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Research Article

Discount Rate for Health Benefits and the Value of Life in India

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This study contributes to the literature by estimating discount rate for 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 varies across regions ranging 2.4–5.1 percent, which is closer to the financial market rate for the study period. The estimated value of a statistical life is Rs. 20 (US $ 1.107) million. The results thus provide no empirical support for utilizing a separate rate of discount for health benefits of life-saving policies in developing countries like India.

1. Introduction

A debate in the discounting rate literature 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 interest rate (e.g., [1, 2]). These studies are broadly grouped in to stated preference studies and revealed preference studies. In the former, individuals are asked to evaluate the stylized intertemporal 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 [3] 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. For instances, Hausman [4] found 17–20 per cent for air conditioners and Gately [5] showed 45–300 per cent for refrigerators. 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 [6], Markov decision (MD) model [7], and life cycle (LC) model [8]. The wage responses to the variation in life years at risk provide the direct estimates of discount rates that workers apply to their future utility in these models. Interestingly, the estimated rates in these studies, ranging 2 and 17 per cent, have a more plausible range than consumers' implicit discount range for appliance energy efficiency.

This study aims 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 nonexistent 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 [9] and Atmadja [1] provide the estimates of discount rate, ranging between 10–70 per cent. A few revealed preference studies such as Kula [2] and Shanmugam [10] also provide the estimates of discount rate. This study enables us to check the robustness of the results of past studies, particularly Shanmugam [10] which uses the DELY model and estimates the rate ranging 7.6–9.7 per cent. The rest of this study proceeds as follows. Section 2 outlines the methodology, and Section 3 explains the data and variables used in the study. Section 4 discusses the empirical results, while Section 5 provides the concluding remarks.

2. Methodology

This study utilizes the LC model developed in Moore and Viscusi [8], 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: $V = \int_0^{T(p)} U^1(Y(p))e^{-rt}dt$ (the model assumes that the worker's state-dependent/time separable preferences are $U^j(Y^j)$, 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., $T_p < 0$)). Taking logarithms on both sides of the first order condition for a maximum yields: $\ln(\partial Y/\partial p) = \alpha_i - rT + \varepsilon$, where ε captures errors in the approximation: $\ln(e^{rT} - 1)^{-1} \approx -rT$ and the term, $\alpha_i (= \ln(-r^* \partial T/\partial p^* U/U_Y)$ 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. The empirical strategy involves two steps: in the first stage the following wage equation is specified and estimated using the Nonlinear Least Square (NLS) method:

$$\ln Y_i = \sum_k (\alpha_k R_{ik} p_i + \beta_k R_{ik} p_i^2) + \sum_m \gamma_m X_m + u_i, \quad (1)$$

where R_{ik} is a dummy indicator of the region of residence of worker i. p, the risk term, is entered in 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 nonpecuniary 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 (1), 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 (since observations with negative implicit price are lost in the log transformation, the wage-risk tradeoff $\partial Y_i/\partial p_i$ is used in (2)):

$$\frac{\partial Y_i}{\partial p_i} = Z_i \varphi - r^* T_i + \varepsilon_i, \quad (2)$$

where Z, a vector of variables (dummy indicators for education levels, union status, backward community, private employment, and owing a house). As the 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:

$$\begin{aligned} r &= \left[\frac{\partial \ln(\partial Y_i/\partial p_i)}{\partial T}\right] \\ &= \left[\frac{1}{(\partial Y_i/\partial p_i)}\right] \times \left[\frac{\partial(\partial Y_i/\partial p_i)}{\partial T}\right] \\ &= r^* \left[\frac{1}{(\partial Y_i/\partial p_i)}\right]. \end{aligned} \quad (3)$$

3. Data and Variables

This study utilizes the primary survey data collected from 522 blue-collar male employees in 17 manufacturing industries in Madras district (in southern India, later renamed as Chennai) in 1990. The collected data set consists of information on workers' personal as well as firm characteristics, including the worker's subjective risk assessment of whether his job 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, Chennai. For the administrative purpose, the sample district is divided into 4 divisions/regions and the respondents are distributed in all regions (see Shanmugam [10, 11] for details of sampling procedure, etc. Number of samples from region 1, region 2, region 3, and region 4 are 68, 226, 156, and 72, resp.). The administrative report of each division provides data pertaining to the total number of male workers and the number of death/injury accidental cases among them on an annual basis at the 2-digit NIC level.

Since these risks varied widely over the years and were particularly high when there was a major catastrophe resulting in multiple deaths, the average probabilities of fatal risk per 100,000 workers (p = risk measure 1) over 1987–1990 were computed and matched to the sample workers, using their industrial code and location. Worker's age, sex, and life expectancy tables were used to compute T (remaining life of worker). 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). Column 1 of Table 1 shows means and standard deviations of the study variables (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 [12], which uses the data collected from the same sample area, shows that the average fatal risk is 11.35 per 100000 workers.)

4. Empirical Results

Table 1 presents the NLS estimation results of (1). The dependent variable is the natural logarithm of hourly wages

Table 1: Nonlinear least square estimates of the market wage equations.

Variables	Mean [S.D] (1)	Risk measure 1(= p) (2)	Risk measure 2 (= p* Danger) (3)
Region 1 × job risk	—	0.0617 (5.735)	0.0620 (5.765)
Region 1 × job risk^2	—	−0.0015 (3.440)	−0.0016 (3.522)
Region 2 × job risk	—	0.0146 (2.072)	0.0196 (2.703)
Region 2 × job risk^2	—	0.0002 (0.509)	0.0000 (0.036)
Region 3 × job risk	—	0.0421 (5.292)	0.0440 (5.330)
Region 3 × job risk^2	—	−0.0008 (2.394)	−0.0009 (2.417)
Region 4 × job risk	—	0.0350 (1.864)	0.0335 (1.807)
Region 4 × job risk^2	—	−0.0006 (0.575)	−0.0005 (0.499)
Dummy for high school education	0.2625 [0.440]	0.3248 (9.383)	0.3335 (9.862)
Dummy for HSc education	0.3985 [0.490]	0.3815 (11.208)	0.3931 (11.822)
Dummy for college degree	0.0766 [0.266]	0.5159 (8.916)	0.5168 (9.088)
Job experience in years	13.952 [7.035]	0.0343 (16.541)	0.0349 (17.202)
Indicator for backward caste	0.6456 [0.478]	0.2231 (8.062)	0.2219 (8.114)
Indicator for union status	0.5249 [0.499]	0.2765 (8.677)	0.2607 (8.278)
Firm size	90.96 [273.66]	0.0001 (2.453)	0.0001 (2.120)
Indicator for supervisor status	0.2701 [0.444]	0.0163 (0.393)	0.0224 (0.545)
Indicator for job security	0.6226 [0.485]	0.1871 (6.085)	0.2099 (6.893)
Indicator for decision making	0.4617 [0.499]	0.1799 (4.812)	0.1541 (4.172)
Indicator for irregular job hours	0.4080 [0.491]	0.1049 (3.594)	0.0944 (3.259)
Indicator for private job	0.8697 [0.337]	—	—
Indicator for own house	0.4348 [0.496]	—	—
R^2 [Adjusted R^2]	—	0.4678 [0.4488]	0.4798 [0.4612]

Note: Mean (S.D) of after tax hourly wage (W) is 5.3026 (2.248) and job-related fatal risks, p is 10.441 (9.257). Mean value of (p× Danger) variable is 9.7304. Figures in parentheses are absolute t values.

after taxes (this is computed by assuming 2000 hours worked per year). In column 2 of Table 1, the fatal risk p (risk measure 1) interacts with four regional dummies. 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 increase with job experience and firm size. The union differential is approximately 32 per cent. Workers who belong to backward community tend to earn more, indicating that they are more productive in blue-collar risky jobs. Supervisors earn more, but this result is not strongly supported by t value. Workers in jobs providing good security receive somewhat more, which is unexpected (however, 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 also receive more.

The results of primary interest are the effects of the region-job risk interaction terms. The linear risk effect is positive and statistically significant at 5 per cent level in all regions, except in region 4, 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 and job risk levels and multiplying the resulting value by 2000 hours to annualize the figure and by 100,000 to reflect the scale of p yields a trade-off of Rs. 17.9 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 $ 1.11) million, Rs. 26.3 (US $ 1.46) million and, Rs. 30.2 (US $ 1.67) million respectively. The average value of life is Rs. 20 (US $ 1.107) million (Viscusi [13]' survey showed that the range of value of life (in 1990 dollars) was US $ 0.6–16.2 million in the United States, Britain, Canada, Australia, and Japan. Although the estimated value of life of our study is lower than values from developed nations, it is closer to the estimated values from developing nations such as Taiwan (ranging from US $ 0.135 to 0.589 million.)) More or less similar results are obtained in column 3 of Table 1 where the risk measure 2 is utilized. The value life of workers in respective regions is estimated as Rs. 14.9 million, Rs. 20.9 million, Rs. 26.2 million, and Rs. 30.2 million. 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.

Table 2: Two-stage least square estimates of implicit price equations.

Variables	(1)	(2)	(3)	(4)
Constant	0.1284 (6.786)	0.1224 (6.022)	0.1273 (6.912)	0.1212 (6.225)
Life years lost ($-r^*$)	−0.0030 (4.760)	−0.0028 (4.031)	—	—
Discount rate (r)	*0.029*	*0.0272*	—	—
$-r^*\times$ region 1	—	—	−0.0048 (7.009)	−0.0052 (7.140)
r in region 1	—	—	*0.047*	*0.051*
$-r^*\times$ region 2	—	—	−0.003 (4.915)	−0.0026 (4.051)
r in region 2	—	—	*0.030*	*0.026*
$-r^*\times$ Region 3	—	—	−0.0026 (4.219)	−0.0024 (3.705)
r in region 3	—	—	*0.025*	*0.024*
$-r^*\times$ region 4	—	—	−0.0012 (1.654)	−0.0010 (0.488)
r in region 4	—	—	*0.012*	*0.010*
High school education	0.0010 (0.099)	−0.0024 (0.218)	0.0073 (0.751)	0.0055 (0.529)
Higher secondary education	0.0066 (0.738)	0.0000 (0.005)	0.0103 (1.197)	0.0046 (0.506)
College education	0.0014 (0.099)	−0.0063 (0.403)	0.0057 (0.399)	−0.0014 (0.094)
Indicator for own house	0.0130 (1.810)	0.0169 (2.197)	0.0084 (1.202)	0.0105 (1.423)
Union status	0.0139 (1.882)	0.0177 (2.235)	0.0053 (0.737)	0.0062 (0.807)
Backward community	0.0104 (1.406)	0.0140 (1.770)	0.0096 (1.346)	0.0125 (1.647)
Private job	0.0297 (2.813)	0.0260 (2.290)	0.0345 (3.324)	0.0329 (2.999)
R^2 [Adjusted R^2]	0.085 [0.070]	0.076 [0.061]	0.151 [0.133]	0.170 [0.152]

Note: Mean values are 25.058 for life years lost variable and 0.1035 for estimated wage-risk trade-off from column 2 of Table 1 (0.1028 from column 3 of Table 1). Absolute t values are in parentheses.

Table 2 displays the TSLS estimation results of (2). The dependent variable ($\partial Y_i/\partial p_i$) in columns 1 and 2 are derived from results in column 2 and in column 3 of Table 1, respectively. In both columns, the education dummies are not significant even at 10 per cent level. Union dummy has positive parameter in both columns, but it is significant at 5 per cent level only in column 2 (in column 1 it is significant at 10 per cent). 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.

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 intertemporal choice. The estimated real discount rate using (3) is approximately equal to 3.0 per cent in column 1 and 2.7 per cent in column 2 of Table 2. 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 rate on fixed deposits given by private people in India was 12 per cent in 1990. However, the interest rate that India has to pay on external loans was only 8 per cent in 1990. 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.

Equation (2) is 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 (see [8] for details). Using the coefficients in column 1 (column 2) of Table 2 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 the formula for computing WTP for longevity ($V(T) = T_0(\partial Y/\partial p(T_0)) + (1/2)T_0(\partial Y/\partial p(0) - \partial Y/\partial p(T_0))$) 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.

To get region specific rates, we can now allow the region dummies to interact with T in columns 3 and 4 of Table 2. Interestingly almost all the interaction terms are negative and statistically significant at 1 per cent level except the interaction of region 4. However, it is significant at 10 per cent level in column 3. Using the results in column 3 (4), the estimated real discount for workers in region 1 is 4.7 (5.1) per cent. The estimated rate is 3 (2.6) per cent for region 2, 2.5 (2.4) per cent for region 3 and 1.2 (1) per cent for workers in region 4. Thus, the rates vary across regions. Results indicate that on average workers with larger wage-risk trade-offs (or with less risk) use less r than workers with smaller wage-risk trade-offs (or with larger risk). That is, rich uses less r than poor.

5. Summary and Conclusions

The most notable result of the study is that the Indian workers discount future life years at a real rate of 2.4–5.1 per cent. Although this rate with respect to health risk was below the nominal market rate on debt to private creditors of 8 per cent in 1990, it might be equivalent to the real rate of return to capital in India. Interestingly the estimated rates of this study are close to the rates estimated by another Indian labor market study by Shanmugam [10]. Thus, the result provides no empirical support for utilizing a separate rate for health benefits of life-saving policies in developing countries like India.

A recent survey by Zhuang et al. [14] shows that developing nations apply higher discount rate (8–15 per cent) than developed nations (3–7 per cent). Our finding that rich uses lower rate than poor is also consistent with this. Since some changes have happened in the macroeconomic conditions (i.e., per capita income increased), including low interest rate regime and 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.

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