Estimating Social Time Preference Rate for India: Lower Discount Rates for Climate Change Mitigation and other Long Run Investment Projects*

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Abstract: This paper provides estimates of social time preference rate for the appraisal of investment projects in India, It uses generalized Ramsay rule that accounts for impatience and wealth effects and precautionary effects of uncertain future consumption on rate of discount.Using relevant data from different sources for India, all three components of Ramsey rule mentioned above are estimated. Two approaches: (i) equal absolute sacrifice approach and (ii) Euler equation approach from optimal Ramsey growth models are used for estimating the elasticity of social marginal utility of consumption, a crucial parameter that determines both the wealth and precautionary effects. Estimates of social time preference rates for India are obtained as 8 percent and 6 percent respectively with original Ramsey rule and generalized Ramsey rule. Estimates of rates of discount for India based on further extended Ramsey rule accounting for uncertainty and persistence or correlation of future growth rates may suggest a term structure of declining discount rates. These rates could be 8, 6 and 4 percent respectively for projects with gestation periods 30, 50 and more than 100 years.

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1 Introduction

Social time preference rate is an important national parameter used in investment project appraisal by the government. In an economy with perfect capital markets, the literature[1] shows that the socially efficient discount rate can be estimated in three different ways. First, as the interest rate observed in financial markets, that reveals important information about society's willingness to transfer wealth to the future. Second, as the marginal rate of return on productive capital in the economy and third, as the welfare-preserving rate of return on savings which guarantees that reduction in current welfare is more than compensated for by increase in the future welfare.

In an economy with imperfect capital markets, the welfare preserving rate of interest which is society's or government's time preference rate could be lower than either interest rate observed in the financial markets or the rate of return on investment. It is because that uncertainty associated with an individual's future consumption plans makes individual rationality in relation to inter-temporal choice unreliable. Therefore, an individual's preferences for saving that are revealed through the market may be different from the society's preferences for savings. There are externalities of capital accumulation, which a competitive capital market cannot take into account in determining the time preference rate. Failure of the capital market to take into account these externalities may result in a savings rate less than the optimal level in the economy. Social rate of discount is the rate associated with that level of savings which society chooses as the optimal one.

The two well-known methodologies of investment project appraisal: UNIDO[2] and OECD[3] methods recognize this. The UNIDO and OECD methods call the social time preference rate as social rate of discount and consumption rate of interest respectively. The methodology for estimating social time preference ratedescribed in the next section identifies three components of

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[1] See Gollier (2012).
[2]See Sen, Marglin and Dasgupta (1972)
[3]See Little and Mirrlees (1972)

social time preference rate: impatience effect, wealth effect and the effect of uncertainty of future state of the economy (precautionary effect). The impatience effect is measured as pure rate of time discount or utility rate of discount because individuals value future utility at lower rate than current utility. It could be due to their life uncertainty in future or due to their impatience to foresee the importance of future in relation to present. The wealth effect is due to the inter-temporal welfare effects of positive rate of growth in the economy. Positive rate of growth means that the current generation is poorer than the future generation and therefore, the current society could show the aversion to the inequality of distribution of income over time. Uncertainty effect is due to uncertainty of future rate of growth in the economy, and uncertain state of the economy in the very long run due to problems like climate change, unforeseen catastrophic events like wars, species extension, environmental un-sustainability etc.

Original Ramsey formula[4] for the consumption rate of discount accounting for both impatience and wealth effects has been extended to account for uncertainty of future consumption and growth. This extension is made in two stages[5]. First, by using the assumption that consumption next year is a random variable which is independently and identically normally distributed with known mean and variance. It results in a constant lower rate of discount than that is given by original Ramsey formula. Second, by using the assumption that shocks to consumption growth are positively correlated overtime or rate of growth of consumption is independently and identically distributed with unknown parameters. This extension shows declining rate of discount over time. Several authors[6] have dealt with this problem of lower and declining discount rates, especially in the context of considering very long run effects on future growth of consumption arising out of climate change problems and other catastrophic effects.

The following Section 2 describes the generalized Ramsey formula and provides a review of available estimates of social time preference rates for different countries made using this formula. Section 3 discusses the methodologies of estimating the elasticity of social marginal utilityof income and provides estimates of it for Indian economy. Section 4 describes the estimate of individuals' pure rate of time preference using Census of India Life Tables data.

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[4] See Ramsey (1928)

[5] See Gollier (2012) for more details.

[6] See Arrow et al. (2014), Weitzman (1998, 2001,2004), Gollier and Hammit (2014), Nordhaus (1994,2007)

Section 5 discusses about the rates of growth of income and population in India and provides an estimate of the rate of growth of per capita income in India. Section 6 presents the estimates of social time preference rates for India while Section 7 provides conclusion.

2. Generalized Ramsey Rule

Original Ramsey rule as explained by equation (1) decomposes the social time preference rate as impatience effect (p) and the wealth effect (-vg)

$$r = p + (-vg) \qquad (1)$$

where p is pure rate of time discount, v is elasticity of social marginal utility of consumption and g is rate of growth of consumption.The generalization of Ramsey rule for accounting of uncertainty of future consumption yields the extended Ramsey formula as

$$r = p - v\text{g} - 0.5v^2\sigma^2 \qquad (2)$$

whereg and $\sigma^2$are respectively mean and variance of probability distribution of rate of growth.Equation (2) accounts for impatience effect (p), wealth effect (-vg) and uncertainty of future consumption and growth $(-0.5v^2\sigma^2)$[7]

Ramsey rule has been a basis for calibrating discount rates used by different countries and suggestions of different authors in the literature. Gollior (2012) has calibrated extended Ramsey rule given in equation (2) for different countries including India assuming estimates of p and v as 0 and 2. He has obtained the country specific estimates of g and σ^2 using time series data as shown in Table 1. China is shown to have highest rate of discount of 14.82 percent followed by South Korea, 10.41, Taiwan, 9.93 and India, 6.61 forming a range of 15-6 percent for the emerging economies. Among the developed countries Japan is shown to have the highest discount rate of 4.47 percent forming a range of 3-5 percent for this block of countries that includes USA, Germany, UK and Japan.

Table 1: Country-specific Discount Rate Computed from the Extended Ramsey Rule using the Historical Mean g and Standard Deviation σ of Growth Rates of Real GDP Per capita 1969–2010

Country	g (%)	σ^2(%)	r (%)
USA	1.74	2.11	3.35
Germany	1.76	1.83	3.42
UK	1.86	2.18	3.57

[7] See Gollior (2012) and Murty et al. (2017) for details about the derivation of generalized Ramsey rule.

Japan	2.34	2.61	4.47
China	7.60	3.53	14.82
South Korea	5.38	3.40	10.41
Taiwan	5.41	5.20	9.93
India	3.34	3.03	6.61
Russia	1.54	5.59	2.14

Source: Gollier (2012)

In many of the estimates of rate of discount obtained in different studies the values used for impatience effect (p) and inter-temporal inequality aversion (v) respectively range from 0-1.5 percent and 1 - 2. Gollier (2012) has used values of 0 and 2 for calibrating Ramsey formula for different countries including India as reported in Table 1. Weitzman[8] suggests using value 2 percent for both p and g and 2 for v to compute rate of discount as 6 percent for climate change mitigation projects. Instead Nordhaus[9] suggests 5 percent rate of discount using 1 percent for impatience. Stern suggested 1.4 percent rate of discount using 0.1, 1.3 and 1 percent respectively for p, g and v.

There are many theoretical arguments in the literature providing for declining term structure of discount rate over time. Most are related to uncertainty and persistence in either growth or discount rates. If growth of consumption is interrelated overtime meaning that current growth rate determines the future growth rate or growth is subjected to persistent changes, it is shown that there is a case for declining discount rates over time[10].Wietzman (2001) has shown that the responses in a survey of the opinions of 2,160 economists, about the possible rate of discount for evaluating investment projects with long term benefit and cost profiles such as investments for climate change mitigation form gamma distribution. He has found out empirically that the second, non-exponential parameter of the gamma distribution plays, or at least should play an extremely significant role in actual long-term discounting. Wietzman has found that the aggregate responses from the panel of experts have a probability distribution with mean $\mu = 4$ percent per annum and standard deviation $\sigma = 3$ percent per annum. Using these numerical values, he has calibrated his model of gamma discounting to arrive at a schedule of discount

[8]See Weitzman (2007)
[9]See Nordhaus (2008)
[10] See Gollier (2012)

rates to be used for evaluating climate change investments as given in Table 2. This table shows that the discount rate uncertainty generates declining effective discount rate schedule for evaluating long term environmental projects.

Table 2: Calibrated Discount Rates for Evaluating Long Run Investments

Time Period (Years)	Name	Marginal Discount Rate (%)
1-5	Immediate Future	4
6-25	Near future	3
26- 75	Medium Future	2
76- 300	Distant Future	1
300 -	Far Distant Future	0

Source: Wietzman (2001)

3. Methods ofEstimation of Elasticity of Social Marginal Utility of Income

3.1. Methods of Estimation

There are four methods of estimating the elasticity of social marginal utility of income (v) considered in the literature. They are (i) equal absolute sacrifice approach (ii) Euler equation approach from optimal Ramsey growth models, (iii) the want independent approach of Frisch based on estimates of consumer demand systems and (iv) the subjective wellbeing approach using directly observed individuals/households responses of subjective wellbeing through survey methods. Methods (ii) and (iii) assume that there is a perfect capital market in the economy. A paper by Groom and Maddison (2013) attempting a meta-analysis of estimates of v for UK based on these four approaches, has recommended an estimate of 1.5 for this parameter. In the following the estimation of elasticity of social marginal utility of income (v) is attempted for India using two approaches: (i) equal absolute sacrifice approach and (ii) Euler equation approach from optimal Ramsey growth models,

3.2Revealed Preference Method of Equal Absolute Sacrifice

An estimate of the elasticity of social marginal utility (v) of income could be obtained by modeling Government behavior manifested in the form of policies that affect the distribution of income in the economy. The Government uses tax instruments: income and commodity taxes to bring the desired income distribution in the economy. The Government may resort to progressive taxation and pro poor expenditure policies to achieve its objective of income distribution in the economy. A number of studies since Stern (1977) provide estimates of v for some countries especially UK and some other European countries using revealed preference method of equal absolute sacrifice[11]. Earlier estimates of v for India using this method could be found in Murty (1982) and Murty and Goldar (2007). A method of estimation of v implicit in the tax policies of Government using equal absolute sacrifice approach is described as follows.

Assume that the Indian tax structure is based on the 'principle of equal absolute sacrifice'. This supposes that the social welfare loss attached by the government to the various amounts of tax it collects from the individuals in different income/expenditure groups is identical. Given the assumption of diminishing marginal utility of income, this principle implies that people with higher incomes will pay higher absolute amounts of taxes resulting in progressive taxation of income. If the tax levied on income Y is T (Y) and utility of income is U (Y), the absolute sacrifice of utility implies

$$U(Y) - U\big(Y - T(Y)\big) = Constant\ for\ all\ Y\ and\ T(Y) > 0 \qquad (3)$$

Differentiating (3) with respect to Y gives (4)

$$\frac{dU(Y)}{dY} - \frac{dU\big(Y-T(Y)\big)}{dY}\left(1 - \frac{dT(Y)}{dY}\right) = 0 \qquad (4)$$

Define $U(Y) = \dfrac{AY^{1-v}}{1-v}$ (5)

where, v is the elasticity of marginal utility with respect to income, which is constant. It follows from (5)

$$\frac{dU(Y)}{dY} = AY^{-v} \qquad (6)$$

Substituting (6) in (4) and taking logarithms (4) could be written as

$$\ln\left(1 - \frac{dT(Y)}{dY}\right) = v\ln\left(\frac{Y}{Y-T(Y)}\right) \qquad (7)$$

Given the data on pre-tax and post-tax incomes Y and (Y-T(Y)) and marginal rates of taxes $\frac{dT(Y)}{dY}$ for a representative sample of individuals in the economy, equation (7) could be estimated to obtain the estimate of v.

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[11] See Groom and Maddison (2013)

Incidence of Commodity and Income Taxes in India

Incidence of commodity taxes in India by fractile groups of monthly per capita expenditure (MPCE) classes and 15 commodity groups for both rural and urban sector is estimated.The National Sample Survey (NSS) consumer expenditure data of 68th round, 2011-2012 and the information about state Vat rates and central excise or Mod Vat rates for the year 2013-14 are used for this purpose. The estimates of state vat rates are obtained as averages of rates in 10 major states in India. Since commodity groups considered for tax purposes is much broader than the NSS commodity groups, an attempt is made to match the NSS groups with tax groups after careful examination.

Tables A1 and A2 in Appendix A provide frequency distribution of NSS sample households, and estimates of commodity tax liability T(Y) and marginal tax rates $T^{/}$ (Y) by monthly per capita expenditure (Y) classes respectively for rural and urban sectors in India. Given the data from these tables, equation (7) is estimated using pooled data of both rural urban sectors. Since there is a frequency distribution of sample households with computed relative frequencies, weighted least squares method or regression for grouped data is used for estimation. Table 3 reports the estimated equation. The estimates of marginal tax rates reported in these tables reveal that commodity taxes (central excise plus state vat) are not consistently progressive as the MPCE increases up to median level and become regressive after words. This resulted ina lower estimateof v equivalent to -0.916.

Table 3: Estimate of Elasticity of Social Marginal Utility (v) Implicit in Commodity Taxes in India

Variable	Coefficient	Std Error	t-value	R^2
ln(Y/(1-T(Y))	-0.916	0.060	-15.337	0.937
D	0.014	0.013	1.130	

Source: Estimated as explained in the text.

Incidence of income taxes in India is estimated using income tax schedules for the assessment years 2012-13, 2013-14 and 2014-15. Tables A3, A4 and A5in Appendix A provide estimates of tax liability and marginal tax rates for gross income classes respectively for the assessment years 2012-13, 2013- 14 and 2014-15.Given that income tax schedules reported in these tables provide frequency distribution of tax payers by taxable income groups, least squares regression for grouped data is used for estimating equation (7). Estimates are made using data for pooled time series cross section data of three assessment years considered. The pooled time series cross section data is expressed at constant prices of assessment year 2014-15. Table (4) provides estimate of equation (7) in this case. The estimate of v based on pooled data of three assessment years is obtained as -1.748.

Table 4: Estimate of Elasticity of Social Marginal Utility (v) Implicit in Income Taxes in India

Variable	Coefficient	Std Error	t-value	R^2
ln(Y/(1-T(Y))	-1.748	0.172	-10.190	0.888
d1	0.021	0.014	1.490	
d2	-0.023	0.013	-1.720	

Source: Estimated as explained in the text.

3.3Standard Ramsey Optimal Growth Model and Estimation of Elasticity of Social Marginal Utility (v)

Consider an economy producing a commodity X_t using capital, K_t and labor L_t at time t. The production function of X_t is given by

$$X = F(K_t, L_t) \qquad (8)$$

F is concave and an increasing and continuously differentiable function of each of its variables with $\delta X_t / \delta K_t \geq 0$ and $\delta X_t / \delta L_t \geq 0$

Dividing (8) throughout by L_t we have

$$x_t = f(k_t) \text{ with } df(k_t)/dk_t = f'(k_t) \geq 0 \qquad (9)$$

wherex_t and k_t represent output-labor and capital-labor ratios.

Let C_t represent aggregate consumption and c_t per capita consumption at time t. The net accumulation of man-made capitaldk/dt= $(\dot{k})$ satisfies the condition (10)

$$\dot{k} = f(k) - c - a\,k \qquad (10)$$

where, a is rate of depreciation of man-made capital. Considering the pure rate of time preference p, the planner's problem is

$$Maximize \int_0^\infty e^{-pt}\, U(c)dt \qquad (11)$$

with respect to c subject to the condition

$$\dot{k} = f(k) - c - ak$$

The current value Hamiltonian of the problem is

$H = U(c) + q(f(k) - \text{ak})$ (12)

where c_t is control variable, k_t is state variables, and q is co-state variable.

The first order condition for maximizing H with respect to control variable is

$$U_c(c) = q \qquad (13)$$

The canonical equation of Hamiltonian (12) defining the time paths of co-state variable is given as

$$\dot{q} = q(p + a - f'(k)) \qquad (14)$$

Taking the time differential of (13) and substituting for $\dot{q}$ from (14) we have

$$\frac{\dot{C}}{C} = 1/v\ [\ (f'(k) - p - a)] \qquad (15)$$

where

$v = -\,(U_{cc}/U_c)C$, elasticity of marginal utility of consumption with respect to consumption.

Equation (15) explains the relationship between rate of growth of consumption and the rate of return on capital. Considering time series data of rate of growth of consumption, net rate of return on investment, above equation could be estimated. The utility rate of discount may be taken as zero or constant 2 percent as we considered in the report.

Estimation of the Model

The time series data of rate of growth of real per capita income for India during the last 44 years obtained from Economic Survey, Government of India, 2016-17 is considered for the estimation of equation (15). Therefore, rate of growth of real per capita income is taken as a proxy for rate of growth of per capita consumption ($\frac{\dot{C}}{C}$). Using production accounts for the Indian industry from the Annual Survey of Industries (ASI) data, time series estimates of net rate of return on capital invested in the industry ($f'(k) - a$) are obtained for the last 44 years. Figure 1 shows the graphs of rate of growth of real per capita income and net rate of return on investment over the period 1971-2014. Table 5 provides the descriptive statistics of variables considered for estimation. The mean rate of growth real per capita income during last 44 years is found to be 5.66 percent while the mean net rate of return on investment is found to be around 17.36 percent. Table 6 reports the estimated growth equation. The estimated coefficient of variable net rate of return on capital (0.85) in the equation is interpreted as elasticity of inter temporal consumption substitution. The inverse of this coefficient (1/0.85) is elasticity of social marginal utility of consumption with respect to consumption (v) which happens to be 1.176. This estimate of v is found to be well within the range of estimates made using revealed preference method and commodity tax and income tax data for the Indian economy.

Table 5: Descriptive Statistics of Rate of Return on Capital and Growth Rate

	N	Mean	Variance
Growth Rate	44	5.66	8.3521
Net Rate of Return on Capital	44	17.36	22.3729

Figure1: Graph for Growth rate of GDP and ROR over the period 1970-2014

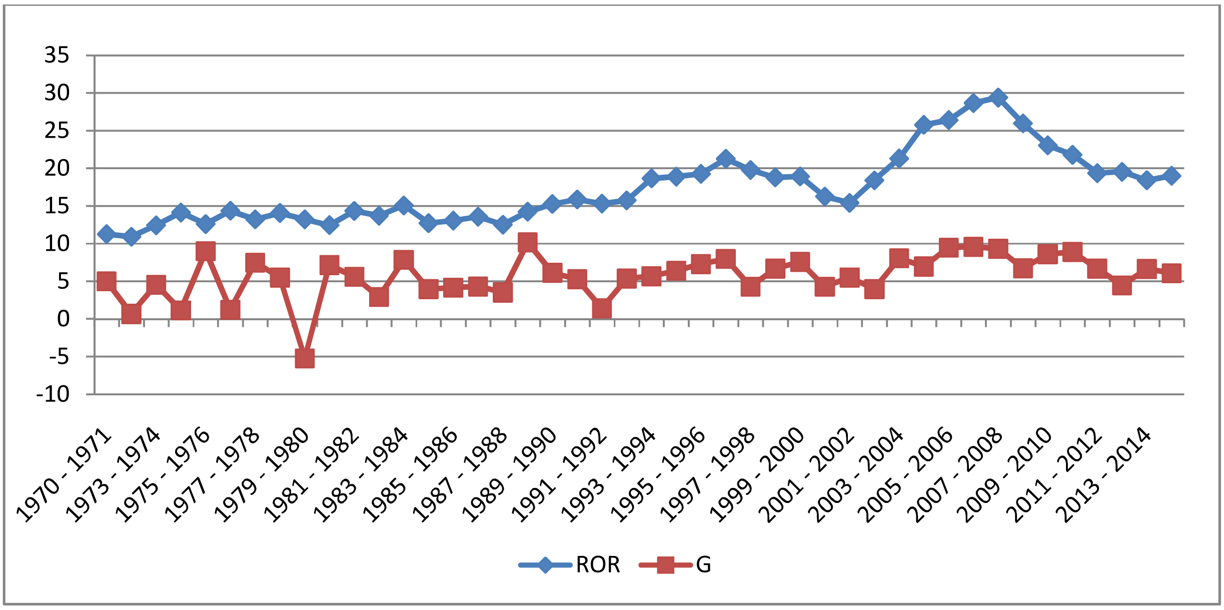

Table 6: Estimate of Ramsey Growth Equation

	Coef.	**S.E.**	**t**	R^2
Rate of Return	0.85	0.165	5.16	0.5787
Lag of Growth Rate	0.87	0.165	5.26	
Constant	7.79	1.39	5.59	

4. Pure Rate of Time Discount

Pure rate of time preference (p) may be interpreted as the extra premium an individual puts on the present consumption due to life uncertainty. The lower the life expectancy of people in a country, the higher should be the pure rate of time preference. This rate may be interpreted as the probability of a person belonging to a given population group or class not to survive a year after. It could be estimated as the probability of a representative person in India not surviving a year after. An estimate of p for the Indian economy could be obtained as

$$p = \sum_{i=1}^{15} p^i a^{i^1} \qquad (16)$$

where, p^i: is probability of a person belonging to i^{th} age group not to survive a year after and a^i: is population proportion in i^{th} age group.

It may be appropriate to consider that only population above 15 years of age in India will express pure rate of time preference while taking savings and consumption decisions. Children up to the age of 15 years may not be having opportunities to take decisions affecting their present and future consumptions. Table 7 reports estimates of p for All India population and population above 15 years age as per the Census of India data 2011-12. The estimate of pure rate of time discount for the Indian economy is obtained as 2.34 per cent.

Table 7: Estimates of Pure Rate of Time Discount for Indian Economy

	All India		
	Total	**Male**	**Female**
P	0.0221	0.0245	0.0195
p*	0.0234	0.0274	0.0193

Notes: p: pure rate of time preference of the entire population
p*: pure rate of time preference for the population of age above 15 years
Source: Estimated as explained in the text.

5. Rate of Growth of Per capita Income

India has been one of the fast growing economies in the world. Table 8 reports the real rates of growth of GDP in India for some recent years. The average rate of growth during last six years being 6.6 percent one could expect that the economy could at least maintain this rate of growth during next few years. Table 9 gives rates of growth of population in India during last few decades. During last two decades the rate of growth of Indian population has gone down from

2.12 per cent to 1.64 per cent. Given the current rate of growth of population as 1.64 percent, the rate of growth of per capita real GDP for the Indian economy could be calculated as 4.96 per cent. Economics Survey, 2015-16 reports the average rate of growth of real per capita income in India during 2012-2013 to 2013-2014 at 2011-12 prices as 4.3 percent[12].

Table 8: Real Growth Rates of GDP (at factor cost) in India

Year	Real growth rate of GDP
2010-11	8.9
2011-12	6.7
2012-13	4.5
2013-14	6.6
2014-15	6.1
2015-16	7.2

Source: Economic Survey, Government of India, 2016-17

Economic Survey 2016-17 reports the rates of growth of real per capita GDP of India for the past 60 years during 1955-56 to 2015-16. This historical time series data of GDP growth of India shows significant volatility in the rate of growth as shown in Figure 2. Table 10 gives frequency distribution of growth rates of real net national income per capita in India during last 60 years by growth slabs. This table shows that there are episodes of negative growth rates for at least 9 years and also there are episodes of very high growth rates of 8-10 percent for 2-3 years.

Table 9: Rates of Growth of Population in India during last Four Decades

Decade	Growth Rate
1971-1981	2.22
1981-1991	2.11
1991-2001	1.95
2001-2011	1.64

Source: Census Registrar of India

Table 10: Frequency Distribution of Growth Rates of Real Net National Income Per capita of India

Range	Frequency
<0	9
0-2	11
2-4	15

[12] See Economic Survey, 2015-2016, Government of India.

4-6	14
6-8	9
8-10	2
Total	**60**
Mean: 2.805	**Std: 3.667**

6. Estimates of Social Rate of Discount

Estimation of social discount rate or consumption rate of discount using the extended Ramsey formula derived in Section 2 requires the estimates of parameters accounting for all three effects: impatience effect, wealth effect and precautionary effect. The impatience effect p is estimated as the probability of a representative individual not to survive a year after. Using Census Life Table data of 2010-11, this is estimated as 2.34 percent as reported in Section 4.

Estimation of wealth effect requires the estimates of parameters of rate of growth of per capita income (g) and the elasticity of social marginal utility of income (v) for India. Section 5 above provides this estimate of g as 4.66 percent. Section 3 describes methods of estimation of v. The estimate of v based on the incidence of commodity taxes on rural and urban households in India is found to be 0.916. On the other hand an estimate of v based on income taxes in India is found to be around 1.748. Therefore, we adopt for this study an estimate of 1.332 which happens to be an average of these two estimates. Therefore, given these estimates an estimate of social time preference rate for India as per the original Ramsey formula is obtained as 8.5 percent (0.0234 + 1.332x0.0466 = 0.085).

Volatility of growth rates displayed by historical data explained in Section 5 could be an indication of uncertain growth rates in the near and far off future in India. The extended Ramsey formula given in equation (2) accounts for precautionary effect assuming that the growth next year is a random variable which is independently and identically distributed with normal distribution having mean μ and standard deviation σ. In this way of modeling uncertainty of growth, it is assumed that growth rates over time are constant and not correlated. Therefore the rate of discount is constant over time even with this extended Ramsey rule but lower than the one given by conventional Ramsey rule.

The historical data of last 60 years of growth rates in India discussed in Section 5 displays certain volatility as shown Table 10. It has a frequency distribution with mean growth rate of per capita national income as 2.805 percent and standard deviation of 3.667 percent. Given the estimates of p and v respectively as 2.34 percent and 1.332 and the mean growth rate of per capita consumption and standard deviation respectively as 2.805 percent and 3.667, the social time preference rate as per the extended Ramsey rule is estimated as 6 percent.

However if the historical average rate of growth of real per capita net national income as low as 2.805 per cent is any indication of rate of growth in far off future in India, the discount rate for long run investment projects could be as low as 6 percent. In this particular way of modeling uncertainty of future growth, the discount rate is constant but it is relatively low. However, in the case of modeling uncertainty of growth rates by considering that there is correlation between growth rates over time, there will be time dependent or term structure of discount rates as shown in the literature. In this case there will be a distribution of growth rates in each year with unknown parameters with the mean growth of this distribution itself having a probability distribution. Literature shows in this case that there will be declining discount rates or term structure with declining rates. Given that rates of growth of income may be correlated over time and may be lower in the long run in India, there could be case for having term structure of discount rates for India. These rates could be 8, 6 and 4 percent respectively for projects with gestation periods 30, 50 and more than 100 years.

7. Conclusion

Rate of discount that has to be used in social cost benefit analysis could be estimated as either consumption rate of discount or as rate of return on investment in the economy. But these two rates could differ if capital market is imperfect and the level savings in the economy is not optimum. This could be a situation in an emerging economy like that of India requiring the estimation of social time preference rate as subjective or consumption rate of discount. The most celebrated Ramsey rule is commonly used to estimate this rate. The generalized Ramsey rule used in this paper accounts for three components of social time preference rate: impatience effect, wealth effect and the effect of uncertainty of future state of the economy. These three components are identified and estimated for the Indian economy in this paper.

The impatience effect or pure rate of time discount (p) is estimated by using Census of India Life Tables data as the probability of a representative individual in India not to survive a year after. Using 2010-11 Census data it is estimated as 2.34 percent for India. The wealth effect is estimated by using data of policies of Indian government that affect distribution of consumption over time. Information related to commodity and income tax policies and various growth scenarios for India is used for this purpose. Two estimate of elasticity of social marginal utility (v), the crucial parameter determining wealth effect are made. One is based on the incidence of commodity and income taxes by expenditure and income groups in India. Another estimate of is obtained using Ramsey growth model. The average of these estimates equal to 1.332 is considered as an estimate of v for India. The rate of growth of real per capita income which is another important parameter determining wealth effect is considered to be 4.66 per cent in India based on information from recent estimated trends of growth. Given these estimates an estimate of social time preference rate for India as per the original Ramsey rule is obtained as 8.5 percent.

Estimation of precautionary effect requires information about the probability distribution of future rate of growth in India as per the extended Ramsey formula. One way is to assume that the probability distribution of historical growth rates in India could be an indicator of uncertainty of future growth rate. The frequency distribution of last 60 years growth rates of real per capita net national income in India is found to have mean 2.805 percent and standard deviation 3.667 percent. Given these estimates and the estimates of pure rate of time preference and the elasticity of social marginal utility reported earlier, an estimate of social time preference rate as per the extended Ramsey rule is obtained as 6 percent for India. Therefore, if the historical average rate of growth of real per capita net national income as low as 2.805 per cent is any indication of rate of growth in far off future in India, the discount rate for long run investment projects could be as low as 6 percent.

Literature shows that if there is uncertainty of future rates of growth and the growth rates are correlated over time there will be a term structure with declining discount rates.In this case there could bea case for having term structure of discount rates for India. These rates could be 8, 6 and 4 percent respectively for projects with gestation periods 30, 50 and more than 100 years.

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Appendix A

Table A1: Incidence of Indirect Taxes by Expenditure Groups in India (RURAL)

Fractile Class	Y	T(Y)	T'(Y)	F(Y)
0-5%	446.18	57.47707		0.03366
5-10%	563.69	72.41371	0.127109	0.035637
10-20%	663.47	85.87039	0.134864	0.072523
20-30%	773.81	100.1125	0.129074	0.076327
30-40%	876.19	114.108	0.136701	0.080676
40-50%	976.58	127.2605	0.131015	0.086307
50-60%	1099.82	144.3651	0.13879	0.094334
60-70%	1248.53	162.0554	0.118959	0.103723
70-80%	1451.73	187.0058	0.122787	0.118245
80-90%	1785.61	224.5504	0.112449	0.135216
90-95%	2291.9	274.9539	0.099555	0.075875
95-100%	4525.64	383.4684	0.04858	0.087479
all classes	1278.94	153.9477	0.070694	1

Table A2: Incidence of Indirect Taxes by Expenditure Groups in India (URBAN)

Fractile Class	Y	T(Y)	T'(Y)	F(Y)
0-5%	617.69	78.52402		0.074867
5-10%	795.78	101.3367	0.128097	0.062478
10-20%	978.5	121.29	0.109201	0.116754
20-30%	1192.04	146.206	0.116681	0.103063
30-40%	1400.87	167.3871	0.101427	0.095704
40-50%	1632.16	190.932	0.101798	0.086193
50-60%	1907.49	219.8462	0.105016	0.089518
60-70%	2245.74	253.59	0.09976	0.090613
70-80%	2729.81	300.5479	0.097007	0.092307
80-90%	3562.57	370.584	0.084101	0.098073
90-95%	4994.43	475.7544	0.07345	0.051012
95-100%	10279.41	722.7752	0.04674	0.039417
all classes	2399.24	245.9511	0.060509	1

Table A3: Incidence of Income Taxes in India (Assessment Year 2012-13)

Average income (Y)	No of individuals	Relative Frequency F(Y)	Tax Liability T(Y)	Marginal Tax Rate T'(Y)
78000	3757935	0.120105723	0	
180000	7692552	0.245858302	0	0
222000	4528552	0.144735077	4200	0.1
293000	4949387	0.158185201	11300	0.1
374000	1456626	0.046554589	19400	0.1
424000	1222875	0.039083775	24400	0.1
474000	1061284	0.033919235	29400	0.1
524000	896094	0.02863967	34400	0.1
698000	3090118	0.098761915	53600	0.11
975000	161161	0.005150796	109000	0.2
1205000	869656	0.027794696	159500	0.22
1718000	328148	0.010487795	313400	0.3
2228000	173780	0.005554107	466400	0.3
3375000	245981	0.007861692	810500	0.3
6891000	93444	0.002986523	1865300	0.3
19484000	60612	0.001937194	5643200	0.3
69568000	6421	0.000205219	20668400	0.3
153663000	4125	0.000131837	45896900	0.3

Table A4: Incidence of Income Taxes in India (Assessment Year 2013-14)

Average Gross Total Income in INR	F(Y)	Tax Liability= T(Y)	T'(Y)
76000	0.095222681	0	0
186000	0.156856621	600	0.01
221000	0.183298887	4100	0.1
295000	0.186207577	11500	0.1
374000	0.055630535	19400	0.1
424000	0.046246266	24400	0.1
475000	0.039771324	29500	0.1
524000	0.033997547	34400	0.1
696000	0.113207035	53200	0.11
975000	0.005573033	109000	0.2
1206000	0.030670625	159800	0.22
1716000	0.01180468	312800	0.3
2225000	0.005699711	465500	0.3
3375000	0.008430164	810500	0.3
6878000	0.003026165	1861400	0.3
19246000	0.001906963	5571800	0.3
69056000	0.000192401	20514800	0.3
153096000	0.000111488	45726800	0.3

Table A5: Incidence of Income Taxes in India (Assessment Year 2014-15)

Average Gross Total Income in INR	F(Y)	T(Y)	T'(Y)
75000	0.079838665	0	0
184000	0.077713346	400	0.004
224000	0.220028564	4400	0.1
296000	0.211737572	11600	0.1
373000	0.061331089	19300	0.1
424000	0.047821488	24400	0.1
475000	0.04162259	29500	0.1
524000	0.036143122	34400	0.1
696000	0.128889112	53200	0.11
974000	0.006278482	108800	0.2
1204000	0.033130286	159200	0.22
1718000	0.013469681	313400	0.3
2224000	0.006684736	465200	0.3
3382000	0.009419129	812600	0.3
6888000	0.003317399	1864400	0.3
19234000	0.001891907	5568200	0.3
69078000	0.000185033	20521400	0.3
151922000	0.000109588	45374600	0.3
346746000	3.75943E-05	103821800	0.3

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