Business Cycle Accounting of the Indian Economy

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Abstract

Can we use neoclassical growth model to single out the important transmission channels through which primitives affected the Indian economy and caused the remarkable growth of the period 1982 to 2002? In this paper, we answer the question by applying the new technique of business cycle accounting to the Indian economy. Business cycle accounting procedure is based on the idea that primitives affect the economy through three possible channels: through changes in productivity, through changes in labor market frictions or through changes in investment market frictions. Our results show us that the primary conduit of policies that brought about significant growth in India was productivity that registered an unprecedented increase particularly in the nineties. Our results further indicate that changes in labor market frictions and investment market frictions did not play a significant role.

Keywords: Business cycle accounting, Indian growth, wedges, neoclassical growth

JEL Classification : E13, E32

1 Introduction

The economic performance of India in the last six decades of development can be divided into two phases: the first phase constitutes the decades following independence from the British rule in 1947 and continued to about 1980, when the growth rate of GDP stood at 1.1% . The period after that can be thought about as the golden age of economic reconstruction when the growth rate increased to an average of 6%. The figures are particularly meaningful when we look at them in the context of the long term growth rate of GDP per capita achieved

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by some of the developed countries of the world. As is well known in business cycle literature, the long term growth rate of GDP per capita in United States is 2% which is taken as a benchmark in economic analysis. Japan, a country that had been considered by many as an economic miracle, maintained a growth rate of 8% following the second world war and then stabilized to a GDP per capita growth rate of 3% in the eighties before it crashed in the nineties. India, for its part, maintained a GDP per capita growth rate of 1.5% in the eighties, still not quite up to the benchmark but not dismal either. The picture drastically changed in the nineties, when the growth rate of GDP per capita reached an average of 5%, much beyond the benchmark and a small miracle on its own.

Many factors have been attributed for this economic transition. Literature in this area has been comparatively sparse, though much debate has ensued as to what caused India's small miracle? There are quite a few papers which agree with the contribution of Indian IT sector as the catalyst of economic growth. On one hand we have Nirvikar Singh (2004) who argues in favor of the important role played by the Indian IT sector in promoting growth. This view, perhaps not surprisingly, finds great support among the IT pioneers of India. NR Narayan Murthy, Chairman of Infosys, one of the fastest growing IT companies that originated in India hails the changing climate in India by arguing that "...the economic reforms of 1991 changed the Indian business context from one of state-centered, control orientation, to a free, open market orientation - especially for hi-tech companies. It allowed Indian companies to start competing effectively on a global scale" at the Indian Economy Conference at Cornell University (2002) . On the other end of the spectrum, we have Dani Rodrick and Arvind Subramanian (2004) who investigate "... a number of hypotheses about the causes of this growth – favorable external environment, fiscal stimulus, trade liberalization, internal liberalization, the green revolution, public investment – and find them wanting." They argue that " .. growth was triggered by an attitudinal shift on the part of the national government towards a pro-business (as opposed to pro-liberalization) approach."

The common consensus reached amongst economists is that the Indian economy saw an unprecedented spurt of software development, which coupled with drastic changes in policy encouraging free markets and liberalization led to a rapid growth in productivity. This development, coupled with the fact that India is traditionally a cheap labor market, which now became a source of skilled labor, at least in the software arena, led to increases in output per capita. In economic parlance, we can therefore say that it was a spurt in productivity, along with labor and investment market policies that all played a role in shaping India's future. As to which of these factors played a major role, the jury is still out. One area in which the literature is comparatively silent is numerical accounting of the growth experience of India that would help us put numbers to the contributions of different factors that led to the economic growth in India. In a previous paper entitled "Technology as a channel of economic growth in India (*forthcoming* "India Macroeconomics Annual, 2006) we examined the role of technology or productivity growth in bringing about the economic miracle in India using a neoclassical framework following the growth accounting procedure of Edward Prescott and Finn Kydland (1982, 1986), where technology is treated as an external shock. This is an area with scope for further research, where researchers can numerically examine the role of other potential factors that led to the Indian economic miracle.

However, in addition to the primitives which have played a role in Indian economic development, another issue of interest is "how" they affected the economy. Thus a study of numerically accounting for Indian economic growth is incomplete unless in addition to identifying the primary forces that were particularly successful in generating economic growth in India, we also identify the "transmission channels" through which these factors worked. In this paper, we concentrate on this second issue and this leads us to examine the growth of India during the eighties and the nineties through the lens of business cycle accounting.

What is business cycle accounting (BCA) procedure? The BCA procedure, a relatively new procedure developed by economists V.V. Chari, Ellen R. McGrattan and Patrick J Kehoe in 2002 is based on the fundamental observation that external frictions or policies can affect an economy primarily through three different channels: through an impact on productivity (so in this approach technological progress is treated as a channel of growth more than an external shock), through an impact on labor market, and through an impact on investment market. For example, if we believe that economic liberalization and free market policies were the primary forces behind Indian economic growth, two obvious channels through which these policies affected the economy seems to be the productivity channel and the investment market channel where the frictions that made it costly for Indian firms to gain access to funds were considerably lessened if not completely eradicated. Business cycle researchers and policy makers alike are interested in the transmission channel of frictions or policies as it explains "how" a policy might affect the economy, or if a friction affects the economy through more than one channel, which channel is the primary one?Economists also consider government spending to be an important channel through which government can directly affect the economy .

Once we establish the need for not only identifying the primitive frictions or external policies that played a major role in the economic reconstruction, but also the need to correctly identify the transmission channel through which these primitives played a role, we come to the question of how to do the job? In other words, how do we model an economy such that we can identify transmission channels of external shocks? This is where the key idea of business cycle accounting procedure comes in. Suppose an economy does not have any frictions affecting it then the economy would achieve the first best outcome. However, when frictions affect the economy, it distorts the economic outcome and prevents the economy from achieving the first best outcome. If we model the economy in a neoclassical general equilibrium setup, then the frictions would appear as wedges in the necessary first order conditions, thereby distorting them and keeping the economy from achieving efficiency. The way that these frictions affect the economy is thus similar to the way that taxes appear in a growth model To understand this point, consider an economy facing binding collateral constraints like that of Nobuhiro Kiyotaki and John Moore (1997) in that the economic agent can only raise capital equal to a certain fraction of his or her wealth. The fraction is called the Loan-to-Value (LV) ratio and determines how much money an agent can raise. Thus it may be considered like an investment friction that affects investment and prevents the economy from raising money beyond a certain limit. An easing of the LV ratio would mean a relaxation of the investment friction and presumably would lead to more investment hence higher growth. Now consider an economy that does not have collateral constraints but there is a tax on investment. If the tax is high enough then that creates a disincentive to invest and a lowering of the investment tax encourages further investment. Thus the role played by investment taxes in an unconstrained economy is very similar to that of the Loan to Value ratio in a collaterally constrained economy and has similar effect on the economy. So one way of modelling external frictions is as taxes that affect the economy. Note that these taxes are not "taxes" in the common sense of the word as in they are not a result of government policies. More appropriately, they are actually wedges that prevent the economy from achieving its first best outcome. We call these wedges as "taxes" as they play a role similar to what taxes do and therefore at least on the face value, look and act like taxes.

To apply the BCA procedure to India, we take a neoclassical growth model and extend it to include time varying efficiency or productivity wedge that is the Solow residual, labor wedges that are modelled as labor income taxes, investment wedges that resemble taxes on investment expenditure and government wedges that is actually government spending . The solution of the model involves two parts: since the wedges represent frictions, there is no data available on them and we need to use the results of our model to calculate the wedges (this step is somewhat like back calculating the value of frictions). The primary idea here is that the wedges summarize all possible frictions that affect the economy. Hence in theory the data on output, investment or labor that we observe is a function of these wedges. Since we know the data from National income accounts we can use them and the policy functions from our model to calculate the wedges. At this point note that since the four wedges that we have modelled are assumed to be the only way that external frictions affect the economy, if we put in all four wedges together in our model, we will be able to exactly replicate the data by construction. That is not what we are after. What we are interested in is the question which of these wedges are most significant in accounting for the observed data? That is the second part of solving this model and is known as "decomposition".

The rest of the paper is organized as follows: in the next section we outline our model and also highlight a simplification that we use from the original business cycle accounting procedure. Section 3 provides us with the results of calculating the wedges and Section 4 provides the decomposition results. Section 5 concludes the paper.

2 Business Cycle Accounting

We begin this section by first providing a description of the neoclassical growth model used in business cycle accounting. BCA procedure uses a standard growth model with four stochastic variables or wedges: *efficiency wedge* A_t , which appears like time varying productivity; the *labor wedge* τ_{nt} , which acts like a time varying tax on labor income, and the *investment wedge* τ_{xt} , which acts like a tax on investment expenditure. Further, per capita government expenditure g_t, is also considered as '*government wedge*', which can have a significant impact on the economy. It should be emphasized that each of the wedges represent the overall distortion to relevant first order conditions and do *not* identify the primitives driving these wedges.

2.1 Theoretical model

We assume that the economy every period comprises of a measure N_t of identical and infinitely lived agents who are endowed every period with one unit of time that can be used for work and leisure. The economy also consists of measure one of identical firms that own the production process. For purposes of analysis, we assume that population grows at a constant rate η every period, where the population growth rate is exogenous to the model. We assume that there is one output that is produced and consumed in the economy. There is a government that collects income and investment taxes and uses the proceeds to finance government expenditure and transfers in such a fashion as to balance the budget every period. Given the structure of the economy, we can summarize the problems facing the agents of the economy as:

2.1.1 Representative consumer's problem

The representative consumer in the economy chooses per period consumption c_t and labor l_t to maximize present discounted value of lifetime utility. The consumer receives income from two sources: labor income and rental income from capital. In addition, every period, the consumer also receives some transfers from the government. The proceeds of the income and transfers are used to finance consumption and investment expenses every period. Further, every period, the consumer has to pay income and investment taxes to the government at an exogenously determined rate. Thus the representative consumer's problem can be written as:

$$Max\ E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, 1 - l_t)$$

subject to:

$$c_t + (1 + \tau_{xt})x_t \leq w_t l_t (1 - \tau_{nt}) + r_t k_t + Tr_t$$

$$k_{t+1} \leq (1 - \delta)k_t + x_t$$

nonnegativity constraints

where k_t denotes per capita capital stock, x_t denotes per capita investment, after-tax labor income is $w_t l_t (1 - \tau_{nt})$ and rental income is $r_t k_t$ where w_t is the wage rate and r_t is the rental rate on capital stock, β is the discount factor, δ is the depreciation rate on capital stock, and Tr_t denotes transfers from the government received at period t.

2.1.2 Representative firm's problem

Every period, the representative firm produces a single output using labor and capital to maximize profits. Output is subject to an exogenously given production technology. Hence the representative firm's problem every period is given by:

$$Max\ y_t - w_t l_t - r_t k_t$$

subject to:

$$y_t \leq F(k_t, A_t l_t)$$

where y_t denotes per capita output and A_t denotes productivity. For my analysis I assume that the production technology is labor augmenting. I further assume that the long run rate of technical progress is given by $(1 + g_z)$.

2.1.3 Equilibrium

The equilibrium in this economy is given by a vector of price functions $\{w_t,\ r_t\}_{t=0}^{\infty}$ and a vector of allocation functions $\{c_t,\ l_t\ x_t,\ y_t\}_{t=0}^{\infty}$ such that the price and allocation functions satisfy the following equations every period:

$$c_t + x_t + g_t = y_t \tag{1}$$

$$y_t = F(k_t, A_t l_t) \tag{2}$$

$$\frac{u_{nt}(c_t, l_t)}{u_{ct}(c_t, l_t)} = (1 - \tau_{nt}) F_{lt}(k_t, A_t l_t) \tag{3}$$

$$\begin{gathered} \beta E_t u_{ct+1}(c_{t+1}, l_{t+1}) \{F_{kt+1}(k_{t+1}, A_{t+1} l_{t+1}) + (1 - \delta)(1 + \tau_{xt+1})\} \\ = (1 + \tau_{xt}) u_{ct}(c_t, l_t) \end{gathered} \tag{4}$$

where notations like $u_{ct},\ u_{nt},\ F_{lt},\ F_{kt}$ etc. denotes the first derivative of the utility function and production function with respect to different arguments like consumption, labor, and capital. Equation (1) represents the resource constraint faced by the economy every period. Equation (2) shows that output every period is subject to the production technology. Equation (3) equates the marginal rate of substitution between consumption and leisure to the after tax marginal return to labor, where in equilibrium, the marginal return to labor or the wage rate is equal to the marginal product of labor. Equation (4) is the inter-temporal equation taking into account the fact that in equilibrium, rental rate on capital is equal to the marginal product of capital. The four equations outlined above summarize the equilibrium conditions of the economy every period. Note that the time varying productivity and taxes on labor income and investment expenditure distort the first order conditions and keeps the economy from achieving the first best outcome, the same way that frictions affect the economy.

It is interesting to note that the BCA technique in a way can be considered a 'dual' to the usual technique of business cycle accounting first forwarded by Edward Prescott and Finn Kydland (1982) and Prescott (1986). In the traditional technique of business cycle accounting widely used in literature, the economy is modeled as a dynamic general equilibrium, which is affected by exogenous frictions and shocks. The procedure involves identifying predetermined frictions and using them to simulate the model outcome. The model is evaluated on how close the simulated results match the actual data. In contrast, in BCA approach the wedges are measured using data and the first order conditions of the model so that the model replicates the data exactly when all the wedges are jointly fed. The evaluation of the model takes the form of feeding in the calculated value of the wedges one by one and in various combinations in the model and identifying the ones that are needed to best replicate the data, keeping in mind that by construction, feeding in all the wedges jointly will exactly replicate the data. The only studies in literature that we are aware of that also uses the BCA approach to study business cycle fluctuations are those of Keiichiro Kobayashi and Masaru Inaba (2005) and Mark Wynne, Finn Kydland and Alan Ahearne (2006).

2.2 Application to India

We want to apply the Business Cycle Accounting technique to India to account for fluctuations during the period 1982 to 2002. For this we need to specify the utility and the production functions and take into account the population growth rate while deriving the first order conditions. We assume a Cobb-Douglas production function and a standard monotonically increasing and strictly concave utility function represented by:

$$\begin{aligned} u(c_t, l_t) &= \frac{\left(c_t^{\alpha}(1-l_t)^{1-\alpha}\right)^{1-\sigma}}{1-\sigma}, \text{ when } \ \sigma \neq 1 \\ &= \alpha \log \ c_t + (1-\alpha) \log \ (1-l_t) \text{ when } \ \sigma = 1 \end{aligned} \tag{5}$$

$$y_t = k_t^{\theta}(A_t l_t)^{1-\theta} \tag{6}$$

The functional forms that we use are same as those used by Chari, Kehoe and McGrattan (2002) as well as by Prescott and Hayashi (2002). Note that on a balanced growth path, the variables $c_t, \ k_{t+1}, \ y_t,$ and g_t grow at a rate $(1+g_z)$. Furthermore, we can substitute out the value of consumption c_t from Equation (1) and replace it in Equations (3) and (4). Taking into account the population growth rate η, and discounting the model variables with respect to their long term trend $(1+g_z)$, the fundamental equations of our model reduce to:

$$\widehat{y}_t = F(\widehat{k}_t, \widehat{A}_t l_t) \tag{7}$$

$$\frac{u_{nt}(\widehat{c}_t(\widehat{y}_t, \widehat{x}_t, \widehat{g}_t), \ l_t)}{u_{ct}(\widehat{c}_t(\widehat{y}_t, \widehat{x}_t, \widehat{g}_t), \ l_t)} = (1-\tau_{nt}) F_{lt}(\widehat{k}_t, \widehat{A}_t l_t) \tag{8}$$

$$\begin{aligned} \beta E_t u_{ct+1}(\widehat{c}_{t+1}(\widehat{y}_{t+1}, \widehat{x}_{t+1}, \widehat{g}_{t+1}), \ l_t)\{F_{kt+1}(\widehat{k}_{t+1}, \widehat{A}_{t+1} l_{t+1}) + (1-\delta)(1+\tau_{xt+1})\} \\ = (1+\tau_{xt}) u_{ct}(\widehat{c}_t(\widehat{y}_t, \widehat{x}_t, \widehat{g}_t), \ l_t)(1+g_z) \end{aligned} \tag{9}$$

where I denote a variable z_t detrended by the long-term growth rate of technological development $(1+g_z)^t$ as $\widehat{z}_t$ where $\widehat{z}_t = \frac{z_t}{(1+g_z)^t}$. Given the wedges $\widehat{A}_t, \ \tau_{nt}, \ \tau_{xt}$, and $\widehat{g}_t$, the equations 7 to 9 solve for output, investment and labor in terms of the wedges. The BCA procedure involves feeding in the wedges one by one and in different combinations to see which wedges or combinations of wedges can best replicate the data. The accounting procedure has two parts: first we need to estimate the wedges from the data and then we feed in the wedges in our model to generate output, labor and investment. This later procedure is called decomposition. Note that by construction of the BCA procedure, if we feed in efficiency, labor, investment and government wedges in the model all together, then we will get back the data.

Taking into account the population growth rate, and the functional forms outlined in equations (5) and (6), equations (7) to (9) reduces to:

$$\widehat{y}_t = \widehat{k}_t^{\theta}(\widehat{A}_t l_t)^{1-\theta} \tag{10}$$

$$\left[\begin{array}{c} \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{\widehat{y}_t-\eta(1+g_z)\widehat{k}_{t+1}+(1-\delta)\widehat{k}_t-\widehat{g}_t}{1-l_t}\right) \\ = (1-\theta)(1-\tau_{nt})\frac{\widehat{y}_t}{l_t} \end{array} \right] \tag{11}$$

$$\left[\begin{array}{c} \frac{\beta}{(1+g_z)}E_t\left(\frac{\widehat{y}_t-\eta(1+g_z)\widehat{k}_{t+1}+(1-\delta)\widehat{k}_t-\widehat{g}_t}{\widehat{y}_{t+1}-\eta(1+g_z)\widehat{k}_{t+2}+(1-\delta)\widehat{k}_{t+1}-\widehat{g}_{t+1}}\right)\left(\theta\frac{\widehat{y}_{t+1}}{\widehat{k}_{t+1}}+(1-\delta)(1+\tau_{xt+1})\right) \\ = (1+\tau_{xt}) \end{array} \right] \tag{12}$$

where the value of σ in equation (4) is taken as 1.

2.3 Simplifying the model

In the previous section, note that given parameter values we can solve equations (10) to (12) and get decision rules for output $y(t)$, labor $l(t)$, and capital stock next period $k(t+1)$ in terms of productivity or efficiency wedge $A(t)$, labor wedge τ_{nt}, investment wedge τ_{xt} and government consumption wedge $g(t)$. Once we get the decision rules, we can plug in the time series of the wedges one by one in our decision rules while holding other wedges constant at their steady state values and thereby account for the contribution of each wedge in generating the macro variables.

The problem here is that we do not have time series data available on productivity A_t, labor wedge τ_{nt}, and investment wedge τ_{xt} as they represent frictions affecting the labor and investment markets and are therefore intangible. So we need to use data from national income accounts and our equations to back out the values of these wedges. The job is relatively simple for efficiency wedge $A(t)$, and labor wedge τ_{nt} which we can derive given equations (10) and (11) and the time series data on output $y(t)$, labor $l(t)$, and capital stock next period $k(t+1)$.

The job is not so easy for calculating investment wedges τ_{xt} as it involves knowing not only the time series of aggregate macro data but also the expectations that people form about the future as equation (12) highlights. Researchers have used many variations to get around this problem. Chari, Kehoe and McGrattan (2003) hold efficiency and labor wedges constant at their steady state values and let investment wedges be whatever they should be so that they can replicate the investment data exactly to get an approximate idea for the series and then they iterate such that their model outcomes (feeding in all the wedges) can replicate the data exactly. Others, including Keiichiro Kobayashi and Masaru Inaba (2005) work with a deterministic form of the model to get around the problem of forming expectations.

What we do in our analysis is to hold the investment wedges constant at their steady state value. We then ascertain how much of the observed data can we generate with efficiency, labor and government wedges jointly. If after feeding in efficiency, labor and government wedges, we still have a large part of observed data still unexplained, then we can say that investment wedges must have played a significant role as by construction, the model is supposed to replicate the data exactly when all four wedges are fed in.

Thus with our simplification, the equations reduce to:

$$\widehat{y}_t = \widehat{k}_t^{\theta}(\widehat{A}_t l_t)^{1-\theta} \tag{13}$$

$$\left[\begin{array}{c} \left(\frac{1-\alpha}{\alpha}\right)\left(\frac{\widehat{y}_t-\eta(1+g_z)\widehat{k}_{t+1}+(1-\delta)\widehat{k}_t-\widehat{g}_t}{1-l_t}\right) \\ =(1-\theta)(1-\tau_{nt})\frac{\widehat{y}_t}{l_t} \end{array} \right] \tag{14}$$

$$\left[\begin{array}{c} \frac{\beta}{(1+g_z)}E_t\left(\frac{\widehat{y}_t-\eta(1+g_z)\widehat{k}_{t+1}+(1-\delta)\widehat{k}_t-\widehat{g}_t}{\widehat{y}_{t+1}-\eta(1+g_z)\widehat{k}_{t+2}+(1-\delta)\widehat{k}_{t+1}-\widehat{g}_{t+1}}\right)\left(\theta\frac{\widehat{y}_{t+1}}{\widehat{k}_{t+1}}+(1-\delta)(1+\overline{\tau_x})\right) \\ =(1+\overline{\tau_x}) \end{array} \right] \tag{15}$$

where $\overline{\tau_x}$ is the steady state value of investment wedge τ_{xt}. The model does not allow us to calibrate for the parameter values as we do not know the steady state value of the wedges. So our fist step for solving the model is to pick parameter values from literature. We assume β or the rate of time preference to be .95 as is commonly used in business cycle literature. We take α to be .8251 and θ to be .36 from Chakraborty (2006) and we assume that depreciation rate $\delta = .25$ that we derive from the Indian tax code that allows non-residential corporations to claim tax relief for depreciated capital stock at a maximum depreciation rate of 25%.

Once we have our parameter values, we can calculate the wedges as follows

$$\widehat{A}_t = \left(\frac{\widehat{y}_t}{\widehat{k}_t^{\theta} l_t^{1-\theta}}\right)^{\frac{1}{1-\theta}} \tag{16}$$

$$\tau_{nt} = 1 - \left[\begin{array}{c} \left(\frac{1-\alpha}{\alpha}\right) * \\ \frac{1}{(1-\theta)} * \frac{l_t}{\widehat{y}_t}\left(\frac{\widehat{y}_t-\eta(1+g_z)\widehat{k}_{t+1}+(1-\delta)\widehat{k}_t-\widehat{g}_t}{1-l_t}\right) \end{array} \right] \tag{17}$$

$$\overline{\tau_x} = 1 - \frac{\theta * \frac{\overline{y}}{\overline{k}}}{\frac{(1+g_z)}{\beta} - 1 + \delta} \tag{18}$$

where equation (18) is the steady state variation of equation (15) and helps us to get the steady state value of the investment wedge, $\overline{\tau_x}$. Off course, one can easily get the steady state value of the efficiency wedge and labor wedge that we denote by $\overline{A}$ and $\overline{\tau_n}$ respectively from the steady state version of equations (16) and (17).

Once we have calculated the realized wedges, we are interested to get an intuitive idea of if they look promising in generating economic growth in India. To get an idea let us begin by graphically demonstrating the evolution of GDP per capita over the period 1982 to 2002 with respect to a long term time trend of 1.5%. Figure 1 graphically demonstrates the index of detrended GDP per capita. The way we arrive at this figure is by first detrending GDP per capita during 1982 to 2002 at the rate 1.5% which is the long term trend of growth in India that we derived by taking the average growth rate of GDP per capita during 1960 to 2002. Then, we take the value of detrended GDP per capita in 1982 as 100 and recalculate the detrended GDPper capita in the following years with respect to 100. This gives us the index of detrended GDP per capita and is quite useful in charting how GDP per capita has performed over the years. From Figure 1, we can summarize that GDP per capita has consistently grown above the trend growth rate in the eighties and the nineties.

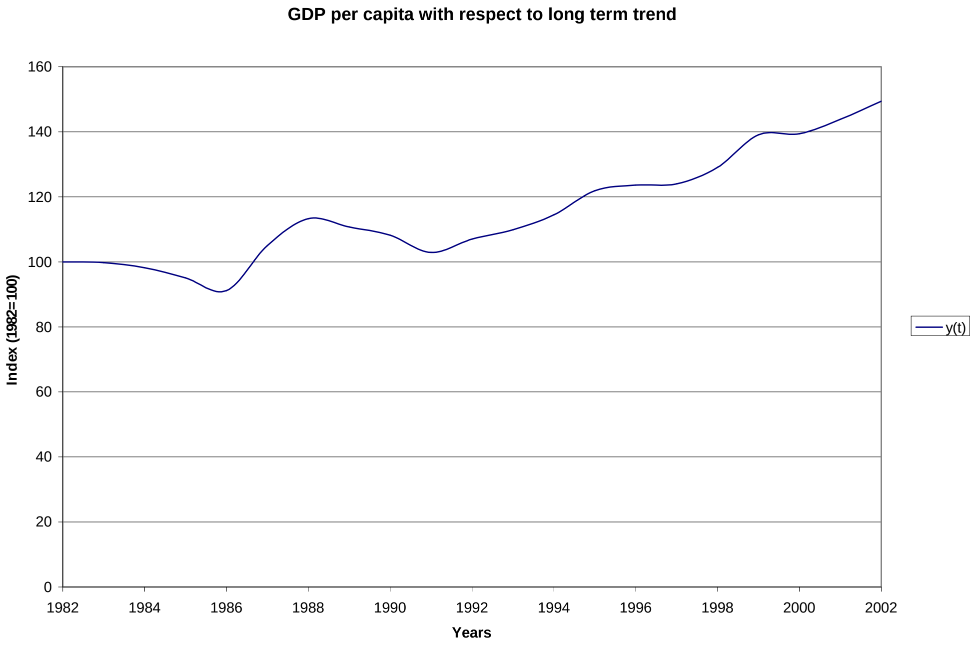

Figure 1: GDP per capita detrended at 1.5%

Next, we are interested to see whether efficiency or labor wedge could have played a role. We can also look at government consumption wedge that we are not plotting here for the sake of brevity. Figure 2 plots the index of efficiency wedge, where we take the value of A_t in 1982 to be a 100. We find that productivity also grew during 1982 to 2002 with respect to the long term trend which at least intuitively is conducive to economic growth.

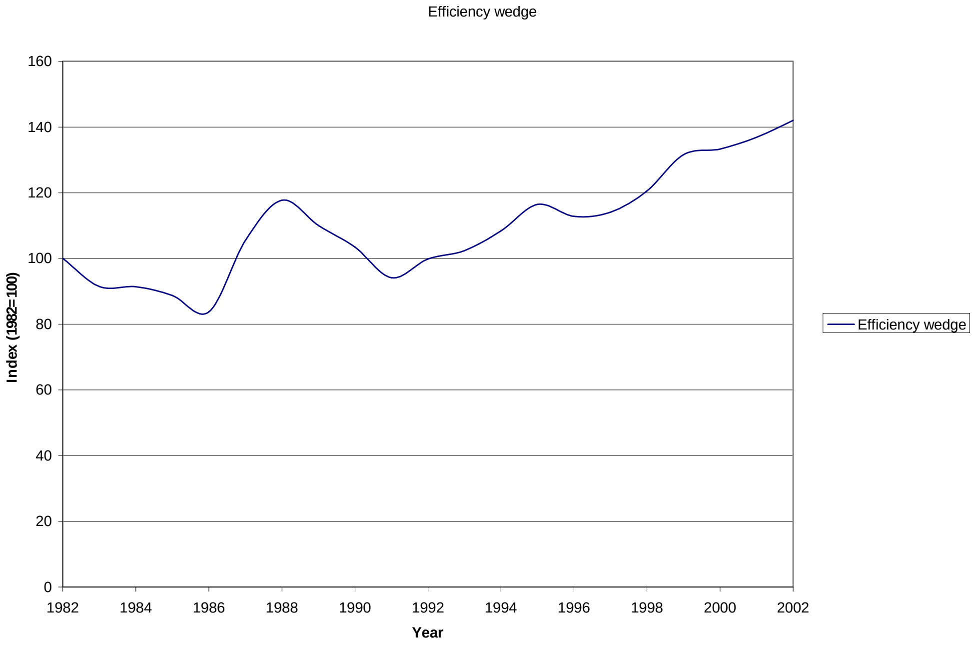

Figure 2: Realized efficiency or productivity wedge

Figure 3 plots the labor wedge as calculated from equation (17). Note that except for between 1982 to 1983 when we find labor wedge declined, labor wedge has not changed much over the last two decades. Now keeping in mind that labor wedges represent labor market frictions that keep the economy from achieving the first best outcome, we should expect economic growth to be associated with a decline in value of labor wedge or a decline in labor market frictions. So, if labor wedge does not show any such decline, intuitively it could not have played a role in bringing about economic growth in India. As for the dramatic decline in 1982 to 1983, we attribute it to a data mis-specification as we find that labor data shows a dramatic shift in 1982 which cannot be attributed to any drastic labor market policy. Our belief is that labor market data reporting which has been consistent only after the mid eighties could have somehow contributed to this big jump, and so we do not take this seriously.

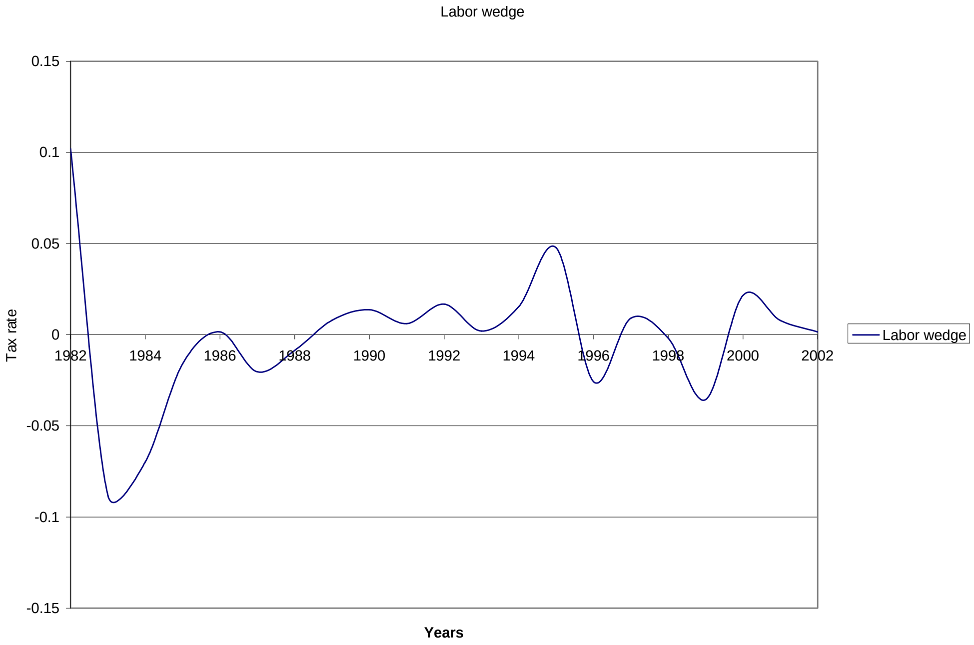

Figure 3: Labor wedge

3 Decomposition

Our objective in this paper is to account for observed changes in aggregate macro variables by changes in efficiency wedge, labor wedge and government wedge. In the previous section, we showed how we derive the time series for the wedges. In this section we show the model outcomes generated by feeding in the realized values of the wedges one by one and in various combinations in our decision rules and evaluate how well they can approximate the macro data.

We solve for the decision rules using the log-linearization techniques of Robert King, Charles Plosser and Sergio Rebelo (1988). The decision rules are derived as:

$$\begin{bmatrix} \widetilde{k}_{t+1} \\ \widetilde{y}_t \\ \widetilde{l}_t \end{bmatrix} = PP * \widetilde{k}_t + QQ * \begin{bmatrix} \widetilde{A}_t \\ \widetilde{\tau}_{nt} \\ \widetilde{g}_t \end{bmatrix}$$

where PP is a 3x1 matrix and QQ is a 3x3 matrix of coefficients where the log deviation of a variable z_t from its steady state value $\overline{z}$ is denoted by $\widetilde{z}_t$.

The only exception in this specification is $\widetilde{\tau}_{nt}$ which is equal to $\tau_{nt} - \overline{\tau}_n$ where we follow Chari, Kehoe and McGrattan's (2002) specification. We begin by first stating the correlations between output, efficiency wedge and labor wedge during the period 1982 to 2002. The correlation between GDP per capita and efficiency wedge is .98 and that between GDP per capita and labor wedge is .1. Given our model, we expect a positive correlation between productivity or efficiency wedge and output and that is supported by correlation figures. However the correlation between output and labor wedge is positive though small which indicates that frictions in labor market and output per capita moved in the same direction, which indicates that output increased despite of labor market frictions, not because labor frictions declined.

Next, we graphically depict the model outcomes feeding in various realizations of wedges in our model and comparing them with data. As Figure 4 depicts the model outcome with efficiency wedge alone can very well replicate the output per capita observed in India, however the model outcome feeding in labor wedges cannot explain any of the observed data on output per capita.

If we feed in efficiency, labor and government wedges jointly in our model we can almost wholly account for observed output per capita in the data which leads us to conclude that investment wedges played a limited role if at all in the Indian economy during the eighties and the nineties.

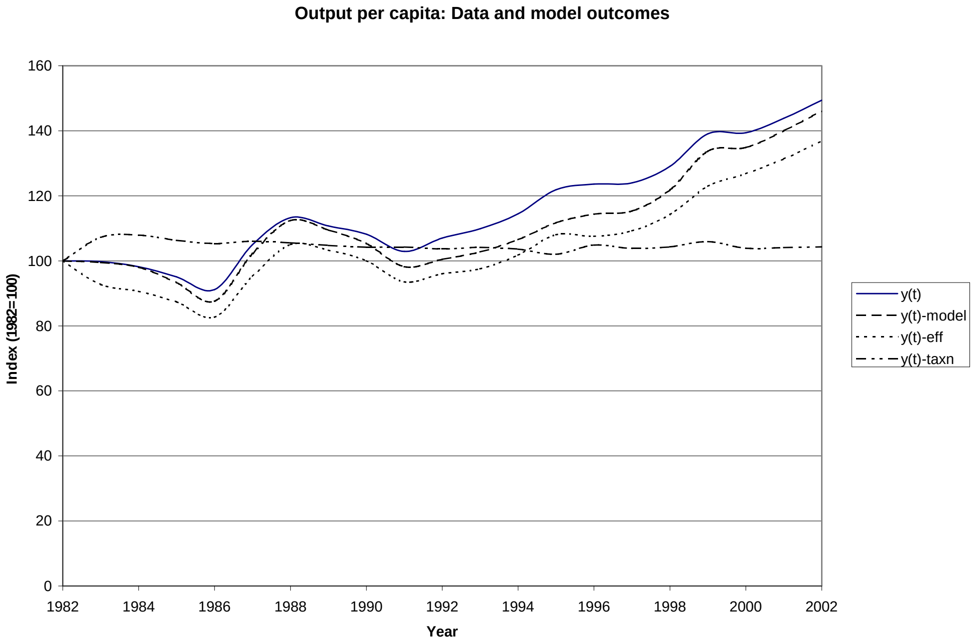

Figure 4: Output per capita: Data and Model outcomes

To verify our analysis we also look at an alternative variable, the capital-output ratio. The results are pretty similar to what we saw for output per capita. With efficiency wedges alone the model well replicates the data on capital-output ratio but feeding in labor wedges alone we cannot account for the observed capital-output ratio. However, feeding in efficiency, labor and government wedges jointly in the model, the model outcome closely replicates the data which supports our previous conclusion that investment wedges at best played a limited role in Indian economic development.

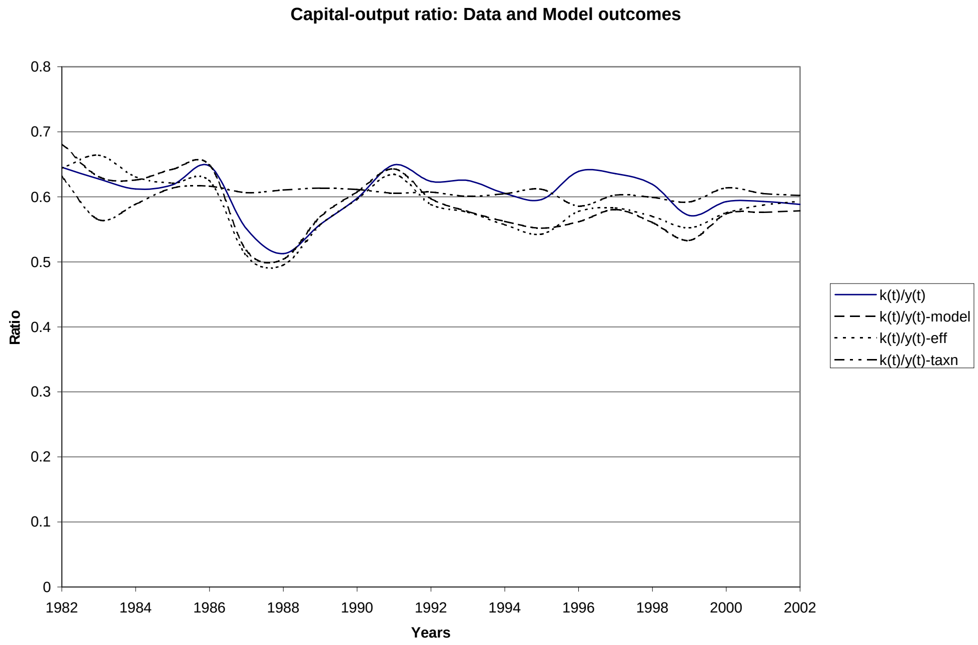

Figure 5: Capital-Output ratio Data and Model outcomes

4 Conclusion

After decades of unremarkable growth following independence, Indian economy took off in the eighties and continued to grow well into the nineties. While a number of economists have brought forward theories to explain this growth phenomenon, empirical studies that attempt a numerical growth accounting of India is at best limited. In an earlier paper (Chakraborty 2006), we had attempted to understand the role of technological progress, held by many as the primary reason for Indian growth using a neoclassical growth analysis.

In this paper, our attempt is to apply a comparatively new procedure of growth accounting called "Business Cycle Accounting (BCA)" procedure to India. Our objective is to figure out not the primitives that brought about economic growth in India but the "transmission channels" through which the primitives played a role. For example, if we establish that liberalization policies in the eighties and nineties generated the economic revolution, did liberalization policy act by increasing productivity, did they reduce frictions in the labor market thus encouraging growth or did liberalization policies break down investment market barriers? This paper helps us answer such questions. The BCA procedure is particularly suited for this job as it is based on the key observation that most primitives affect the economy through productivity, or causing labor market frictions or investment market frictions and neoclassical model can be used to study these frictions as the frictions resemble taxes at least on the face value. Thus by solving the neoclassical growth model and by inserting the frictions one by one and in various combinations we can decipher which frictions affected the economy the most and thereby understand the most important transmission channel of the primitive forces that affected the economy.

Our results show that primitives affected the Indian economy primarily by causing changes in productivity. Labor market frictions or investment market channel was not particularly important.

We can therefore go one step further and suggest that future research should concentrate on the primitives that might have caused increases in productivity. It would also be interesting to look at micro data and provide evidence of such technical progress.

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