



Reassessment of National Parameters for Appraisal of Public Investment Programmes/Projects in India

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and

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Foreword

(A practice note on the use of the National Parameters)

1. Public investment decisions across infrastructure, energy, transport, urban services and social sector programmes are generally appraised using economic cost-benefit analysis, which requires discounting future streams of economic benefits and costs into present values. A proposal is acceptable only if the present value of its expected benefits exceeds the present value of its expected costs. Any such comparison, therefore, requires an appropriate rate at which future economic benefits and costs are discounted, and that rate is termed the Social Discount Rate (SDR).
2. Cost-benefit analysis of this kind requires adjustment of the financial or market prices, since these are distorted by taxes, subsidies, administered wage floors, and other policy-induced wedges that separate observed prices from the opportunity cost of resources and the value of benefits to society. Project appraisal, therefore, requires a set of “shadow” or accounting parameters, or conversion factors, through which market prices can be converted into estimates of the resource cost of inputs and the economic benefits to society. Thus, in practice, the Shadow Wage Rate Factor is used for labour, and, depending on whether costs and benefits are expressed in domestic or world prices, either a Shadow Exchange Rate Factor or a Standard Conversion Factor is used for traded items. An item-specific conversion factor is estimated for the non-tradables. In addition, where a project has material greenhouse gas impacts, a shadow price of carbon is also required.
3. The last comprehensive assessment of these parameters for the country was undertaken by NITI Aayog through the Institute of Economic Growth (IEG) in 2018. IEG followed the Ramsey approach to estimate the Social Rate of Time Preference (SRTTP) as the Social Discount Rate (SDR) and recommended an SDR of 8 per cent for projects with a duration of up to 50 years, 6 per cent for projects with a duration of 50 years or more, and a rate below 6 per cent for projects with a duration of more than 100 years. The Shadow Exchange Rate Factor (SERF) was estimated at 1.08. The estimation of the Standard Conversion Factor and the Shadow Wage Rate for labour was not taken up. Since these parameters are intended to reflect prevailing economic conditions rather than remain fixed indefinitely, they require periodic reassessment as new data become available.
4. NITI Aayog engaged the Indian Statistical Institute (ISI), Delhi, to re-estimate these parameters. ISI has drawn on National Accounts Statistics, the Periodic Labour Force Survey (PLFS), the Annual Survey of Industries (ASI), KLEMS, Direct Tax Statistics, trade data and cross-country growth data, together with a review of the methodological advances in the discounting literature, with particular attention to the Social Discount Rate.
5. **Social Discount Rate:** The analysis of the Social Discount Rate is particularly involved. The literature indicates an intense debate over the appropriate method to estimate the SDR, and whether the SDR should vary with tenure of the projects. Jenkins, Kuo, and Harberger (2011) list four approaches for estimating the discount rate in public-sector project evaluation.

- a) The first holds that all investment projects, public and private alike, should be discounted at the marginal productivity of capital in the private sector (Hirshleifer, DeHaven and Milliman 1960). The rationale, as Jenkins, Kuo and Harberger present it, is that a government seeking to maximise national output should direct funds to wherever the return is highest, i.e. where private projects offer a higher expected economic return than the available public projects, the funds are better left in private hands.
 - b) A second approach, developed by Little and Mirrlees (1974), building on the OECD (1969), and adapted for World Bank use by Squire and van der Tak (1975), employs an accounting rate of interest (ARI). Jenkins, Kuo and Harberger (2011) characterise the accounting rate approach as essentially a rationing device that allocates a fixed public investment budget.
 - c) A third approach discounts costs and benefits at the Social Rate of Time Preference (SRTP) for consumption, after converting flows that displace or augment private investment into their consumption-equivalent values using a shadow price of investment. Proponents include the UNIDO *Guidelines* (Dasgupta, Sen and Marglin 1972), Marglin (1963) and Feldstein (1964), with the formal treatment usually attributed to Bradford (1975).
 - d) A fourth approach holds that the discount rate should be the Economic Opportunity Cost of Capital (EOCK): the weighted average of the returns forgone on the sources from which public funds are actually drawn. In its simplest closed-economy form (Harberger 1968, reprinted 1972), this is a weighted average of the return on displaced private investment and the rate of time preference of savers. In an open economy, a third term is added for the marginal cost of incremental foreign capital. The premise is that the additional government borrowing required to finance public investment partially displaces private investment, induces additional domestic saving at the expense of current consumption, and draws in foreign capital. The SDR is therefore estimated as the weighted average of the returns forgone from these three sources, with the weights derived from the interest elasticities of domestic saving, private investment, and the foreign supply of funds.
6. This report estimates the SDR using two approaches: the SRTP approach using the Extended Ramsey Rule (the Ramsey rule with a precautionary adjustment for uncertainty in consumption growth), and the EOCK approach or the weighted-average approach, following Burgess and Zerbe (2011).
- a. Under the Ramsey rule, if consumption per head is expected to rise, a unit of consumption delivered to a richer future society is worth less at the margin than the same unit today, so a higher expected growth rate of per capita consumption implies a higher discount rate. Calibrating that growth rate is difficult. Virmani (2024) puts real per capita GDP growth (2017 PPP dollars) over 2020–50 at 5.9% per annum in a conservative case, 6.4% in a median case, and 6.9% in an optimistic one. On the

conservative 5.9% path, ISI estimates an SRTP of 9.4%; and on the average per capita growth of about 4.7% actually experienced over the past three decades, it estimates 7.3%.

- b. EOCK has been calculated using the weighted-average approach, based on the estimated rate of return to capital in the private sector from the National Accounts Statistics (NAS) data. Estimates based on broad stock market returns – the NIFTY 500 Total Returns Index – and on ASI data have also been used as cross-checks. The risk-free rate has been set at the real rate of return on central government securities, and the interest rate on foreign borrowing has been estimated using annual data from India's External Debt Status Reports. These estimates, combined with the subcomponent weights, yield an EOCK of 9.23%.
7. This report recommends the weighted average or the EOCK approach as the basis for the Social Discount Rate for India for projects of up to 30 years, and the SRTP approach as the basis for the SDR applicable to longer horizons.

The report compares SDR estimates across various countries and institutions. Among the 25 countries and institutions assessed, 14 have SDR estimates based on the social opportunity cost of capital (SOC) or weighted average (WA) approach, 9 have estimates based on the social rate of time preference (SRTP) approach, and 2 have estimates available under both approaches. A broadly similar pattern appears in Groom et al. (2022), which reviews 20 countries and institutions: 12 rely on an SOC-based approach alone, 6 on the SRTP alone, and 2 (Denmark and the United States) draw on both. On either count, the SOC/WA approach is the more common of the two across the jurisdictions surveyed. The middle-income jurisdictions appearing in these compilations — Chile, Mexico, Brazil, Colombia and Peru — use SOC-based rates, most of them following the weighted-average formulation set out in Harberger (1969); and as of the mid-2000s, most multilateral development banks applied rates of 10–12% derived on a weighted-average basis (Zhuang et al., 2007).

This may reflect a judgment about capital scarcity, though the rationale is not elaborated in the sources. ADB's 2017 Guidelines for the Economic Analysis of Projects report that the weighted average approach has been considered the preferred method for empirically estimating the SDR because it explicitly accounts for market imperfections and credit constraints on investment.

Moreover, in practice, using the SRTP would require a separate shadow price of capital to convert the investment component into its consumption equivalent, which is difficult.

Accordingly, the recommendation for the Weighted Average approach for projects with a tenure of up to 30 years is in line with prevailing practices in comparable economies.

8. One of the terms of reference for the report was to assess whether a single constant discount rate is appropriate for projects with widely differing life spans, such as environmental and social sector projects, whose returns accrue over much longer periods.

By construction, discounting places greater weight on nearer-term than on more distant net benefits. Too high a rate undervalues the long-term social benefits of public investment, while too low a rate understates the opportunity cost of the funds committed, and so admits projects that displace higher-yielding uses of the same resources. This matters most where horizons differ widely: infrastructure and construction projects typically generate the bulk of their returns within a few decades, whereas investments in education, healthcare and climate mitigation may yield returns over much longer periods. The calibration of the discount rate, therefore, shapes the balance of the public investment portfolio between near-term returns and long-term value.

9. A single constant rate can therefore leave projects whose benefits accrue over several decades unable to show a positive net present value (NPV) over their lifetime. This is particularly relevant for the country, given its ambition to become Viksit Bharat by 2047 along with its commitment to achieving Net Zero by 2070. The Viksit Bharat vision, as a medium-term objective, underscores the importance of prioritising high-return investments to support higher growth and income levels. The Net Zero 2070 commitment involves initiatives such as climate mitigation projects that may not appear economically viable due to their capital-intensive nature and long gestation periods, even though they would deliver long-term economic benefits.

Several methods are used to accommodate long-term benefits in cost-benefit analysis: sensitivity analysis to account for uncertainty; differentiated rates, such as a lower rate for health and environmental benefits; and a declining discount rate applied over the project's tenure. The ADB *Guidelines for the Economic Analysis of Projects* (2017) set a minimum required economic internal rate of return of 9% in general and permit a lower rate of 6% for social sector projects and for projects that primarily generate environmental benefits. One reason is that many environmental protection and conservation projects have long-term impacts.

Thus, while practice varies across jurisdictions, the guiding principle should be that whatever is adopted remains simple enough to apply consistently in routine cost-benefit analysis. The 2018 assessment also adopted a declining schedule.

The current report acknowledges the difficulty of calibration and states that the choice of a specific declining schedule is a matter of practicality rather than theory. It further states that for very long horizons, the Ramsey approach provides a more robust and theoretically grounded basis for the SDR. The literature points in the same direction: over long horizons, the appropriate weighted-average rate converges on the consumption rate of interest (Li and Pizer 2021)³.

³ https://www.nber.org/system/files/working_papers/w25413/revisions/w25413.rev0.pdf

Using the Ramsey rule for longer time horizons, the report recommends a declining schedule for the social discount rate: 6.2% (30-50 years), 4.8% (50-75 years), and 3.4% (75-100 years).

The extant practice has been to apply a single hurdle rate to all projects, together with a sensitivity analysis for uncertainties such as inflation projections. Going forward, it is suggested that for projects with a tenure exceeding 30 years, either of two approaches may be adopted, depending on the project profile: the sensitivity analysis just described, as at present, or a declining discount rate (DDR) schedule applied over the longer duration. Where it is used, the appraisal should require that the project generate a non-negative economic net present value under the applicable schedule over its full horizon.

10. Shadow Exchange Rate Factor (SERF), Standard Conversion Factor (SCF) & Shadow Wage Rate Factor (SWRF):

All projects use inputs or produce outputs that can either be tradable or non-tradable. Non-tradables are goods whose prices are primarily determined domestically, whereas the prices of tradables are largely set internationally. Examples of tradables include importable and exportable commodities such as steel, wood, iron, and chemicals. Examples of non-tradables include electricity, water, all public services, construction, real estate, local transport, hotel accommodation, and low-value/high-bulk goods such as gravel, for which freight makes export unprofitable. For the reasons set out in para 1 above, the financial prices at which these items are bought and sold cannot be used as such; each must be converted to an economic value.

- a) The Shadow Exchange Rate is the economic price of foreign exchange expressed in domestic currency. The Shadow Exchange Rate Factor (SERF) is the ratio of the Shadow Exchange Rate to the Official Exchange Rate. This is typically above unity due to tariffs and other distortions. The value derived in this report is 1.09. This is marginally higher than the 1.08 estimated in the 2018 study.
- b) Likewise, the economic prices of tradables and non-tradables must be estimated after removing distortions such as taxes, subsidies and price controls. For tradables, the principal distortion is trade taxes. To simplify the analysis, a Standard Conversion Factor (SCF) is sometimes used in place of item-specific adjustment: it converts the financial price to its international market-price equivalent, adjusting for trade taxes. The value estimated in this report is 0.92. Where an item accounts for a small share of total cost, or where item-specific information is not available, the SCF is an adequate approximation. The costs of transport and distribution between the border and the project must, however, be added separately to arrive at the economic cost or benefit.
- c) Non-tradables, when used as inputs to a project, should be valued at their marginal economic cost of supply; and as outputs of a project, these should be valued at the willingness to pay or at the alternative cost of supply (if the project is an alternative source of supply of the non-tradable). For instance, in the case of power projects,

economic value is the alternative cost of generating an equivalent flow of energy by some standard means.

This report mentions that the conversion factor for non-tradables is 1, in line with the ADB guidelines (2017). However, it should be clarified that this conversion factor of 1 only indicates that the price is set in the domestic market. It does not state that the domestic price is not distorted. As such, commodity-specific conversion factors are preferred for non-tradables.

- d) The shadow wage rate factor (SWRF) is the ratio of the Opportunity cost of labour to the wage the project actually pays. Actual wages differ from the opportunity cost of labour because of complex issues related to unemployment and labour market rigidities. When involuntary unemployment or underemployment exists, workers are likely to accept a lower wage rather than remain unemployed. However, it is also incorrect to treat the opportunity cost of employing labour that would otherwise be unemployed as nil. It is also incorrect to assume that a reduction in unemployment equals the number employed in the project, as some of the labour is likely to be displaced from other employment. As such, the treatment of labour costs depends on the nature of the project. However, for simplicity, a standard wage-rate factor can be used. For scarce or skilled labour, SWRF can normally be taken as 1.0.

This report estimates the SWRF for unskilled labour using the Periodic Labour Force Survey (PLFS) and minimum wage notifications, disaggregated by state, sector, and gender. The estimated SWRF is 0.86. It should be clarified, however, that where labour is a large share of costs, or where workers are a key beneficiary group, a project-specific SWRF based on local labour market analysis is required, and the state-specific estimates should be used in preference to the national figure; the national value is an approximation for simplified appraisal only.

The practical guidance on the use of the conversion factors is summarised in the table below:

Category	Treatment
Traded items valued at world prices, converted at the official exchange rate	Multiply by SERF
Non-traded items valued at domestic prices or WTP	Multiply by 1.00 (or use the commodity-specific CF if there are significant distortions like subsidies in the domestic market)
Tariffs, indirect taxes, subsidies on the item	Removed, as these are transfers
Labour — unskilled or in surplus supply (skilled or scarce labour: 1.00)	Multiply by the applicable SWRF, using the state-specific value where labour is a material share of cost

11. **Social cost of carbon (SCC):** The social cost of carbon is used in appraisal practice to account for the externalities associated with carbon emissions in a project. Broadly, two distinct constructs emerge regarding what the social cost of carbon represents, i.e., whether it measures *damages* or *abatement costs*.

The *damage-based* measure is the present value of future societal damages from emitting an additional tonne of CO₂ today. This is the construct underlying the ADB, Canadian and US guidance on cost-benefit analysis. This report also suggests a value of US\$10 per tonne of CO₂, using a damage-based measure that accounts only for damages incurred within India.

12. The *abatement-cost* measure is the marginal cost of abating an additional tonne along a least-cost path to a stated climate goal. This is the construct underlying the cost-benefit guidance of several European countries and institutions, such as the UK, the EIB, and the World Bank.
13. In this context, the recent launch of a Carbon Credit Trading Scheme, 2023, under the Energy Conservation Act, 2001, as amended in 2022, is relevant. It adopts an emission-intensity-based model for Carbon Credit Certificates (CCCs). The CERC's 2026 regulations provide that CCCs are to be traded through power exchanges within a floor price and a forbearance price. The CCC price should therefore serve as a proxy for the abatement-cost measure of the social cost of carbon in the regulated sectors, once trading matures, and the price is formed above the floor. However, it is recommended that a single carbon shadow price be applied to all project emissions in both covered and uncovered sectors. Accordingly, it is suggested that the same may also be used as the carbon price in project appraisal. The report also recommends that a separate study be undertaken to empirically determine the country-specific cost of carbon.
14. It is clarified that receipts from the sale of CCCs and payments for their purchase are cash flows to be used in the financial analysis. These are, in effect, transfers between residents and should not be included in the economic analysis. The project's residual emissions must still be valued as an externality in the economic analysis.
15. To sum up, the values indicated in the table below are recommended for the national parameters based on the current report, after rounding for practical use in cost-benefit analysis:

Parameter	Recommended Value
Social Discount Rate (< 30 years)	9.50%
Social Discount Rate (30-50 years)	6.50%
Social Discount Rate (50-75 years)	5%
Social Discount Rate (75-100 years)	3.50%

Standard Conversion Factor (SCF)	0.92
Shadow Exchange Rate Factor (SERF)	1.09
Shadow Wage Rate Factor (SWRF) - Total	0.86
Shadow Wage Rate Factor (SWRF) - Male	0.88
Shadow Wage Rate Factor (SWRF) - Female	0.82
SCC (not accounting for damages outside India)	US\$ 10/tCO ₂ e ⁴

Where a declining discount rate is used, each year's net flow should be discounted at the rate applicable to the period in which it falls, rather than the whole stream being discounted at a single rate selected by reference to the project's total life. Applying a single lower rate to every year of a long-lived project would create a discontinuity at the 30-year boundary and an incentive to specify a longer appraisal period than the project warrants. In such cases, the test of viability is a non-negative economic net present value, rather than a comparison of an economic rate of return with a single hurdle rate.

16. In conclusion, the discount rate tests whether a project earns more than its funds could earn elsewhere. While passing that test means the project is worth undertaking, it does not establish that the limited budget could not have been used better elsewhere. The objective should therefore be to select the combination of projects that yields the highest total net present value within the available budget, rather than simply accepting every project that clears the discount rate. In practice, ranking is difficult because projects reach appraisal at different times and in varying states of readiness. A rough ordering can nevertheless be built from whatever determines returns in a sector — say, projected traffic in transport — but only where forecasts follow a common, independently set standard, since demand forecasts prepared by project proponents tend towards optimism. Project readiness, land availability and strategic priorities also matter and can override economic ranking; in such cases, the specific reasons should be recorded.

The parameters estimated here — the social discount rate, in the form of the economic opportunity cost of capital for shorter horizons and a Ramsey-based declining schedule for longer ones; the shadow exchange rate factor and its reciprocal, the standard conversion factor; the shadow wage rate factor; and the shadow price of carbon — help establish whether a project is worthwhile in national economic terms and allow projects across sectors to be compared on a common basis. Both uses require that the parameters be applied consistently and revised as the economy changes.

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⁴ tonne of carbon-dioxide equivalent

Executive Summary

Background

Public investment is a central instrument through which India advances its long-term development objectives. Large-scale expenditures on infrastructure, energy systems, transport networks, urban services, and social programmes require a rigorous appraisal framework that can determine whether the present value of economic benefits from a project exceeds its economic cost. Such appraisal cannot rely solely on financial prices, because market prices incorporate taxes, subsidies, administered wage floors and other policy-induced distortions that cause them to diverge from the underlying opportunity costs of resources. Economic appraisal therefore requires translating financial magnitudes into economic values using parameters such as discount rates, conversion factors, shadow wage rates, and the social costs of carbon which measure climate damage valuations.

The last comprehensive national assessment of these parameters was conducted by NITI Aayog in 2018, which provided estimates for use in public project appraisal. The study recommended a social discount rate of 8 percent for projects with horizons up to 50 years, with a lower rate of 6 percent for long-gestation infrastructure and environmental projects. It further suggested rates below 6 percent for projects extending beyond 100 years. It also estimated a 10 percent rate of return on capital, recommended as the hurdle rate for financial analysis, and identified an 8 percent foreign-exchange premium reflecting the gap between the economic value and the market price of foreign currency.

Since the 2018 assessment, new rounds of official data and methodologies offer a stronger empirical foundation for revising the parameters used in economic appraisal. Since these are intended to reflect prevailing economic conditions, the parameters require periodic reassessments. The present study re-evaluates the parameter values for the social discount rate, standard conversion factor and shadow prices using recent datasets and new methodological frameworks, which build on the previous assessment by NITI Aayog conducted in 2018.

Objectives of the Study

The objectives of this study are to provide updated estimates of the five parameters required for the economic appraisal of public-sector projects in India, which include:

- (i) **Social Discount Rate (SDR):** This measures the societal trade-off between present consumption and future consumption. It is used to discount the future stream of benefits generated from public investments undertaken today. Projects with long timespans are sensitive to future economic growth rates, which impact the social discount rate. Thus, we estimate social discount rates for projects with differing lifetimes, based on the latest methodologies in the discounting literature.
- (ii) **Standard Conversion Factor (SCF):** It is estimated by comparing domestic market prices of tradable goods with their border-price equivalents and is used to convert financial costs of traded inputs into economic costs that exclude the effects of import duties. An SCF value below 1 indicates that domestic market prices of tradable goods exceed their economic (border-price) values, largely due to import duties. This adjustment is relevant for costs of imported inputs in project evaluation, since this can tilt the cost-benefit ratio for public projects that rely on imported inputs relative to domestic inputs.
- (iii) **Shadow Exchange Rate Factor (SERF):** It adjusts the market exchange rate to reflect the economic cost of foreign exchange. The SERF incorporates the impact of import tariffs and subsidies that create a wedge between domestic and border prices.
- (iv) **Shadow Wage Rate Factor (SWRF):** It is estimated by comparing observed wages from the PLFS with statutory minimum wages notified for unskilled labour. In many states, minimum wages exceed prevailing market wages, causing financial labour costs to overstate the economic opportunity cost of labour. The SWRF adjusts for this divergence by valuing unskilled labour at market-determined wages.
- (v) **Social Cost of Carbon (SCC):** It represents the present value of economic damages associated with an additional tonne of CO₂ emissions and is derived from long-horizon climate-damage modelling studies. The study compiles global SCC estimates to provide an approximate value of the social cost of carbon for India that can be applied in the economic appraisal of public projects.

These updated parameters aim to provide a consistent and empirically grounded basis for evaluating the economic viability of public-sector projects.

Scope

The study covers the conceptual rationale, empirical estimation, and application of each parameter within India's cost-benefit analysis framework. It adopts the Little and Mirrlees (1974) accounting-price approach, which recognises that market prices, which are affected by taxes, subsidies, tariffs, and labour-market rigidities, may diverge from economic values.

The analysis relies exclusively on official Government of India datasets, including the National Accounts Statistics, Household Consumer Expenditure Survey, Annual Survey of Industries, Periodic Labour Force Survey, and administrative data from the Reserve Bank of India, Ministry of Finance, and Ministry of Commerce and Industry. These datasets provide the empirical basis for estimating the parameters in a manner consistent with India's current macroeconomic structure and institutional context.

Methodology

The methodological approach is parameter-specific and grounded in established economic theory.

For the social discount rate, the study tests various approaches and applies the Ramsey rule, which determines the discount rate by estimating the trade-off between present and future consumption. This is based on the degree of inequality aversion and the expected future economic growth rate for India. We estimate the inequality-aversion parameter using the equal-sacrifice principle, and derive long-run economic growth from past trends in per-capita GDP. The extended Ramsey rule is used to incorporate the effect of uncertainty in future economic growth, for downward adjustment of the social discount rate for long-horizon projects.

The social discount rate is also computed based on estimated market-based rates of return such as the social opportunity cost of capital and the weighted average approach. These methods estimate the real returns to government securities, the private sector's marginal product of capital which is estimated using data from the Annual Survey of Industries, and a weighted-average financing-cost measure that reflects domestic and external borrowing conditions. This combined approach provides a consistent basis for determining discount rates for projects with different time horizons.

The Standard Conversion Factor (SCF) is estimated by comparing domestic market prices of traded goods with their border-price equivalents, after adjusting for import duties in import values. Export values, already recorded at border prices, are taken as reported. These import and export ratios are then aggregated across product categories to obtain an economy-wide SCF. An SCF below 1 indicates that domestic market prices are higher than economic (border) prices due to border taxes, which implies that using financial prices would overstate the true economic costs of tradable inputs.

The Shadow Exchange Rate Factor (SERF) measures the ratio of the economic price of foreign currency to its market price and is obtained as the reciprocal of the Standard Conversion Factor ($1/\text{SCF}$). This reflects the foreign-exchange premium after removing import duties and other trade-related distortions, based on product-level trade and tariff data.

The Shadow Wage Rate Factor (SWRF) is estimated using wage data from the Periodic Labour Force Survey (PLFS) for unskilled workers in rural and urban areas. Since market wages reflect the economic opportunity cost of labour, the study compares these observed wages with the statutory minimum wages notified by the Central Government through the Chief Labour Commissioner, for employment under the central government's jurisdiction. For occupations where minimum wages exceed actual market wages, common for agricultural labour in rural areas and informal workers in urban areas, the minimum wage would overstate the economic cost of labour, and the SWRF adjusts this downward by taking the ratio of market wages to minimum wages. This approach yields opportunity-cost-based labour valuations suitable for economic appraisal of public projects.

Lastly, the Social Cost of Carbon is compiled from global studies which estimate the economic damages associated with incremental CO₂ emissions, applying discount rates that are consistent with long-run time horizons.

Key Findings

The mean Social Discount Rate for projects with a time horizon up to 30 years is 9.23 percent based on the weighted average approach, with various methods yielding a range of 7.3 – 11 percent. For longer project horizons, we recommend using the uncertainty-adjusted Ramsey approach such that the social discount rate declines to 6.2 percent (30–50 years), 4.8 percent (50–75 years), and 3.4 percent (75–100 years).

The Standard Conversion Factor is estimated at 0.92, indicating that domestic prices for tradable goods exceed their economic values once duties and taxes are removed. The corresponding Shadow Exchange Rate Factor is 1.09, implying a foreign-exchange premium of approximately 9 percent. The Shadow Wage Rate Factor is estimated at 0.86 for unskilled labour, with average values of 0.88 for men and 0.82 for women, reflecting wage distributions observed in PLFS data. Lastly, the Social Cost of Carbon for India is estimated at USD 10 per tonne of CO₂, with a broader evidence-based range of USD 9–87 per tonne.

Key Policy Extracts and Indicative Ministries

The updated parameters have implications for ministries involved in public investment planning and appraisal. The SDR is relevant for the Ministry of Finance, NITI Aayog, and sectoral ministries preparing long-duration project proposals for appraisal by the Public Investment Board and Expenditure Finance Committee. It is particularly applicable to infrastructure, energy, irrigation, and environmental projects.

The SCF and SERF provide a consistent valuation basis for traded goods and foreign-exchange components in capital-intensive sectors, including commerce, industry, transport, ports, power, and renewable energy. These parameters ensure that project costs reflect economic rather than financial prices.

The SWRF is applicable to labour-intensive programmes under the Ministry of Labour and Employment, Ministry of Rural Development, and state governments implementing public works and construction projects.

The SCC offers an estimate of the economic damages associated with an additional tonne of CO₂ emissions and can be used in project appraisal where valuation of climate-related externalities is required.

Conclusion and Implications

These updated parameters provide an improved analytical foundation for public investment decisions undertaken by the Government of India. By ensuring that project benefits and costs are assessed at economic rather than market values, the revised estimates reinforce the credibility of appraisal exercises and support more efficient allocation of public resources. Their systematic use will help ensure that major public investments are evaluated on a consistent basis, strengthening the quality of India's development planning.

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1. Introduction

This study aims to assess key parameters for appraisal of public sector investments undertaken by the Government of India. The Government's budget allocation towards diverse sectors of the economy aims to maximise the present value of economic benefits, net of costs, that will accrue to society on account of public sector investments.

1.1. Objectives

This study will extend previous analyses of parameters for project appraisal conducted by the NITI Aayog (2018). We will estimate the following parameters used in cost-benefit analysis:

1. Appropriate Discount Rate to be used as a hurdle rate for public investments. It should include recommendations on whether it is appropriate to use the same hurdle rate in financial as well as economic analysis. It should also include recommendation on whether to use different hurdle rates for projects with different lifespans over which the returns are expected such as the large hydro power and irrigation projects, or for projects which do not have very well-defined financial returns such as the environmental and social sector projects.
2. Shadow exchange rate factor (SERF) - Ratio of economic price of foreign currency to its market price.
3. Standard conversion factor (SCF) - Ratio of economic price value of all traded goods in the economy at their border price equivalent values to their domestic market price values.
4. Shadow wage rate factor (SWRF), for Unskilled labour, both in rural and urban areas.
5. Social cost of carbon (SCC) - net present value of climate change impacts over the next 100 years (or longer) of one additional tonne of carbon emitted.

We conduct a detailed literature review of the latest methodologies applied in estimating these parameters and evaluate methods appropriate for estimation in the Indian context.

In estimating these parameters, we analyse several databases provided by the Ministry of Statistics and Programme Implementation (MOSPI), Government of India, including inter alia,

the National Accounts Statistics, the NSSO's Household Consumer Expenditure Survey, several rounds of the Annual Survey of Industries and the Periodic Labour Force Survey. We further draw on databases provided by the Reserve Bank of India (RBI), Ministry of Finance and Ministry of Commerce and Industry, Government of India.

In the subsequent sections, we briefly describe each of the parameters for re-assessment in this study and highlight their importance in cost-benefit analysis in the public sector.

1.2. Social Discount Rate

The social discount rate measures the rate at which individuals in society are willing to trade present consumption against future consumption. The social discount rate is applied in project appraisal in the public sector to evaluate the *present value of net benefits* that are expected to accrue from a public sector investment over the lifespan of the project. The present value of expected lifetime benefits from the project is compared to the current cost of incurring the project. If the present value of expected benefits exceeds the current cost of the project, it is economically feasible and socially beneficial to undertake the investment. In this context, the social discount rate may be referred to simply as the “discount rate.”

The social discount rate plays a key role in cost benefit analysis (CBA) in the public sector, as it measures the *annual rate* at which expected future benefits are to be discounted, to obtain the present value of benefits from the project. The social discount rate differs from the rate of return on investments undertaken in the private sector, as the former captures the full range of economic costs and benefits that may accrue to all individuals in society, whereas the latter reflects only the private rate of return to actors in the economy. When the government aims to maximise social welfare (i.e. welfare of all individuals in society), it is the social discount rate which ought to be applied in cost-benefit analysis in the public sector.

1.3.Accounting (Shadow) Prices

Measuring the costs of a public sector programme involves the financial costs and the *economic* costs. While financial costs are measured at market prices (such as budget allocation towards a project at current prices), economic costs also measure the opportunity costs of the project, in terms of the *loss in social welfare* from an alternative investment. Hence, economic costs measure the financial costs and the trade-off associated with funds being allocated to a specific project vis-à-vis to other projects.

Cost-benefit analysis of public sector projects ought to be undertaken at the economic costs of the factors of production, such as raw materials (produced domestically and imported), labour costs and the cost of capital. Little and Mirrlees (1974) refer to the economic or “shadow” prices for factors of production as “accounting prices.” These accounting prices reflect the opportunity cost of the various factors of production, which may not necessarily be reflected in the observed market prices (which also comprise indirect taxes on goods and services).

In this study, we compute the (i) shadow exchange rate factor, which is used to calculate the shadow or “accounting” exchange rate, (ii) standard conversion factor, which is used to measure tradables at accounting prices, and (iii) shadow wage rate factor for unskilled labour, which reflects the opportunity cost of labour.

1.4. Social Cost of Carbon

The social cost of carbon (SCC) measures the monetary damage to society from an additional ton of carbon dioxide (CO₂) emission. Given high potency of greenhouse gases such as CO₂, the SCC is typically measured over long timescales of over 100 years. The expected damages from increases in temperature associated with rising CO₂ concentrations are then discounted each year to obtain the net present value of damages from additional CO₂ emissions. Rennert et al. (2022) compute the SCC using simulations of potential damages due to higher CO₂ concentrations over a 300-year timescale, applying a social discount rate of 2% per year. We conduct a detailed literature review and provide a range of estimates for the social cost of carbon for the Indian context.

1.5.Reassessment of parameters from NITI Aayog (2018) report

- A social discount rate of 8% was recommended for short-term projects (with a duration of up to 50 years).
- For projects related to environment and infrastructure with a duration of more than 50 years, a social discount rate of 6% was recommended.
- It was recommended that for projects with a duration of more than 100 years, the social discount rate should be lower than 6%.
- The rate of return on capital was estimated at 10% using data from the Annual Survey of Industries. This was the recommended internal rate of return to be used as a hurdle rate in financial analysis.
- A social premium of 8% on foreign exchange was recommended.

2. Social Discount Rate: Methods and Results

The literature on cost-benefit analyses of public sector projects dates to the 1970s, where Little and Mirrlees (1974) and Dasgupta, Marglin and Sen (1972) developed techniques for project appraisal, specifically for developing countries. Harberger (1972) and Marglin (1967) also provided frameworks for project appraisal for the case of India, in collaboration with the erstwhile Planning Commission.

These frameworks discussed the key role of shadow prices, which are used to determine the full economic costs and benefits of programmes, extending beyond the financial costs and benefits. Dasgupta and Pearce (1972) and Drèze and Stern (1987) provided comprehensive social welfare frameworks, within which to evaluate the optimal allocation of public sector funds to various projects, considering their impacts on individual and social welfare.

2.1. Literature Review on Social Discount Rate

Policymakers face trade-offs between allocation of public funds across diverse projects. Projects related to infrastructure and construction may yield a high rate of return, as they generate immediate economic benefits (Little and Mirrlees 1974). On the other hand, projects which expand access to education, healthcare and environmental services may only generate benefits over a longer time horizon (Groom et al. 2022; Marglin 1967). Therefore, policymakers create a portfolio of projects, with public sector investments spread across sectors, offering different rates of return.

In evaluating these trade-offs, the social discount rate becomes highly pertinent (Dasgupta 2008). An excessively high social discount rate would underestimate the long-run social benefits of public investments and lead to sub-optimal investment in public programmes. On the other hand, a relatively low social discount rate would understate the benefits of consumption in the immediate future and lead to inefficient public spending. Investments in high-return projects could generate immediate revenues for the public sector which could be invested in generating long-term societal gains. The level of the social discount rate is therefore key to generating an optimal portfolio of public sector investments.

Accumulation of human capital via investments in healthcare and education would not only generate welfare gains to individuals, but also confer benefits to society through positive externalities (Aghion and Howitt 2008). An example is knowledge spill-overs through R&D investments, which can stimulate economic growth and create productive jobs in the economy. Non-optimal human capital may also result from consumption externalities, i.e. when one's consumption is affected by the consumption level of others in society (Bishnu 2013). The latest advances in macroeconomic theory highlight the importance of technological progress in bringing about economic growth, particularly in the context of developing countries, which typically exhibit sub-optimal levels of investment (Aghion and Howitt 2008). Hence, research and development activity requires government subsidies to ensure optimal levels of knowledge creation and economic progress.

In contrast to the discount rate, the hurdle rate is applied in financial analysis as the minimum rate of return on investments by private firms. As the OECD recommends, governments ought to apply the social discount rate for project evaluation and for selection of projects (Coleman 2021). While governments may conduct financial analysis to evaluate certain investments by

the private sector, such as in public-private partnerships, governments are advised to apply the social discount rate for project selection and evaluation (Perkins 1995).

The social discount rate can be computed based on two broad approaches. The first approach is based on the Ramsey rule, which is derived by asking what is the optimal saving rate for society each year, accounting for the future expected economic growth rate of consumption and the degree of inequality aversion in society (NITI Aayog 2018; Ramsey 1928; Dasgupta 2008). This is explained further in Section 2.2.1.

The second approach to calculating the social discount rate is based on market rates of return to capital. This can further be sub-divided into three methods. The first method measures the social discount rate as the real rate of return on government securities which are relevant for consumers' savings decisions. This method is used by the United States' Office of Management and Budget (OMB) to calculate social discount rates for the U.S. economy (US OMB 2023). The second method measures the real rate of return to capital in the economy, which is also known as the social opportunity cost of capital (SOC) (Harberger 1972). The social opportunity cost of capital can be measured as the real interest rate on loans. It can also be measured as the productivity of capital, or the marginal addition to output from an incremental rise in the capital stock in firms. The third method calculates the social discount rate as a weighted average of the discount rates obtained in the above two methods – (i) the rate of return to government deposits and (ii) the market rate of return to capital), and (iii) the cost of foreign borrowing by the Government (Harberger 1972; ADB 2017; Zhuang et al. 2007).

In the previous assessment, the recommended real social discount rate of 8% was based on the Ramsey rule (NITI Aayog 2018). Sensitivity checks using different methods had been conducted to ensure robustness of the proposed discount rate. A recent assessment by NABARD finds a relatively lower value of the social discount rate of 4.5% in real terms (Dholakia et al. 2024).

In this study, we review the NITI Aayog's (2018) assessment and recent studies conducted for India, to identify the most appropriate methods that ought to be used in computing the social discount rate by the Government of India. In so doing, we also review the academic and policy literature for high-income and middle-income countries to draw on the latest guidance by various country governments.

2.2. Methodologies to compute the Social Discount Rate

In this section, we present the two approaches to estimating the social discount rate (sections 2.2.1 and 2.2.2).

The first approach uses the Ramsey rule as the social discount rate for public sector projects. This is the rate at which individuals trade present consumption against future consumption in society. This is based on the rate of time preference, the degree of inequality aversion and the expected future economic growth rate of consumption (Dasgupta 2008; Dholakia et al. 2024; NITI Aayog 2018; Ramsey 1928). This approach requires an estimate for the inequality aversion parameter, to compute the social discount rate.

The second approach measures the social discount rate as the real rate of return to capital. This can be measured in three ways. First, the discount rate can be measured as the long-term real rate of return on government securities, which reflects a safe rate of return on household savings. The United States' Office of Management and Budget (OMB)'s latest guidance recommends using the real rate of return on government bonds as the social discount rate (US OMB 2023). The United States has recently revised its social discount rate downward to 2%. Second, the social discount rate can be measured as the social opportunity cost of capital (SOC), which reflects the market rate of return to capital (Harberger 1972). This can be measured as the minimum real lending rate by the Reserve Bank of India to commercial banks, which reflects the cost of loans to capital owners and thus the rate of return to capital.

The real rate of return to capital can also be measured via a broad stock market index (e.g. NIFTY 500) over a 30-year time horizon, to reflect the real rate of return on private investments in the economy. Alternatively, the marginal product of capital measured using firm-level survey data may best reflect the productivity of capital use in the economy (Burgess and Zerbe 2011). Third, the social discount rate can be measured as a weighted average of the (i) rate of return on government securities, (ii) the market rate of return to capital (social opportunity cost of capital) and (iii) the real interest rate on the government's external borrowing (Harberger 1972; ADB 2017; Zhuang 2007).

In this study, we will apply each of the aforementioned methods to provide a range of values for the social discount rate for short-term projects. In addition to computing the short-term social discount rate, we will compute the social discount rate for longer-term projects (greater than 30 years), following the extended Ramsey rule (Gollier 2024; Gollier and Hammitt 2014). Further, we will adjust for uncertainty in future economic growth and compute the risk-adjusted social discount rate, which has been adopted in policy guidance in several European countries, including France, Denmark and Sweden (Groom et al. 2022).

2.2.1. Ramsey Social Discount Rate

The Ramsey rule has been extensively applied as a benchmark method in project appraisal in several countries (Groom et al. 2022; Dasgupta 2008; Gollier and Hammitt 2014; NITI Aayog 2018). The previous report on project appraisal of the NITI Aayog also used the Ramsey rule to calculate the social discount rate for cost-benefit analysis in public sector projects (NITI Aayog 2018). We derive the Ramsey social discount rate from a social welfare maximisation problem, following Dasgupta (2008).

Approximate Ramsey Rule

Consider a representative consumer who gets utility $U(C_t)$, from consuming an amount C_t in period t . The government that seeks to maximise the welfare of the representative consumer may discount utility from consumption in future periods at rate, δ . This is known as the social rate of time preference (Dasgupta 2008). The government then seeks to maximise the present value of lifetime utility, W_0 , as follows:

$$W_0 = U(C_0) + \frac{U(C_1)}{(1+\delta)} + \dots + \frac{U(C_t)}{(1+\delta)^t} + \dots = \sum_{t=0}^{\infty} \frac{U(C_t)}{(1+\delta)^t} \quad (1)$$

From the government's maximisation problem in equation (1), we can derive the approximate simple Ramsey rule for the social discount rate.⁵ This is stated as follows:

$$\rho_t \approx \delta + \eta g_t \quad (2)$$

⁵ The derivation is presented in Appendix A.

The social discount rate, ρ_t , depends on the (i) growth rate of consumption, g_t , (ii) the social rate of time preference, δ and (iii) the elasticity of the marginal utility of consumption, which is assumed to be a constant η . The elasticity of the marginal utility of consumption measures the percentage increase in marginal utility from a 1 percent increase in consumption. The utility function is assumed to be concave, with marginal utility diminishing in consumption, which are standard assumptions in the economics literature (Mas-Colell et al. 1995). This means that additional consumption is considered more valuable for individuals who are consuming very little compared to those who are already consuming a lot. The parameter η measures the curvature of the utility function and the degree of inequality aversion of the government. A high value for η suggests a high degree of inequality aversion. In this case, the government will discount future consumption at a high rate if it expects positive economic growth, because it then expects consumption to be higher in the future, so that additional units of consumption in the future add less to utility than they do for poorer present consumers. Drupp et al. (2018) conduct a survey of 180 experts on discounting and find the most common reported value of $\eta = 1$.

The social rate of time preference measures the rate at which future *utility* (not consumption), is discounted relative to present utility. Since this report is concerned with social cost-benefit analysis, it is the *social* rate of time preference that is relevant, not the rate of time preference used by individuals. For example, older individuals may have a high rate of time preference, but this is not relevant for social decision-making since they will be replaced by younger individuals. The Intergovernmental Panel on Climate Change (IPCC) which made a comprehensive and authoritative assessment of the literature, noted in its 2014 report that there is “*a broad consensus for a zero or near-zero pure rate of time preference*” (IPCC 2014).

However, Drupp et al. (2018) reported a median value of the pure rate of time preference, $\delta = 0.5\%$ in their survey of 180 economic experts on discounting. We thus apply this value to compute the Ramsey social discount rate for short- and long-term projects.⁶ We present syntheses of estimates of the social discount rate based on the simple Ramsey rule in Table 1 based on Gollier and Hammitt (2014).

⁶ Some prominent economists (Dasgupta 2008 and Stern 2006) have suggested a value of δ very close to zero, with Stern (2006) recommending $\delta = 0.1\%$. Stern (2006) justifies a positive, rather than zero, value based on the assumption that there is a very small probability in each period that humanity will cease to exist. Another survey of 14 philosophers with value judgements on climate policy yields a median value of δ of zero (Nesje et al. 2023).

To determine the per capita consumption growth rate, we use estimates of annual per capita GDP growth rates at constant prices for the period 1993-94 to 2022-23, from the National Accounts Statistics, Ministry of Statistics and Programme Implementation.⁷ We compute the average annual real GDP per capita growth rate over the last 30 years and apply $g = 4.7\%$, as a minimum annual rate of per capita GDP growth that may be expected over the next 30 years. Finally, we require an estimate of the elasticity of marginal utility of consumption. We follow Groom and Maddison (2019) and test various methods to estimate η .

Table 1: Synthesis of parameter estimates for social discount rate

Author	Inequality aversion, η	Growth rate, g	Discount rate, ηg
Stern (1977)	2		
Cline (1992)	1.5	1%	1.5%
IPCC (1995)	1.5–2	1.6–8%	2.4–16%
Arrow (1999)	2	2%	4%
HM Treasury (2003)	1	2%	2%
Lebègue (2005)	2	2%	4%
Arrow (2007)	2–3		
Dasgupta (2007)	2–4		
Stern (2007)	1	1.3%	1.3%
Weitzman (2007a)	2	2%	4%
Nordhaus (2008)	2	2%	4%
Pindyck (2013)	1–3		

Source: Gollier and Hammitt (2014). Note: These estimates are based on the approximate Ramsey rule with social rate of time preference, $\delta = 0$.

Estimating the elasticity of marginal utility of consumption (η)

Groom et al. (2022) and Gollier and Hammitt (2014) review parameter values for inequality aversion (η) across countries based on the Ramsey rule. Most of the studies report values of the inequality aversion parameter around 1, with a consensus around 1.5, based on different methods of estimation across countries (Groom and Maddison 2019; Del Campo et al. 2024).

⁷ We apply the growth rate in GDP per capita rather than private consumption expenditure as a better metric for individuals' standard of living given lower annual fluctuations in GDP compared to consumption expenditure.

Groom and Maddison (2019) outline five different methods which may be used to compute the elasticity of marginal utility of consumption (η). These are the (i) equal sacrifice approach, (ii) Euler equation approach, (iii) risk-aversion approach, (iv) Frisch approach and the (v) subjective well-being approach. Groom and Maddison (2019) test each of these methods and apply them to the context of the United Kingdom.

We test four of these five methods and compare our results with those from contemporary studies such as by NABARD (Dholakia et al. 2024) and NITI Aayog (2018). While the study by NABARD applied the Frisch approach to estimate the discount rate, the previous study by NITI Aayog applied the equal sacrifice and Euler equation approaches to estimating the social discount rate. We omit the risk aversion approach due to lack of data in the Indian context to apply that approach.

In this chapter, we outline and present results from the equal sacrifice approach, which yields reliable estimates of the elasticity of marginal utility of consumption. The other approaches do not yield reliable estimates. In particular, we do not recommend the use of the Frisch approach in computing the social discount rate for public sector projects by the Government of India, due to unreliable estimates.

We test these approaches using data for the Indian economy and consistent with the literature (Groom and Maddison 2019), find negative values for η in some cases. We also do not recommend the subjective well-being approach to calculate η as this method relies on assumptions about the individual's utility function and uses subjective information, rather than objective data. Lastly, we do not apply the Euler equation approach for project evaluation as it generates implausibly large estimates from our datasets. This is likely due to sparse data points available for time series regressions which we use for estimation. We present results from these other approaches in Appendix A.

Equal sacrifice approach

The equal sacrifice approach to estimating η assumes that the government distributes the burden of income taxation among people so that each bears the same utility loss as a result of the tax, given a system of progressive income taxation.

Consider a representative individual with income Y_i and utility from income, $U(Y_i)$. Define the tax function, $T(Y_i)$, as the direct tax paid by individual i on income, Y_i . The equal sacrifice principle states that the difference in the individual's utility levels between the pre-tax income, $U(Y_i)$, and the post-tax income, $U(Y_i - T(Y_i))$, is equal to a constant, k (Evans 2004). This holds for all individuals in society where a progressive income tax system is in place. Formally, the principle states:

$$U(Y_i) - U(Y_i - T(Y_i)) = k \quad \forall i \quad (4)$$

Following Evans (2004), a formulation can be derived for the elasticity of marginal utility of consumption, η :

$$\eta = \frac{\ln(1-MTR)}{\ln(1-ATR)} \quad (5)$$

where ATR is the average tax rate, defined as $\frac{T(Y_i)}{Y_i}$ and MTR is the marginal tax rate, defined as $\frac{\partial T(Y_i)}{\partial Y_i}$. Intuitively, η reflects the degree of inequality aversion. A high average tax rate and relatively low marginal tax rate, i.e. $\eta > 1$, suggests a high degree of inequality aversion, where the marginal utility of consumption declines sharply with increasing consumption levels.

Data Sources

To estimate the elasticity of marginal utility of consumption, η , we use annual data on “Direct Tax Statistics” from the Income Tax Department (ITD), for the assessment years, 2012-13 to 2023-24. We use data on average incomes (“Average Salary Income (in lakh INR)”) for each income category from the annual reports of the “Direct Tax Statistics.”

Next, we obtain information on marginal tax rates (and surcharges) for each tax slab, by year, from the Annual Finance Bill Memoranda, Union Budgets, for the years 2011-12 to 2022-23. The assessment years (AY) for the income tax returns follow the financial years (FY), such that FY 2012-13 corresponds to the AY 2013-14. We apply the marginal tax schedules to the average incomes reported in each income category to calculate the corresponding tax paid in

each category, by year.⁸ Subsequently, we calculate average tax rates for each income category, by year.

Results

In this section, we present results from the equal sacrifice approach. In Table 2, we present average incomes, average taxes paid, average tax rates (ATR) and the marginal tax rates (MTR) for all income categories for the assessment year 2023-24, as an illustration.

Based on data for average tax rates and marginal tax rates for each of 22 income categories and 11 years of data, we estimate the elasticity of marginal utility of consumption (η). We estimate a pooled Ordinary Least Squares (OLS) regression, with the constant term suppressed. We apply frequency weights with the number of returns filed in each income category as weights for each category.

In this case, a fixed effects estimator is not required since the income categories do not represent a source of unobserved individual heterogeneity. Further, we cannot include time controls in the regression as the entire variation in the data used to estimate η arises from annual changes in tax rates.

Table 2: Average incomes, income taxes, average tax rates and marginal tax rates by income category, assessment year 2023-24

Income Category	Average Income (INR)	Average tax paid (INR)	ATR	MTR
>0 and <=1,50,000	66,000	-	0.00	0.00
>1,50,000 and <= 2,00,000	1,76,000	-	0.00	0.00
>2,00,000 and <=2,50,000	2,33,000	-	0.00	0.00
>2,50,000 and <= 3,50,000	3,03,000	150	0.00	0.05
>3,50,000 and <= 4,00,000	3,75,000	3,750	0.01	0.05

⁸ Sample calculation: Consider an average income level of INR 12,05,000. Based on the marginal tax schedule for the assessment year 2012-13, we apply a zero marginal tax rate for income up to INR 1,80,000, and then marginal tax rates of 10% for income between INR 1,80,001 – 5,00,000, 20% for income between INR 5,00,001 – 8,00,000 and 30% on income between INR 8,00,001 – 12,05,000. Hence, taxes paid on an average income of INR 12,05,000 = INR 2,13,500. Thus, the average tax rate is 18%, while the marginal tax rate (on incomes above INR 8,00,000) is 30%.

>4,00,000 and ≤ 4,50,000	4,26,000	6,300	0.01	0.05
>4,50,000 and ≤ 5,00,000	4,81,000	9,050	0.02	0.05
>5,00,000 and ≤ 5,50,000	5,22,000	22,200	0.04	0.10
>5,50,000 and ≤ 9,50,000	6,99,000	24,900	0.04	0.10
>9,50,000 and ≤ 10,00,000	9,75,000	56,250	0.06	0.15
>10,00,000 and ≤15,00,000	12,06,000	91,200	0.08	0.20
>15,00,000 and ≤ 20,00,000	17,17,000	2,15,100	0.13	0.30
>20,00,000 and ≤ 25,00,000	22,25,000	3,67,500	0.17	0.30
>25,00,000 and ≤ 50,00,000	33,95,000	7,18,500	0.21	0.30
>50,00,000 and ≤ 1,00,00,000	68,06,000	19,15,980	0.28	0.30
>1,00,00,000 and ≤5,00,00,000	1,89,53,000	64,63,080	0.34	0.30
>5,00,00,000 and ≤10,00,00,000	6,94,46,000	2,66,93,940	0.38	0.30
>10,00,00,000 and ≤25,00,00,000	15,46,05,000	5,99,05,950	0.39	0.30
>25,00,00,000 and ≤50,00,00,000	34,95,84,000	13,59,47,760	0.39	0.30
>50,00,00,000 and ≤100,00,00,000	69,73,89,000	27,15,91,710	0.39	0.30
>100,00,00,000 and ≤500,00,00,000	2,05,81,72,000	80,22,97,080	0.39	0.30
>500,00,00,000	23,81,85,11,000	9,28,88,29,290	0.39	0.30
Overall average	1,23,57,39,318	48,15,98,168	0.17	0.18

Source: Data on average income are from the Direct Tax Statistics, Income Tax Department, and data on marginal tax rates (MTR) are from the Annual Finance Bill, Union Budget, Government of India. Average taxes paid and average tax rates (ATR) are calculated for average incomes in each income category.

The regression results are displayed in Table 3, which show an estimate of $\eta = 1.8$, for the main specification. Column (2) of Table 3 presents a robustness check using only the last three years of data on income tax assessments (2021-22 to 2023-24).

Table 3: Estimate of the elasticity of the marginal utility of consumption (η)

ln(1-MTR)	(1)	(2)
ln(1-ATR)	1.81*** (0.078)	1.86*** (0.158)
Observations	242	66
R^2	0.827	0.833

Robust standard errors in parentheses.

Constant term suppressed.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Based on parameter values, $\delta = 0.5\%$, $\eta = 1.8$ and $g = 4.7\%$, the Ramsey rule yields a social discount rate (in real terms) of 8.9%. In nearly all studies that apply social discount rates based on the Ramsey rule (displayed in Table 1), the inequality aversion parameter (η) takes a value greater than one. In its 2018 report to NITI Aayog, the Institute of Economic Growth (IEG) reported an average value of $\eta = 1.2$, based on the equal sacrifice principle and the Euler equation approach. A recent study by NABARD applies a value of $\eta = 0.8$, based on the Frisch approach (Dholakia et al. 2024). However, our application of the Frisch approach yields a negative value for η , which is consistent with results from other studies (Groom and Maddison 2019). Thus, we recommend the equal sacrifice approach to estimate η and the social discount rate based on the Ramsey rule.

The expected growth rate of 4.7% is based on historical annual growth rates observed in India over the last 30 years. Alternatively, we may compute the social discount rate using the Government of India's Viksit Bharat targets for 2047, applied to the simple Ramsey rule. According to NITI Aayog (2024), the Indian economy may be reasonably expected to grow at 5.9% per year in real terms in a conservative scenario. A projected annual growth rate of 5.9% yields a social discount rate (based on the simple Ramsey rule) of 11.1%. However, the report mentions a caveat based on observations from other countries' past growth rates:

"Sustained fast growth is extremely rare; Virmani (2012) showed that there were only a dozen non-resource rich countries, which had a per capita GDP growth rate of 7% or higher for more than a decade, of which half sustained it for less than two decades."

Therefore, we consider the high, Viksit Bharat target growth rate as an upper bound estimate for a 30-year period and consider a lower average annual growth rate of 4.7% for projects which last more than 30 years.

Social Discount Rate with uncertainty adjustment (Extended Ramsey Rule)

Public sector investments would also be subject to uncertainty in the future rate of growth of consumption. External shocks to the economy, for instance due to pandemics, wars or climate crises, may unexpectedly reduce future GDP and per capita income. To account for uncertainty in the future rate of economic growth, policymakers ought to consider a risk-adjusted social

discount rate for project appraisal. The latest economic research recommends adjusting the discount rate for uncertainty and volatility in consumption growth, based on the extended Ramsey rule (Groom et al. 2022; Gollier and Hammitt 2014; Gollier 2024). This is more important for developing countries that have high and more uncertain growth rates than developed countries. As uncertainty in the future level of consumption compounds over time, projects with longer time spans may need to be discounted at lower rates, due to the uncertainty in future economic growth. A lower social discount rate allows social planners to invest in risk mitigation measures such as emission abatement technologies (which would reduce economic damages from climate change) in a cost-effective manner, and thereby insure society against future risk in consumption.

As an example, consider a pensioner who faces uncertainty in the expected future pension, which depends on government revenue as a result of future economic growth. If the pensioner were to receive a certain pension of say, INR 1,00,000 per month, they would experience higher utility levels than in the uncertain case, where they may receive a pension of INR 50,000 with probability 0.5 and a pension of INR 1,50,000 with probability 0.5. The second case represents uncertain future economic growth and in turn, government expenditure. In the latter case, the policymaker is inclined to apply a lower discount rate for precautionary savings in the event of lower economic growth and consumption levels in the future, compared to the case of high economic growth with certainty. This result relies on the convexity of the marginal utility of consumption, a standard assumption in macroeconomics, which stems from the expected utility theory (Caballero 1990; Rabin 2000).

The extended Ramsey rule, derived in Gollier (2024), is expressed as follows:

$$\rho_t \approx \delta + \eta\mu_t - 0.5\eta^2 t\sigma_t^2$$

Where ρ_t is the uncertainty-adjusted social discount rate, δ is the social rate of time preference, η is the degree of inequality aversion, μ_t is the expected rate of future economic growth between $t = 0$ and t , and σ_t^2 is the variance in the expected growth rate.⁹ The extended Ramsey rule assumes that consumption growth (or equivalently, economic growth), over the next t

⁹ This follows Equation 20 in Gollier (2024). Gollier takes ρ to be zero and has another term accounting for a possible correlation between future consumption and the returns to a particular public investment project. Since we are interested in a single discount rate for public projects and it is unclear what the correlation with future consumption, if any, will be for different classes of projects, we ignore this term.

years, follows a normal distribution, so that $g_t = \frac{1}{t} \ln \ln \left(\frac{c_t}{c_0} \right) \sim N(\mu_t, \sigma_t^2)$. Further, t is the lifetime duration of the public project, which allows the social planner to compute discount rates for different project timespans. This results in a term structure for discount rates (Gollier and Hammitt 2014). This is because for a given level of uncertainty σ_t^2 in the growth rate between now and t , the uncertainty in consumption at time t relative to today $\left(\frac{c_t}{c_0} \right)$, is increasing in t due to compounding. The precautionary motive pushes us to save more, leading to a lower discount rate. This is less of a problem for developed countries that have a lower variance in their growth rates.

We compute the term structure for discount rates, accounting for uncertainty in the growth rate. Existing studies typically use the historical time series of growth rates for a particular country to estimate the variance in the growth rate (Gollier 2012). However, the observed variance in a country's economic growth over the past 30 years is likely to substantially *understate the potential variance in future economic growth*. Instead, we draw on other countries' experiences to predict potential variance in India's expected economic growth over the next 30 years.¹⁰

We draw on country-level data on annual real GDP per capita levels and growth rates for 266 countries from the World Bank's World Development Indicators (WDI) database for the 1960-2023 period. We construct a comparison group of countries for India based on similarity of per capita income levels and past economic growth rates. In 2023, India's per capita GDP stood at US\$ 2,239 (in US\$ 2015 constant prices). Further, India exhibited an average annual growth rate of real GDP per capita of 4.7% between 1993-2023.

We construct the comparison group of countries based on two measures. First, we restrict the sample to countries that exhibited real GDP per capita levels (in US\$ 2015 constant prices) in the range of India's GDP per capita +/- 50%, i.e. between US\$ 1,120 and US\$ 3,359, between the 1970-1993 period. This large band of per capita incomes ensures a sizeable number of countries which exhibited similar per capita incomes in the past to India's present income. Second, we restrict the sample to countries which also exhibited similar growth rates to India's average growth rate +/- 50%, over the preceding 30 years. Specifically, we consider countries which exhibited average annual growth rates between 2.35% and 7.05% in the preceding time

¹⁰ The necessary adjustment for uncertainty in computing the discount rate is smaller for developed countries that have a lower variance in their growth rates.

period, i.e. until 1993. Hence, we observe a sample of 20 countries which exhibited similar per capita incomes as India's current income, prior to 1993 and similar economic growth rates as India's recent average growth rate, prior to 1993. The list of countries is presented in Table 4.¹¹

Table 4: List of countries for computing variance in the growth rate

S. No.	Country	Initial GDP per capita (2015 US\$, Constant Prices)	Past GDP per capita growth rate, % (till 1993)	Subsequent GDP per capita growth rate, %
1	Belize	3,233	2.7	1.9
2	China	1,239	5.0	7.6
3	Dominica	3,288	2.9	2.9
4	Dominican Republic	3,179	2.5	3.4
5	Ecuador	3,337	2.4	1.0
6	Egypt, Arab Rep.	2,040	3.0	2.4
7	Eswatini	2,110	3.5	2.3
8	Grenada	3,243	5.7	3.1
9	Indonesia	1,707	3.2	3.0
10	Kyrgyz Republic	1,203	4.1	-0.2
11	Malaysia	3,292	4.5	3.1
12	Maldives	3,275	5.1	3.5
13	Malta	3,212	2.4	5.5
14	Mauritius	3,256	3.1	3.8
15	Morocco	1,668	2.6	2.3
16	Paraguay	3,274	4.1	1.2
17	Sri Lanka	1,488	2.6	3.3
18	Syrian Arab Republic	1,122	2.7	-1.1
19	Thailand	3,167	5.1	2.3
20	Turkey	3,274	2.7	2.3

Source: World Development Indicators, World Bank Group.

Note: Initial GDP per capita (constant 2015 US\$) refers to the 1970-1993 period.

¹¹ We select this range of GDP as the minimum range of GDP required to ensure a sufficient sample size of comparison countries to predict the potential variance in the future economic growth rate for India. We also conducted this analysis for the interquartile range of GDP. However, that resulted in a very limited set of comparison countries, which were insufficient to predict the variance in future economic growth for India.

Next, we compute the economic growth rates for each of these 20 countries over the subsequent 30-year period from 1993-2023 and record the observed variance in growth rates across countries. We use this observed variance in growth rates as a reasonable prediction for potential variance in India's future economic growth. We observe a range of expected future growth rates between -1.1% in Syria to 7.6% in China. The resulting term structure of discount rates is presented in Table 5.

The simple Ramsey social discount rate is 11.1% for an expected economic growth rate of 5.9% over the next 30 years based on the Viksit Bharat 2047 growth projection (NITI Aayog 2024). When this growth rate is adjusted for future uncertainty, the social discount rate is revised downward to 9.4%. Similarly, for an expected growth rate of 4.7% based on past performance, the social discount rate for a 30-year time horizon is estimated at 8.9%, based on the Ramsey rule. Adjusting for future uncertainty reduces this discount rate to 7.3%.

Table 5: Term structure of discount rates, with uncertainty adjustment in growth rates

Social rate of time preference	Inequality aversion	Mean growth rate (India)	Project Term	Variance in 30-year growth rates of other countries	Simple Ramsey discount rate (%)	Uncertainty term (%)	Extended Ramsey discount rate (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
δ	η	μ_t	t	σ_t^2	$\delta + \eta\mu_t$	$0.5\eta^2 t \sigma_t^2$	ρ_t
0.5	1.8	0.059*	30	0.000344	11.1	1.7	9.4
0.5	1.8	0.047	30	0.000344	8.9	1.7	7.3
0.5	1.8	0.047	50	0.000344	8.9	2.8	6.2
0.5	1.8	0.047	75	0.000344	8.9	4.2	4.8
0.5	1.8	0.047	100	0.000344	8.9	5.6	3.4

Note: *This refers to the conservative growth rate scenario over the next 30 years, according to NITI Aayog (2024).

Based on an expected annual economic growth rate of 4.7% and adjusting for future uncertainty yields the following term structure of social discount rates (corresponding project terms): 7.3% (< 30 years), 6.2% (30-50 years), 4.8% (50-75 years) and 3.4% (75-100 years). Given potential uncertainty in future economic growth, we recommend applying the extended Ramsey rule to compute social discount rates (adjusted for uncertainty), for varying time horizons.

2.2.2. Market Rates of Return to Capital

a) Real Return on Government Securities

The real rate of return on government bonds reflects the risk-free rate at which individuals might trade present consumption against future consumption (e.g. see US OMB 2023). We calculate the real rate of return on central government securities, using data on nominal interest rates and the Consumer Price Index (CPI)-based inflation rates, which are available at annual frequency, published by the Reserve Bank of India, for the period 1993-94 to 2022-2023.¹² Government securities provide households a safe, risk-free option to invest their savings over the long term. Hence, the rate of return on these securities provides households a risk-free interest rate to use in intertemporal consumption and savings decisions.

We find an average annual, pre-tax *real rate of return of 3.46%* on central government securities using annual data for the 1993-94 to 2022-23 period. We take this to be a *lower bound value* for the social discount rate.

b) Social Opportunity Cost of Capital

The second approach to calculating the short-run discount rate (for projects with lifetimes of 30 years or less) is to measure the social opportunity cost of capital in the economy. The productivity of capital deployed in production yields the rate of return to capital, which is a measure of its opportunity cost (or its next best use). The social discount rate would equal the social opportunity cost of capital (SOC) in an economy without financial market imperfections or externalities. The social opportunity cost of capital should thus be reflected in the market interest rate, as the market interest rate equals the marginal product of capital in an economy at equilibrium. Thus, we estimate the marginal product of capital deployed in manufacturing sector production in private firms.

Studies by Poterba (1998) and Jenkins et al. (2011) compute the rate of return to capital using country-level national accounts. However, this method may lead to significant overestimation of the marginal return to capital and is likely to generate an upward bias in the calculated

¹² In addition to central government securities, we also analysed data on real interest rates for fixed deposits with maturities over 5 years and the real rate of return on gold, for the 1993-2023 period. We selected central government securities as these yielded the highest rates of return compared to the other savings instruments.

discount rate, as discussed in Poterba (1998).¹³ Here, the rate of return to capital, measured as the ratio of income from capital to the stock of capital for a given year, can be estimated using data from the National Accounts Statistics on an annual basis, following the approach outlined in Jenkins et al. (2011). We find the average real rate of return to capital to be 10.6% over the 2012-13 to 2022-23 period. The detailed calculations for this method are presented in Appendix A.

Next, we outline a robust econometric method to estimate the *marginal return to capital*, using annual firm-level data from the Government of India's Annual Survey of Industries. The drawback of this approach, however, is that it only applies to the formal, organised manufacturing sector and omits the informal sector from analysis, which accounts for a sizeable share of the economy.

Estimating the marginal product of capital

We estimate a production function at the firm-level, following Levinsohn and Petrin (2003). Consider a firm-level production function, $Y = f(K, L, M)$, where firms produce output Y , using capital (K), labour (L) and other raw materials (M) as inputs in production. We estimate the marginal product of capital, or regression coefficient, β in the regression equation below.

$$Y_{it} = \alpha_i + \gamma_t + \beta K_{it} + \tau L_{it} + \omega M_{it} + \varepsilon_{it}$$

where i and t specify the firm and year, respectively. The regression includes firm-level fixed effects α_i and year fixed effects γ_t .

Estimating β requires an external source of variation in the capital input that is uncorrelated with the firm's unobserved productivity. Since changes in the capital stock are likely to be correlated with firms' unobserved productivity levels, Levinsohn and Petrin (2003) recommend using alternative input purchases, such as raw materials or fuels like electricity as a proxy variable. The proxy variable is used as an instrumental variable for changes in the capital stock. In this analysis, we use electricity input costs as the proxy variable given that we

¹³ Economic theory suggests the average rate of return (calculated as the ratio of income from capital to the capital stock) overestimates the rate of return to capital on the marginal project (Poterba 1998). The marginal rate of return to capital accurately measures the expected rate of return to investment in an additional project commissioned by the government.

observe expenditure on electricity incurred by each firm in the survey. This relies on the assumption that electricity usage, which complements capital use, is likely to be uncorrelated with unobserved firm-level technology shocks or other productivity changes which may be linked to capital usage.

Electricity use also varies at a higher frequency than changes in the firm's capital stock. In other words, we expect changes in electricity use to respond more flexibly than changes in the capital stock of the firm. We find this assumption to be validated in the empirical literature (Allcott et al. 2016). Further, we use data on electricity expenditures rather than electricity consumed to be consistent with the Levinsohn-Petrin approach, which uses data on inputs expressed in value terms, rather than quantities. Also, electricity prices charged to firms have remained relatively stable across firms as the firm-level reported prices are highly correlated with the state-level tariffs charged to firms by the distribution companies. Hence, we do not expect large fluctuations in electricity prices over the timeframe observed.

Data Sources

We draw on firm-level panel data from the Annual Survey of Industries, conducted by the Ministry of Statistics and Programme Implementation (MOSPI), for the period 2009-10 to 2019-20. The ASI is a nationally representative survey of registered firms. The survey data contain detailed information on input use and output production. We compute real gross value added (GVA), following the ASI tabulation programme and deflating GVA by the Wholesale Price Index (WPI). Next, we compute the real capital stock at the firm-level, which comprises both fixed capital and working capital. Then, we calculate employment at the firm as the “average persons worked,” provided in the ASI survey. We also compute material and fuel costs (excluding electricity), in real terms, as other inputs in production. The cost of electricity purchases is used as the proxy variable. We exclude Public Sector Enterprises (PSEs) from this analysis.

Results

The results are displayed in Table 6. The estimated elasticity of output with respect to capital is 0.22. We compute the median ratio of output to capital, $\frac{Y}{K}$, across the distribution of firms in

our sample, which equals 0.46. The derived marginal product of capital, or the real annual rate of return to capital is 10%.¹⁴ We also find similar rates of return to capital if we utilise data on “number of man-days worked” at the firm.

Table 6: Estimating the Marginal Product of Capital

ln (Real GVA)	(1)
ln (Capital)	0.217*** (0.007)
ln (Labour)	0.625*** (0.004)
ln (Materials)	0.0725*** (0.002)
Observations	148,394
Wald test (<i>Chi-sq.</i>)	163.65
Median Ratio: Real GVA/Real Capital	0.46
Real return to capital	10.0%
Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$	

The third method to compute the rate of return to capital is based on a broad stock market index, which reflects the return on private investments. We calculate the annual real rate of return on the NIFTY 500 Total Returns Index, which comprises price appreciation and dividend payments, for the 1999-2025 period.¹⁵ We find an annual, pre-tax real rate of return of 11% over this period.¹⁶

The NIFTY 500 index comprises the top 500 publicly-listed companies on the National Stock Exchange, based on market capitalisation. Thus, it includes approximately 250 companies with relatively low market capitalisation, 150 companies with medium market capitalisation and 100 companies with large market capitalisation. Thus, the real rate of return would not need to

¹⁴ This can be derived as follows: $\ln Y \ln K = \beta$. The marginal product of capital, $\partial Y / \partial K = \beta Y / K$.

¹⁵ Data for the NIFTY 500 Total Returns Index are only available online from 1996.

¹⁶ This estimate can be contrasted with the real interest rate for loans set by the Reserve Bank of India for Scheduled Commercial Banks. Analysing the minimum lending rate by commercial banks for the 1993-2023 period, using data published by the RBI, we find an average minimum real lending rate of 4.3%, which may be considered a *minimum safe rate of return on investment* in the long run.

be adjusted further for size premiums, which often accrue to companies with small market capitalisation. While the literature on corporate finance shows that private equity firms tend to observe higher rates of return on investment than publicly-listed firms on the stock market, empirical research in the context of India shows that these higher rates of return to private equity are on account of a selection effect, whereby investments are targeted towards more productive firms, but unproductive firms do not gain in productivity due to private investments (Smith 2015; Officer 2007).

Therefore, the higher rate of return accruing to the private equity firms should not be applied as the social opportunity cost of capital for public project evaluation. The rate of return to investment observed in the stock market can be considered an appropriate real rate of return to private investment in the Indian economy. This is particularly so for the Total Returns Index which accounts for both price appreciation of the stock and dividend payments made to investors, which have an outsized impact on the total return on the stock market (Golez and Koudijs 2018). The stock market return represents the opportunity cost of capital used in the public sector under the assumption that this capital would otherwise have been invested in a listed private sector firm.

The first method to estimating the rate of return to capital, using the national accounts, measures an average return but captures the whole economy, and yields 10.6% for the 2012-13 to 2022-23 period. The second method measures the marginal rate of return and yields 10%, but only captures the formal sector in the economy. The third method measures the rate of return on the stock market and yields 11%, but only measures the return in privately listed companies. In what follows, we apply a rate of return to capital of 10.6% derived from the national accounts.

The estimated figures broadly represent the return on domestic capital in the economy. However, they may not strictly correspond to the return on private capital, which is likely to be higher, as the estimates are based on aggregate national accounts data that include both private and government sectors. In principle, one approach would be to adjust the estimates by deducting components that relate to the government sector in order to approximate the return on private capital. However, such adjustments are constrained by limitations in the available data, as a clear and precise segregation of the relevant components is not always possible. Accordingly, the estimates should be interpreted as providing an indicative measure of the

overall return to capital in the economy, rather than a precise estimate of the return to private capital alone.

c) Weighted Average Approach

The weighted average approach, proposed by Harberger (1972) and widely adopted in cost-benefit analysis (Burgess and Zerbe 2011; ADB 2017), is premised on the assumption that additional government borrowing undertaken to finance public sector projects is likely to displace, in part, household consumption, private investment, and foreign borrowing. As government borrowing raises the demand for funds in the market, the interest rate rises in the short-run, which leads to reductions in household consumption, private investment, and the government's external borrowing. The social discount rate based on the weighted average approach can be expressed as follows (Harberger 1972; Zhuang et al. 2007):

$$\rho_{WA} = \alpha r_g + \beta \rho_K + (1 - \alpha - \beta) i_f$$

where r_g is the net of tax real interest rate on government securities, ρ_K is the social opportunity cost of capital and i_f is the real interest rate on the government's external borrowing. The weights, α and β measure the marginal displacement of private consumption and private investment due to an increase in the government's borrowing to finance public sector expenditure.

Burgess and Zerbe (2011) derive a tractable formula to estimate these weights and compute the social discount rate, as follows:

$$\rho_{WA} = \frac{\rho_K - \left(\frac{e}{n}\right) \left(\frac{S}{I}\right) r_g + \left(\left(\frac{1}{SRC}\right) - 1\right) i_f}{-\left(\frac{e}{n}\right) \left(\frac{S}{I}\right) + \frac{1}{SRC}}$$

where $\left(\frac{S}{I}\right)$ is the ratio of domestic savings to private investment in the economy and SRC is the savings retention coefficient, which measures the association between the domestic savings rate and the investment rate (i.e. investment as a proportion of GDP associated with savings as

a proportion of GDP), following Feldstein and Horioka (1980).¹⁷ The parameters, e and n , respectively measure the sensitivity of savings to the interest rate and the sensitivity of investment to the interest rate. In Appendix A, we decompose the above formula to display the weights attached to each of the three parameters, ρ_K , r_g and i_f , expressed in terms of the remaining parameters.

Results

We estimated the real rate of return on central government securities as 3.46% (section 2.2.2a). To calculate the net of tax rate of return, we use data on marginal tax rates for different income slabs for the latest assessment year (2023-24) and compute a weighted average marginal tax rate. The marginal tax rate in each slab is weighted by the number of ITR filers in the corresponding slab. We obtain a weighted average marginal tax rate of 10%. Hence, the net of tax rate of return on government securities, r_g , is 3.1%. We obtained an estimate for the marginal product of capital, ρ_K , of 10.6%, as the average real return from the National Accounts Statistics (Section 2.2.2b).

Next, we analyse data on the Government of India's external borrowing, drawing on annual status reports of "India's External Debt Position," published by the Ministry of Finance. We obtain an average real interest rate, i_f , over the 2016-17 to 2023-24 period of 4.9%.¹⁸ Further, we compute the savings-investment ratio from the National Accounts Statistics for the latest year available, 2023-24, $\left(\frac{S}{I}\right) = 0.95$. We estimate the savings retention coefficient as the correlation coefficient between the savings-GDP ratio, $\left(\frac{S}{Y}\right)$ and the investment-GDP ratio, $\left(\frac{I}{Y}\right)$, and find $SRC = 0.95$.

Finally, we estimate the interest elasticities of investment and savings, n and e , respectively. We estimate n using panel data on investments by firms from the Annual Survey of Industries, for the period, 2011-12 to 2019-20. We use data on minimum real lending rates published by the RBI (adjusted by CPI-inflation rates) to estimate $n = -0.3$, with a 95% confidence interval

¹⁷ The savings retention coefficient measures the proportion of incremental savings invested domestically relative to the proportion of incremental savings invested abroad.

¹⁸ To calculate the real interest rate from the nominal interest rate reported in the annual status reports, we compute the annual percentage change in the reciprocal of the real effective exchange rate (REER). Then, the real interest rate is the nominal interest rate less the percentage change in REER.

of (-0.48, -0.12).¹⁹ Lastly, we estimate e as the product of the reciprocal of the elasticity of marginal utility $\left(\frac{1}{\eta}\right)$ and the consumption-wealth ratio $\left(\frac{C}{W}\right)$, as explained in Burgess and Zerbe (2011). We estimated $\eta = 1.8$ (section 2.2.1) and obtain the consumption-wealth ratio as $\left(\frac{C}{W}\right) = 0.1$, from Bharti et al. (2024) and the World Inequality Database. Hence, we obtain an interest elasticity of savings, $e = 0.06$.

In Table 7, we present calculations of the social discount rate, with sensitivity checks. The social discount rate varies from 8.1% to 9.6%, with a mean estimate of 9.23%. The range of discount rates is based on the 95% confidence interval for the interest elasticity of investment, which provides a range of estimates for n .

Table 7: Social Discount Rate – Weighted Average Approach

Rate of return on capital	Rate of return to household savings	Interest rate on external borrowing	Savings-Investment Ratio	Savings Retention Coefficient	Interest elasticity of savings	Interest elasticity of investment	Social Discount Rate (%)	Remarks on Interest elasticity of investment
ρ_K	r_g	i_f	$\left(\frac{S}{I}\right)$	SRC	e	n	ρ_{WA}	
10.6	3.1	4.9	0.95	0.95	0.06	-0.30	9.23	Mean estimate
10.6	3.1	4.9	0.95	0.95	0.06	-0.48	9.59	Upper bound
10.6	3.1	4.9	0.95	0.95	0.06	-0.12	8.12	Lower bound

Note: The lower and upper bound values are based on the 95% confidence interval of the interest elasticity of investment.

¹⁹ We estimate the following regression equation:

$$\ln I_{it} = i + t + r_t + \varepsilon_{it}$$

where I_{it} is investment by firm i in year t and r_t is the real interest rate on loans by commercial banks. The panel regression includes firm and year fixed effects, i and t .

2.2.3. Comparison of Social Discount Rates

We compare the estimates of the short-run social discount rate obtained from these approaches in Table 8. These discount rates pertain to projects with lifetimes of less than 30 years. Our estimates of the short-run social discount rate range from 6.8% to 11% with mean estimates of 6.8% and 9.23% from the Ramsey rule and weighted average methods, respectively.

The long-term social discount rates, with varying project maturities and accounting for potential uncertainty in future consumption growth, are presented in Table 5 in preceding section 2.2.1. To compare our estimates for India with those for other developed and developing countries, we present estimates of social discount rates from several countries surveyed by Groom et al. (2022) in Table 9. These studies synthesize guidance on discounting for project appraisal across national governments in different countries and across empirical studies.

Table 8: Comparison of Social Discount Rates across approaches

Approach	Method	δ	η	Expectation of g	Variance of g	SDR
Ramsey Rule	Equal sacrifice principle	0.5	1.8	0.047	0.000344	7.3
SOC	Real rate of return to capital	-				10.6
Weighted Average	Lower bound	-				8.12
	Mean estimate	-				9.23
	Upper bound	-				9.59

The social opportunity cost of capital (SOC) and weighted average (WA) methods are being adopted around the world. Social discount rates based on these approaches are typically upwards of 8% in middle-income countries such as Mexico, China, and Colombia, which may provide a reasonable benchmark for India in terms of future public investment and expected future economic growth. Discount rates based on the Ramsey approach are typically lower in the range of 1-5% in real terms for European countries. Given high rates of economic growth observed in developing countries, the Ramsey approach yields higher discount rates of 8% and above in the case of China and India (ADB 2017).

Table 9: Synthesis of parameter estimates for SDR across countries for various methods

Country/ Institution	Year	Social Discount Rate	SOC/STP/Weighted Average (WA)	Social rate of time preference	Inequality Aversion	Uncertainty	Nonmarket effects
ADB	2017	9%	STP	1%	1.5		6% SDR for environmental or social benefits
Australia	2020	7%	SOC			Sensitivity with 3% and 10%, DDR to 3.7% (> 300 years), lower risk premium for nonmarket benefits	4% SDR for nonmarket benefits
Brazil ^a	2020	8.5%	WA				
Canada	2020	8%	SOC				3% SDR may be used for health and environmental goods
Chile	2021	6%	SOC				
China	2021	8% for short- and medium-term projects; less than 8% for long- term projects	WA				
Colombia ^a	2019	9%	WA				
Denmark	2021	3.5%	Both STP & SOC	0.1% to 3%	1.25	1.5% systematic risk premium, falling to 0% (>70 years). DDR to 1.5% (>70 years)	
European Union	2021	3%	STP			DDR for >50 years	
France	2017	4.5%	STP			Risk-free SDR from 2.5% to 1.5% and risk premium from 2% to 3% (> 2070)	RPA for environmental goods
Germany	2018	1%	STP	0%	1		

IDB	2021	12%	SOC				
Ireland	2019	4%	STP	1%	1–1.5	DDR to 1.5% (>275 years)	
Japan	2015	4%	SOC				
Mexico ^a	2014	10%	WA				
The Netherlands	2020	2.25%	SOC				1% RPA for environmental goods
New Zealand	2020	5%	SOC				
Norway	2021	4%	SOC			DDR from 4% to 2% (>75 years); 1.5% risk premium	
OECD Countries	2018	Average rate of 4.78% for energy and 4.64% for transport	STP				
Peru ^a	2021	8%	WA			DDR from 8% to 1% (>200 years)	
The Philippines	2020	10%	SOC				
Poland	2021	5%	STP				
Sweden	2020	3.5%	STP	0.5%	1	1% catastrophic risk premium	
United Kingdom	2020	3.5% for 0–30 years, 3% for 31–75 years, and 2.5% for 76 years or more	STP		1	1% catastrophic risk premium; DDR to 2.14% (>75 years)	SDR for health (1.5% for 0–30 years; 1.29% for 31–75 years and 1.07% for 76 years or more); 2% RPA for air pollution damages
USA	2023	2%	Both STP & SOC				

Source: Groom et al. (2022) and from the authors' collection based on governmental guidelines. Abbreviations: ADB, Asian Development Bank; DDR, declining discount rate; IDB, Inter-American Development Bank; RPA, relative price adjustment; SCC, social cost of carbon; SDR, social discount rate; SOC, social opportunity cost of capital; STP, social time preference (or Ramsey approach).

3. Shadow Prices

The frameworks developed by Little and Mirrlees (1974) and Dasgupta, Marglin and Sen (1972) for project appraisal highlight the role of “accounting” or “shadow” prices for labour and tradeable commodities, in estimating the social costs of public sector projects. We follow the approach outlined by Little and Mirrlees (1974) to estimate shadow or “accounting” prices used in cost-benefit analysis. Here, we estimate the (i) standard conversion factor (SCF), (ii) shadow exchange rate factor (SERF) and (iii) shadow wage rate factor (SWRF). These conversion factors are applied to evaluate financial costs and benefits in economic terms for public sector projects.

3.1. Literature Review on Shadow Prices

The shadow exchange rate measures the economic value of foreign currency, whereas the market exchange rate measures the financial value of foreign currency. To compute the shadow exchange rate, we require the standard conversion factor. The standard conversion factor is a measure of the economic value of traded commodities relative to their market or financial value. While market prices for tradables would include import duties and other indirect taxes, the “accounting” prices for tradables reflect the border prices of imports, exclusive of import duties and taxes. The shadow exchange rate is obtained as the product of the standard conversion factor and the market exchange rate. It is measured as the ratio of the value of tradable goods and services in domestic prices relative to world prices (in foreign currency) (ADB 2017).

The standard conversion factor is typically less than one, which suggests that tradables have higher social value than what is reflected in the observed market prices. The standard conversion factor helps adjust costs of imports at market prices to economic prices (or border prices, excluding import tariffs), while the shadow exchange rate adjusts the official exchange rate to the economic price of foreign currency, accounting for border duties (ADB 2017; Little and Mirrlees 1974).

The shadow wage for unskilled labour is relevant when evaluating the economic costs of labour in public sector projects and the prospect of employment creation from public investments. Shadow wage rates for unskilled labour, typically available in large numbers and drawn from

agriculture, may be below market wage rates if there is involuntary unemployment (Little and Mirrlees 1974). Several studies compute the shadow wage rate as the economic opportunity cost of labour (Jenkins et al. 2011; Dinwiddie and Teal 1994; Curry and Weiss 2023). Since involuntary unemployment among unskilled labour is less prevalent in the Indian context (Dhingra and Kondirolli 2022), the market wage rate is likely to best represent the opportunity cost of workers' time (Jenkins et al. 2011), particularly for unskilled labour.

Thus, from the policymaker's perspective, for government projects, the shadow wage rate ought to reflect the divergence between the government's stipulated minimum wage rate and the prevailing market wage rate for agricultural workers in rural areas and the market wage rate for informal sector workers in urban areas (Gupta 1986).

The Government of India stipulates minimum wage rates for unskilled labour for some sectors on a bi-annual basis. The observed market wage rates for unskilled labour likely differ from the stipulated minimum wages. If the market wage rates exceed the minimum wage rates stipulated by the Central Government, the shadow wage rate factor may be taken as '1' for unskilled workers. In this case, minimum wage costs may be used to evaluate the costs and benefits for public sector projects.

3.2. Standard Conversion Factor: Methodology and Results

First, we compute the standard conversion factor (SCF), which measures the accounting price or factor costs of tradables relative to their market price. The market costs of imported inputs largely comprise import duties. Since import duties differ across commodities, we compute a weighted average standard conversion factor, following the Asian Development Bank (Lagman-Martin 2004):

$$SCF = \frac{Imports_{cif} + Exports_{fob}}{Imports_{cif} + Net\ Import\ Taxes + Exports_{fob} + Net\ Export\ Taxes}$$

where import values are recorded at border prices (cost, insurance, and freight), export values are recorded at border prices (free on board) and net import and net export taxes are included. Since net export taxes and subsidies on exports are zero (due to the Government of India's RODTEP scheme), we measure exports at market prices. To compute import values at border

prices, we deduct the import tariff for each tradable good and service from its market price to generate its accounting price.²⁰

We draw on trade data for 2023-24 from the Ministry of Commerce and Industry, Government of India, and product-level data on import tariffs for 2023 from the World Trade Organisation (WTO). Data on quantities and purchase values at the Harmonised System (HS) 8-digit product level are drawn from the Export-Import Data Bank (Ministry of Commerce and Industry), while corresponding data on 8-digit level import tariffs (as percentage of the product price) are from the WTO.

We merge the two databases at the 8-digit product level to compute the standard conversion factor. Then, we generate average standard conversion factors at the HS 2-digit product level and an overall SCF across all products. The results are presented in Table 10.

We observe an average standard conversion factor of 0.92, with a range from 0.24 to 1.00 across products. The standard conversion factor does not apply to non-tradable sectors and commodities such as electricity, local construction, local transportation services etc, since the domestic market prices reflect the economic costs of these inputs. Since import tariffs will not apply to non-tradable goods and services, the market prices of these commodities reflect their economic costs. Since their “shadow prices” equal their market prices, the implicit conversion factor for non-tradable commodities is 1.

Table 10: Standard Conversion Factors, by HS 2-Digit Products

HS Code (2-digit)	Industry description	SCF
01	Live animals	0.82
02	Meat and edible meat offal	1.00
03	Fish and crustaceans, molluscs and other aquatic invertebrates	0.99
04	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included	0.97
05	Products of animal origin, not elsewhere specified or included	0.96

²⁰ Alternatively, $SCF = \frac{Imports(1-\tau) + Exports}{Imports + Exports}$ where import and export values are recorded at market prices and τ is the product-level import tariff.

06	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	0.92
07	Edible vegetables and certain roots and tubers	0.79
08	Edible fruit and nuts; peel of citrus fruit or melons	0.73
09	Coffee, tea, mate and spices	0.90
10	Cereals	0.99
11	Products of the milling industry; malt; starches; inulin; wheat gluten	0.96
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder	0.87
13	Lac; gums, resins and other vegetable saps and extracts	0.92
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included	0.79
15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes	0.47
16	Preparations of meat, of fish or of crustaceans, molluscs or other aquatic invertebrates	0.99
17	Sugars and sugar confectionery	0.80
18	Cocoa and cocoa preparations	0.78
19	Preparations of cereals, flour, starch or milk; pastrycooks' products	0.94
20	Preparations of vegetables, fruit, nuts or other parts of plants	0.96
21	Miscellaneous edible preparations	0.95
22	Beverages, spirits and vinegar	0.24
23	Residues and waste from the food industries; prepared animal fodder	0.94
24	Tobacco and manufactured tobacco substitutes	0.98
25	Salt; sulphur; earths and stone; plastering materials, lime and cement	0.93
26	Ores, slag and ash	0.97
27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes	0.93
28	Inorganic chemicals; organic or inorganic compounds of precious metals, of rare- earth metals, of radioactive elements or of isotopes	0.93
29	Organic chemicals	0.94
30	Pharmaceutical products	0.99
31	Fertilisers	0.92
32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other colouring matter; paints and varnishes; putty and other mastics; inks	0.95
33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations	0.89

34	Soap, organic surface-active agents, washing preparations, lubricating preparations, artificial waxes, prepared waxes, polishing or scouring preparations, candles and similar articles, modelling pastes, "dental waxes" and dental preparations with a basis of plaster	0.93
35	Albuminoidal substances; modified starches; glues; enzymes	0.82
36	Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations	0.99
37	Photographic or cinematographic goods	0.91
38	Miscellaneous chemical products	0.94
39	Plastics and articles thereof	0.92
40	Rubber and articles thereof	0.95
41	Raw hides and skins (other than furskins) and leather	0.97
42	Articles of leather; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk- worm gut)	0.98
43	Furskins and artificial fur; manufactures thereof	0.96
44	Wood and articles of wood; wood charcoal	0.93
45	Cork and articles of cork	0.93
46	Manufactures of straw, of esparto or of other plaiting materials; basketware and wickerwork	0.99
47	Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper and paperboard	0.94
48	Paper and paperboard; articles of paper pulp, of paper or of paperboard	0.95
49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, typescripts and plans	0.97
50	Silk	0.86
51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric	0.90
52	Cotton	0.98
53	Other vegetable textile fibres; paper yarn and woven fabrics of paper yarn	0.89
54	Man-made filaments; strip and the like of man-made textile materials	0.93
55	Man- made staple fibres	0.95
56	Wadding, felt and nonwovens; special yarns; twine, cordage, ropes and cables and articles thereof	0.93
57	Carpets and other textile floor coverings	0.98
58	Special woven fabrics; tufted textile fabrics; lace; tapestries; trimmings; embroidery	0.94

59	Impregnated, coated, covered or laminated textile fabrics; textile articles of a kind suitable for industrial use	0.88
60	Knitted or crocheted fabrics	0.88
61	Articles of apparel and clothing accessories, knitted or crocheted	0.98
62	Articles of apparel and clothing accessories, not knitted or crocheted	0.98
63	Other made up textile articles; sets; worn clothing and worn textile articles; rags	0.98
64	Footwear, gaiters and the like; parts of such articles	0.93
65	Headgear and parts thereof	0.97
66	Umbrellas, sun umbrellas, walking- sticks, seat- sticks, whips, riding- crops and parts thereof	0.89
67	Prepared feathers and down and articles made of feathers or of down; artificial flowers; articles of human hair	0.99
68	Articles of stone, plaster, cement, asbestos, mica or similar materials	0.96
69	Ceramic products	0.97
70	Glass and glassware	0.93
71	Natural or cultured pearls, precious or semi- precious stones, precious metals, metals clad with precious metal, and articles thereof; imitation jewellery; coin	0.91
72	Iron and steel	0.91
73	Articles of iron or steel	0.95
74	Copper and articles thereof	0.94
75	Nickel and articles thereof	0.96
76	Aluminium and articles thereof	0.96
78	Lead and articles thereof	0.96
79	Zinc and articles thereof	0.97
80	Tin and articles thereof	0.94
81	Other base metals; cermets; articles thereof	0.94
82	Tools, implements, cutlery, spoons and forks, of base metal; parts thereof of base metal	0.94
83	Miscellaneous articles of base metal	0.91
84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof	0.95
85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles	0.93

86	Railway or tramway locomotives, rolling- stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical (including electro- mechanical) traffic signalling equipment of all kinds	0.93
87	Vehicles other than railway or tramway rolling- stock, and parts and accessories thereof	0.92
88	Aircraft, spacecraft, and parts thereof	0.93
89	Ships, boats and floating structures	0.94
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; parts and accessories thereof	0.94
91	Clocks and watches and parts thereof	0.89
92	Musical instruments; parts and accessories of such articles	0.94
93	Arms and ammunition; parts and accessories thereof	0.97
94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, not elsewhere specified or included; illuminated signs, illuminated name- plates and the like; prefabricated buildings	0.92
95	Toys, games and sports requisites; parts and accessories thereof	0.86
96	Miscellaneous manufactured articles	0.93
97	Works of art, collectors' pieces and antiques	0.95
	Overall Average	0.92

3.3. Shadow Exchange Rate Factor: Methodology and Results

The shadow exchange rate factor (SERF) measures the economic cost of foreign exchange relative to its market price and is used to adjust foreign exchange earnings and costs incurred in public projects to obtain their economic values. The shadow exchange rate (SER) can be obtained as a product of the official market exchange rate and the shadow exchange rate factor (SERF) to obtain the economic value of foreign exchange (as opposed to its market value). Little and Mirrlees (1974) formulate the shadow exchange rate factor as the reciprocal of the standard conversion factor, i.e. $SERF = 1/SCF$.

The Standard Conversion Factor (SCF) is applied to the market value of imports to obtain their economic value. Since import tariffs create a distortion between the market price of the imported product and its economic price, it is important to undertake a downward adjustment

of the market price of imports (by applying the standard conversion factor) to obtain the economic cost of imports. Since import tariffs (and export subsidies) distort the economic value of foreign products relative to domestically produced goods, it is key to adjust for taxes and subsidies in evaluating the economic costs and benefits of public sector projects that entail imports and exports. As the Standard Conversion Factor (SCF) is estimated at 0.92, the $SERF = \frac{1}{SCF} = 1.09$, which reflects a 9% premium on foreign exchange.

Jenkins et al. (2011) provide an alternative method to compute the economic price of foreign exchange as functions of import demand and export supply elasticities, following theory developed in Balassa (1974) and Bacha and Taylor (1971). Balassa (1974) discusses the theoretical conditions under which these formulae simplify such that the standard conversion factor and the shadow exchange rate factor are inversely related, as outlined in Little and Mirrlees (1974).²¹

The previous assessment conducted by NITI Aayog followed a simplified formulation to derive the shadow exchange rate factor, applying the average import demand and export supply elasticities across all traded products, rather than product-specific elasticities (NITI Aayog 2018). We present calculations of the shadow exchange rate factor using this approach for the last five years in the Appendix. This approach yields substantially different values for the shadow exchange rate factor, primarily due to the lack of updated estimates in the literature on import demand and export supply elasticities. We apply available estimates of these trade elasticities from an IMF study for the 2001-2004 period (Tokarick 2010). Since there are no recent estimates, this method does not yield updated and accurate estimates of the shadow exchange rate factor for the Indian context.

Pending further updates to methodology and estimation of trade elasticities for more recent data, we would recommend relying on the methodology suggested by the ADB (2004) to estimate the shadow exchange rate factor as the reciprocal of the standard conversion factor. This methodology yields an estimate of the SERF of 1.09, which reflects a foreign exchange premium of approximately 9% for the year 2023-24. This estimate of SERF is only marginally higher than the previously computed value by NITI Aayog (2018) of 1.08 for 2015-16.

²¹ The theoretical conditions depend on symmetry between import demand and export supply elasticities (Balassa 1974).

The difficulty in measurement of trade elasticities has been noted in the literature (Devarajan et al. 2023; Kee et al. 2008). Several complex econometric approaches have been followed to circumvent problems of endogeneity in naïve OLS-based estimation of trade elasticities. Given the difficulty in precise estimation of trade elasticities, we would not recommend following this approach for the Indian economy. The accurate implementation of this approach would require precise estimates of trade elasticities at the HS 2-digit product level for the recent period. To the best of our knowledge, these estimates are not available for the Indian economy. Therefore, we would recommend calculating the shadow exchange rate factor as the reciprocal of the standard conversion factor (ADB 2004). Following this method, we obtain a shadow exchange rate factor of 1.09, which suggests a 9% premium on foreign exchange.

Export subsidies are not applicable in this analysis for India as *the government does not provide an explicit subsidy to boost exports*, in compliance with WTO regulations. The Government of India launched the Remission of Duties and Taxes on Exported Products (RoDTEP) scheme in 2021 to provide tax rebates to exporters. However, these rebates are on taxes paid to the government, but are not explicit subsidies for exported products. Hence, export prices received by producers (net of taxes) remain unaffected by this scheme.²²

Similarly, the government launched the Production-linked Incentive (PLI) scheme to boost domestic manufacturing. While the scheme provides incentives to producers (as a fraction of the revenue from sales), which could indirectly boost exports, these incentives nevertheless are not a form of export subsidies as they do not alter the prices of exports received by producers. Hence, the introduction of the RODTEP and PLI schemes does not impact our calculation of the shadow exchange rate factor. Since import tariffs are updated annually, the standard conversion factor and the shadow exchange rate factor can be revised on an annual basis, using readily available data on import volumes and tariffs at the product level, published by the Ministry of Commerce and Industry.

²² In addition, the average rate of tax rebate under the RODTEP scheme across products is 1.1%, which would have a negligible impact on the calculation for the shadow exchange rate factor, given import tariffs are an order of magnitude higher than tax rebates under the RODTEP export promotion scheme.

3.4. Shadow Wage Rate Factor: Methodology and Results

We compute the shadow wage rate factor (SWRF) for unskilled labour. The market wage reflects the opportunity cost of labour and thus the market valuation of time (Little and Mirrlees 1974). The shadow wage rate factor, which we measure as the ratio of market wages to minimum wages for specific occupations, is used to adjust the cost of labour in project cost-benefit analyses. A market wage which falls short of the minimum wage for workers in rural or urban areas would imply that minimum wages overstate the opportunity cost of labour in those sectors. Insofar as projects funded by the government are aimed at generating employment, the shadow wage rate which equals the market wage rate, can be utilised for project evaluation.

We obtain individual-specific data on weekly hours worked and wages earned for the principal and subsidiary activities of employment from the nationally representative Periodic Labour Force Survey (PLFS), 2023-24. We compute the daily wage rate for all individuals employed in mining and construction for urban areas and agriculture for rural areas. To compute the SWRF for unskilled labour, we exclude individuals with college degrees and diplomas from analysis. This yields a sample of 6,905 individuals in rural areas and 3,170 individuals in urban areas. In both cases, we assume an 8-hour work day to compute the daily wage.²³ We further compute the shadow wage rate factor by gender to account for gender-specific differences in observed average wages for unskilled labour.²⁴

Next, we use the latest data available on minimum wages, which are set on a bi-annual basis by the Chief Labour Commissioner (Central), Ministry of Labour and Employment. As minimum wages are set at the district-level, we match minimum wages for unskilled labour employed in agriculture (for rural areas) and construction (for urban areas), across regional areas A, B and C, to districts in the PLFS survey. We select the construction sector (NCO occupation code – 931) for urban areas since this is the third most commonly reported

²³ The Factories Act, 1948 prohibits manual work for more than 40 hours per week.

²⁴ We compute the annual shadow wage rate factor which accounts for seasonal differences in wage rates, particularly in the agriculture sector.

occupation in the PLFS and is relevant for project evaluation. For rural areas, we use data on reported market wage rates in the agricultural sector (occupation code – 921).²⁵

Finally, we compute the shadow wage rate factor as the ratio of observed market wages to minimum wages for unskilled workers, i.e. $SWRF = \frac{\text{Market wage}}{\text{Minimum wage}}$. We compute the SWRF for rural and urban areas, by State and Union Territory (UT), applying survey weights from PLFS, which ensure population-representative statistics at the state-level. To obtain the combined shadow wage rate factor for each state/UT, we also compute a weighted average of the corresponding shadow wage rate factors for rural and urban areas, weighted by the shares of the working population residing in each of these areas, reported in the PLFS survey. The results are presented in Table 11. Table 12 also presents the average annual wages obtained from the PLFS, used to compute the shadow wage rate factors. Finally, Table 13 and Table 14 present average wages and shadow wage rate factors for male and female unskilled workers by States/UTs, respectively.

Table 11: Shadow Wage Rate Factors (SWRF) for unskilled labour, 2023-24

State/UT	Rural SWRF	% Rural % population	Urban SWRF	% Urban Population	Total
Andaman & Nicobar Islands	1.00	55.59	1.00	44.41	1.00
Arunachal Pradesh	1.00	70.64	1.00	29.36	1.00
Assam	0.80	89.07	0.94	10.93	0.82
Bihar	0.95	90.9	0.85	9.1	0.94
Chandigarh	-	0	0.65	100	0.65
Chhattisgarh	0.49	80.57	0.47	19.43	0.49
Dadra & Nagar Haveli	-	-	-	-	-
Daman & Diu	0.83	42.53	-	57.47	0.83
Delhi	0.93	2.44	0.68	97.56	0.69
Goa	1.00	41.59	1.00	58.41	1.00
Gujarat	0.63	58.55	0.75	41.45	0.68

²⁵ The minimum daily wage rates are applied based on the Minimum Wage Notifications by the Chief Labour Commissioner, Ministry of Labour and Employment, available at a bi-annual frequency. Minimum wage rates are matched to individual data in the PLFS based on quarter of the survey.

Haryana	0.95	61.87	0.91	38.13	0.93
Himachal Pradesh	0.98	87.63	0.97	12.37	0.98
Jammu & Kashmir	0.36	81.01	0.96	18.99	0.47
Jharkhand	0.84	81.57	0.68	18.43	0.81
Karnataka	0.86	62.78	0.88	37.22	0.87
Kerala	1.00	52.38	1.00	47.62	1.00
Lakshadweep	-	28.5	1.00	71.5	1.00
Madhya Pradesh	0.61	74.46	0.74	25.54	0.64
Maharashtra	0.75	57.72	0.92	42.28	0.82
Manipur	0.86	71.23	1.00	28.77	0.90
Meghalaya	0.90	85.69	0.87	14.31	0.90
Mizoram	0.94	54.79	0.98	45.21	0.96
Nagaland	1.00	71.97	1.00	28.03	1.00
Odisha	0.62	85.05	0.72	14.95	0.63
Puducherry	1.00	37.33	1.00	62.67	1.00
Punjab	0.90	61.81	0.80	38.19	0.86
Rajasthan	0.83	73.23	0.84	26.77	0.83
Sikkim	-	76.86	1.00	23.14	1.00
Tamil Nadu	0.91	54.22	1.00	45.78	0.95
Telangana	0.94	60.31	1.00	39.69	0.96
Tripura	1.00	82.37	0.99	17.63	1.00
Uttar Pradesh	0.79	79.26	0.74	20.74	0.78
Uttarakhand	1.00	74.6	0.90	25.4	0.97
West Bengal	0.75	70.94	0.82	29.06	0.77
Overall Average	0.85	63.51	0.88	36.49	0.86

Note: States with insufficient data in the PLFS to compute the shadow wage rate factor are marked with ‘-’.

We observe shadow wage rate factors in the range of 0.36 – 1.00 for unskilled labour employed in agriculture in rural areas and between 0.47 – 1.00 for unskilled workers employed in the construction sector in urban areas, across states and UTs. Overall, the average SWRF is 0.86 for unskilled labour in both rural and urban areas. Thus, the combined shadow wage rate factor across rural and urban areas is 0.86. Shadow wage rate factors significantly below one suggests that minimum wages might be considerably overstating the opportunity costs of workers’ time.

Applying these shadow wage rate factors can lower the costs of labour in project evaluation. However, in some states and UTs, shadow wage rate factors that exceed one have been replaced with “1.00” in Table 11. These reflect average market wages which exceed minimum wage rates, even for unskilled labour. In these cases, we recommend the use of $SWRF = 1$, for unskilled labour, similar to that for skilled labour (ADB 2017).

Table 12: Average daily wage for unskilled labour, by rural and urban areas, 2023-24

State/UT	Average daily wage (INR) -	
	Rural	Urban
Andaman & Nicobar Islands	712	684
Arunachal Pradesh	434	585
Assam	350	500
Bihar	411	442
Chandigarh	-	409
Chhattisgarh	215	272
Dadra & Nagar Haveli	-	-
Daman & Diu	356	-
Delhi	444	509
Goa	527	885
Gujarat	274	455
Haryana	413	502
Himachal Pradesh	424	496
Jammu & Kashmir	162	554
Jharkhand	369	394
Karnataka	374	519
Kerala	597	876
Lakshadweep	-	883
Madhya Pradesh	267	389
Maharashtra	330	529
Manipur	377	555
Meghalaya	394	480
Mizoram	400	495
Nagaland	501	722

Odisha	268	401
Puducherry	481	676
Punjab	391	440
Rajasthan	359	472
Sikkim	-	671
Tamil Nadu	396	637
Telangana	411	717
Tripura	469	500
Uttar Pradesh	344	419
Uttarakhand	440	479
West Bengal	327	427
Overall Average	394.10	544.67

Note: States with insufficient data in the PLFS to compute the shadow wage rate factor are marked as ‘-’.

Table 13: Shadow wage rate factor for male unskilled workers, by States/UTs, 2023-24

State/UT	Average daily wage (INR) - Rural	Rural SWRF	% Rural Population	Average daily wage (INR) - Urban	Urban SWRF	% Urban Population	Total
Andaman & Nicobar Islands	712	1.00	56.15	684	1.00	43.85	1.00
Arunachal Pradesh	491	1.00	71.13	596	1.00	28.87	1.00
Assam	379	0.87	89.13	497	0.96	10.87	0.88
Bihar	418	0.96	90.68	436	0.83	9.32	0.95
Chandigarh		-	0	400	0.64	100	0.64
Chhattisgarh	231	0.53	79.97	299	0.45	20.03	0.51
Dadra & Nagar Haveli	-	-	-	-	-	-	-
Daman & Diu	-	-	40.18	-	-	59.82	-
Delhi	444	0.93	2.63	482	0.64	97.37	0.65

Goa	506	1.00	41.99	-	-	58.01	1.00
Gujarat	277	0.64	58.11	438	0.74	41.89	0.68
Haryana	419	0.97	61.9	505	0.93	38.1	0.95
Himachal Pradesh	424	0.98	86.35	508	0.97	13.65	0.98
Jammu & Kashmir	162	0.36	81.01	564	0.96	18.99	0.47
Jharkhand	397	0.89	81.28	409	0.69	18.72	0.85
Karnataka	421	0.97	62.39	505	0.81	37.61	0.91
Kerala	747	1.00	52.82	895	1.00	47.18	1.00
Lakshadweep	-	1.00	28.79	-		71.21	1.00
Madhya Pradesh	277	0.63	74.88	426	0.77	25.12	0.67
Maharashtra	376	0.86	57.06	492	0.88	42.94	0.87
Manipur	376	0.90	71.44	539	1.00	28.56	0.93
Meghalaya	401	0.91	85.93	415	0.72	14.07	0.88
Mizoram	400	0.94	55.85	480	0.94	44.15	0.94
Nagaland	501	1.00	71.08	800	1.00	28.92	1.00
Odisha	329	0.77	84.47	396	0.68	15.53	0.76
Puducherry	655	1.00	39.26	-		60.74	1.00
Punjab	409	0.94	61.42	438	0.82	38.58	0.89
Rajasthan	382	0.88	72.15	515	0.84	27.85	0.87
Sikkim	-		75.74	690	1.00	24.26	1.00
Tamil Nadu	497	1.00	54.7	636	1.00	45.3	1.00
Telangana	453	1.00	59.04	771	1.00	40.96	1.00
Tripura	490	1.00	82.61	509	1.00	17.39	1.00
Uttar Pradesh	364	0.84	78.71	413	0.70	21.29	0.81
Uttarakhand	436	0.99	74.62	489	0.94	25.38	0.98
West Bengal	335	0.77	71.04	422	0.81	28.96	0.78
Overall Average	423.63	0.89	63.37	521.63	0.86	36.63	0.88

Note: States/UTs marked '-' did not have sufficient data in the PLFS survey to generate shadow wage rate factors.

Table 14: Shadow wage rate factor for female unskilled workers, by States/UTs, 2023-24

State/UT	Average daily wage (INR) - Rural	Rural SWRF	% Rural Population	Average daily wage (INR) - Urban	Urban SWRF	Urban Population Share	Total
Andaman & Nicobar Islands	-	-	54.98	519	1.00	45.02	1.00
Arunachal Pradesh	388	0.89	70.17	561	1.00	29.83	0.92
Assam	307	0.71	89	451	0.96	11	0.74
Bihar	401	0.93	91.12	414	0.83	8.88	0.92
Chandigarh		-	0	409	0.64	100	0.64
Chhattisgarh	203	0.47	81.18	221	0.45	18.82	0.47
Dadra & Nagar Haveli	-	-	-	-	-	-	-
Daman & Diu	356	0.83	45.41	287	-	54.59	0.83
Delhi	444	0.93	2.22	370	0.64	97.78	0.65
Goa	576	1.00	41.19	646	-	58.81	1.00
Gujarat	275	0.63	59.03	348	0.74	40.97	0.68
Haryana	397	0.91	61.84	468	0.93	38.16	0.92
Himachal Pradesh	428	1.00	88.9	260	0.97	11.1	1.00
Jammu & Kashmir	343	0.78	81.01	498	0.96	18.99	0.81
Jharkhand	347	0.80	81.89	318	0.69	18.11	0.78
Karnataka	326	0.75	63.19	499	0.81	36.81	0.77
Kerala	391	0.90	52	771	1.00	48	0.95
Lakshadweep	-	-	28.19	811	-	71.81	0.00
Madhya Pradesh	253	0.58	74	321	0.77	26	0.63
Maharashtra	284	0.65	58.42	419	0.88	41.58	0.75
Manipur	383	0.88	71.03	574	1.00	28.97	0.91
Meghalaya	383	0.87	85.46	392	0.72	14.54	0.85

Mizoram	400	0.94	53.71	503	0.94	46.29	0.94
Nagaland	-	-	72.85	632	1.00	27.15	1.00
Odisha	235	0.54	85.61	268	0.68	14.39	0.56
Puducherry	293	0.67	35.55	627	-	64.45	0.67
Punjab	348	0.80	62.22	406	0.82	37.78	0.81
Rajasthan	338	0.78	74.31	367	0.84	25.69	0.80
Sikkim	-	-	78.17	587	1.00	21.83	1.00
Tamil Nadu	329	0.75	53.78	520	1.00	46.22	0.87
Telangana	384	0.88	61.55	590	1.00	38.45	0.93
Tripura	440	1.00	82.15	426	1.00	17.85	1.00
Uttar Pradesh	297	0.68	79.83	383	0.70	20.17	0.68
Uttarakhand	459	1.00	74.58	440	0.94	25.42	0.98
West Bengal	304	0.70	70.83	399	0.81	29.17	0.73
Overall Average	355.59	0.80	63.69	491.91	0.86	36.31	0.82

Note: States/UTs marked '-' did not have sufficient data in the PLFS survey to generate shadow wage rate factors.

The following tables present time trends of shadow wage rate factors computed for the preceding four years, 2019-20 to 2022-23, at the state-level.

Table 15: Shadow Wage Rate Factors (SWRF) for unskilled labour (2019-2020)

State/UT	Average daily wage (INR) - Rural	Rural SWR F	% Rural Population	Average daily wage (INR) - Urban	Urban SWR F	% Urban Population	Total
Andaman & Nicobar Islands	-	-	58.93	-	-	41.07	-
Arunachal Pradesh	285	0.82	68.45	464	0.77	31.55	0.80
Assam	281	0.8	88	485	0.68	12	0.79
Bihar	274	0.79	89.31	498	0.7	10.69	0.78
Chandigarh	-	-	4.74	503	0.61	95.26	0.61
Chhattisgarh	152	0.44	81.96	465	0.48	18.04	0.45
Dadra & Nagar Haveli	-	-	43.59	-	-	56.41	-

Daman & Diu	166	0.46	21.7	-	-	78.3	0.46
Delhi	272	0.71	3.83	606	0.64	96.17	0.64
Goa	450	1.00	38.47	-	-	61.53	1.00
Gujarat	200	0.57	57.43	534	0.6	42.57	0.58
Haryana	319	0.91	64.81	474	0.78	35.19	0.86
Himachal Pradesh	313	0.9	86.94	403	0.66	13.06	0.87
Jammu & Kashmir	410	1.0	80.35	497	0.87	19.65	0.97
Jharkhand	164	0.47	79.29	495	0.62	20.71	0.50
Karnataka	226	0.65	59.3	543	0.66	40.7	0.65
Kerala	524	1.0	50.67	518	1.0	49.33	1.00
Lakshadweep	-	-	20.1	448	1.0	79.9	1.00
Madhya Pradesh	189	0.55	73.11	467	0.55	26.89	0.55
Maharashtra	200	0.57	58.12	551	0.61	41.88	0.59
Manipur	286	0.83	72.13	431	0.93	27.87	0.86
Meghalaya	225	0.64	83.28	501	0.62	16.72	0.64
Mizoram	-	-	52.55	443	0.82	47.45	0.82
Nagaland	302	0.84	69.22	-	-	30.78	0.84
Odisha	252	0.73	84.8	469	0.52	15.2	0.70
Puducherry	183	0.52	32.75	603	0.75	67.25	0.67
Punjab	282	0.81	62.35	498	0.66	37.65	0.75
Rajasthan	262	0.75	74.55	492	0.65	25.45	0.72
Sikkim	500	1.0	74.75	433	1.0	25.25	1.00
Tamil Nadu	273	0.78	53.21	540	0.71	46.79	0.75
Telangana	263	0.75	59.58	447	1.0	40.42	0.85
Tripura	345	0.99	79.78	467	0.82	20.22	0.96
Uttar Pradesh	224	0.63	77.8	524	0.63	22.2	0.63
Uttarakhand	266	0.76	72.89	439	0.78	27.11	0.77
West Bengal	232	0.67	70.14	476	0.66	29.86	0.67
Overall Average	277.33	0.74	61.40	490.47	0.73	38.60	0.74

Note: States/UTs marked '-' did not have sufficient data in the PLFS survey to generate shadow wage rate factors.

Table 16: Shadow Wage Rate Factors (SWRF) for unskilled labour (2020-2021)

State/UT	Average daily wage (INR) - Rural	Rural SWRF	% Rural Population	Average daily wage (INR) - Urban	Urban SWRF	% Urban Population	Total
Andaman & Nicobar Islands	679	1.0	56.73	-	-	43.27	1.00
Arunachal Pradesh	310	0.84	67.54	446	0.96	32.46	0.88
Assam	285	0.77	87.8	592	1.0	12.2	0.80
Bihar	285	0.78	90.57	392	0.83	9.43	0.78
Chandigarh	-	-	4.47	280	0.52	95.53	0.52
Chhattisgarh	172	0.47	80.85	228	0.53	19.15	0.48
Dadra & Nagar Haveli	200	0.54	56.38	-	-	43.62	0.54
Daman & Diu	-	-	20.56	-	-	79.44	-
Delhi	-	-	2.85	440	0.69	97.15	0.69
Goa	529	1.0	39.59	-	-	60.41	1.00
Gujarat	201	0.54	59.27	296	0.65	40.73	0.58
Haryana	349	0.95	66.67	397	0.92	33.33	0.94
Himachal Pradesh	359	0.97	90.67	428	1.0	9.33	0.97
Jammu & Kashmir	356	0.96	80.36	478	1.0	19.64	0.97
Jharkhand	176	0.48	79.6	288	0.56	20.4	0.50
Karnataka	255	0.69	63.07	415	0.86	36.93	0.75
Kerala	526	1.0	53.11	798	1.0	46.89	1.00
Lakshadweep	-	-	27.76	-	-	72.24	-
Madhya Pradesh	192	0.52	73.05	291	0.65	26.95	0.56
Maharashtra	230	0.62	60.34	372	0.74	39.66	0.67
Manipur	409	1.0	71.71	481	1.0	28.29	1.00
Meghalaya	218	0.59	82.3	309	0.61	17.7	0.59
Mizoram	329	0.9	51.53	338	0.79	48.47	0.85
Nagaland	429	1.0	71.29	-	-	28.71	1.00
Odisha	233	0.63	84.88	274	0.64	15.12	0.63

Puducherry	250	0.67	40.62	-	-	59.38	0.67
Punjab	300	0.82	61.99	349	0.75	38.01	0.79
Rajasthan	271	0.74	77.83	351	0.75	22.17	0.74
Sikkim	-	-	72.29	478	1.0	27.71	1.00
Tamil Nadu	296	0.8	54.32	492	1.0	45.68	0.89
Telangana	320	0.86	59.33	474	1.0	40.67	0.92
Tripura	326	0.89	80.35	366	0.86	19.65	0.88
Uttar Pradesh	263	0.71	79.72	321	0.68	20.28	0.70
Uttarakhand	302	0.82	71.04	379	0.78	28.96	0.81
West Bengal	256	0.7	71.72	301	0.7	28.28	0.70
Overall Average	310.20	0.78	62.63	394.79	0.80	37.37	0.79

Note: States/UTs marked '-' did not have sufficient data in the PLFS survey to generate shadow wage rate factors.

Table 17: Shadow Wage Rate Factors (SWRF) for unskilled labour (2021-2022)

State/UT	Average daily wage (INR) - Rural	Average daily wage (INR) - Urban	Rural SWRF	% Rural Population	Urban SWRF	% Urban Population	Total
Andaman & Nicobar Islands	705	584	1.0	51.63	1.0	48.37	1.00
Arunachal Pradesh	376	474	1.0	69.97	1.0	30.03	1.00
Assam	348	392	0.92	89.74	0.89	10.26	0.92
Bihar	365	387	0.97	91.88	0.88	8.12	0.96
Chandigarh		413	-	4.87	0.75	95.13	0.75
Chhattisgarh	210	182	0.55	81.31	0.41	18.69	0.52
Dadra & Nagar Haveli	-	-	-	-	-	-	-
Daman & Diu	391	178	1.0	38.46	0.41	61.54	0.64
Delhi		191	-	3.45	0.29	96.55	0.29
Goa	404	514	1.0	38.82	0.94	61.18	0.96
Gujarat	233	275	0.62	57.09	0.59	42.91	0.61
Haryana	396	417	1.0	65.57	0.94	34.43	0.98

Himachal Pradesh	428	232	1.0	90.3	0.53	9.7	0.95
Jammu & Kashmir	309	457	0.81	80.88	1.0	19.12	0.85
Jharkhand	307	266	0.82	80.19	0.58	19.81	0.77
Karnataka	311	453	0.82	64.31	0.95	35.69	0.87
Kerala	527	785	1.0	50.06	1.0	49.94	1.00
Lakshadweep	-	793	-	27.5	1.0	72.5	1.00
Madhya Pradesh	219	280	0.58	75.67	0.63	24.33	0.59
Maharashtra	270	384	0.71	56.94	0.75	43.06	0.73
Manipur	477	443	1.0	73.38	1.0	26.62	1.00
Meghalaya	326	261	0.86	85.67	0.56	14.33	0.82
Mizoram	400	359	1.0	53.96	0.82	46.04	0.92
Nagaland	442	456	1.0	75.1	1.0	24.9	1.00
Odisha	259	303	0.69	85.96	0.67	14.04	0.69
Puducherry	301	489	0.79	37.08	0.96	62.92	0.90
Punjab	346	357	0.91	65.8	0.77	34.2	0.86
Rajasthan	361	332	0.96	74.21	0.73	25.79	0.90
Sikkim	-	220	-	79.03	0.5	20.97	0.50
Tamil Nadu	375	460	0.99	56.4	0.98	43.6	0.99
Telangana	382	457	1.0	65.04	1.0	34.96	1.00
Tripura	439	389	1.0	82.16	0.89	17.84	0.98
Uttar Pradesh	328	348	0.86	80.33	0.75	19.67	0.84
Uttarakhand	413	432	1.0	74.95	0.98	25.05	0.99
West Bengal	316	373	0.84	72.57	0.84	27.43	0.84
Overall Average	365.47	392.24	0.89	64.13	0.79	35.87	0.86

Note: States/UTs marked '-' did not have sufficient data in the PLFS survey to generate shadow wage rate factors.

Table 18: Shadow Wage Rate Factors (SWRF) for unskilled labour (2022-2023)

State/UT	Average daily wage (INR) - Rural	Rural SWRF	% Rural Population	Average daily wage (INR) - Urban	Urban SWRF	% Urban Population	Total
Andaman & Nicobar Islands	571	1.0	56.75	676	1.0	43.25	1.00
Arunachal Pradesh	412	1	70.49	533	1.0	29.51	1.00
Assam	421	1	96.69	468	0.94	3.31	1.00
Bihar	364	0.91	92.17	419	0.85	7.83	0.91
Chandigarh		-	5.08	418	0.68	94.92	0.68
Chhattisgarh	204	0.5	81.27	248	0.47	18.73	0.49
Dadra & Nagar Haveli	-	-	-	-	-	-	-
Daman & Diu	337	0.83	35.81	-	-	64.19	0.83
Delhi	-	-	2.67	512	0.68	97.33	0.68
Goa	428	1.0	41.16	839	1.0	58.84	1.00
Gujarat	242	0.59	56.73	405	0.77	43.27	0.67
Haryana	425	1.0	66.15	468	0.79	33.85	0.93
Himachal Pradesh	397	0.97	90	417	0.87	10	0.96
Jammu & Kashmir	475	1.0	82.92	529	1.0	17.08	1.00
Jharkhand	208	0.51	82.69	386	0.72	17.31	0.55
Karnataka	337	0.83	63.84	490	0.88	36.16	0.85
Kerala	525	1.0	53.38	850	1.0	46.62	1.00
Lakshadweep	-	-	23.98	783	1.0	76.02	1.00
Madhya Pradesh	243	0.6	74.99	352	0.69	25.01	0.62
Maharashtra	305	0.74	58.19	484	0.82	41.81	0.77
Manipur	460	1.0	72.43	519	1.0	27.57	1.00
Meghalaya	387	0.95	84.86	390	0.74	15.14	0.92
Mizoram	400	0.99	53.69	455	0.97	46.31	0.98
Nagaland	461	1.0	74.33	512	1.0	25.67	1.00

Odisha	297	0.73	85.78	393	0.78	14.22	0.74
Puducherry	282	0.68	36.19	527	1.0	63.81	0.88
Punjab	371	0.91	64.4	416	0.84	35.6	0.89
Rajasthan	368	0.9	76.09	429	0.84	23.91	0.89
Sikkim	566	1.0	79.07	541	1.0	20.93	1.00
Tamil Nadu	380	0.94	57.25	566	1.0	42.75	0.97
Telangana	383	0.94	62.87	580	1.0	37.13	0.96
Tripura	437	1.0	82.73	472	1.0	17.27	1.00
Uttar Pradesh	339	0.82	80.24	409	0.77	19.76	0.81
Uttarakhand	411	1.0	74	477	0.98	26	0.99
West Bengal	322	0.79	71.47	418	0.87	28.53	0.81
Overall Average	379.29	0.88	64.42	496.39	0.88	35.58	0.88

Note: States/UTs marked ‘-’ did not have sufficient data in the PLFS survey to generate shadow wage rate factors.

4. Social Cost of Carbon

The social cost of carbon (SCC) is a measure of the present discounted value of the societal damages associated with an additional ton of CO₂ emissions incurred today. It reflects the global economic damages due to rise in temperature associated with increasing CO₂ concentrations in the atmosphere. Since carbon dioxide remains in the atmosphere for more than 300 years, the SCC measures the continuum of economic damages incurred over this timeframe (Rennert et al. 2022). The SCC integrates climate science, economics, and social welfare considerations to provide a single monetary figure useful for cost-benefit analyses of climate policies.

Estimating the SCC proceeds in seven steps using Integrated Assessment Models (IAMs) (Carleton and Greenstone 2022). First, the model entails future projections of CO₂ concentrations in response to various socioeconomic pathways, which include business-as-usual, ambitious climate policy and so on. Second, the climate science module relates rise in CO₂ concentrations to probable increases in mean surface temperature, termed climate sensitivity. Third, the model accounts for future economic damages due to higher temperatures, associated with a rise in CO₂ emissions. Fourth, the model converts future economic damages

to present value terms, applying an appropriate social discount rate for a long timescale. The remaining three steps are normative in nature and involve value judgements to be made by the policymaker. Here, the model assesses whether to evaluate only domestic or local damages or also global damages. Subsequently, the model accounts for potential uncertainty in future consumption. Finally, the model considers integrating inequality aversion in evaluating the SCC (Carleton and Greenstone 2022).

The existing literature has analysed a range of IAMs, with incremental improvements made to various aspects of IAMs over the last few decades. Nordhaus' foundational work with the Dynamic Integrated Climate-Economy (DICE) Model evaluated the optimal transition path to mitigating the rise in greenhouse gas concentrations while maximising social welfare (Nordhaus 1993a; Nordhaus 1993b). Nordhaus (1993b) proposed a modest carbon tax as an effective policy instrument to mitigate the rise in CO₂ emissions, while ensuring steady economic growth over a long-time horizon.

4.1. Global SCC values

In the most recent update of the DICE model (DICE-2023), Barrage and Nordhaus (2024) find SCC values ranging from US\$ 37 – 571 per tonne of CO₂ for 2025 (at 2019 US\$ prices), for constant social discount rates, ranging from 5% to 1% per year respectively. Higher social discount rates generate lower values for the social cost of carbon. They find an SCC which maximizes global welfare of \$59 in 2025 (in 2019 US\$ prices). The associated social discount rate declines over time due to adjustment for uncertainty in the long-run future growth rate of world GDP. This optimal path is associated with a temperature increase of 2.6°C in 2100 in their model.

In contrast, a recent study by Rennert et al. (2022) uses the open-source model, Greenhouse Gas Impact Value Estimator (GIVE), following recommendations by the US National Academies of Science, Engineering and Medicine (NASEM), to update the latest models in evaluating the SCC. Rennert et al. (2022) apply a risk-free social discount rate of 2% and find a mean SCC estimate of US\$ 185/ton CO₂ in real terms (at 2020 US\$ prices), with a 5%-95% confidence interval of US\$ 44 – 413/ton CO₂.

Higher SCC estimates reported by Rennert et al. (2022) reflect a lower social discount rate as well as an improved understanding of long-term economic risks to climate change via the GIVE model, which integrates probabilistic climate projections and updated socio-economic data. In particular, the model accounts for the potential rise in energy consumption due to temperature rise based on work by Clarke et al. (2018), premature mortality due to heat stress from high temperature based on Cromar et al. (2022) and economic damages in agriculture due to high temperatures and drought based on Moore et al. (2017).

Importantly, Hänsel et al. (2020) update the DICE model to integrate damage functions from Howard and Sterner (2017), which leads to substantially higher damages from climate change. They revise the social discount rate used to evaluate the present value of damages, based on the Ramsey rule, applying an expert elicitation survey by Drupp et al. (2018), which finds a median social rate of time preference (δ) and lower degree of inequality aversion (η) of 0.5% and 1 respectively, compared to $\delta = 1.5\%$ and $\eta = 1.45$ used in the DICE-2016R model by Nordhaus (2017).²⁶ These revisions lower the social discount rate used to evaluate climate damages and increase the social cost of carbon to US\$ 101/ton CO₂.

Moore et al. (2024) synthesize evidence on the social cost of carbon by combining 1,823 SCC estimates from 147 studies and conduct an expert elicitation survey of authors of the reviewed studies. From these studies which cover over three IAMs including DICE, FUND and PAGE, the authors find a mean SCC estimate of US\$ 132/ton CO₂ (at 2020 US\$ prices). In contrast to published estimates, their expert elicitation survey and a random forest-trained model results in a synthetic distribution with higher SCC estimates. The synthetic distribution results in a mean SCC value of US\$ 185/ton CO₂ (at 2020 US\$ prices), with an interquartile range of US\$ 97-369/ton CO₂.

In addition to global SCC estimates, recent studies provide sector-specific estimates of the social damage associated with rising temperatures. Rode et al. (2021) develop the Data-driven Spatial Climate Model (DSCIM) of the Climate Impact Lab, at the University of Chicago, to estimate the impact of rising temperature on the global energy demand for heating and cooling. Estimating econometric regression models for 146 countries over the 1971-2020 period, the authors find that while higher temperatures increase energy consumption from air conditioning,

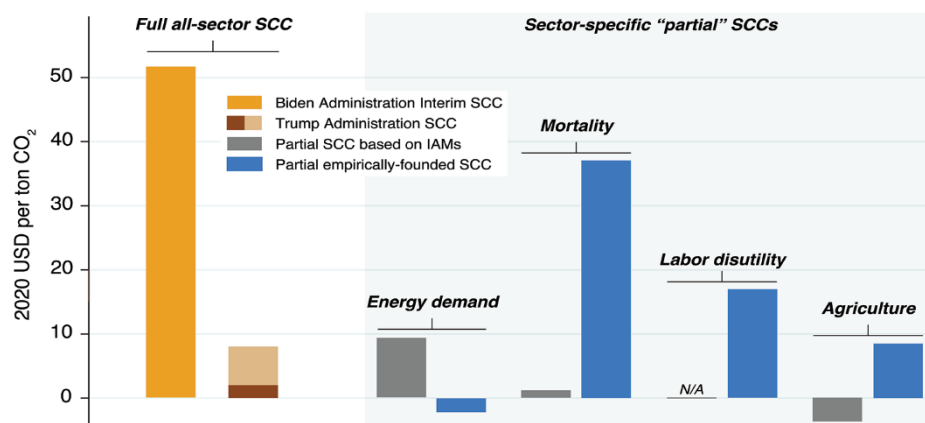
²⁶ The modal value of the social rate of time preference in the survey was zero.

particularly in India and other tropical countries, the rise in temperature is associated with a decline in demand for residential heating from other fuels such as oil and gas, which outweighs the rise in demand for cooling. Overall, rising temperatures from higher CO₂ concentrations lead to a net decline in energy consumption from all fuels combined, resulting in negative SCC estimates for the energy sector (Rode et al. 2021). Rode et al. (2021) present a significant methodological advance in computing the social cost of carbon, based on empirical estimates, compared to modelled estimates used in previous studies.

Similar to the energy sector, Carleton et al. (2022) estimate excess mortality due to climate-induced increases in temperature at the subnational level for 40 countries, accounting for the projected increase in incomes and adaptation to climate change. The authors estimate the mean ‘partial SCC’ for temperature-induced mortality at US\$ 37/ton CO₂, with an interquartile range of US\$ -8 to 73/ton CO₂. Analogously, Moore et al. (2017) present partial SCC estimates for the agriculture sector, ranging from US\$ 3.5/ton CO₂ to US\$ 8.5/ton CO₂.

Estimates from empirical studies for energy consumption and mortality differ significantly from sector-wise estimates from integrated assessment models, as displayed in Figure 1 (Rode et al. 2021; Carleton et al. 2022). While the SCC associated with energy consumption is significantly smaller than that used in IAM-based modelling studies, the partial SCC for mortality costs due to temperature rise are an order of magnitude larger than costs presumed in modelling studies. The nascent empirical literature critically informs debates on the aggregate, global value of the social cost of carbon (Carleton and Greenstone 2022; US EPA 2023).

Figure 1: Sector-specific SCC estimates from empirical studies vs. IAMs



Source: Carleton and Greenstone (2022)

4.2. Country-specific SCC values

While most studies present global aggregate estimates of the social cost of carbon, some studies analyse country-specific economic damages in response to rising temperatures. Global damages then equal the sum of country-specific damages, aggregated across all countries. Ricke et al. (2018) combine climate-economic estimates to compute the country-specific social cost of carbon for several countries. Their results show that India is particularly vulnerable to climate change and economic damages incurred in India account for 21% of global damages from climate change.

Ricke et al. (2018) apply the empirical model of Burke, Hsiang and Miguel (2015), who analyse the global non-linear impact of temperature rise on economic output. Ricke et al. (2018) estimate a mean country social cost of carbon (CSCC) for India of US\$ 86/ton CO₂, with a range from US\$ 49-157/ton CO₂. The study applies simplified functions of the economic response to increases in temperature, which are drawn from cross-country or global studies, rather than empirical estimates specifically from the Indian context.

The recent study by Moore et al. (2024) provides a synthesis of the evidence on the global social cost of carbon, reviewing nearly 150 studies to provide a range of estimates of the SCC. Similarly, Rennert et al. (2022) utilise updated damage functions and climate sensitivity relationships to estimate the global SCC. A synthesis of estimates for the social cost of carbon from the literature is presented in Appendix Table A.6.A.

As Ricke et al. (2018) provides evidence to suggest that India accounts for around one-fifth of global damages from climate change, we utilise the estimates from the studies by Moore et al. (2024) and Rennert et al. (2022) to estimate a plausible range of values for the SCC for India. We find a mean CSCC for India of US\$ 39/ton CO₂ with a range of US\$ 9 – 87/ton CO₂, by using the assumption that damages to India are one-fifth of global damages. This would need a further downward adjustment since the social discount rate for India will be higher, at least in the short-term, than the rate used in the global analyses cited above.

Global analyses typically apply a near-term discount rate of 2%, whereas the present study estimates a higher social discount rate of 7% for India. Since previous studies do not provide

estimates for the social cost of carbon corresponding to higher discount rates, it is beyond the scope of this report to estimate the precise social cost of carbon. However, based on earlier studies, we estimate a lower-bound value for the social cost of carbon for India. Hence, we would recommend a minimum social cost of carbon of US\$10 per ton of CO₂ to be applied in project evaluation for public sector projects by the Government of India. Further research is needed to analyse the relationship between temperature rise and economic output for the Indian context, which would inform estimates for the social cost of carbon for India.

5. Recommendations

This study reassessed key parameters for cost-benefit analysis in public sector projects undertaken by the Government of India. We evaluated short-run and long-run social discount rates, following several state-of-the-art methods in the academic and policy literature. We also computed conversion factors for foreign exchange, traded commodities, and labour usage in production. Finally, we synthesized the literature to present a range of plausible estimates for the social cost of carbon for cost-benefit analysis. In this section, we summarise our key recommendations on parameters for use in cost-benefit analyses for public sector projects.

5.1. Social Discount Rate

The social discount rate or “discount rate” measures the trade-off between present and future consumption. It is used to obtain the present value of the future benefits of a public investment project. We computed the social discount rate based on two broad approaches, including (i) the Ramsey approach, that gives a discount rate of 7.3% for a time horizon up to 30 years and (ii) market rates of return, which gave a range of discount rates from 8.1% to 11%, across methods (Table 5). These discount rates pertain to projects with lifetimes of less than 30 years. Our estimates of the short-run social discount rate range from 7.3% to 11% with mean estimates of 7.3% and 9.23% from the Ramsey rule and weighted average methods, respectively (Table 8).

We recommend using the weighted average method for projects with time horizons up to 30 years, since this method accounts for consumers’ savings decisions and societal trade-offs between present and future consumption, while also accounting for displacement of private

investment and government borrowing. This suggests an upward revision of the social discount rate from 8% in the previous assessment (NITI Aayog 2018) to 9.23% in real terms, for short-term projects with maturities up to 30 years.

For longer horizons, however, we suggest using the uncertainty-adjusted Ramsey approach to calculate the social discount rate, since this approach accounts for uncertainty about future growth rates, which can be substantial in the case of a developing country like India. Lower social discount rates over longer time horizons would also place higher value on socially beneficial projects whose benefits only accrue after a few decades (such as those in health, education, or for environmental protection). Thus, for longer term projects, we recommend applying a term structure of discount rates, adjusting for uncertainty in future economic growth (Table 5).

Further, we recommend the use of a social discount rate for selection and evaluation for public projects, instead of the hurdle rate. The hurdle rate is applied in evaluation of private sector investments by private companies. Hence, the social discount rate is the appropriate metric to apply in the context of public project evaluation by the Government.

5.2. Shadow Prices

We computed conversion factors for foreign exchange, imports, and labour costs in production. We obtained standard conversion factors at the Harmonised System 2-digit product code level for all traded commodities, with an average standard conversion factor (SCF) of 0.92. We also obtained a shadow exchange rate factor (SERF) of 1.09. This reflects a 9% premium on foreign exchange. This exceeds the foreign exchange premium of 8% calculated in the previous assessment report (NITI Aayog 2018). Finally, we computed shadow wage rate factors for unskilled labour for rural and urban areas across states and UTs (Table 11), with an average shadow wage rate factor of 0.86. These are to be applied when minimum wages, rather than market wages, are used for calculating labour costs in project evaluation.

5.3. Social Cost of Carbon

We synthesized the latest advances in science to reflect on the global social cost of carbon, which measures the present value of the monetary social damage due to an incremental ton of

CO₂ emissions. Based on our review of the literature, a country social cost of carbon for India incorporating only damages to India rather than global damages, may be about US\$ 10/ton CO₂, with a range of US\$ 9 – 87/ton CO₂, based on recent global studies. Further research is needed to improve the calculation of the SCC for the Indian context, in particular, to incorporate economic damages for India into global damage functions and to reconcile empirical estimates with those from modelling studies. In this respect, we recommend that a research study be conducted by the Government of India to estimate the appropriate social cost of carbon for India.

5.4. Comparison of parameters

We compare our recommendations on parameter values with those applied in the previous assessment by NITI Aayog (2018) in Table 19.

Table 19: Updating of national parameters since NITI Aayog (2018)

Parameter	NITI Report (2018)	NITI Report (2026)
Social Discount Rate (< 30 years)	8%	9.23%
Social Discount Rate (30-50 years)	8%	6.2%
Social Discount Rate (50-75 years)	6%	4.8%
Social Discount Rate (75-100 years)	< 6%	3.4%
Standard Conversion Factor (SCF)	-	0.92
Shadow Exchange Rate Factor (SERF)	1.08	1.09
Shadow Wage Rate Factor (SWRF) - Total	-	0.86
Shadow Wage Rate Factor (SWRF) - Male	-	0.88
Shadow Wage Rate Factor (SWRF) - Female	-	0.82
SCC (not accounting for damages outside India)	-	US\$ 10/ton CO ₂

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Appendix

A.1. Derivation of the Ramsey rule

We follow Dasgupta (2008) to derive the social discount rate based on the Ramsey rule. Consider a representative consumer who maximises lifetime utility, $U(C_t)$, where C_t represents consumption in period t , with $t = 0$ to $t = \infty$. The utility function, $U(C_t)$, is strictly quasi-concave, with marginal utility of consumption, $U'(C_t) > 0$. The utility function exhibits diminishing marginal utility of consumption, i.e. $U''(C_t) < 0$. The present value of lifetime utility, W_0 , discounted at rate δ , is given by:

$$W_0 = U(C_0) + \frac{U(C_1)}{(1+\delta)} + \dots + \frac{U(C_t)}{(1+\delta)^t} + \dots = \sum_{t=0}^{\infty} \frac{U(C_t)}{(1+\delta)^t} \quad (\text{A.1})$$

Next, we define parameters, η - the elasticity of marginal utility of consumption, and g_t - the growth rate of private household consumption:

$$\eta = -\frac{\partial U'(C)}{\partial C} \frac{C}{U'(C)} = -\frac{C U''(C)}{U'(C)} \quad (\text{A.2})$$

$$g_t = \frac{C_{t+1}}{C_t} - 1 \quad (\text{A.3})$$

We assume a constant relative risk aversion (CRRA) utility function to ensure the elasticity of marginal utility η , is constant (i.e. it does not vary with the level of consumption). The CRRA utility function is defined as follows:

$$U(C_t) = \begin{cases} \frac{C_t^{1-\eta}}{1-\eta}, & \eta > 0; \eta \neq 1 \\ \ln C_t, & \eta = 1 \end{cases}$$

Note that for any t , $U'(C_t) = C_t^{-\eta}$ for $\eta > 0$ and $\eta \neq 1$. Further, assume there are small changes in consumption growth rates between two consecutive time periods, such that variations in ΔC_t and ΔC_{t+1} leave the individual's present value of lifetime utility, W_0 , unchanged.

Next, take the differential of W_0 , as follows:

$$\Delta W_0 = \frac{U'(C_1)}{(1+\delta)} \Delta C_1 + \dots + \frac{U'(C_t)}{(1+\delta)^t} \Delta C_t + \frac{U'(C_{t+1})}{(1+\delta)^{t+1}} \Delta C_{t+1} = 0$$

The previous assumption implies that for any pair of consecutive changes in consumption growth rates, ΔC_t and ΔC_{t+1} , $\Delta W_0 = 0$. This leads to the following equation:

$$\frac{U'(C_t)}{(1+\delta)^t} \Delta C_t + \frac{U'(C_{t+1})}{(1+\delta)^{t+1}} \Delta C_{t+1} = 0 \quad (\text{A.4})$$

Next, we multiply the above equation by $\left(\frac{(1+\delta)^t}{\Delta C_t}\right)$:

$$U'(C_t) + \frac{U'(C_{t+1})}{(1+\delta)} \frac{\Delta C_{t+1}}{\Delta C_t} = 0$$

Subsequently, we substitute the values of $U'(C_t)$ and g_t in the above equation, as follows:

$$C_t^{-\eta} + \frac{C_{t+1}^{-\eta}}{(1+\delta)} \frac{\Delta C_{t+1}}{\Delta C_t} = 0 \quad (\text{A.5})$$

Next, we define the social discount rate, following Dasgupta (2008), as follows:

$$\rho_t = -\frac{\Delta C_{t+1}}{\Delta C_t} - 1 \quad (\text{A.6})$$

We substitute equation (A.6) into (A.5), as follows:

$$\frac{1}{C_t^\eta} - \frac{1}{C_{t+1}^\eta (1+\delta)} (1 + \rho_t) = 0 \quad (\text{A.7})$$

Lastly, we substitute the growth rate of consumption, g_t , in the above equation, as follows:

$$\left(\frac{C_{t+1}}{C_t}\right)^\eta - \frac{(1+\rho_t)}{(1+\delta)} = (1 + g_t)^\eta - \frac{(1+\rho_t)}{(1+\delta)} = 0 \quad (\text{A.8})$$

This leads to the approximate Ramsey rule for the social discount rate, ρ_t :

$$\rho_t \approx \delta + \eta g_t \quad (\text{A.9})$$

A.2. Social Opportunity Cost of Capital Approach

We apply the methodology derived in Poterba (1998) and explained in Jenkins et al. (2011) to estimate the *rate of return to capital* from the National Accounts Statistics. The rate of return to capital is measured as the ratio of the national income derived from capital and the capital stock in the economy, i.e. $r_A = \frac{I_K}{K}$. Theoretically, the average rate of return (or average product of capital) would intersect the marginal rate of return (or marginal product of capital) when the average product of capital is at its highest value in the production function. To calculate income from capital (which is not directly reported in the national accounts), we apply the methodology outlined in Jenkins et al. (2011). The calculations are presented below in Table A.2.1. We find an average rate of return to capital of 10.6% over the 2012-13 to 2022-23 period, with this approach.

Specifically, we estimate the rate of return to capital using the National Accounts Statistics (NAS), following the methodology of Jenkins et al. (2011). Capital income is derived by applying the capital share of Gross Value Added (GVA) to aggregate GVA (in constant prices) and deducting depreciation (consumption of fixed capital – CFC, in constant prices). The rate of return is then computed as the ratio of capital income net of depreciation to the net capital stock at the beginning of the accounting year, as reported by NAS. The net capital stock is available only in current prices in the NAS database. To derive this in constant price terms, we derive the capital stock deflator as the ratio of gross capital formation (GCF) in current prices to the GCF in constant prices, both of which are reported in the NAS.²⁷ Thus, we derive the real rate of return to capital, as follows:

$$r_K = \frac{(GVA_t \cdot \kappa_t) - CFC_t}{Net\ Capital\ Stock_{t-1}}$$

We apply capital shares of GVA using the RBI KLEMS database, for the 2012-13 to 2022-23 period. These capital shares are reported at the sector-level. To derive an economy-wide capital share of GVA for year t , κ_t , we compute a weighted average across sectors, using the sector-level contributions to national GVA as weights. This calculation is conducted as follows:

²⁷ Net Capital Stock_{t-1}=Net Capital Stock_{t-1}, Current PricesCapital Stock Deflator_{t-1}, where Capital Stock Deflator=GCFCurrent pricesGCFConstant prices.

$$\kappa_t = \sum_s w_{st} k_{st}$$

The economy-wide capital share of GVA for year t , κ_t , is a weighted average of sectoral capital shares of GVA, k_{st} , weighted by sector-level weights, w_{st} . The weights, w_{st} , in turn, are derived as follows:

$$w_{st} = \frac{GVA_{st}}{\sum_s GVA_{st}}$$

However, the Jenkins et al. (2011) approach requires modification for the Indian context, because it derives capital income from GDP as the residual of labour, land income from agriculture and resource income. The NAS does not separately report operating surplus and mixed income, preventing accurate decomposition of mixed income/ operating surplus into labour and capital components. Since mixed income includes substantial labour earnings of self-employed households, particularly in the informal sector, which is typically underreported, capital income is likely to be overestimated. In addition, land income from agriculture is not estimated separately in the KLEMS database. As a result, the estimated capital income and rate of return are likely to overstate the true economy-wide rate of return to capital, since this is an average return to capital, rather than the marginal return.

Table A.2.1. Average rate of return to capital estimated from National Accounts Statistics

Year	GVA (constant prices, INR crores)	Capital share of GVA	Capital income (INR Crores)	Consumption of fixed capital (Depreciation, constant prices, INR Crores)	Net capital stock (constant prices, INR crores)	Rate of return to capital, in real terms (%)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2012-13	85,46,275	0.50	42,90,426	10,10,661	2,66,76,772	12.3%
2013-14	90,63,649	0.50	45,17,051	11,00,610	2,96,88,120	11.5%
2014-15	97,12,133	0.50	48,27,952	11,78,644	3,20,75,086	11.4%
2015-16	1,04,91,870	0.50	52,48,999	12,70,890	3,58,53,477	11.1%
2016-17	1,13,28,285	0.49	55,87,142	13,81,526	3,75,40,296	11.2%
2017-18	1,20,34,171	0.49	58,88,773	14,89,921	3,95,77,694	11.1%
2018-19	1,27,33,798	0.49	61,83,330	16,14,455	4,24,24,566	10.8%
2019-20	1,32,36,100	0.48	63,27,168	17,31,178	4,69,73,698	9.8%
2020-21	1,26,87,345	0.48	60,96,735	18,32,759	4,95,49,369	8.6%
2021-22	1,38,76,840	0.48	66,63,430	19,55,788	4,89,10,789	9.6%
2022-23	1,48,78,028	0.48	70,92,668	20,87,964	5,14,45,594	9.7%
Average						10.6%

Note: The formulae applied are: Col. (4) = Col. [(2)*(3)]. Then, Col. (7) = Col. [(4) – (5)/ (6)].

A.3. Weighted Average Approach

The weighted average approach computes the social discount rate as a weighted average of the social rate of time preference (r_g), marginal product of capital (ρ_K) and the real interest rate on foreign borrowings (i_f): $\rho_{WA} = \alpha r_g + \beta \rho_K + (1 - \alpha - \beta) i_f$.

Burgess and Zerbe (2011) provide a tractable formulation of the weighted average discount rate, as follows:

$$\rho_{WA} = \frac{\rho_K - \left(\frac{e}{n}\right)\left(\frac{S}{I}\right)r_g + \left(\left(\frac{1}{SRC}\right) - 1\right)i_f}{-\left(\frac{e}{n}\right)\left(\frac{S}{I}\right) + \frac{1}{SRC}} \quad (\text{A.11})$$

We decompose this formula to derive the weights placed on each of the three discount rates, as follows:

$$\alpha = \frac{-\left(\frac{e}{n}\right)\left(\frac{S}{I}\right)}{-\left(\frac{e}{n}\right)\left(\frac{S}{I}\right) + \frac{1}{SRC}} \quad (\text{A.12})$$

$$\beta = \frac{1}{-\left(\frac{e}{n}\right)\left(\frac{S}{I}\right) + \frac{1}{SRC}} \quad (\text{A.13})$$

$$(1 - \alpha - \beta) = \frac{\left(\frac{1}{SRC}\right) - 1}{-\left(\frac{e}{n}\right)\left(\frac{S}{I}\right) + \frac{1}{SRC}} \quad (\text{A.14})$$

We estimate parameter values for each of the parameters in the above equations to estimate the weights, α and β , as follows:

- Interest elasticity of savings: According to Burgess and Zerbe (2011), the interest elasticity of savings is calculated as the product of the elasticity of inter-temporal substitution and the proportion of wealth that is consumed in the economy. Since the elasticity of inter-temporal substitution is the reciprocal of the elasticity of the marginal utility of consumption, we obtain this as the reciprocal of estimated earlier. Next, we calculate the proportion of national wealth that is consumed based on recent work by Bharti et al. (2024). Thus, we estimate $e = 0.06$.

- Interest elasticity of investment: We estimate this parameter using firm-level data on annual investment from the Annual Survey of Industries and data on the real interest rate from the RBI. We estimate a linear regression model and obtain a mean estimate for. We also conduct a sensitivity check to estimate the range of values for based on the confidence interval of the regression estimate. This leads to a range for n from - 0.48 to -0.12.
- Savings to Investment Ratio: This is obtained from the National Accounts Statistics, 2024, as 0.95.
- Savings Retention Coefficient (SRC): This is calculated as a ratio of the savings-output ratio on the investment-output ratio from the National Accounts Statistics, to assess the fraction of national savings that are retained domestically in the form of investment. We obtain the SRC as 0.95.

Table A.3.1. displays the calculated weights for the weighted average approach, corresponding to the mean estimate and the lower and upper bound estimates presented in Table 7.

Table A.3.1. Weights on private consumption, investment, and foreign borrowing:
WA approach

Remarks on regression coefficient (interest elasticity of investment)	Weight (Private Consumption)	Weight (Private Investment)	Weight (Foreign Borrowing)	SDR
	α	β	$1-\alpha-\beta$	
Mean estimate	0.15	0.81	0.04	9.23
Upper bound	0.10	0.85	0.04	9.59
Lower bound	0.30	0.66	0.03	8.12

A.4. Other approaches to estimating η

The first approach proposed by Groom and Maddison (2019) to estimate the elasticity of marginal utility of consumption, η , is the equal sacrifice principle, which is applied in this report and examined in section 2.2.1. Groom and Maddison (2019) outline four other approaches to estimate η . We investigate three of these four approaches, finding imprecise

estimates of η , with only the equal sacrifice approach yielding plausible results for η and hence the social discount rate, based on the Ramsey rule. We present results from these methods below. We omit the risk aversion approach due to lack of data on insurance premiums in the Indian context.

A.4.1. Euler equation approach

Groom and Maddison (2019) propose the Euler equation approach to estimate the elasticity of marginal utility of consumption, η , drawing on a lifecycle model, where consumers maximise lifetime discounted utility, subject to a lifetime wealth constraint. The optimisation problem leads to the Euler consumption equation, defined as follows:

$$U'(C_t) = \delta(1 + r_t)U'(C_{t+1}) \quad (\text{A.15})$$

where r_t is the real interest rate prevailing in the financial market.

The Euler consumption equation leads to the following estimating equation for the elasticity of marginal felicity, η :

$$\ln \ln \left(\frac{C_{t+1}}{C_t} \right) = \frac{1}{\eta} \ln \ln \delta + \frac{1}{\eta} \ln \ln (1 + r_t) \quad (\text{A.16})$$

where η is the elasticity of marginal felicity.

Results

We draw on annual data on private final consumption expenditure (PFCE) at constant prices from the National Accounts Statistics, MOSPI, for 1950-51 to 2022-23 and real interest rates (nominal bank rate less the annual inflation rate) from the Reserve Bank of India for the corresponding period. We estimate an OLS regression (applying the Newey-West standard errors to correct for heteroscedasticity and ergodicity) to estimate the elasticity of intertemporal substitution, $\sigma = \frac{1}{\eta}$, and correspondingly, η . We find η ranges from 2.2 to 2.9 across

specifications, which significantly exceeds the plausible range of estimates of η observed in the literature.

Table A.4.1. Regression estimates of the Euler equation and elasticity of the marginal felicity of consumption, η

$\ln \ln \left(\frac{C_{t+2}}{C_t} \right)$	(1)	(2)
Compound Real Bank Rate (over two years)	0.34* (0.185)	
Compound Real Deposit Rate (over two years)		0.45** (0.215)
Constant	-0.39 (0.258)	-0.54* (0.298)
Observations	33	26
F-Statistic	3.39	4.46
η	2.94	2.2

Newey-West standard errors in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.4.2. Frisch approach

The next approach is based on the Frisch formula, which assumes commodities satisfy additive separability, to estimate the elasticity of marginal felicity (Groom and Maddison 2019):

$$\eta = \frac{\kappa_i (1 - w_i \kappa_i)}{\varepsilon_{ii}} \quad (\text{A.18})$$

where κ_i is the income (budget) elasticity of demand for good i , w_i is the budget share and ε_{ii} is the own-price compensated elasticity of demand for good i . For parameters to be consistent with consumer theory, $\varepsilon_{ii} < 0$. Hence, for $\eta > 0$ requires $\kappa_i < 0$ or $(1 - w_i \kappa_i) < 0$.

Results

We use household-level data from the NSS Household Consumer Expenditure Survey, 2022-23, to estimate the price and income elasticities of demand for food items, with results displayed in Table A.4.2. Regression estimates based on the Frisch Approach yield negative estimates of the elasticity of the marginal felicity of consumption ($\eta = -0.21$), and hence, negative discount rates. Groom and Maddison (2019) implement this approach on data for the UK and find $\eta = -3.57$. However, NABARD (2024) estimate a positive compensated own-price elasticity of demand, which is inconsistent with economic theory, finding a value for $\eta = 0.8$. Given the inconsistency of our estimates with economic theory, we do not recommend use of this method for calculation of the social discount rate by the Government of India. Groom and Maddison (2019) also acknowledge the limitations of this approach and do not recommend this method for calculation of the social discount rate for government projects.

Table A.4.2. Estimates of risk aversion parameter from NSS HCES data, 2022-23

	(1)	(2)
	Budget Share (Food)	ln (Food Exp.)
ln (Food Exp.)	-0.07*** (0.001)	
ln (Price, Food)	-0.04*** (0.002)	
ln (Price, Other Nondurable)	-0.03*** (0.001)	
HH. Size	0.01*** (0.000)	0.11*** (0.001)
Urban	0.01*** (0.000)	0.04*** (0.002)
ln (Total HH. Exp.)		0.43*** (0.002)
Constant	1.35*** (0.010)	3.88*** (0.026)
Observations	224,555	228,284

R^2	0.371	0.522
κ_i	0.26	
ε_{ii}	-1.10	
w_i	0.40	
η	-0.21	

Note: Robust standard errors in parentheses. Regression includes categorical variables for state code. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.4.3. Subjective well-being approach

The subjective well-being approach measures the association between consumption and utility from directly observable household-level data on self-reported well-being and levels of household consumption (Groom and Maddison 2019). In the absence of these data, we rely on the World Values Survey, which conducted a longitudinal survey of 1,700 individuals from 1989-2022, across six waves, for India. The survey contains subjective questions on individual's self-reported "general satisfaction with life" on a ten-point scale²⁸ and questions on the individual's range of incomes, such as "Less than Rs 500 per month", "501 - 1000 per month" etc. However, data are missing for this question for majority of the sample. Specifically, this question was not posed to respondents after the 1999-2000 survey wave.

To estimate the elasticity of the marginal felicity of consumption (η), we require an additional assumption of the functional form for utility. For consistency with preceding analyses, we assume the utility function is of the constant relative risk aversion (CRRA) form, as follows:

$$U(C_t) = \begin{cases} \frac{C_t^{1-\eta}}{1-\eta}, & \eta > 0; \eta \neq 1 \\ \ln C_t, & \eta = 1 \end{cases}$$

Hence, the marginal utility of consumption, $U'(C_t) = C_t^{-\eta}$ for $\eta > 0$ and $\eta \neq 1$. For an average level of individual consumption (or earnings), C_t , we compute the coefficient of relative risk aversion, η , from our point estimate of the marginal utility of consumption, $U'(C_t)$.

²⁸ The specific question is: "All things considered, how satisfied are you with your life as a whole these days? Using this card on which 1 means you are "completely dissatisfied" and 10 means you are "completely satisfied" where would you put your satisfaction with your life as a whole?"

Results

We use longitudinal data for approximately 1,700 individuals, for 1989-2022, from the World Values Survey to estimate the marginal utility of consumption, $U'_C = C^{-\eta}$ for a CRRA utility function, and calculate the value of η . We find η ranges from 0.3 to 0.4 (Table A.4.3.). We conduct a robustness check using income ranges, provided in the data for the 1999-2004 survey wave. We find a similar point estimate of 0.23, which suggests $\eta = 0.26$.

The relatively low values observed for η appear inconsistent with the literature, which finds estimates approximately close to 1 or greater than 1. This is potentially due to the subjective nature of questions asked in the survey, which may not yield consistent quantitative estimates for η . Hence, we do not recommend this approach to calculating η and the social discount rate.

Table A.4.3. Association between individual's income category and life satisfaction

	Life Happiness	Life Happiness	Life Satisfaction	Life Satisfaction
Income Scale (<i>Estimate of U'_C</i>)	0.10*** (0.004)	0.21*** (0.040)	0.13*** (0.005)	0.23*** (0.008)
Age	-0.01*** (0.001)	-0.01*** (0.003)	-0.00*** (0.001)	-0.01*** (0.001)
Female	-0.04* (0.021)	-0.08* (0.047)	-0.05** (0.019)	-0.07** (0.032)
Observations	11,794	11,794	11,665	11,665
Average Daily Consumption (INR), 2022	270	270	270	270
η	0.41	0.29	0.36	0.27

Note: Robust standard errors in parentheses. Regressions include language categorical variables. The average daily consumption is based on a provisional estimate of annual national income per capita of INR 98,374 for 2022-23, published by the Ministry of Statistics and Programme Implementation.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.5 Shadow Exchange Rate Factor (SERF), based on alternative method

The NITI Aayog (2018) reported calculated the shadow exchange rate factor using the following formula:

$$SERF = \frac{\epsilon_s X + \eta_D M}{\epsilon_s \frac{X}{(1+s)} + \eta_D \frac{M}{(1+\tau)}}$$

where ϵ_s is the price elasticity of export supply, η_D is the price elasticity of import demand, s is the average export subsidy across products, τ is the average import tariff across products, X is the total value of exports and M is the total value of imports under protection. We also calculate the SERF using this alternative method (as applied in NITI Aayog 2018). To do so, we apply an average import demand elasticity (η_D) and average export supply elasticity (ϵ_s), estimated by the International Monetary Fund for India and several other countries, using annual trade data over the 2001-2004 period (Tokarick 2010). Next, we obtain data on the total values of imports and exports for 2023-24 from the Ministry of Commerce and Industry, Government of India. We also present the SERF values using this method for the last five years, i.e. 2019-20 to 2023-24. The results are presented in Table A.5.A below.

Table A.5.A: Shadow Exchange Rate Factor (Alternative Method), 2019-20 to 2023-24

Year	Value of Imports (INR Crores)	Value of Exports (INR Crores)	Average Import tariff (%)	Import demand elasticity	Export supply elasticity	Average Subsidy Rate (%)	SER F
2019-20	33,60,954	22,19,854	11.2	-1.16	1.21	0	1.5
2020-21	29,15,958	21,59,043	12.6	-1.16	1.21	0	2.0
2021-22	45,72,775	31,47,021	11.3	-1.16	1.21	0	1.6
2022-23	57,49,801	36,21,550	12.0	-1.16	1.21	0	1.5
2023-24	56,16,042	36,18,952	12.0	-1.16	1.21	0	1.5

This method suggests a shadow exchange rate factor of 1.48, which is significantly higher than the previously calculated value of 1.09, based on the ADB method. An exchange rate factor of

1.48 suggests an average foreign exchange premium of 48%, which is inconsistent with the observed average import tariff of 12% across tradables for India. It is to be noted that this calculation relies on import demand and export supply elasticities estimated for the 2001-2004 period by the IMF. Since these elasticity values have not been updated over the last two decades, we would not recommend applying this method to compute the shadow exchange rate factor for the Indian economy.

A.6 Synthesis of estimates for the Social Cost of Carbon

Table A.6.A: Synthesis of estimates for the Social Cost of Carbon

Study	Model / Method	Key Assumptions	Social Cost of Carbon (SCC) (USD/ton CO ₂)	Price Base
Moore et al. (2024)	Meta-analysis (1,823 estimates from 147 studies; includes DICE, FUND, PAGE)	Parameter values from expert elicitation surveys and random forest synthesis	Mean: \$132; synthetic mean \$185 (Interquartile Range: \$97–\$369)	2020 US\$
Barrage & Nordhaus (2024)	DICE-2023 (Dynamic Integrated Climate–Economy Model)	Constant discount rates (1–5%)	\$37–\$571 (range by discount rate); \$59 (welfare-maximizing value)	2019 US\$
Rennert et al. (2022)	GIVE (Greenhouse Gas Impact Value Estimator)	Risk-free social discount rate of 2%	Mean: \$185 (95% Confidence Interval: \$44–\$413)	2020 US\$
Ricke et al. (2018)	Empirical climate–economic model (Burke–Hsiang–Miguel 2015 framework)	Country-level SCC (CSCC) using non-linear temperature–output link	Global SCC: \$417; India = \$86 (range \$49–157)	2010 US\$

