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Measuring Sustainability with Macroeconomic Data for India

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Foreword

This paper is an exploration of the macro indicators on wealth and development in an environmentally sustainable manner, on which there have been differing viewpoints. Acknowledging that real-life preferences are contingent on technology and social choices, the paper adopts a welfare economy approach. That an economy's wealth must not decline remains a legitimate concern and bottom-line of sustainable development. These notions and parameters are analysed over a critical period of contemporary India beginning in 1976-77 that marked the end of the Emergency, extending till 2004-05 when countdown to the Millennium Development Goals had begun and climate change occupies the centre stage of political, social and economic discourse.

Data limitations are a central concern in analyses such as these. However, this paper carries forward existing methodologies of capturing genuine investment and applies it to the Indian context. It takes a nuanced position on the contribution of education to human capital formation. In the backdrop of rising capital formation and a declining trend in population growth (albeit, slowly in some of the major states) the paper concludes that there has been no net decumulation of assets, notwithstanding the degradation of natural capital stocks.

(Rajiv Kumar)
Director & Chief Executive

May 15, 2008

Abstract

This paper investigates certain macro data on the Indian economy to draw inferences on the sustainability of the economic growth experienced over the last couple of decades. Interpreting sustainability in terms of the maintenance of different forms of capital to ensure that future consumption levels are at least as high as current levels, estimates of investment have been made using theoretically consistent models and data relevant to the Indian context. Subsequently, the paper investigates the extent to which the investment that has taken place over a thirty year period (from 1976-77 to 2004-05) has been aligned with the consumption path. Investment estimates are found to be a reliable indicator of sustainability of the future consumption path and average future consumption is likely to be higher than current consumption. The findings reveal that while capital formation in manufactured assets has been fuelling wealth accumulation in the economy, there has been a rise in the degradation of natural capital stocks. However, considering the aggregate picture, taking note of investment in human capital, produced capital and the depreciation of natural capital, there has been net wealth accumulation in the economy. Per capita wealth has been rising over the period, with a sharp rise observed from the mid 1990s onwards.

Key words: Sustainable Development, Investment, Future Consumption, Per Capita Wealth, Human and Natural capital.

JEL classification Q56, O11

Measuring Sustainability with Macroeconomic Data for India[1]

Purnamita Dasgupta and Shikha Gupta

I. Introduction

The role of natural resources in development has witnessed a number of theoretical developments over the last half a century. Empirical research on the subject is dominated by micro level studies, which have proved difficult to generalize in a policy context. In India, increasingly concerns have been voiced regarding the sustainability of the economic growth witnessed over the last couple of decades. The current apprehensions regarding future adverse impacts of climate change have further fuelled the debate on the long run sustainability of the current pattern of economic growth. The present paper investigates on certain macro indicators of sustainability, which explicitly incorporate environmental considerations, within a larger macro economy welfare context. The empirical model is tested using data over a thirty year period from 1976-77 till 2004-05. The results provide policy insights on the sustainability of the consumption growth path as revealed through current data.

At the macro level, discussions on the role of the environment in development has been in terms of limiting the scale of human activity within carrying capacity. Alternatively, the issue is one of arriving at the optimal scale – optimal in terms of being able to sustain economic growth. Sustainability is thus a key concept in characterizing optimality although there are differing views on what constitutes an optimal scale.

Sustainable development is an interdisciplinary notion, a fact that is highlighted through the definition promoted in the World Commission's report: "...development that meets the needs of the present without compromising the ability of future

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generations to meet their own needs" (*World Commission on Environment and Development 1987, Our Common Future)*. It is thus an amalgamation of various social, economic and environmental goals.

The operationalisation of the notion of sustainability has posed unique problems in economics. At a minimum, sustainability requires that there should be signals which effectively reflect increasing scarcities in the resource base in order to enable economic growth to continue, within an ecological-life support system. (Arrow et al 1995). However, it is equally important to bear in mind that carrying capacities are themselves contingent on technology and preferences of society. Thus, from the macro economy point of view, one needs to look at indicators that are rooted in a welfare economy approach. From this perspective, a key requirement of sustainable development is that the economy's wealth must not decline (Dasgupta 2001, Bhattacharya and Dasgupta 2004). Wealth in turn is defined in terms of the economy's capital assets, it increases with investments in the economy's capital base. Thus, it is the maintenance of different forms of capital that becomes central to the economic goal of achieving sustainability.

Based on this approach, in this study we first derive measures of the sustainability of economic growth witnessed in India over a thirty year period (1976-77 till 2004-2005). Subsequently we investigate the extent to which investment which has taken place during this period has been aligned with the consumption path for this period.

The paper begins with a review of the existing literature on measuring sustainability at the macro economy level in Section II. Section III presents the details of the indicators and the model used for testing the indicators. Section IV describes the data for the study. Section V presents the results while Section VI concludes the paper with a discussion on the implications of the findings for the sustainability of economic growth in India.

II. Marco Measures of Sustainability

Theoretical Development

Hicksian Income and Investment

The notion of sustainable development is implicit in the Hicksian definition of income i.e. income which is available for consumption without consuming the stock of capital. Recent efforts to correct national income accounts for the consumption of natural capital constitute an attempt to get to the true Hicksian income. "….the concept of income was to give people an estimate of the amount which they can consume without impoverishing themselves." (*Hicks, 1946)*. Thus, an implicit link between investment and the future consumption stream is established, since current income is the maximum income that can be consumed without compromising on future consumption levels. Sustainability implies ensuring that consumption levels available to future generations are at least as high as that available to the present generation. To achieve this, the aggregate capital stock, broadly defined, requires to be maintained. It follows that investment streams can be used to explain the future consumption differentials.

Adopting wealth as the indicator of economic well-being for an economy implies that sustainable development requires the creation of wealth, or at a minimum, that an economy's wealth must not decline over time. Wealth is the accounting value (or the social worth) of an economy's capital assets (Dasgupta 2001). An economy's wealth in a given period is its wealth in the previous period plus net investment made during the previous period. It follows that wealth increases when there is net capital accumulation in the economy. Such capital accumulation is termed as *genuine investment* with the corollary that the well-being of the economy improves if genuine investment is positive. More correctly, after adjusting for population growth, the indicator for sustainability becomes genuine investment per head.

Defining genuine investment (I_t) at a point in time t, as the sum total of all the forms of capital in the economy; If M_{it} – quantity of i_{th} manufactured asset; H_{jt} – j_{th} form of human capital; N_{kt} – k_{th} type of natural capital and given the accounting prices for these as: (p_{it}, h_{jt}, n_{kt}) respectively, genuine investment can be defined as:

$I_t = \Sigma(p_{it}\, dM_{it}/ dt) + \Sigma (h_{jt}\, d H_{jt} / dt) + \Sigma (n_{kt}\, d N_{kt} / dt)$

Alternative formulations have been made to broaden the above definition of capital for sustainable development. Dasgupta (2001) enlarges the definition of the economy's productive base to account for knowledge capital. Hamilton et al (2006) in calculating wealth of countries extend the framework to include the value of urban land and intangible capital.

Aligning Consumption with Investment

Weitzman's (1976) analysis of an economy with a single consumption good, multiple capital goods, stationary technology and inter-temporal welfare equal to the discounted sum of consumption, leads to an alternative way of characterizing sustainability. Net National Product (NNP) here is given by the sum of consumption and net investment:

$$Y(t) \equiv C(t) + p(t)\, I(t)$$

Where p(t) is a competitive price vector for capital goods; I(t) is a vector of net changes in stocks of capital goods; C is a single consumption good and K are multiple capital goods. Weitzman demonstrated that NNP in this model equals the stationary equivalent of future consumption, where the stationary equivalent is defined as the hypothetical constant consumption amount that yields the same inter-temporal welfare as the actual consumption path: $\bar{C}(t) = Y(t)$.[2]

Among others, Ferreira and Vincent (2005) have contributed to the empirical literature on the links between investment and future economic growth. We adopt their framework for our model. This is explained below.

[2] Dasgupta and Maler (2000) derive the result that with specific resource allocation mechanisms that translate capital stocks into future flows in the economy, the maximization of social welfare implies that net investment would equal the change in social welfare even in a nonoptimizing framework.

A complete and accurate accounting of changes in a country's capital stocks should predict whether a country's average future consumption level will be above or below its current level, which can be taken as an indication of economic sustainability. In terms of the consumption differential, $\Delta(t)$, subtracting $C(t)$ from each side of the equation yields: $\Delta(t) = p(t) I(t)$ ----------------------(1)

Where $\Delta(t) = \bar{C}(t) – C(t)$.

This provides a method for judging to what extent the investment taking place in the economy is aligned with future consumption possibilities.

Empirical Estimations

Pearce and Atkinson (1993) provided the first set of sustainability indicators for 18 countries. Their estimates are based on the assumption of substitutability between natural and manmade capital. An economy is sustainable if it saves more than the combined depreciation on two forms of capital i.e. natural and manmade capital.[3]

The World Bank has published a series of investment estimates – termed as genuine savings – which attempt to incorporate investments in human and natural capital. Hamilton, Atkinson and Pearce (1997) in a theoretical exploration of genuine investment, concluded that persisting with policies that lead to negative genuine savings rates must lead to declines in welfare. Hamilton and Clemens (1999) calculated similar indicators for developing countries using data for the period 1970-1993. They find that South Asia exhibits moderately positive rates of genuine savings and for India it was 8.4% of GNP in 1970s as compared to 7.2 in 1993. More recently, Hamilton et al (2006) compile genuine savings for the year 2000. They find that as compared to a gross national saving of 24.2% of gross national income, the genuine saving after accounting for natural and human capital, is 12.9% of gross national income for the Indian economy. Dasgupta (2001) however finds that in per capita

[3] This weak sustainability indicator, allowed for unconstrained elasticities of substitution between natural and man-made capital. In contrast, a strong sustainability indicator would require that there should be no depreciation of the natural capital stock.

terms there has been a net decumulation of assets in India since the 1970s. Given the difficulties of obtaining reliable data for compiling the data series on human capital and natural capital, particularly depreciation of natural capital, it is not surprising that the estimates have varied. Given the uncertainties, much depends also on the underlying assumptions made about resource rents and the productivity of human capital.

III. Investment Indicators and Future Consumption

The total manufactured or produced capital in the economy has been the conventional sense in which investment has been defined. In this section we will expand this definition to include two other important components of capital assets in the economy, which can affect future consumption possibilities. These are human capital and natural capital. We discuss these two forms of capital in some detail below since measurement issues have proved to be a matter of some contention and debate in the literature on both these forms of capital.

Accounting for Human Capital

The stock of human capital has been variously defined as consisting of the knowledge, skills, experience and inventiveness of people. Researchers (Griffin 1989, Psacharopoulos and Patrinos 2002) have emphasized that countries that have given high priority to human capital formation have performed relatively better in terms of growth, employment and poverty alleviation. Measuring human capital formation is a complicated matter since there are complementarities amongst various kinds of human capital expenditures. For instance, there are strong complementarities between primary health care, nutrition and education expenses for children. However measuring net investment in health or nutrition is problematic since it is difficult to isolate what part of total expenditure is for maintaining the stock of human capital and is therefore not new investment. We therefore leave out health human capital from our model for the present and concentrate instead on educational human capital. We take the view that net investment in human capital can be approximated upto a point by expenditure on formal education (Bhattacharya and Dasgupta 2004).

We derive the estimate for human capital formation by weighting the current expenditures, both private and public, using the average estimates of the social rate of return to schooling developed by Psacharapolous and Patrinos (2004) for low income countries. The inclusion of private expenditure on education, and the methodology used in calculating the educational capital formation is an innovation of this paper.

Empirical research has shown that schooling contributes significantly to human capital, although the rates of return fall by level of education and levels of economic development. Further, according to some studies (Card 2001, Griliches 1970) effects of ability and related factors do not tend to exceed more than 10 per cent of the estimated schooling co-efficient. Hence, the returns to schooling can therefore be assumed to be a reflection of the human capital formation from expenditures incurred on education, including all such expenses. In fact, one would expect the calculations made thus to be an underestimate to the extent that one expects higher returns from educational expenditures at higher levels particularly in skill formation by adopting a productivity approach (although evidence on this is mixed). Typically private rates of return are found to be higher than social rates of return on schooling. The reason being that it is more difficult to measure the social externality benefits from schooling, while social costs get included in the calculation of social returns, unlike the returns calculated on private education expenses. In keeping with the definition of human capital and given the rising share of the private sector in education expenditures in India, we innovate on existing studies by using both public sector and private sector expenses on education. However, these are scaled by the returns to education as discussed above in order to be conceptually appropriate.

Accounting for Natural Resource Depletion

Hotelling Rent for Resources

Hartwick (1977) demonstrated that sustaining a country's consumption level required an investment in reproducible capital equal to that of the economic depreciation of its natural resources. The theoretical conceptualisation is that a comprehensive measure of an economy's net savings, which accounts for all forms of depreciation including natural resource depreciation, should be positive in order to sustain long run consumption possibilities. In other words, a rising future consumption level requires investing more than Hotelling rent, in order to expand (not merely maintain) the economy's total natural capital stock. For natural resources, the Hartwick rule implies that it is the Hotelling part of total resource rent which constitutes economic depreciation. This would translate into marginal rent (price minus marginal cost) times the quantity extracted for a non-renewable resource and marginal rent times the difference between quantity extracted and resource growth in the case of a renewable resource.

Vincent and Castaneda (1997) derive Hotelling rents for various economies, for two commercially extractive resources, minerals and roundwood. They also develop estimates of economic depreciation of agricultural soils due to soil degradation for the year 1992. The minerals included in the analysis are two fossil fuels (coal and petroleum) and five metals (copper, iron ore, lead, manganese and tin). Wood includes logs, pulpwood and fuelwood. On-site production activities were considered in the calculation of economic depreciation of agricultural soils. The productivity change method was applied, where the depletion value of a unit of soil equals the capitalized value of the future agricultural revenue that is forgone due to the loss of that unit. We use their estimates for India to arrive at the Hotelling rent for the study. Thus, we use a more accurate accounting for natural resource depletion by using marginal rents, unlike previous estimates which have used average rents.

Accounting for Carbon Damages

The paper adopts the existing convention in the literature (Hamilton et al 2006) in accounting for carbon damages. A correction is made to the estimates of capital formation by subtracting the value of carbon emissions. A recent study (Ghoshal and Bhattacharya 2007) estimated carbon di oxide emissions for India, based on fuel usage patterns in different states in India. Unlike country level data, the data used in the study have the advantage of being built up from state level data on emissions. The methodology applied is an adaptation of that of the Oak Ridge National Laboratory (ORNL), from which country level data is usually sourced by most studies. The advantages of using an India specific model that takes note of regional fuel production and consumption patterns are obvious. For valuing carbon damages, we use Frankhauser's (1994) estimates.

We define five alternative measures of investment. These are as follows:

- Gross Domestic Capital Formation
- Net Domestic Capital Formation (GDCF less depreciation of produced capital)
- NDCF and Human Capital (NDCF and Education Expenses)
- NDCF, Human Capital and Natural Resource Depletion (approximated by Hotelling Rent)[4]
- NDCF, Human Capital, Natural Resource Depletion and CO_2 Damage.

Econometric Model for Future Consumption

Adopting Ferreira and Vincent's (2003) approach, equation (1) for the consumption differential can be expressed as follows in a testable econometric form:

$\Delta_t = \alpha + \beta X_t + \varepsilon_t$ --------------------- (2)

where Δ_t is the consumption differential in year t, X_t is investment and ε_t is a randomly distributed error term. The purpose is to determine whether investment is associated with the consumption differential in a way consistent with theory and whether it provides a reliable indicator of it. If the consumption differential and investment were to coincide completely, α would equal 0 and β would equal 1. In order to investigate whether investment is a consistent indicator of future consumption, we examine the following questions/ hypotheses.

- Is the consumption differential increasing with increasing investment? (correctly signed: $\beta > 0$)
- As the definition of investment is extended to include more forms of capital, does the consumption differential increase? This implies that $\beta \rightarrow 1$ as X is expanded to include more types of capital. This in essence means that investment is moving in the right direction. As the definition of capital is broadened, the coefficient value increases moving towards 1.

[4] This measure is hereafter referred to as genuine investment in the paper.

- Do broader estimates of investment provide more information on future consumption possibilities? This implies that the predictive power of the equation should increase when X includes more forms of capital. The equation should predict the consumption differential more accurately when X includes more types of capital. The rationale being that broader estimates of investment provide more information about changes in capital stocks and thus more information about future consumption possibilities.

To test the above two statements, the equation will be estimated using the five alternative definitions of investment derived above as the independent variable. For the consumption differential, the first step is to construct the stationary equivalent of future consumption, which is constructed as the weighted average of per capita future consumption expenditure using an appropriate time horizon and consumption discount rate. The stationary equivalent of future consumption when expressed in discrete time (for estimation using annual data) is:

$$\acute{C}_t = \{\Sigma C_s (1+r)^{-(s-t)}\} / \{\Sigma (1+r)^{-(s-t)}\}$$

Where, $s = t+1, t+2, \ldots\ldots t+T$.

Here, $\acute{C}t$ represents the weighted average of per capita future consumption expenditure and C is private final consumption expenditure in India, in per capita terms.

IV. Data for the Study

The variables of interest for the paper are Private Final Consumption Expenditure (PFCE) for the economy, Gross Domestic Capital Formation (GDCF), Net Domestic Capital Formation (NDCF), Public Sector and Private Sector Education expenditures, CO_2 emissions and Hotelling rent. Each of these variables is described in some detail.

PFCE is the household final consumption expenditure and the final consumption expenditure of non-profit making bodies serving households. It is taken at constant prices (1999-00 prices). The data is expressed in per capita terms using population data for the Indian economy. Data on PFCE and mid year estimates of population were taken from National Accounts Statistics (NAS) Division (various reports) of the Ministry of Statistics and Program Implementation.

For constructing the stationary equivalent of future consumption, the real interest rate was calculated as the mean of the lending rate adjusted for inflation for the study period. The rate of discount works out to be approximately 0.07, based on data from the Reserve Bank of India. The median value is also close to this value. Since the deposit rate is likely to be lower, while the non-prime lending rates are likely to be higher, this is probably a good reflection of the median of the lending and deposit rates.

The time horizon (T) is set at 7 years. The assumption would be that an estimate of investment in time t, predicts the consumption differential over the next seven years. Although it has been argued in the literature that a time period of 10 years is a more likely assumption from a long term macro policy perspective, major public sector investment decisions can be linked to a certain extent with the five year planning cycle followed in India. So, we choose an in-between value of 7 years for setting the time horizon. The consumption differential was subsequently constructed. Note that setting a time horizon of 7 years reduces the estimation period by 7 years, i,e. the consumption differential can be constructed for the period from 1976-77 to 1997/98. The stationarity properties of the series on consumption differential was tested using the Phillips Perron Test and the Augmented Dicky Fuller Test. The null hypothesis is rejected and the series does not have unit root.

Gross Domestic Capital Formation is the sum of Gross Fixed Capital Formation and changes in stocks in an accounting year. GDCF is accumulation of total machines, equipments, buildings and assets in an accounting year within the domestic territory of the country. Both GDCF and estimates of NDCF (which subtract the depreciation on GDCF) were taken at constant prices (1999-00 prices). Mid year estimates of population were used to arrive at per capita GDCF and per capita NDCF. Data on GDCF and NDCF are taken from NAS (Various Reports).

Current total expenditure on education is computed as the sum of current government expenditure and current private expenditure on education. Data is taken from NAS (Various Reports). The data on private final consumption expenditure on education was available at constant prices. The current government expenditure on education was deflated to convert the series into constant prices and added to private sector expenditure. In order to compute human capital investment, the returns on schooling were applied to the total current expenditures on education. The average return on education expenditure is taken as 0.136 per rupee spent.

CO_2 emissions for India were available for the years 1980/81-1999/00. Based on the available values, estimates were made by extrapolation, for the years 1976/77-1979/80 and 2001/02-2004/05. CO_2 emissions in metric tons of carbon were valued at $20 per ton of carbon, and subsequently converted to Indian currency for comparability. For purposes of extrapolation for the period 1976/77-1979/80, the average of the value of CO_2 emissions to GDP was taken for the three years 1980-81 to 1982-83. Similarly, CO_2 emissions for the period 2001/02 to 2004/05 were extrapolated on the basis of data for the period 1998/99 to 2000/01. Tol (2005) in a review of estimates of the marginal value of carbon dioxide emissions costs finds that there is a wide range of values with the median value at $14 per ton of carbon. To keep comparability of the exercise with other studies, we adopt Frankhauser's (1994) estimates of the value of carbon at $ 20 per ton of carbon.

The estimates of total rent to GDP and ratio of Hotelling rent to total rent were used as computed for India by Vincent and Castaneda (1997). The ratios for total rent to GDP and Hotelling rent to total rent were available for each decade and were used along with data on GDP at factor cost to make the calculations.

It maybe noted that all the data were expressed in constant prices (1999-2000 prices) and in per capita terms. The period for which data was available is 1976-77 till 2004-05 which is approximately 14 years post and pre the benchmark reform year of 1991. Graph 1 presents estimated GDCF, NDCF and genuine investment (accounting for human, natural and produced capital) as a percentage of GNP.

Graph 1

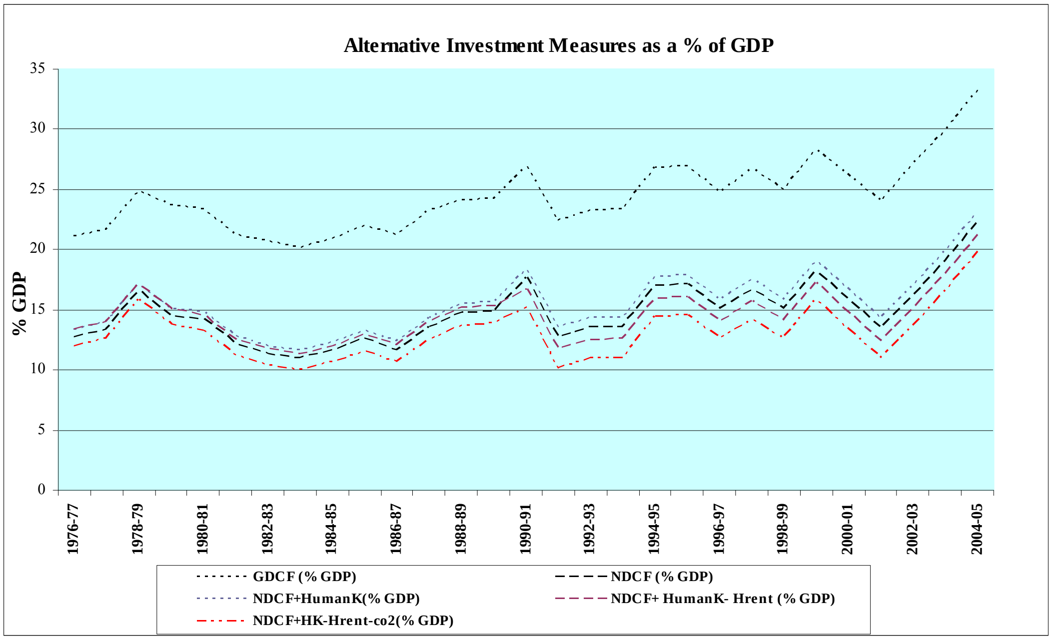


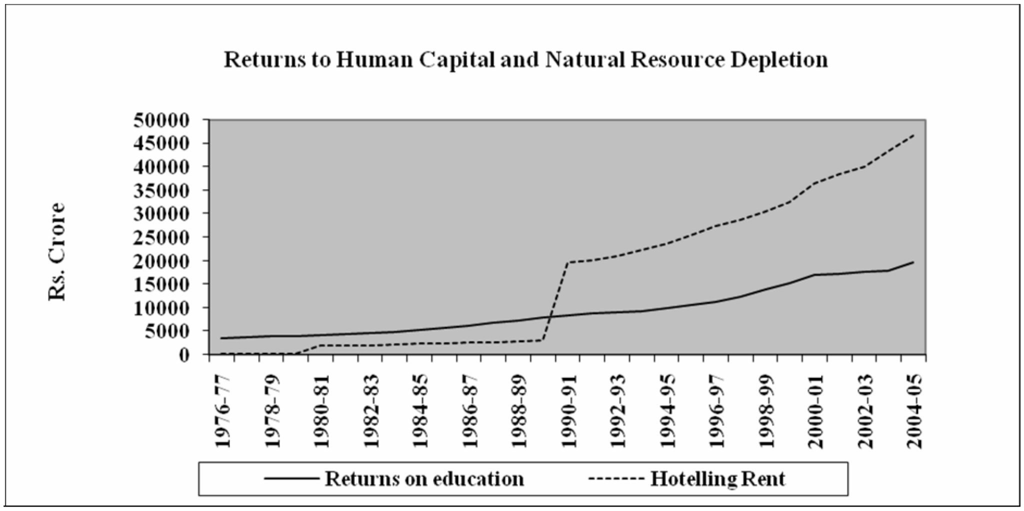
Table 1 below shows the percentage share of investment in GDP, for different forms of capital as per our methodology. It is the increase in produced capital that has been fuelling growth.

Table 1: Investment as a % of GDP

Investment (%GDP)	**1980s**	**1990s**	**2000/01**	**2003/04**	**2004/05**
GDCF	22.10	25.45	26.20	29.95	33.30
NDCF	12.78	15.68	15.81	19.09	22.32
NDCF+HK	13.48	16.46	16.72	19.89	23.14
NDCF+HK-Hrent	13.18	14.64	14.77	17.94	21.19
NDCF+HK-Hrent-CO2	11.77	13.16	13.38	16.55	19.80

While human capital formation adds to the investment measure, this is more than offset by the joint depletion of natural resources and carbon damages. The returns on education and the Hotelling rent over the time period for the study are depicted in graph 2. While the two seem to have been moving closely over the 1980s, the gap has widened considerably during the 1990s due to the steep rise in Hotelling rent. Returns to education have increased steadily, but at a slower pace. The Hotelling rent has a significant and positive relationship with the GDP, whereas the returns to human capital do not show such a significant relationship.

Graph 2



V. Findings

Table 2 presents the estimates for β obtained from the estimation of equation 2, for the five alternative definitions of investment. The coefficients are labeled by subscripts 1 to 5 to distinguish across investment measures. The Ramsey test for omitted variables was done. The null hypothesis that the models had no omitted variables was not rejected. The estimated coefficients can be interpreted with reference to the three questions raised in section III. We analyse what the investment measures indicate about future consumption possibilities.

Table 2: Results from Econometric Model

Independent Variable	**Co-efficient Estimate***	**Interpretation**
Conventional Gross Investment	β_1= 0.16, β_1>0 , β_1<1	-
Conventional Net Investment	β_2= 0.21, β_2>0 , β_2<1	β_2 is 40% higher than β_1
Net Investment+ Human K	β_3=0.21, β_3>0 , β_3<1	No significant change
Net Investment+ Human K-Hrent	β_4=0.22 β_4>0 , β_4<1	β_4 is 5% higher than β_2
Net Investment+ Human K-Hrent-CO2	B_5=0.23 β_5>0 , β_5<1	B_5 is 5% higher than β_4; β_5 is 44% higher than β_1.

**All significant at 5% level*

The first issue is to examine whether the consumption differential is increasing with increasing investment. This requires that the coefficient for investment should be positive ($\beta > 0$). As is evident from the results, this condition is fulfilled consistently across all the five estimations. The investment estimates move in the same direction as the consumption differential. Average future consumption is likely to be above current consumption.

The second question is to check whether the consumption differential increases as the definition of investment is extended to include more forms of capital. This implies that as the definition of capital is broadened to include human and natural capital, the coefficient value should increase. The β coefficient, expectedly, increases substantially by 40%, on accounting for depreciation on produced capital and marginally on adjusting for natural capital depletion. There is no significant change however in the coefficient value after including human capital. The coefficient remains virtually the same while the explanatory power of the equation increases marginally[5]. To that extent the estimated equation performs slightly better than found in previous studies. This is attributable to the fact that we use both private and public current expenditure and also weight these by the rate of return to education. Overall, the investment measures seem to be a reliable indicator of sustainability.

Finally, we ask whether broader estimates of investment provide more information on future consumption possibilities. These estimations explain less than 50% of the variation in the consumption differential. Broader measures of investment do not increase the explanatory power of the equation significantly. Does the predictive power of the equation increase as the investment measure expands to include more forms of capital? The equation should predict the consumption differential more accurately since broader estimates of investment provide more information about changes in capital stocks and thus more information about future consumption possibilities. To test whether more accurate predictions of the consumption

[5] We tried the alternative of using only the entire public sector expenditure on education as human capital in keeping with earlier studies and find that the results are much poorer, with lower β values and lower overall explanatory power of the estimated equation. These results were similar to the ones found by other studies which used only current public sector expenditures as a proxy for human capital and found that it behaves poorly with regard to linking investment with consumption differentials.

differential are obtained if investment is defined more broadly, we calculate Theil inequality statistics, using one step ahead forecasts to test for predictive accuracy.

To construct the Theil statistic, we estimate the equation for a period of 7 years, beginning from 1976-77, and use the estimated β coefficient to forecast for the subsequent year. We repeat the procedure by expanding to the next consecutive year and thus generate a series of estimated consumption differentials. Given Y_t as the computed consumption differential and Z_t as the forecasted consumption (based on an investment measure) for year t, Y_t and Z_t series are computed for each of the 5 different investment measures. The Theil statistic is computed as:

$$T = \frac{\sqrt{1/7 \sum (Y_t - Z_t)^2}}{\sqrt{1/7 \sum (Y_t)^2} + \sqrt{1/7 \sum (Z_t)^2}}$$

The statistic can be interpreted following Ferreira and Vincent (2005). A value of T = 0 is a perfect forecast while T= 1 is the worst case scenario. The Theil statistic computed for our study gives a value of 0.38, indicating fairly good predictive accuracy. Unfortunately the statistic does not change appreciably with broader definitions of investment implying that the model may not be reliable if it is to be used for the purpose of predicting by how much future consumption exceeds current consumption.

We note that there could be several reasons why our investment expenses do not translate into consumption in the estimation i.e. why β does not equal one. While there is obvious scope for data inaccuracies in the investment measures, it is also possible that investment expenses as compiled here do not actually translate into investment. Further, even if they do so, it could be in unproductive investment. To the extent that investment does not translate into consumption, β would be different from 1. The role of technological innovation, governance and quality of institutions would mediate the link between investment and future consumption, all of which may not have been adequately reflected in the investment expenses estimate.

VI. Conclusion

Existing studies of genuine investment have been compiled primarily on the basis of the World Bank's methodology. In this paper we improve upon this methodology by incorporating three specific changes. Firstly, we use the results of an India specific method for estimating carbon di oxide emissions. Secondly, we use the Hotelling Rent for computing natural resource depletion. This is a theoretically more consistent approach to measuring economic depreciation for natural resources. Thirdly, we do not attribute the entire public sector current expenditures on education alone to human capital formation. Rather we add private final consumption expenditure on education, which is important given the rising share of private sector spending on education and skill enhancement in India. Further, we compute human capital formation on the basis of the returns to education rather than impute the total value of expenditures which would have amounted to an overestimate. Nor would it be consistent with the existing literature on the productivity of human capital for purposes of economic growth. The estimated genuine investment is 13.54% of GNI for the year 2000.

There are some obvious caveats that need to be highlighted here, in interpreting the trends in the investment indicators. The total investment estimates are based on an assumption of substitutability between different forms of capital. Thus, one could technically have monotonically increasing investment with a composition of assets which is changing unfavourably away from natural resources[6].

Data limitations have also been a major constraint in estimating comprehensive investment measures. There is a need for better investment estimates, particularly for natural and human capital. Adjustments for natural resource depletion for underground water resources and biodiversity for instance remain a difficult task given the limitations of available methods for valuing these services.

Having said that, nevertheless the investment indicators have an important story to tell as we have seen through our estimates. We can calculate the percentage change in

[6] Partly to check on this argument, Hamilton et al (2006) use a production function approach to Gross National Income and find a fairly high degree of substitutability between land and other forms of capital, where land is taken as the proxy for natural resource.

wealth per capita on the basis of our investment estimate. Given a total wealth estimate of W, population P and population growth rate g, the change in wealth per capita is given by the formula (Hamilton et al 2006):

$$\Delta [W / P] = (\Delta W / P) - g. W/P \text{ ------------- } (3)$$

Assuming an output-wealth ratio of 0.25 (Dasgupta 2001), the Gross National Income is used to compute total wealth. This is subsequently expressed in per capita terms (W/P) and multiplied by the population growth rate (g) to obtain the second term on the right hand side of equation 3. ΔW is approximated by genuine investment and expressed in per capita terms to obtain the value of (ΔW / P). We are thus able to compute the change in wealth per capita as the difference between genuine investment per capita and population growth rate times the total wealth per capita. Graph 3 presents the results over the time period of the study.

Table 3 gives the decadal averages and the figures for the last few years for the change in wealth per capita.

Graph 3

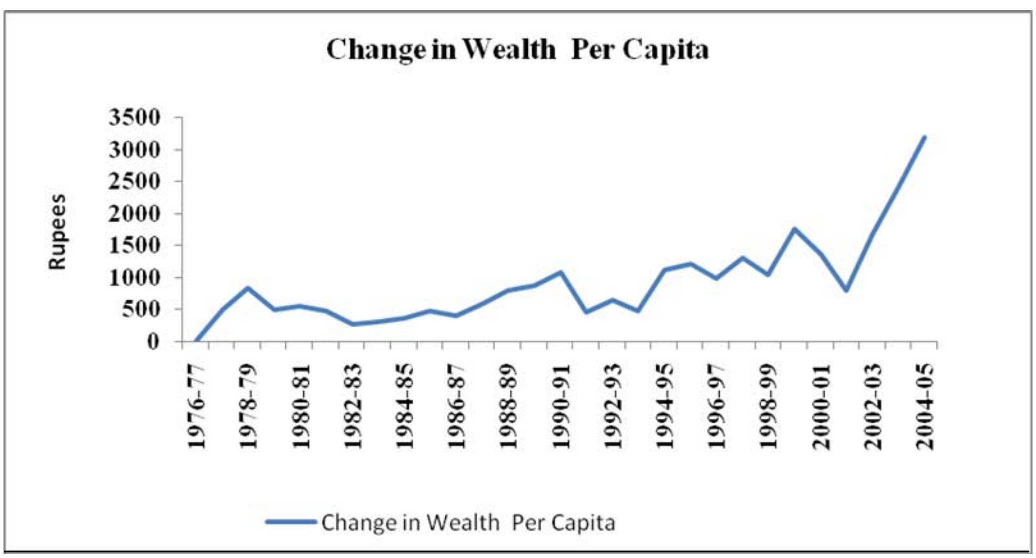


Table 3: Wealth per capita, Population growth rate and Change in Wealth per capita (Decadal)

Year	Wealth per capita (Rs)	Population growth rates	Change in Wealth per capita (Rs)
1977-78	31400.50	0.022	485.07
1980-81	31512.96	0.022	545.19
1990-91	42419.30	0.020	1083.92
2000-01	60262.61	0.017	1364.11

It is evident that there has been no net decumulation of assets as revealed through the figures on changes in wealth per capita. There are however, fluctuations in the series and in some years the addition to wealth per capita has in fact been lower than the previous year. The decadal average remains positive with wealth per capita growing at an annual average of Rs. 31.87 during the 1980s, and increasing to Rs. 66.53 during the decade of the nineties. Thus, there is an increase in wealth per capita during the 1990s as compared to the 1980s. From 2002-2003 the estimate goes up appreciably, primarily because of the twin effects of a rise in produced capital formation and the falling population growth rates, although there is increasing depreciation of natural capital.

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