (i.e., workers are myopic) when making the valuation of their future health risks. The bank interest rate on fixed deposits given by private people in India was 12 percent in 1990. However, the interest rate that India has to pay on external loans (i.e., the average interest rate on debt to private creditors such as the World Bank) was only 8 percent in the same year. Thus, the estimated real rate is lower than the nominal interest rate on external debt and bank rate for fixed deposits. If we allow a 4 per cent inflation rate, our estimated real rate is closer to the real rate on external debt.

The equation (5) is essentially a linear demand curve for longevity, where the implicit price of longevity is a declining function of the quantity demanded. Using a willingness to pay (WTP) approach, we can calculate the value of longevity by summing the area under this demand curve as shown in Figure 1. The WTP for longevity T_0 is:

$$V(T)=T_0(\partial W/\partial p(T_0))+(1/2)T_0(\partial W/\partial p(0)-(\partial W/\partial p(T_0)) \qquad (7)$$

Using the coefficients in column 1 (column 2) of table 3 and the average values of the explanatory variables given in table 1, the implicit price when T=0 (i.e., $\partial Y/\partial p(0)$) equals 0.1769 (0.1696 in column 2) and when T_0=25 equals 0.102 (0.0996). These values can be substituted in (7) to get the amount that a worker is willing to sacrifice which is approximately 5.35 (5.10) rupees in hourly wages for a risk exposure of 25 additional years of life. In terms of annual premium with a present value, the same worker would accept Rs. 10720 (Rs. 10230) for putting 25 years of longevity at risk. The worker with a risk exposure of one additional year of life (T_0=1) would accept the annual compensation with a present value of approximately Rs. 360 (Rs. 340). This WTP is fairly substantial as it constitutes about 3.4 (3.2) per cent of annual earnings.

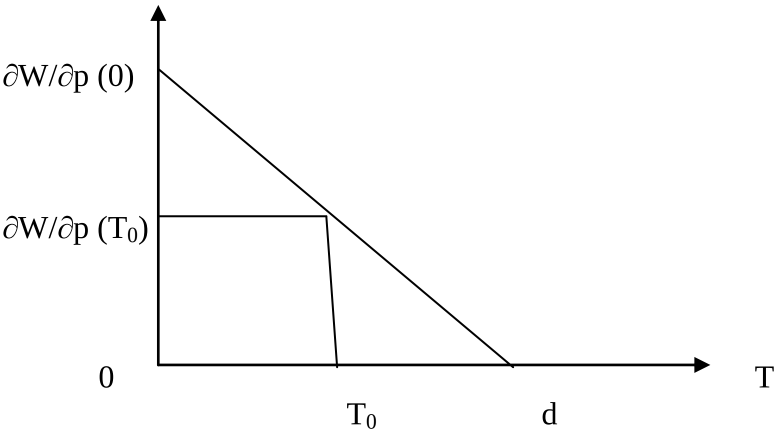

Figure 1: Demand Curve for Longevity

Finally, we can compare our estimated discount rate with those from past (selected) studies that consider health/life years (Table 4).

Table 4 Summary of (selected) Studies Estimating Implicit Discount Rates

Study/Year	Category	Good (s)	Elicitation Method	Annual Discount rate
Atmadja (2008)*	Stated Preference	Money and Health	Choice	10-25%
Chapman (1996)	Stated Preference	Money and Health	Matching	Negative to 300 %
Dreyfus and Viscusi (1995)	Revealed Preference	Life Years	Choice	11-17 %
Ganiats et al., (2000)	Stated Preference	Health	Choice	Negative to 116 %
Johanneson and Johansson (1997)	Stated Preference	Life Years	Pricing	0-3 %
Kula (2004)*	Revealed Preference	Food and mortality	Pricing	5.2%
Loewenstein (1987)	Stated Preference	Money and Pain	Pricing	-6 to 212 %
Moore and Viscusi (1988)	Revealed Preference	Life Years	Choice	10-12 %
Moore and Viscusi (1990)	Revealed Preference	Life Years	Choice	2 %
Pender (1996)*	Stated Preference	Rice	Choice	45%-70%
Shanmugam (2006)*	Revealed Preference	Life Years	Choice	7.6-9.7 %
Van der Pol and Cairns (1999)	Stated Preference	Health	Choice	7 %
Van der Pol and Cairns (2001)	Stated Preference	Health	Choice	6-9 %
Viscusi and Moore (1989)	Revealed Preference	Life Years	Choice	11 %

* Studies relating to India.

In almost all stated preference studies (using hypothetical choices) the implied discount rates vastly exceeded market interest rates and differed substantially across studies (eg., Chapman, 1996; Ganiats et al., 2000; Loewenstein, 1987). However, in studies such as Johannesson and Johansson (1997) and Van Der Pol and Cairns (1999) the estimated rates are closer to the market rate. Interestingly, the rates provided in the revealed preference studies considering the life years are broadly consistent with real market interest rate. Viewed in this light, our rate seems reasonable as it falls in the range (2-17 per cent) estimated in the existing revealed preference studies.

SUMMARY AND POLICY IMPLICATIONS

In this paper an attempt has been made to estimate the statistical value of life of Indian workers and the implicit discount rate that they reveal through their choice of job risk. Results of the study indicate that workers in the sample is willing to accept an annual compensation with a present value of Rs. 10720 for putting 25 years of longevity at risk and Rs. 360 for putting one additional year at risk. This constitutes about 3.4 percent of annual income of an average worker. The estimated implicit value of one's future life is about Rs. 20 million in 1990. When we convert our estimates in 1990 US dollars, we arrive at the value of US $ 1.107 million. Viscusi (1993) listed almost all existing studies on life values and found that the range of value per statistical life (in 1990 dollars) was US $ 0.6 – 16.2 million in the United States, Britain, Canada, Australia and Japan. The estimated value of life of our study is lower than values from developed nations. However, our value is closer to the estimated values from developing nations such as Taiwan (ranging from US $ 0.135 to 0.589 million in 1990 dollars).

Another notable result is that the Indian workers discount future life years at a real rate of 3.0 percent. Although this real rate with respect to health risk was below the nominal market rate on debt to private creditors of 8 percent in 1990, it might be equivalent to the real rate of return to capital in India. Moreover, the estimated rate falls in the

2-17 percent range and it is consistent with earlier revealed preference studies from developed nations and another Indian labor market study by Shanmugam (2006). Thus, the results of the study provide no empirical support for utilizing a separate rate of discount for health benefits of environment/development policies in developing countries like India.

Since some changes have happened in the macroeconomic conditions (i.e., per capita income increased), including social profiles of the country, one may argue that the rate obtained in this study using the data drawn in 1990 may be biased upward. However, currently because of higher inflationary situation, the interest rates are continuously increased to more than 9 per cent. Therefore, our rate seems to be valid. We hope our estimates can aid policy makers, international agencies and researchers in evaluating health projects in India and other developing countries. They can also be used to carry out comparisons with values obtained for developed nations.

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