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Estimating Optimum Growth Rate for the Indian Economy: A Dynamic Macroeconomic Model

Sarat Chandra Dhal*

The dominant viewpoint in growth theory literature is that an economy's optimum growth rate depends upon its structural characteristics encompassing inter-industry production technology and industrial interlinkages, structure of sector-wise capital inputs, commodity composition of household consumption and external trade especially imports. In this context, the paper demonstrates how the optimum growth trajectory, alternatively known in general equilibrium theory as Von Neumann's growth rate can be estimated from a dynamic sectoral macroeconomic model for the Indian economy. The empirical solution to the dynamic model using information on nine major sectors culled out from the latest inter-industry accounts provided by C.S.O for the year 1989-90 yields into the optimum growth rate of output at 6.37 per cent. If recent changes in household propensity of consumption pattern are taken into account along with the underlying trends in capital-output coefficients of broad sectors, then the optimum growth rate is estimated at 6.52 per cent, a marginal improvement over the base line scenario. On the otherhand, if only consumption demand shock is considered and the implied productivity trend as reflected in capital-output ratio set to improve, then optimum growth rate can be maximised at about 7-8 per cent for the Indian economy.

Introduction

Exploring the frontiers of economic growth has been a major preoccupation among economists in the post world war II period. Drawing upon the foundation of growth theory laid by the Harrod-Domar model, several alternative growth models have been developed to analyse wide spatial differences in growth rates of countries arising out of differing structural characteristics of these economies, economic agents' behaviour as regards consumption, savings, capital accumulation, modes of production and the state of technology. The evolution of growth theory has lost momentum since the 1970s, the endogenous growth model (Romer 1987, 1990) being notable exception. At the empirical level, linkages

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with underlying economic model have weakened in the face of erosion in explanatory power and growth tracking performance of these models. Empirical analysis has tended to be driven by atheoretic and semi-theoretic considerations.

At the same time and increasingly so in the recent period, information about an economy's optimum growth rate and the output gap i.e., deviation of actual output from the optimum is regarded as vital for policy authorities and markets. Macroeconomic policies are evaluated in the public domain. Welfare considerations constrain policy makers to pursue policies which minimise risks at the maximum attainable or optimal path. For the markets, the optimum growth rate is an indication of the long run potential of an economy and in the short run, deviation of actual output from the optimum or potential level and the extent of fluctuations in the deviations signal on capacity accumulation, safety of investment and profitability of business sector. Consequently, measuring optimum growth rate assumes critical significance.

In fact, in the recent period the absence of official estimates of the output gap has not deterred independent assessment driven by several *atheoretic* and *semi-theoretic* considerations, especially, the univariate time series models which decompose output into its trend (or permanent) and cyclical compoenents. However, these time series models have been criticised for being *atheoretic* as they neither relate to nor explain the evolving structural and behavioural relations which ultimately determines the optimum output growth trajectory.

In contrast, this paper argues that the capacity growth rate of real sector output depends upon macroeconomic fundamentals of the real sector and it should be investigated using a host of structural information of the Indian economy. The study has two major objectives: First, it provides a framework for empirically analysing optimum growth rate in relation to major structural characteristics of the economy. Secondly, these structural informations are identified broadly into two types of shocks i.e., one originating from changes in propensity of consumption or saving and another coming from changes in capital-output coefficients of producing sectors. The study exemplifies how differently and to what extent these two predominant shocks affect optimum growth rate of output in the Indian economy. The rest of the paper is organised into three parts. Section I outlines the theoretical model for estimating the optimum growth rate. Section II analyses the empirical results and evaluates the growth path in light of alternative structural configurations. Section III provides the summary findings and conclusion.

Section I

A Theoretical Outline of the Sectoral Macroeconomic Model

In most of the theoretical and empirical studies on the topic, economic growth is analysed at an aggregate level with respect to aggregate measure of economic activity and the proximate determinants such as aggregate savings and aggregate capital stock. Also, the studies which use the framework of production function rely on an economy-wide production technology. However, in reality an economy produces a number of goods and services and propensity to consume also differs across these goods and services. These goods and services are produced with different technology. Accordingly, structural informations are relevant for investigating the overall growth path of the economy. In this regard, on the empirical plane, the study uses the framework of a multisectoral model based on Leontief's dynamic input-output system for estimating the optimum growth rate of the Indian economy[1]. The underlying model is based on certain economic logic ***i.e., the material balance condition*** as it recognises that potential growth rate of output depends upon commodity composition of household consumption, the nature of sector-wise capital accumulation and external trade, particularly import structure besides the state of inter-industry production technology.

The objective of a dynamic multisectoral type general equilibrium model is to analyse how economic agents including households, producers and government interact with each other and converge to equilibrium. The starting point is the steady state macroeconomic balance which can be set out in terms of national income accounting. It is assumed that the economy consists of 'm' producing sectors, a household sector and the Government sector. The economy is open to external trade. The producing sectors, operate with fixed coefficient type Leontief production functions. The macroeconomic balance of this multisectoral production economy for any time period can be written in the form of the following

$$X_t = A\ X_t + C_t + G_t + I_t + E_t - M_t \qquad (1)$$

where **X** denotes for the vector of gross output of m sectors, **A** is the input-output technical coefficient matrix, **C** is the vector of household consumption of 'm' goods and services, **G** is the Government's current consumption, **I** is sector-wise investment, **E** represents exports and **M**, imports. The macroeconomic balance equation entails that supply of commodities **X** equals their demand in the form of intermediate consumption (**AX**) of business sectors, private consumption, government expenditure, investment, exports and imports.

In order to ascertain the underlying growth rate of the economy, the steady state macro model needs to be transformed into a dynamic process, preferably after endogenising the major components of the final demand vector including consumption and investment. As per the received tradition of macroeconomic models, government expenditure and exports are treated as exogenous variables. There are three major ways to transform the steady state macro-economic model into a dynamic model: (i) by incorporating time lags between demand and supply, (ii) by setting excess demand type partial adjustment process and (iii) by accentuating capital accumulation process. For instance, if we assume that consumption and investment are functions of past incomes *a la* the Samuelson's multiplier-accelerator model does, then the dynamic model can be suitably configurated in terms of a consumer oriented growth and/or investment induced growth models. Among various alternative models, one which endogenises the process of investment using capital-output coefficients has an edge over other competing models as the later alone can reflect on full capacity growth of a developing economy. As the growth path of a developing economy is constrained largely by saving (and investment) and productivity conditions, a dynamic sectoral model using the capital-output coefficients is built upon a powerful economic logic.

Let us assume that a producing sector 'j' requires in the medium term '**k**' units of capital to produce one unit of output. The capital stock accumulation process implies that the business sector is forward looking. At time t-1 , it accumulates capital stock $\mathbf{S}_t$ in order to produce planned output $\mathbf{X}_t$:

$$S_{j,t} = k_j \; X_{j,\,t} \tag{2}$$

By definition, investment is the changes in capital stock. Thus, taking first difference of the capital output relationship (2), we can derive the equation of investment as

$$I_{j,t} = S_{j,t} - S_{j,t-1} = k_j \; dX_{j,t} \tag{3}$$

Setting a growth trajectory (g) for output of X_j, the investment equation can be rewritten as

$$I_{j,t} = k_j \; g_j \; X_{j,t-1} \tag{4}$$

On extension to all the producing sectors, the equation for investment in matrix notation turns out to be

$$I_t = K \; g \; X_{t-1} \tag{4.1}$$

Where K is a matrix of capital-output coefficients ($\mathbf{k}_{ij}$) of various producing sectors. Under the framework of dynamic interlinkages among various producing sectors, let us further assume that producers' decision to accumulate capital (or make investment) will be guided by the consideration that they have a tendency to grow along a unique optimal macroeconomic growth trajectory (g_0). Thus, the investment equation is modified into

$$I_t = g_0 \; K \; X_{t-1} \tag{4.2}$$

Now substituting the investment equation (4.2) into the macroeconomic model (1), we have .

$$X_t = A \; X_t + C_t + G_t + g_0 \; K \; X_{t-1} + E_t - M_t \tag{5}$$

By advancing the macroeconomic system to prevail for time period t+1 as planned by the business sector, it can be expressed as

$$X_{t+1} = A \; X_{t+1} + C_{t+1} + G_{t+1} + g_0 \; K \; X_t + E_{t+1} - M_{t+1} \tag{5.1}$$

The macroeconomic model has taken the shape of a dynamic model in the form of a first order difference equation system (Chiang,1988) and the optimum growth rate has been incorporated into the system of difference equations. In the literature on multi-sectoral models, there exists the celebrated *Turnpike Theorem*[2] which suggests that the solution to the optimal growth rate can be achieved from the homogenous solution of the difference equation of the macroeconomic model(Tsukui,1970 and Mathur,1973). Treating the final demand component **(C+G+E-M)** as an exogenous component (**F**$_0$), we have

$$X_{t+1} = A \; X_{t+1} + g_0 \; K \; X_t + F_0 \tag{6}$$

For which the homogenous solution shall entail that

$$(I-A)X_{t+1} - g_0 KXt = 0$$

Now, pre-multiplying B i.e., inverse of (I-A) in both sides, it implies that

$$X_{t+1} - g_0 \; BK \; Xt = 0$$

According to the *turnpike theorem*[3], there exists a unique positive vector Z such that the above homogenous solution should satisfy the condition

$$(I - g_0 BK)Z = 0$$

Since **Z** is non-zero and furthermore, setting $\lambda = (1/g)$ and multiplying it in both sides we get

$$\lambda I - BK = 0$$

and if, $D = BK$,

$$\lambda I - D = 0$$

. *This last expression is an eigen system and thus, an eigen decomposition of the structural matrix **D** for the values of* λ *will enable us to ascertaining the optimum growth rate. The eigen solution has some interesting interpretation according to Frobenius Theorem. First, for a unique solution of growth rate according to Frobenius Theorem,* λ_o *should be the largest positive eigen value associated with a positive characteristic vector (Z). Secondly, the turnpike growth estimated as the reciprocal of largest eigen value is called balanced growth or Neumann's growth* (g_o) *and the Z the Neumann output ray*[4]. The interesting insights from the eigen system is that the **D** matrix is the product of inter-industry intermediate technology and capital-output coefficients. The structural characteristics of the economy relating to production structure and their interlinkages and capital accumulation are intertwined in the **D** matrix for arriving at the optimum growth rate.

This is the simplest kind of a dynamic sectoral model for estimating the optimum growth rate. It is also necessary to take note of some limitations. In the process of derivation of the eigen system, some of the major components of demand were not explicitly recognised particularly, the commodity structure of private final consumption which has a strong influence on the economy's optimum growth trajectory. Moreover, a proportion of imports constitutes a leakage from the domestic income stream as domestic producers will face reduced demand for their products. In such circumstances, the entire technology matrix **A** and household consumption should relate to domestic dependence implying that these items in the macroeconomic model should be expressed net of their respective import contents[5]. Thus, our exercise should endogenise the effects of consumption and imports into the growth model.

In order to incorporate the consumption effect, the consumption-income relationship is postulated to take the form of

$$C_t = C_o + c\ Y_t = C_o + cV\ X_t \qquad (7)$$

Where **c** is a column vector of marginal propensities to consume various goods and services, **Y** the aggregate income which equals to sum of value added in producing goods and services **(VX)**[6]. The **V** is a row vector of value added coefficients. Finally, after adjusting to imports, we have the dynamic general equilibrium model

$$X_{t+1} = (A\text{-}Am)X_{t+1} + (c\text{-}cm)VX_{t+1} + g_oKX_t + F_a \qquad (8)$$

Where $\mathbf{F_a}$ is the sum of exogenous components i.e., government expenditure **(G)**, exports **(E)** and autonomous components of consumption $\mathbf{C_o}$ and imports $\mathbf{M_o}$. The eigen system can be derived after suppressing the autonomous component to a null vector **(0)** in the form of

$$\lambda\ I - H = 0$$

$$\text{where } H = ((I\text{-}(A\text{-}Am)\text{-}(c\text{-}cm)V)^{-1}\ K$$

and A_m is a matrix of intermediate import intensity coefficients, **cm**, the vector of import intensity of private consumption. As defined earlier, the optimal growth rate of output will be estimated as the reciprocal of largest positive eigen value for which a positive characteristics vector Z exists for the structural matrix **H**:

$$g_o = 1/\lambda_{max}(H)$$

The optimum growth rate obtained from the above derives from general equilibrium framework and embodies various structural relationships as the **H** matrix uses information pertaining to producers' intermediate requirements, their capital structure and households' consumption choice of various commodities and imports.

Section II

Empirical Results and Analysis

The data on inter-industry requirements have been culled out from the latest input-output accounts produced by Central Statistical organisation (C.S.O) for the year 1989-90. The C.S.O has produced input-output table for 115 sectors. The input-output accounts provide detailed information on inter-industry transactions, private consumption, government expenditure, gross capital formation, exports and inter-industry import transactions against each of the producing sectors. However, there is no information on the structure of capital inputs of producing sectors. Since at the heart of the dynamic macroeconomic model are the capital-output coefficients for various producing sectors, a capital-output coefficient matrix has been prepared in the paper for broad sectors of the economy comprising agriculture (AG), mining (MNG), manufacturing (MNF), construction (CNS), electricity (ELC), transport (TRP), trade (TRD), banks and financial services (FINS) and miscellaneous services (MSC).

Construction of Capital Coefficients

The capital stock coefficient matrix can be constructed on the basis of information pertaining to its components i.e., fixed capital and inventory. The average fixed capital-output coefficient was further bifurcated into machinery (falling into the manufacturing category) and construction components. Since capital stock includes inventory, the data on the later were distributed across the sectors using the approach suggested in Tsukui (1979) and Mathur (1973):

$$b_{ij} = \left(\sum_{j=1}^{m} b_{ij}\right) \left(a_{ij} / \sum_{j=1}^{m} a_{ij}\right)$$

The above relation states that inventory data are distributed according to the relative magnitude of current input coefficients (a_{ij}). Mathur (op.cif) suggested that this proportionality rule must be augmented with some precise knowledge of real world technology. Many producing sectors can not store inventory in the form of services. For instance, it will not be correct to assume that agriculture sector holds inventory in the form of services like railways and transport, mining and quarrying and electricity. Similarly, administration and community services sector does not hold inventory in the form of mining and quarrying output. Table 1 sets out the sectoral capital coefficients.

Table 1 : Capital-Output Coefficients Matrix of Nine Broad Sectors in India (Coefficients except the Last row in the Table are multiplied by 10^4)

Sectors	AG	MNG	MNF	CNS	ELC	TRP	TRD	FINN	MSC
AG	3.38	0.00	2.73	0.00	0.00	0.22	10.38	0.00	0.12
MNG	0.00	1.22	1.60	0.00	5.16	0.00	0.00	0.00	0.00
MNF	7201.42	35519.95	8574.90	2177.72	35396.46	21210.98	6812.41	8283.00	4800.83
CNS	4800.26	897.29	35.17	27.92	21905.41	1892.87	3401.70	73317.46	15000.02
ELC	0.00	4.63	1.12	0.05	6.61	0.29	4.48	0.04	0.06
TRP	0.00	1.84	1.21	0.07	2.15	0.75	24.96	0.10	0.10
TRD	0.57	2.57	1.96	0.74	0.00	0.00	4.19	0.05	0.17
FINN	0.00	0.00	0.77	0.99	0.80	0.50	5.48	0.19	0.15
MSC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Total (K/X)	**1.20**	**3.64**	**0.86**	**0.22**	**5.73**	**2.31**	**1.03**	**8.16**	**1.98**

Computed Optimum Growth Rate

The computed eigen values and their corresponding eigen vectors for the model which takes into account import leakages in both intermediate technology and household consumption are shown in Table 2.1 and 2.2. Quite interestingly, the results point out that there is only one large positive eigen value for which the associated characteristics vector is positive. The largest positive eigen value associated with a positive characteristic vector for the model which allow imports of goods for private consumption but intermediate technology are shown in Table 2.1. The computed optimum growth rate as the reciprocal of the largest eigen value 16.90 is about 5.92 percent. On the otherhand, the largest eigen value for which the associated characteristic vector is positive for the structural matrix characterising domestic dependence on domestic technology and domestic consumption turned out 15.70 (Table 2.2). As a result, the estimated optimal growth rate for this model is 6.37 per cent. Thus, commodity composition of imports of goods for private consumption constrains the economy's growth rate approximately by a half percentage point.

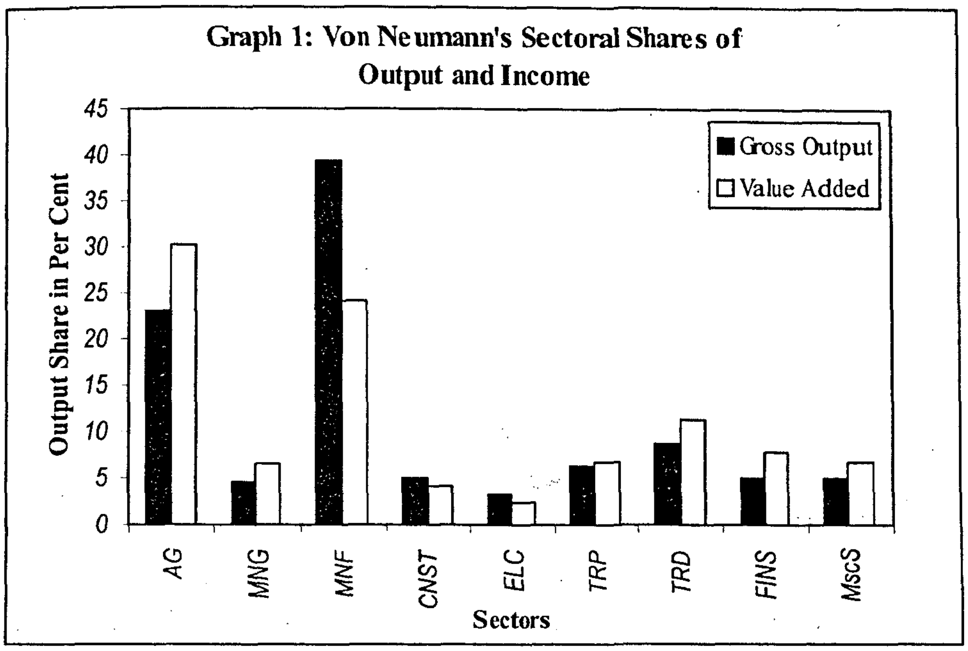
Table 2.1 : Eigen Solution to the Dynamic Macroeconomic Model (Imports included in Private Consumption) Structural Matrix H = $(I-A-Am-cV)^{-1}K$

Table 2.1	Eigen Values								
Normalised	16.89640	2.16E-01	-1.84E-03	-3.50E-04	-3.50E-04	7.62E-04	-4.46E-04	2.42E-04	1.56E-05
Eigen Vector	Corresponding Eigen Vectors								
22.9440	0.479300	6.88E-02	-5.54E-02	-9.44E-02	-1.69E-02	-6.44E-01	-2.40E-01	8.14E-01	-1.51E-02
4.5907	0.095900	2.32E-02	-3.26E-02	-1.32E-02	-3.10E-02	1.25E-01	-2.52E-01	1.38E-02	-1.39E-02
39.2772	0.820500	-6.02E-01	2.70E-01	7.63E-01	-2.77E-01	-2.78E-01	8.08E-01	-3.81E-01	-2.86E-02
4.9832	0.104100	7.93E-01	-3.43E-01	-3.90E-01	5.86E-01	6.64E-01	-4.46E-01	2.56E-01	-8.41E-02
3.2121	0.067100	-1.86E-02	3.49E-03	-4.14E-02	2.17E-03	1.43E-01	5.58E-02	1.16E-01	1.18E-02
6.2853	0.131300	3.95E-02	-5.25E-04	-1.51E-01	1.19E-01	-1.65E-01	1.45E-01	-3.28E-01	-1.14E-01
8.7889	0.183600	4.01E-02	-2.25E-02	-1.53E-02	-4.33E-02	-5.57E-02	-5.43E-02	-1.49E-02	1.35E-03
4.9641	0.103700	2.03E-02	4.62E-03	2.11E-02	-1.15E-03	1.02E-02	-8.13E-04	-7.78E-02	-1.98E-01
4.9545	0.103500	3.98E-03	-2.41E-03	9.62E-03	3.85E-03	-2.67E-02	7.42E-03	-4.11E-03	9.69E-01

Table 2.2 : Eigen Solution to the Dynamic Macroeconomic Model (Dependence on Domestic technology as well as Domestic Consumption) Structural Matrix $H = (I-A-Am-(c-cm)V)^{-1}K$

	Eigen Values								
Normalised Eigen Vector	15.70370	2.16E-01	-1.85E-03	-3.50E-04	-3.50E-04	7.61E-04	-4.46E-04	2.42E-04	1.56E-05
	Corresponding Eigen Vectors								
22.7492	0.476800	6.80E-02	-5.53E-02	1.80E-02	-9.33E-02	-6.43E-01	-2.40E-01	8.14E-01	-1.50E-02
4.6090	0.096600	2.33E-02	-3.28E-02	3.11E-02	-1.26E-02	1.25E-01	-2.52E-01	1.37E-02	-1.39E-02
39.1574	0.820700	-6.02E-01	2.71E-01	2.73E-01	7.61E-01	-2.79E-01	8.08E-01	-3.80E-01	-2.86E-02
5.2770	0.110600	7.93E-01	-3.46E-01	-5.85E-01	-3.96E-01	6.64E-01	-4.46E-01	2.56E-01	-8.41E-02
3.2063	0.067200	-1.85E-02	3.52E-03	-1.98E-03	-4.11E-02	1.43E-01	5.59E-02	1.15E-01	1.18E-02
6.2980	0.132000	3.95E-02	-6.10E-04	-1.19E-01	-1.52E-01	-1.65E-01	1.45E-01	-3.28E-01	-1.14E-01
8.7934	0.184300	4.02E-02	-2.27E-02	4.35E-02	-1.45E-02	-5.58E-02	-5.43E-02	-1.48E-02	1.35E-03
4.9621	0.104000	2.03E-02	4.63E-03	1.02E-03	2.09E-02	1.01E-02	-8.59E-04	-7.78E-02	-1.98E-01
4.9478	0.103700	4.01E-03	-2.44E-03	-3.90E-03	9.47E-03	-2.67E-02	7.43E-03	-4.09E-03	9.69E-01

Another important aspect of the solutions to the eigen system is that the normalised characteristic vector corresponding to the largest positive eigen value provides a picture of the sectoral composition of output consistent with optimal growth rate. For both the models described in the above, the characteristic vector appears to be moreover similar. After normalising the characteristic vector to 100 per cent, the sectoral composition of overall output turns out to 23 per cent for agriculture, 4.6 per cent for mining, 39 per cent for manufacturing, 5 per cent for construction, 3 per cent for electricity, 6.3 per cent transport and communication, 8.8 per cent trade and hotels and 5 per cent each for financial services (banking and insurance) and miscellaneous services sectors. In terms of value added i.e., gross domestic product, the output composition yields into the shares of agriculture at 30.18 per cent, mining 6.59 per cent, secondary sector including manufacturing, construction and electricity accounting 30.69 per cent and services (trade, transport and others) 32.54 per cent (Graph 1).



Sensitivity Analysis : Simulating with Alternative Structural Scenarios

In the real world, commodities are produced for the market and it is the size of the market i.e., aggregate effective demand which determines the growth path of the economy over the medium and long term horizon. As the economy grows over time, per-capita income rises and the propensity to consume and save undergoes significant changes. Furthermore, the composition of aggregate demand, particularly commodity composition of consumption and the sector-wise composition of capital accumulation will change and exert substantial influence on the overall growth trajectory of the economy. In the earlier section, the optimal growth rate was estimated using structural information pertaining to a base line scenario. However, structural characteristics of the economy as regards private consumption and capital accumulation are bound to change over medium to long run horizons. Since changes in commodity composition of consumption and capital accumulation will induce different growth rates, there is a need for undertaking a sensitivity analysis of the growth path over a suitable time horizon[7]. In a way, the sensitive analysis will reflect on the structural interpretation of the evolving nature of optimum growth rate in recent years.

Scenario A : Changes in Propensity to Consume

The impact of private consumption on growth rate is evaluated under three alternative scenarios. First, for scenario I, it is assumed that average propensity of consumption changes but not its commodity composition. Secondly, the composition of commodity consumption is allowed to change in response to underlying time paths which can be inferred from latest information provided the National Sample Survey. The National Sample Survey provides information on households' propensity to consume various commodities over the years. The time series data reveal that the average propensity to consume changes slowly year to year but quite significantly over the medium to long run. For instance the propensity to consume has changed from 69 per cent in 1989-90 to 64 per cent by the year 1997-98. The rate of decline is approximately 0.84 per cent. Interestingly, the commodity composition changes drastically for some categories, particularly in the services sector. The share of food items declined at the rate of 1.32 per cent; from 53.8 per cent in 1989-90 to 50.9 per cent by the end of 1996-97. The share of manufacturing sector as a whole in private consumption has been declining at the rate of 1.48 per cent per annum. The consumption of transport and communication services exponentially grow at the rate 4.6 per cent per annum over the same period. The share of trade, hotels and restaurant witnessed a growth rate of 2 per cent. As regards miscellaneous services including recreation, cultural activities and education, the household sector has been going through a qualitative change as its spending on select items like education is growing at the rate of 6 per cent but the sector as whole could grow at the rate of barely 1 per cent per annum. There is no direct information as regards household consumption of financial services. However, the non-fund based earnings of the banking sector shows an annual average growth rate of 3 to 3.5 per cent. Since major part of the banking sector's non-fund based income (about 65 per cent) originate from government and public sector transactions, the private sector can account for about 35 per cent of this income i.e., barely 1 percentage point in terms of growth rate of non-fund income. This information has been utilized for setting a time path[8] for household consumption identified against the 9 sector classification, constituting the scenario II (Table 3).

The third alternative scenario corresponds to a situation where the average propensity to consume declines along with consumption demand for manufacturing goods increase at the rate of 1 per cent per annum and demand for services grows at the rate equivalent to Scenario II and equivalent negative shock to agriculture goods (Table 3). Of these three alternative scenarios, two of them i.e., scenario I and III are considered for comparison purpose only.

The empirical results in case of the alternative scenarios about propensity to consume are shown in Table 4 and Graph 2. First, as a result of decrease in average propensity of consumption, the growth rate will increase from base line rate of 6.4 percent to 7.79 per cent at the end of the terminal horizon. Secondly, if average propensity to consume declines along with changes in its commodity compo-sition (Scenario II), then the growth rate will be somewhat lower at 7.61 per cent at the end of the terminal period. Under scenario III, if manufacturers are asked to increase output meant for final consumption at the rate of 1 per cent for the same average propensity to consume under the Scenario III, then it will weaken inter-industrial linkages and growth rate will be lower at 7.26 per cent. But the terminal growth rate will be higher than the base line scenario. The results of these simulations resemble the postulates of growth dynamics[9] that a reduction in the propensity to consume will increase the saving rate and thus, the capacity growth rate but shifts in composition of goods and services may moderate the overall growth process depending upon the underlying inter-industry linkages.

Graph 2 : Sensitivity of Growth Path to Changes in Consumption

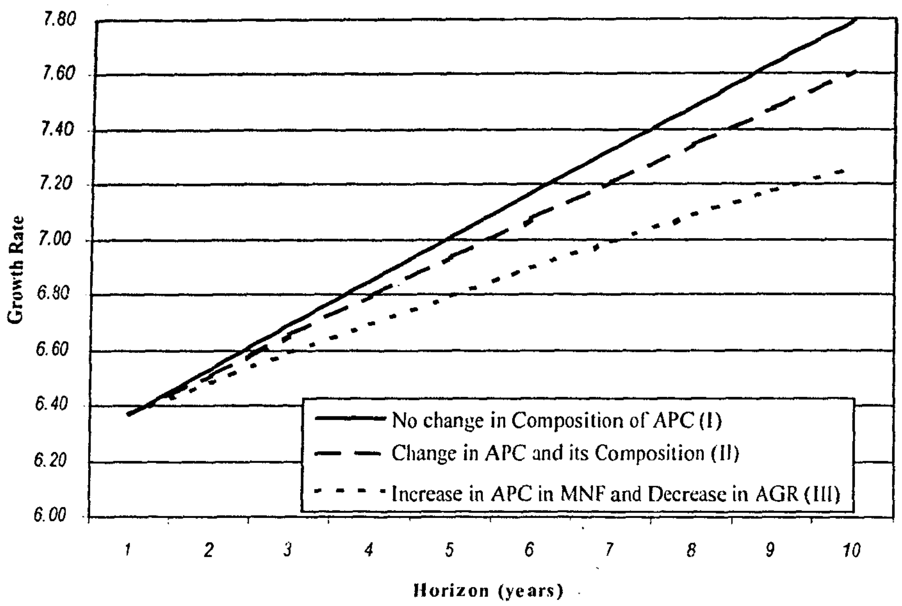


Table 3: Time Path of Private Sector Propensity of Consumption : $F_{j,t}=F_{j,o}e^{bj,t}$

Sectors	Scenario II Consumption growth rate(b)	Scenario III@ Consumption growth rate(b)
AG	-1.35	-2.93
MNG	0.00	0.00
MNF	-1.48	1.00
CNST	0.00	0.00
ELC	6.90	6.90
TRP	4.60	4.60
TRD	2.00	2.00
FINS	1.00	1.00
MSC	1.00	1.00
TOTAL (Average Propensity to consume)	-0.84	-0.84

Table 4 : Sensitivity of Optimum Growth Rate to Changes in Private Consumption

Time Horizon	Maximum Eigen Values			Growth Rates		
	Scenario-I	Scenario-II	Scenario-III	Scenario-I	Scenario-II	Scenario-III
Base	**15.7037**	**15.7037**	**15.7037**	**6.37**	**6.37**	**6.37**
1	15.3108	15.3566	15.4314	6.53	6.51	6.48
2	14.9401	15.0278	15.1758	6.69	6.65	6.59
3	14.5898	14.7161	14.9359	6.85	6.80	6.70
4	14.2582	14.4202	14.7106	7.01	6.93	6.80
5	13.9440	14.1389	14.4989	7.17	7.07	6.90
6	13.6458	13.8713	14.3000	7.33	7.21	6.99
7	13.3624	13.6166	14.1131	7.48	7.34	7.09
8	13.0927	13.3738	13.9376	7.64	7.48	7.17
9	**12.8359**	**13.1422**	**13.7728**	**7.79**	**7.61**	**7.26**

Scenario B : Changes in Capital Intensity of Production

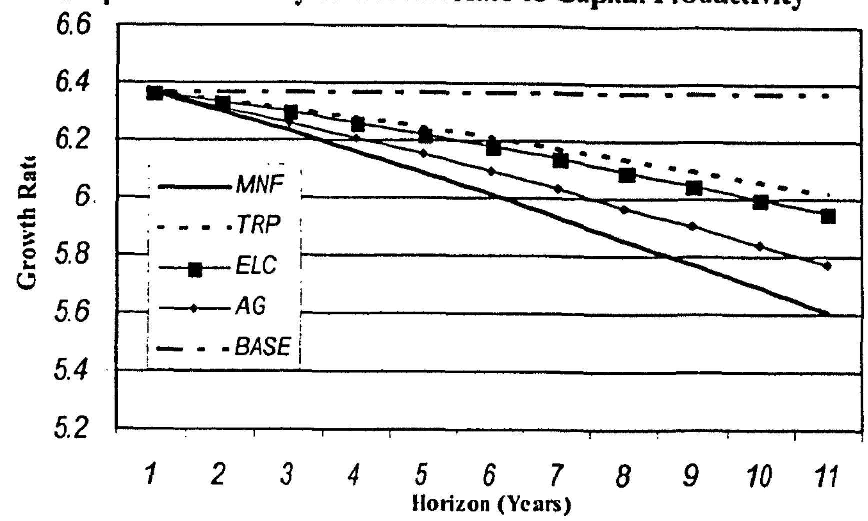
In the recent period, there is growing concern over productivity trends implied by rising capital-output ratios of the industrial sector. An increase in capital-output ratio implies a deterioration of productivity which in turn may weaken the overall growth process of the economy. In this section, the sensitivity analysis evaluates the impact of productivity shocks exerted on the fixed capital coefficients of each of the major sectors i.e., agriculture, manufacturing and services including transport and communication and power (electricity) sectors. For comparison purpose, the fixed capital coefficients of major sectors have been given a uniform and positive 5 per cent shock per annum. The resulting impact on the overall growth trajectory is summarised in Table 5 and Graph 3.

Table 5 : Impact of Capital Productivity Shock (5%) on the Economy's Growth Path

	Shock to Major Producing Sectors			
Horizon	MNF	TRP	ELC	AG
Base	6.370	6.370	6.370	6.370
1	6.301	6.339	6.333	6.316
2	6.232	6.309	6.297	6.263
3	6.160	6.278	6.259	6.208
4	6.087	6.245	6.220	6.151
5	6.012	6.212	6.179	6.093
6	5.934	6.176	6.137	6.032
7	5.855	6.140	6.094	5.970
8	5.774	6.102	6.048	5.906
9	5.690	6.063	6.002	5.840
10	5.605	6.022	5.953	5.772

From Table 5 it is evident that 5 per cent decline in capital productivity of the manufacturing sector has the maximum dampening effect on the overall growth rate. The growth rate declines from the base line rate of 6.37 per cent to 5.61 per cent over ten year horizon, i.e., about 0.76 percentage points. Conversely, if manufacturing productivity improves as capital output ratio falls by 5 per cent per annum, then growth rate will jump by 0.76 percentage point, from 6.37 per cent to 7.12 per cent. The impact of a decrease in capital productivity shocks of two crucial infrastructure sectors viz., electricity and transport and communication shows that the former has relatively greater damaging effect on the growth trajectory than the later. Lastly, the impact of productivity decline in the agriculture sector on the macroeconomic growth trajectory could be greater than that of the major infrastructure sectors. This is possible as decline in agriculture productivity will weaken linkages with the agrobased industries and the manufacturing sector as a whole. It appears therefore, that improving capital productivity in manufacturing sector is the key to realise higher growth path of the Indian economy.

Graph 3: Sensitivity of Growth Rate to Capital Productivity



The numerical simulations in the above exemplified how shocks to capital inputs across the sectors can influence optimum growth rate. However, in reality, shocks to capital inputs never occur at uniform rate for all the sectors. The data on average capital-output ratios reveal some interesting trends in the recent years. The capital-output coefficient of agriculture and mining sector shows a marginal decline at the rate of 0.33 and 0.22 per cent, respectively. The same is increasing at the rate of about 4 per cent per annum in the manufacturing sector. The capital-output coefficient is declining at the rate of 3 per cent in electricity, 2 per cent in trade and hotels, 4 per cent in financial services but only slowly at the rate of 0.6 per cent in construction and transport sectors and 0.7 per cent in administration and community services sectors. Alternatively to put it, the extent of productivity improvement is marginal in agriculture, mining, construction and transport sectors but somewhat sizeable in electricity and financial services. In spite of high growth rate in the 1990s, the capital productivity is falling as capital intensity is rising in the manufacturing sector at the rate of about 4 per cent per annum.

On average, for the economy as a whole, the capital-output ratio is rising at the rate of about 1.3 per cent per annum.

The detail information as regards the major components of capital stock viz., fixed capital and inventory are not available for the recent years. Nevertheless, the average trend in capital coefficient can be utilised for evaluating its impact on the growth process under certain simplified assumption. Firstly, it is assumed that producing sectors hold inventories as fixed proportion of output over time as a part of their contingency plan in order to manage the risks which largely stems from transitory fluctuations in demand condition. Consequently, a major part of the innovations to average capital coefficients can be adduced to innovations to fixed capital coefficients.

Secondly, the underlying changes in consumption and capital coefficients occur simultaneously. Accordingly, it would be more informative if the empirical exercise involves a simulation of growth dynamics in response to changes in consumption and capital coefficients at the same time. In this way, the empirical results will enable us to assess how increases or decreases in productivity shocks offset the impetus to growth originating from underlying changes in propensity to consume (or save).

The results of numerical simulation involving the underlying changes in propensity to consume as well as the changes in capital coefficients as observed in recent periods are shown in Table 6 and Graph 4. The optimum growth rate comes to about 6.52 per cent at the end of ten year horizon, implying a marginal improvement over the base level scenario. As compared to the growth trajectory corresponding to the case of consumption propensity (Scenario II), the rising capital coefficients has offset the growth rate by about 1 per cent over a ten year horizon. Thus, rising capital coefficients in major producing sectors constrain the economy to realise its long run growth at its maximum path corresponding to consumption and saving. Furthermore, another interesting observation is that approximately 1 per cent increase in average capital-output coefficient reduces growth rate by 1 per cent.

Graph 4 : Simultaneous Effect of Changes in Consumption and Capital Coefficients

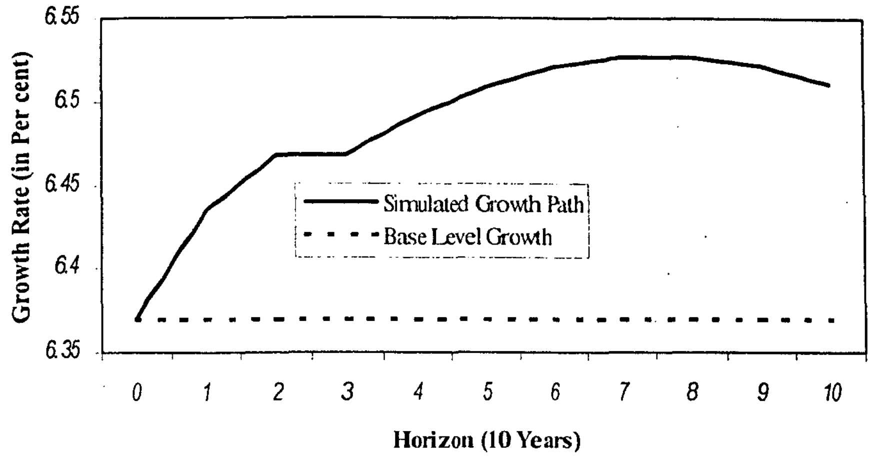


Table 6 : Simultaneous Impact of Consumption and Capital-Output Coefficients

Horizon (Ten Years)	Maximum Eigen Value	Optimum Growth Rate
Base	15.7037	6.37
1	15.5413	6.43
2	15.4605	6.47
3	15.4605	6.47
4	15.406	6.49
5	15.3648	6.51
6	15.3369	6.52
7	15.3224	6.53
8	15.3214	6.53
9	15.3341	6.52
10	15.3604	6.51

Section III

Summary Findings

(i) The paper analysed a dynamic general equilibrium framework for estimating the optimum growth rate of the Indian economy. The analytical insights are based on material balance condition encompassing sectoral equilibrium. Using macroeconomic accounts pertaining to input-output accounts of nine broad sectors for the base year 1989-90, empirical results yielded an estimate of the optimum growth rate at about 6.5 percent.

(ii) The paper also undertook a sensitivity analysis for exploring the changes in optimum growth rate in response to underlying changes in private consumption and found that the growth rate can improve from 6.37 per cent trajectory to 7.61 per cent trajectory.

(iii) In the absence of latest information about capital stocks at disaggregated level, the impact of a capital productivity shock in terms of rising fixed capital-output coefficient on growth rate was analysed in terms of uniform 5 per cent shock to major producing sectors including agriculture, manufacturing, transport and power sectors can dampen the economy's underlying growth process. The results indicated that productivity decline in manufacturing sector can reduce growth rate by a maximum of 0.76 percentage point over a ten year horizon. Conversely, an improvement in capital productivity of the manufacturing sector increases growth rate from 6.37 per cent to 7.12 per cent.

(iv) If recent trends in average capital coefficients of the broad sectors are evaluated in conjunction with the changes in household consumption, then results show that increases in capital coefficients constrain the economy to realise its maximum growth rate along the higher growth path induced by household propensity of consumption. Thus, if the economy has to grow optimally at the rate of about 7-8.0 per cent, then there is a need to improve upon capital productivity in major sectors including agriculture and manufacturing activities.

Thus, it can be inferred that the economy-wide optimum growth rate of output lies within a trajectory of about 6.5 to 7-8.0 per cent under alternative scenarios owing to structural changes in private consumption, capital accumulation and inter-industrial linkages. The empirical results of the study can be improved if somewhat detailed information at more disaggregated sector classification were available. Nevertheless, the results do not conflict with theoretical perceptions and the evolving structure of the economy during the transitional phase of economic reforms.

The empirical analysis, particularly the sensitivity analysis was carried out with the assumption of no technological change in input-output coefficients from the base level scenario. However, there is a gradual change over time in input-output coefficients which can contribute to about 5 per cent of total variation in output over a planning horizon[10]. Using this magnitude of the impact of technology it can be inferred that the optimum growth of output can be enhanced by a maximum of about 0.25-0.35 percentage points over the structural scenarios.

Finally, it is to be noted that the framework provided in the study can be improved upon in the future course of reasearch in several ways, especially, by introducing some explicit constraints relating to resource endowments, by augmenting the model with adequate informations on gestation lags between capital accumulation and production and by incorporating the research and development process into the theoretical framework and empirical analysis.

Notes:

1. See Solow (1953,1959), McKenzie (1963), and Yan (1972) for the proof that an input-output model belongs to a class of multisectoral general equilibrium model as it describes general equilibrium relationship between producers, households, government, investors and external trade sectors. Furthermore, since the model achieves balance between demand and supply forces and these relationships can be empirically fed into the national income accounting model, it is considered as a computable general equilibrium model.

2. See Tsukui (1968) first analysed this theorem for Japanese economy. Mathur (1973) made a similar attempt for the Indian Economy.

3. The theorem requires a set of assumptions described in detail in Tsukui (1978) : (i) A is non-singular and A^{-1} positive, (ii) every column of K must have at least one positive component implying that K is non-singular and its inverse K^{-1} should exist (iii) the minimum of A^{-1} K is attained by a unique process and (iv) (I + A^{-1} K) is non-singular. Turnpike theorem proves that if the economy has a number of production processes for each sector and the business sector uses the most efficient technology i.e., the observed A and B, then growth rate implied by A and B should be largest among all production processes. Furthermore, in a programming framework, the turnpike theorem entails a linear objective function for maximising total output subject to macroeconomic balance condition as characterised by input-output accounting system.

4. The Frobenius root of a non-negative matrix is the positive characteristic root with the largest absolute value among other roots. For economic interpretation see Debreu and Herstein (1953), Mckenzie (1963), Tsukui (1966).

5. See Fujita and James (1992) for this viewpoint.

6. In the absence of detailed data on household consumption classified on the basis of input-output sectors, researchers use simple linear consumption function for which marginal and average propensity to consume will be same and this makes the empirical attempt easier for endogenising consumption-income relationship into the dynamic model.

7. Manne and Weisskopf (1970) worked out the impact of household consumption on growth of output in the Indian economy using dynamic Leontief model.

8. The time path follows simple exponential trend of the form Fk,t = Fk, o ebt where Fk,t is the kth component of a final demand vector, Fk,o is the base level figure and ebt is exponential growth path.

9. For given v, the income growth i.e., s/v = ((1-c)/v) increases with fall in c and vice versa. Similarly, for given s, decrease in v will lead to higher growth and vice versa.

10. See Dhal (1996).

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Composite Index of Leading Indicators for Business Cycles in India

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This paper studies the cyclical behaviour of Indian economy. Using annual and quarterly data on output variables since 1950, it is shown that the GDP from non-agricultural activities can be taken as the reference series for tracking business cycles in India. A Composite Index of Leading Indicators (CILI) with a lead period of two quarters is proposed to forecast the cyclical movements in IIP-Manufacturing which is closely related to aggregate business cycles.

Business cycles are recurring periods of economic expansion each followed by periods of recession. The study of business cycles has a strong relationship with the economics of growth. Over a long period (say, decades), economic growth is appropriately measured by the long-term trends that are influenced by movements in business cycles in the short run. Economic policy-makers attach very high importance to the phase of business cycle through which the economy is passing, *viz.*, whether the economy is in an expanding phase or in a recessionary phase. An early recognition of the course of the business cycle is necessary for introducing counter-cyclical stabilisation policies. Identification of the stage of the business cycle has been the root cause of development of the leading indicators approach of economic forecasting.

This study analyses the cyclical behaviour of the Indian economy and proposes a Composite Index of Leading Indicators (CILI) for cyclical turning points. The paper is organised into six sections. Section I reviews the views on the literature with a focus

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Basic data used in the study are available at author's website www.happyindian.com.

on previous studies in the area relating to the Indian economy. Section II describes the database and the methodology for estimating the cyclical component of time series. Cyclical behaviour of major output variables based on annual data for 1950-97 are analysed in section III. Section IV discusses the steps followed in compiling the CILI for predicting the cyclical turning points in IIP-*Manufacturing*. The issue of selection of leading indicators is further examined in section V. Concluding remarks are made in the Section VI.

Section I

A Review of Literature in the Indian Context

Burns and Mitchell (1946) can be regarded as the first definition of business cycles which according to Moore and Zarnovitz (1986), is still in use at the National Bureau of Economic Research (NBER), where research into the area has been going on for well over half a century "*Business cycles are a type of fluctuations found in the aggregate economic activity of nations that organise their work mainly in business enterprises: a cycle consists of expansions occurring at about the same time in many economic activities followed by similarly general recessions, contractions and revivals that merge into the expansionary phase of the next cycle; this sequence of change is recurrent but not periodic. In duration, business cycles vary from more than a year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own.*" This definition emphasises the co-movement among individual economic variables taking into account the possible leads and lags in timing and also divides business cycles into separate phases or regimes. The NBER's analysis of business cycle consists of separating trends and cycles in time series and relating patterns in cycles across different time series. Mitchell found the prevailing business cycle theories to be incomplete and lacking empirical foundation. He strongly felt that extensive factual knowledge was to be acquired for understanding the complex process of business cycles and argued that "the more thoughtfully one considers the relations between these two phases of knowing [the apprehension of facts and conception of theories], the less separable they become" (Mitchell (1927)).

With the resurgence in global interest in business cycle research in late 1970s following the publication of the seminal paper *Understanding Business Cycles* by Lucas in 1977, economists became more involved with the statistical properties of economic time series. It was found very unlikely that a deterministic trend would persist and prove projectable over long stretches in the light of a multiplicity of factors and the use of stochastic trend was favoured. Nelson and Plosser (1982) studied the time series behaviour of a large number of economic time series extensively and concluded, "stochastic variation due to real factors is an essential element of any model of macroeconomic fluctuations." According to later literature (Campbell & Mankiw (1987) *et al*), the permanent component of an economic time series (*i.e.*, the non-deterministic trend) was found to have a much greater role in business cycles than previously thought. In the subsequent period, the focus was more on the time series properties of just one or few macroeconomic aggregates.

Lucas (1977) also emphasised the co-ordination of economic activity and the resulting co-movement of the output of broadly defined sectors in a business cycle. In the recent period, the co-movements have been given prominence again with the use of dynamic factor models to capture co-movements by obtaining a single common factor from a set of many macroeconomic time series [Stock and Watson (1988, 1991, 1993), Hamilton (1989), Vahid and Engle (1993), Engle and Issler (1995) et al].

Studies on the business cycles mostly relate to developed economies though a few attempts have also been made to study their prevalence in the developing countries. A major reason for this has been the generally agro-dominated nature of the developing economies where the role of organised business enterprises has been relatively less in dealing with the production process. However, over the years, increasing organised business activity is being witnessed in most of the developing countries, which has generated considerable interest in the area of business cycles in these countries.

Studies related to cyclical movements in the Indian economy have been very few largely due to three factors, *viz.*, the high dependence of the economy on agriculture, the strong role of public sector in the economy and availability of time series data on aggregate measures like GDP, savings, investment and capital formation on an annual basis only.

Studies by Brahmananda (1982), Ahluwalia (1985, 1991) and Goldar (1986) have attempted to scrutinise the causes of various phases of growth and tried to link them with productivity. These studies look at the long-term trends in industrial growth at a detailed level of disaggregation. They also analyse the contribution of various factors to industrial growth, particularly the factors behind the turnaround in the eighties, including improvements in the planning and performance of infrastructure sectors.

Sporadic attempts have been made by individual researchers to study the cyclical phenomena in the Indian economy. Chitre (1982) used the growth cycle method to study the cyclical behaviour of major macroeconomic variables during 1950-77 using annual data. Rede (1988) used data from Reserve Bank of India (RBI) studies on Joint Stock Companies to study the cyclical behaviour of the rate of profit in Indian manufacturing industries during 1950-78 based on fluctuations in series of ratio of actual profits to their deterministic trend. The study considered only one variable and did not relate it to the aggregate economic cycle. Gangopadhyay & Wadhwa (1997) used the monthly data on Index of Industrial Production (IIP) for the period 1975:Q2 to 1995:Q1 for obtaining the chronology of Indian business cycles, using deterministic trend (annual growth rate of six per cent). They also attempted to forecast the level of annual Gross Domestic Product (GDP) using monthly data on selected monetary, output and foreign trade variables and found that monthly data on IIP can be used to forecast and update the forecasts of GDP and aggregate investment.

In the Indian context, Hatekar (1993, 1996) studied business cycles in India during 1950-85 using annual data by detrending them with the Hordrick-Prescott filter and described their historical paths and co-movements with other time series. Hatekar tested the real business cycle proposition that nominal magnitudes and real money balances cannot be exogeneous during mechanisms of the business cycle. Mall and Bhole (2000) studied the cyclical behaviour of the private non-financial corporate sector in India during 1950-97 using annual data from RBI studies on Joint Stock Companies and other official statistics on macroeconomic variables. The analysis showed existence of cyclical regularities in the Indian private corporate sector and these cycles were found to be roughly co-terminous with the cycles in major output variables in the non-agricultural sector of the economy.

Section II

Database and Methodology

II.1 The Data

In this study, annual data on macro variables relating to national income, capital formation, general price level and industrial production have been taken from the Govt. of India publications. The data pertaining to the operations of private corporate sector have been taken from RBI studies on Public Limited Companies that dominate the operations of private corporate sector in India. To obtain a time series on sales of private corporate sector, an index (1950-51=100) of sales has been compiled for the period 1950-51 to 1996-97 using the estimates of annual growth rate in sales from the RBI studies. An additional variable, *viz.*, Gross Value Added (GVAD) of the companies covered by the RBI studies has been compiled by subtracting the value of material inputs and compensation to labour from the total value of production. As coverage of each RBI study varies from the previous one, the estimates of annual growth rate of GVAD obtained from the series of RBI studies have been used to compile an index by keeping the GVAD for 1950-51 equal to 100.

The variables considered for analysing the aggregate output cyclical behaviour are:

GDPR	Real Gross Domestic Product (at 1980-81 prices)
PFCE	Private Final Consumption Expenditure (at 1980-81 prices)
GDCF	Gross Domestic Capital Formation (at 1980-81 prices)
NAGR	Non-agricultural GDP (at 1980-81 prices)
MANF	GDP from Manufacturing sector (at 1980-81 prices)
DTRD	GDP from Domestic Trade (at 1980-81 prices)
GVAD	Index of Gross Value Added of Private Corporate Sector (1950-51=100)
SALE	Index of Sales of Private Corporate Sector (1950-51=100)
IPGN	Index of Industrial Production – General (1993-94=100)
IPMF	Index of Industrial Production – Manufacturing (1993-94=100)

Data relating to these variables are presented in Appendix Table 1. The two series relating to the private corporate sector were deflated by WPI-*Manufacturing* (WPMF) to express them in real terms. All the variables are transformed to logarithms before estimating their cyclical components.

The factor considered for selection of monthly / quarterly variables considered for studying the lead-lag relationship are described in section III. These data have been collected for the period January 1980 onwards for the purpose of compilation of the index of leading indicators. As the purpose of the exercise is to forecast the cyclical turns in the industrial activity, data relating to economic structure of distant past would not have served much purpose and in some cases would also have been misleading. Monthly data have been converted to quarterly data by taking average of months falling during the quarter for flow variables and end of quarter levels for the stock variables. Wherever the series base year was officially revised to account for changing structure, the old and revised series have been linked by taking the ratio of average of new and old indices for the new base year as the linking factor. The quarterly data for IIP-*General* and WPI commodity groups have been considered for longer period and are presented in Appendix Table 2 for the period 1950:Q1 to 2000:Q1.

Due to seasonal nature of quarterly data, they were seasonally adjusted using the X-11 ARIMA method of the US Bureau of Census before estimating the cyclical components. Quarterly data relating to the other series finally included in CILI are presented in Appendix Table 3. The Indian economy has undergone a major structural change in the early 1990s with the introduction of various liberalisation measures (Ahluwalia and Little (1998) *et al)*. Forecasting being the objective of this exercise, the post-1991 relationship was more relied upon.

II.2 Methodology

Spectral analysis is an appropriate choice for studying business cycle movements as it emphasises the cyclical properties of data. A series exhibiting oscillatory behaviour over time can be estimated by a sum of cosine waves (cycles).

A Fourier transform of a stationary time series expresses the series as a sum of cyclical components of different frequencies ω. Let x_t be a time series with k different frequencies (t = 1,2,....T) then it can be represented as

$$x_t = \sum_{j=1}^{k} (a_j \cos(\omega t) + b_j \sin(\omega t)) \qquad ...(1)$$

where ω is the angular frequency in radian, a_j 's and b_j 's are parameters that can be estimated as functions of ω and Z_t is stationary stochastic process. The wavelength in terms of cycles per unit of time is given by $2\pi/\omega$. Spectral analysis assesses the total variation arising from different wavelength bands. It assumes that the number of periodic functions in equation (1) is infinitely large by comparison with the size of available data set and, therefore, equation (1) can be written in the form of an integral as follows:

$$x_t = \int_0^{\pi} (a(\omega)\cos(\omega t) + b(\omega)\sin(\omega t))\, d\omega \qquad \ldots(2)$$

where a(ω) and b(ω) are functions of ω.

Equation (2) represents the time series process x_t as the sum of components with periods of oscillation $2\pi/\omega$ for ω lying in the interval 0 to π. This allows to extract the business cycle component of x_t. For example, in the case of quarterly data, if the business cycle is defined as the component corresponding to components with period greater than 8 quarters and less than 32 quarters, then in terms of frequencies of oscillation, this corresponds to ω corresponding to the interval $\underline{\omega} = 2\pi/32$ to $\varpi = 2\pi/8$. Thus if y_t is the business cycle component of x_t, then

$$y_t = \int_{\underline{\omega}}^{\varpi} (a(\omega)\cos(\omega t) + b(\omega)\sin(\omega t))\, d\omega \qquad \ldots(3)$$

Baxter and King (1995) developed a set of optimal approximate band-pass-filters designed for obtaining the cyclical component of a time series by decomposing the data between specified frequency bands. The filter is theoretically sound and is useful for extracting cyclical components for the frequency bands corresponding to the period specified by users. Though the concept is developed in frequency domain, it is actually calculated in time domain.

Let x_t be a time series and a(L) be a polynomial of degree k in the lag operator given by $a(L) = \Sigma\, a_k L^k$ (k ranging between -K to K) where L is the lag operator defined by

$$L^k x_t = x_{t-k}$$

Let y_t be the symmetric moving average of length 2K+1 of the time series x_t is given by

$$y_t = \Sigma\, a_k\, x_{t-k}$$

such that $a_k = a_{-k}$ for $k = 1, 2, \ldots, K$

Let $LP_k(p)$ denote the approximate low-pass filter that has frequency response given by

$\beta(\omega) = 1$ for $|\omega| \leq \omega$
and
$\beta(\omega) = 0$ for $|\omega| > \omega$

Let $b(L) = \Sigma\, b_h L^h$ (where the summation is over the entire range $(-\infty,\infty)$) denote the time domain representation of this ideal low pass filter. The filter weights may be found by the inverse Fourier transformation of the frequency response function

$b_h = \int \beta(\omega)\, e^i\omega^h\, d\omega$

Evaluating the above integral, the filter weights b_h for the ideal filter are

$b_0 = \omega / \pi$
and
$b_h = \sin(h\omega) / h\pi$ for $h = 1,2, \ldots$

The approximate filter for this ideal filter has the frequency response function

$\alpha_k(\omega) = \Sigma\, a_h\, e^i\omega^h$

The ideal band-pass filter passes only frequencies in the ranges $\varpi \leq |\omega| \leq \underline{\omega}$ and is constructed from the two low-pass filters with cut-off frequencies ϖ and $\underline{\omega}$ with frequency response $\bar{\beta}(\omega)$ and $\underline{\beta}(\omega)$, respectively. The frequency response $\bar{\beta}(\omega)$-$\underline{\beta}(\omega)$ for the band-pass filter gives unit frequency response on frequency bands $\varpi \leq |\omega| \leq \underline{\omega}$ and zero elsewhere. If $\underline{b}_h$ and $\bar{b}_h$ are the filter weights for the low-pass filters with cut-off ranges ϖ and $\underline{\omega}$ at the lag / lead h, then the band-pass filter has weights $\underline{b}_h - \bar{b}_h$.

To put constraint that the low-pass filter place unit weight at zero frequency, the filter weights are adjusted and the optimal approximate filter weights are given by $a_h = b_h + \vartheta$, where $\vartheta =$

$(1 - \Sigma b_h) / (2K+1)$, the summation over being the range -K to K. Similar adjustment is necessary when constructing the optimal truncated band-pass filter. The constrained band-pass filter involves the requirement that the sum of its weight must be zero. Hence the weights in the constrained optimal band-pass filter are adjusted as $(\underline{b}_h - \bar{b}_h) + (\bar{\theta} - \underline{\theta})$, where $\bar{\theta}$ is the adjustment coefficient associated with the upper cut-off filter and $\underline{\theta}$ is the adjustemnt coefficient associated with the lower cut-off filter.

In the present exercise, the band-pass filter method of extracting the cyclical component of time series has been used. For annual data, the cyclical component is obtained from the band-pass filter that passes cycles between 2 to 8 years. For quarterly data, the upper cut-off frequency is again 8 years (32 quarters) but cyclical components are obtained for four different lower cut-off frequencies corresponding to 2, 4, 6 and 8 quarters. For the maximum lag-length K, Baxter and King showed that there is no best value for K — increasing K leads to a better approximation to the ideal filter but results in more lost observations. The issue involved is that of balancing these opposing factors. In this study, the value of K is taken as 3 for annual data and 12 for quarterly data following Stock and Watson (1998). The data are padded with one backcast and one forecast in case of annual series and four backcasts and four forecasts in the case of quarterly data.

Section III

Cyclical Fluctuations in Major Output Variables

Table 1 presents the cross-correlations among the cyclical components of ten major variables (described in section II) that are relied upon for selection of variables and dating of business cycles. The correlations coefficients are based on annual data for 1950-97. From Table 1, it is found that the non-agricultural GDP is highly correlated with other major macroeconomic variables relating to output. The cross-correlation coefficients are 0.67 with aggregate GDP, 0.52 with investment, 0.51 with private consumption expenditure, 0.90 with GDP from Manufacturing, 0.88 with GDP from domestic trade, 0.86 with index of manufacturing production and 0.70 with gross value added from private corporate sector. The cyclical component of private consumption expenditure is more closely related to aggregate GDP than to the non-agricultural GDP which implies that private consumption in India has a strong relationship with agricultural output. The correlation of the cyclical component of all other seven variables is much higher with the cyclical non-agricultural GDP than with aggregate GDP (see also Graphs 1 & 2). As the cyclical series do not have trend, these coefficients of correlation indicate strong comovement of these series with cyclical non-agriclutural GDP.

Growth in agricultural output produces strong demand incentives (increased rural consumer demand) and supply incentives (increased food and industrial raw material supply) fostering expansion in industrial activities and also in other sectors of the economy. However, the large dependence on weather and the resulting high volatility in agricultural output makes it difficult to consider it as a part of business cycle analysis. Among the remaining variables, non-agricultural GDP has the widest coverage and is strongly correlated with all other variables that are crucial for business cycle analysis. The non-agricultural GDP is, therefore, an appropriate choice for reference series for dating business cycles in India.

Table 1 : Cross Correlation among Cyclical Components of Macroeconomic Variables (1950-97)

Variable	NAGR	GDPR	GDCF	PFCE	DTRD	MANF	GVAD	SALE	IPGN	IPMF
IPMF	0.86	0.42	0.55	0.31	0.74	0.73	0.64	0.63	0.94	1.00
IPGN	0.82	0.35	0.57	0.18	0.71	0.67	0.68	0.74	1.00	
SALE	0.64	0.23	0.24	0.05	0.57	0.48	0.84	1.00		
GVAD	0.70	0.27	0.38	0.13	0.61	0.63	1.00			
MANF	0.90	0.57	0.47	0.42	0.73	1.00				
DTRD	0.88	0.74	0.49	0.56	1.00					
PFCE	0.51	0.88	0.09	1.00						
GDCF	0.52	0.23	1.00							
GDPR	0.67	1.00								
NAGR	1.00									

Table 2 summarises the statistics related to the cyclical components of the above described ten major variables. It is found that coherence, which is a frequency domain measure of co-movement between two variables is very close to the cross-correlation estimates which gives the proportion of variance in one variable that can be explained by regressing one variable (linearly) against the other variable at given frequency. The average squared coherence are very close to the corresponding estimates of correlation coefficients. Non-agricultural GDP is found to have minimum variation among the ten variables. Aggregate GDP is 1.5 times more variable that NAGR because of higher variability in agricultural output which is the additional component in GDPR. Cyclical NAGR is very weakly correlated with future cyclical GDPR (correlation coefficient -0.06) by cyclical GDPR is positively correlated with future cyclical NAGR (correlation coefficient 0.38) which again implies the strong influence of agricultural output on the remaining activities in the economy. In addition to the high instantaneous relationship, the cyclical component of GDCF, DTRD, MANF, GVAD, SALE, IPGN and IPMF are also positively related with past values of cyclical NAGR highlighting the role of current income in determining the future output. The duration of investment cycles is very long and their relative variability is the highest. Private corporate sector sales are more variable than the gross value added. Cyclical components of private corporate sector variables are found to witness more variation than the remaining variables implying their higher response to market forces.

Taking the non-agricultural GDP as the reference series for tracking business cycles in India and using the supplementary information provided by the cyclical components of other major output variables, business cycle dates are presented in Table 3. In determining the peak and trough years of business cycles, the minor peaks of 1961-62 and 1983-84 are considered to be part of larger cycles. Due to rapid industrial growth during the 1980s, the economy was able to break the barrier of *Hindu rate of Growth* of 3-3.5 per cent per annum and went to the growth trajectory of over five per cent per annum. It is, therefore, considered appropriate to treat the minor cycle in around mid-1980s as a part of the larger cycle.

Table 2 : Cyclical Components of Ten Macroeconomic indicators - General Statistics

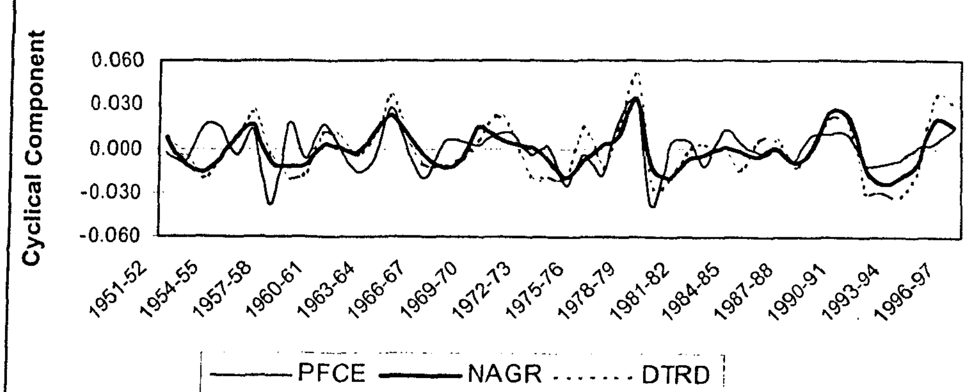
Variable	Standard Deviation	St. Dev. relative to NAGR	Average Squared Coherence	Correlation with NGR		
				t-1	t	t+1
NAGR	0.013	1.00	1.00	0.35	1.00	0.35
GDPR	0.020	1.50	0.70	-0.06	0.67	0.38
GDCF	0.089	6.78	0.54	0.29	0.52	0.04
PFCE	0.015	1.11	0.61	-0.15	0.51	0.28
DTRD	0.019	1.43	0.85	0.21	0.88	0.39
MANF	0.025	1.92	0.89	0.38	0.90	0.26
GVAD	0.032	2.46	0.60	0.37	0.70	0.16
SALE	0.036	2.71	0.60	0.39	0.64	0.15
IPGN	0.023	1.73	0.77	0.45	0.82	0.21
IPMF	0.022	1.69	0.84	0.45	0.86	0.21

Table 3 : Business Cycles in India (1950-97)

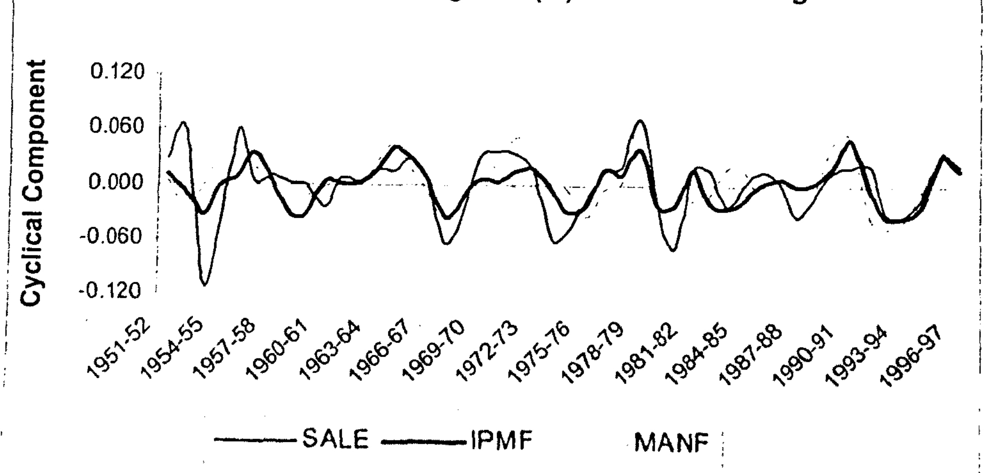
No.	*Cycles*		Duration (in years)	
	Peak	**Trough**	***Contraction***	***Expansion***
	P	**T**	**P to T**	**T to P**
1	1951-52	1953-54	2	3
2	1956-57	1959-60	3	5
3	1964-65	1967-68	3	2
4	1969-70	1974-75	5	4
5	1978-79	1980-81	2	9
6	1989-90	1992-93	4	3
7	1995-96		3	3
Average length			**3**	**4.3**

Industrial activities generate activities in other sectors due to inter-linkages in the economy. Tracking the cyclical behaviour of the private corporate sector is very crucial for business cycle analysis, as response to market forces is maximum from this institutional sector of the economy. The results indicate that industrial production cycles are very closely related with the aggregate economic cycles in India – a fact that is in conformity with the experiences of other countries. Therefore, a leading indicator for industrial cycle should also serve as leading indicator for aggregate economic cycles. As IIP is available with higher frequency (on a monthly basis) than the GDP (which was available on annual basis till recently and is available on a quarterly basis now), the paper now proceeds to explore the possibility of compiling a composite index of leading indicators for IIP-*Manufacturing* (IPMF), which can be used for forecasting the turning points of business cycles two quarters in advance.

Graph 1: Cyclical Components of (i) Non-Agricultural GDP (ii) PFCE and (iii) GDP-Domestic Trade



Graph 2: Cyclical Components of (i) Private Corporate Sales (ii) GDP-*Manufacturing* and (iii) IIP-*Manufacturing*



Section IV

Composite Index of Leading Indicator for IIP

Business cycles differ across a wide spectrum of variables and many economic time series register their turning points prior to the turning points of the corresponding business cycle. These series are called leading indicators. The leading indicator approach involves finding repetitive sequences for identifying and forecasting emerging stages of business cycles. This approach uses a series of economic variables which tend to lead, coincide with or lag behind the movements of aggregate economic activity. Use of leading indicators in forecasting economic cycles is more popular in industrial countries due to the high level of organised business activities in those countries.

Economic theory suggests that a combination of characteristics are observed in each business cycle and therefore the performance of a leading indicator may depend on the causal factors at work during a given period. No single variable can be said to definitely precede the expansionary and contractionary phases of business cycles. Therefore, "To increase the chances of getting true signals and reduce those of getting false ones, it is advisable to rely on a reasonably diversified group of leading series with demonstrated predictive potential" [Zarnovitz (1992)]. In addition, practical problems like measurement errors in preliminary data used for giving forecasts and occasional presence of high noise in individual variables are also arguements in favour of using a composite index of leading indicators rather than relying on a single leading indicator.

A large number of leading indicators are available at international level dealing mainly with national income, industrial production, services sector inflation, etc., in the free-market economies. Specific indicators also deal with telecommunication traffic, demand for passenger cars, sales, etc., in many of these countries. A majority of these countries use a composite index of leading indicators instead of a single leading indicator to get a more reliable picture of the future scenario. Indicators with exceptionally long lead period are generally separated from other leading indicators and are used in compiling long-leading index (i.e., leading indicators with average leads of at least twelve months at peaks and six months at troughs). The short-leading indicators are often found to be more reliable than the long-leading indicators and are used by policy-makers and business investors for an early detention of business cycle turning points.

IV.1 Selection of Variables

Drawing from de Leeuw (1992), the following five economic rationales could be identified as underlying the leading indicators of business cycles identified with industrialised private enterprise economies witnessing recurrent sequences of expansions and contractions:

(i) ***Production Time***: The fact that for many goods it takes months or even years between the decision concerning their production and actual production (These decisions also include production of goods which form input in final product, new orders and contracts, building licences, etc.);

(ii) ***Ease of Adaptation***: The fact that certain dimensions of economic activity have lower cost of short-run variation than other activities;

(iii) ***Market Expectations*** : The fact that some economic time series tend to reflect, or to be especially sensitive to, anticipations about future economic activity;

(iv) ***Prime movers*** : The view that fluctuations in economic activity are driven basically by a few measurable forces, such as monetary and fiscal policies;

(v) ***Change-versus-level:*** The view that changes in economic time series generally turn up or down before levels.

For the CILI in the Indian context, it is difficult to get the time series data on variables that are conventionally used as leading indicators. The major problems encountered in considering available information are the following:

(i) Data on most of the conventional leading indicators used for industrial countries, e.g., housing starts, new orders, contracts for plants & equipment, vendor deliveries, labour working hours/days, unemployment stipend, manufacturing inventories, are either not collected or are not available at the aggregate level;

(ii) On business expectations, regular information worthy for quantification and inclusion in CILI is not available. In the recent years, some agencies like the RBI, the National Council of Applied Economic Research (NCAER), the Confederation of Indian Industries (CII) and M/s *Dun and Bradstreet* have taken initiatives to conduct business expectations surveys. This information is not available for most part of the sample period; and

(iii) Data for some of the macroeconomic variables are available after a considerable time lag and many of the preliminary estimates are prone to major revisions.

The series considered here are generally selected on the basis of their conformity to general business cycles, economic significance based on acceptable business cycle theories, statistical reliability of data with minimum publication lag and smooth month-to-month changes. The following additional criterion were considered in the selection of variables for the exploratory analysis:

(i) In the short-run, business forms expectations about demand and attempts to minimise the cost of those demands. In the absence of direct regular information on producers' future expectations on future demands, more reliance had to be placed on the variables required in early stages of production [Holt, Modigliani, Muth & Simon (1960)]. Accordingly, all the basic and intermediate industrial products have been considered.

(ii) The issue of unemployment has been a central theme of business cycle analysis. The anticipation of inventory built-up due to decline in demand may cause retrenchment of labour. However, as a high share of labour is in the organised public sector and labour welfare legislations have not made the retrenchment of labour an easy task, the labour supply curve has been largely inelastic in India. As a result, shifts in labour supply have not been central to economic fluctuations in the country. Again, information on employment in factories is available only on an annual basis through the Annual Survey of Industries (ASI) after considerable time lag, which is of little help for the purpose of compilation of leading indicators. For these reasons, the variables (e.g., number of vacancies notified, number of applicants on live registers and applicants placed under employment) considered here are based on the statistics relating to Government Employment Bureaus that cover only a portion of the total job vacancies.

(iii) Variables involving transportation of goods, *e.g.*, production of transport vehicles, rail and port traffic, etc., have been considered as they facilitate the future movement of goods;

(iv) Unexpected variations in money are significant in determining the fluctuations of real variables [Stock & Watson (1989) *et al*] The variables considered include monetary and fiscal variables. These variables are available with lesser time lag making them more useful as leading indicators;

(v) The demand of industrial products due to the income generated from agricultural sector is very high and the only related variable, for which information is available with a periodicity of less than one year, is the level of stock of foodgrains with government agencies. In the absence of other information from this sector, prices of various groups of agricultural products have been considered. The prices of basic industrial inputs have also been considered as relative prices of various commodity-groups are found to be significantly different. In addition, consumer price index is also considered. Gold has special value for both consumers and investors in India, for which, its prices are also considered;

(vi) Stock prices, capital mobilised by the corporate sector through public issues, new registration of companies, their authorised capital and related variables are taken. However, during the process of liberalisation in 1990s, the capital market was deregulated and the office of Controller of Capital Issues was abolished in 1991. The securities market observed serious irregularities in 1992. In 1994, Foreign Institutional Investors were allowed to make portfolio investments in the stock market which lacked depth and the availability of lower number of securities pushed up the stock prices again. These two factors have deprived the stock prices of representing the fundamentals of the market during the reference period and any adjustment for these factors would be only too subjective. As we will see later, none of the capital market variables were finally included in CILI;

(vii) With the gradual opening up of the economy, external influences in the industrial sector are becoming prominent. Variables relating to external sector like exchange rates, import at aggregate level, import of raw materials & capital goods, etc., have been considered. Other international variables likely to have influence on the industrial production are also considered - international oil prices, international interest rate and real GDP of the United States have been considered. US GDP was preferred over World GDP due to its quick availability and robustness of estimates and also because cyclical fluctuations in this large economy is likely to have impact on other major economics.

IV.2 Steps involved in compilation of CILI

The preliminary exercise included exploring the relationship between the cyclical component of the reference series with a large number of monthly / quarterly economic time series relating to industrial production, food stock, employment goods transportation, money and banking variables, public finance, prices, capital market, external trade and some international variables.

Using the band-pass filter, cyclical component was obtained from the seasonally adjusted series. Initially, the high-pass filter of cyclical components between 2 to 32 quarters was used for each series. Plot of cyclical component of each variable vis-à-vis that of the cyclical reference series gave a preliminary idea of the lead-lag relationship between the two variables. The relationship between cyclical components of reference series with other series was found by obtaining cross-correlation of filtered series for different lags for two periods, *viz.,* (i) 1981:Q1 to 2000:Q1 and (ii) 1992:Q1 to 2000:Q1. The series having high correlation with the reference series were selected with appropriate lags. The relationships were confirmed using the cyclical bands with lower cut-off frequency of 2, 4, 6 and 8 quarters – the upper cut-off frequency being 32 quarters in all the cases. The cross-correlations between IIP-*Manufacturing* and the selected series for selected lags (post-1980 and post-1991) for four different bands periods for post-1980 and post-1991 periods are presented in Table 4. As the cyclical component of various series had different amplitude, they were divided by their respective standard deviations to obtain standardised cyclical components. For counter-cyclical variables, the reciprocal of variable was taken. It was decided to compile of the index of leading indicator series as an unweighted index of the selected series. One major reason for this was the vibrancy and rapid expansion of the industrial sector leading to changes in production cycles over time.

Table 4 : Cross-Correlation between Cyclical Components of IIP-Manufacturing and Selected Leading Indicators

Vari-able	Lag	Band of the Filter							
		2-32 Quarters		4-32 Quarters		6-32 Quarters		8-32 Quarters	
		Post-1980	*Post-1991*	*Post-1980*	*Post-1991*	*Post-1980*	*Post-1991*	*Post-1980*	*Post-1991*
IPMI	2	0.23	0.49	0.33	0.67	0.36	0.72	0.45	0.73
IPBM	2	0.21	0.50	0.34	0.78	0.45	0.88	0.37	0.85
MMTL	3	0.43	0.47	0.55	0.64	0.61	0.70	0.74	0.79
EMAP	6	-0.30	-0.42	-0.35	-0.52	-0.38	-0.56	-0.44	-0.59
FDST	4	0.15	0.58	0.17	0.64	0.20	0.71	0.20	0.78
WPFD	2	-0.41	-0.32	-0.48	-0.40	-0.57	-0.42	-0.58	-0.34
WPIR	2	0.14	0.50	0.16	0.58	0.17	0.65	0.11	0.69
WPMF	3	0.15	0.49	0.18	0.54	0.22	0.56	0.24	0.54
CWP	2	0.48	0.72	0.60	0.81	0.65	0.88	0.64	0.89
AGDP	5	0.28	0.24	0.42	0.30	0.42	0.28	0.45	0.22
CRDT	2	0.35	0.44	0.37	0.46	0.44	0.49	0.52	0.52
EXPR	2	0.36	0.66	0.47	0.66	0.56	0.73	0.72	0.83
MNOL	2	0.37	0.55	0.46	0.65	0.54	0.71	0.68	0.76
USGP	4	0.38	0.24	0.43	0.25	0.46	0.23	0.48	0.16

The following fourteen series having a lead period of at least two quarters (including the data release lag) were selected as leading indicators on the basis of the cross-correlation of their cyclical components with the cyclical component of the reference series:

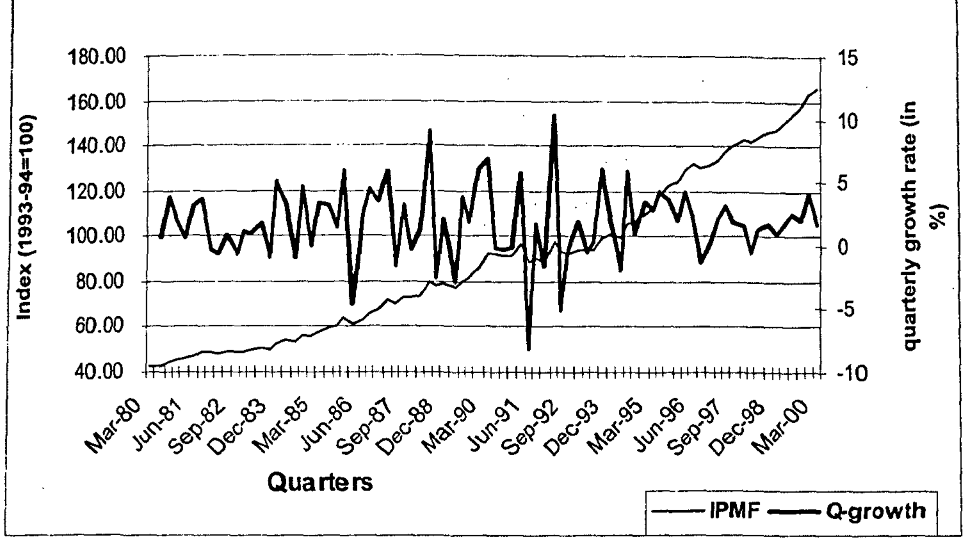
1. IPMI IIP - Mining (1993-94=100)
2. IPBM IIP for Basic Metals & Alloys (1993-94=100)
3. MMTL Import of Metals and Articles of Base Metals
4. EMAP Applicants on Live Registers in emp.exchanges (no.in thousands) *(counter-cyclical)*
5. FDST Stock of Foodgrains with Government (million tonnes)
6. WPFD WPI – Food Articles (1981-82=100) *(counter-cyclical)*

7. WPIR WPI – Industrial Raw Materials (Non-food Articles & Minerals)
8. WPMF WPI - Manufactured Products (1981-82 = 100)
9. CWP Currency with the Public (Rs.crore)
10. AGDP Aggregate Deposits - Scheduled Commercial Banks (Rs. crore)
11. CRDT Bank Credit - Scheduled Commercial Banks (Rs. crore)
12. EXPR Exports (US $ million)
13. MNOL Non-Oil Imports (US $ million)
14. USGP US Gross Domestic Product at 1992 prices (US $ billion)

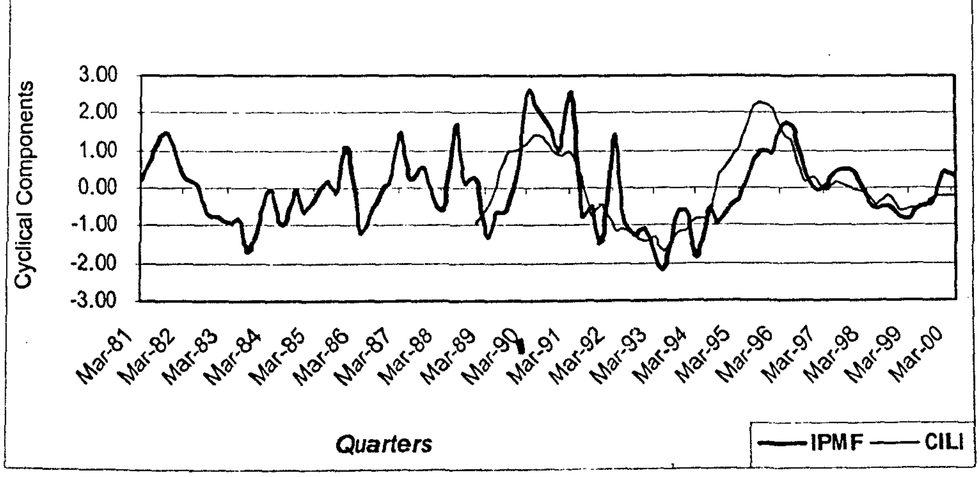
Graph 3 presents the seasonally adjusted quarterly IIP-*Manufacturing* and their quarter-to-quarter growth rates since 1980. As data relating to certain components of CILI could not be obtained for pre-1988 period, CILI is compiled for post-1988 period. The coefficients of correlation between IIP-*Manufacturing* (cyclical) and CILI (cyclical) for the frequency bands corresponding to 2-32 quarters, 4-32 quarters, 6-32 quarters and 8-32 quarters are 0.71, 0.82, 0.85 and 0.88, respectively.

The cyclical components of IIP-*Manufacturing* and CILI are also presented in Graph 4. It may be mentioned here that the standard deviations of cyclical components were standardised to unity before compiling the index. Being a composite index of 14 cyclical variables, movements in CILI are obviously smoother than the movements cyclical component of the single series IIP-*Manufacturing*. One observes that cyclical CILI leads cyclical IIP-*Manufacturing* by a lead period of two quarters. This implies that CILI can be relied upon for predicting the turning points in IIP-*Manufacturing* and, therefore, the turning points of aggregate business cycle as discussed in section II.

Graph 3: IIP-Manufacturing & its Quarterly Growth Rates
(seasonally adjusted data since 1980)



Graph 4: IIP-*Manufacturing* and CILI
(Cyclical component between 2 and 32 quarters)



Section V

The Leading Indicators

There are sufficient economic reasons to include the selected variables as leading indicators of the IIP-*Manufacturing*. IIP-*Mining* is an indicator of movements in raw material inputs for manufacturing industries The basic metals are used as inputs in subsequent stages of production. Similarly, import of metals and articles of base metals also work as leading indicators with a longer lead of three quarters compared to a lead period of two quarters in case of domestic production of basic metals and alloys. Well before the recession, in the event of slowdown new jobs are not available and applicants for employment in the Public Employment Bureaus increase in case of anticipated low level of productive activities. This variable is counter-cyclical and has a long lead period of six quarters.

The level of stock of foodgrains with the government provides stability to food prices. However, food prices are a major factor determining the demand for other products. The high level of food stock has resulted in increased stability in the foodgrains prices in the post-1980s. The PDS off-take of cereals for 1975, 1985 and 1995 were 11.11 million tonnes (m.t.), 13.40 m.t. and 19.44 m.t., respectively. The stocks of foodgrains also increased from 3.34 m.t. in 1975 to 21.20 m.t., in 1985 and further to 26.80 m.t. in 1995. This brought down the volatility in food prices in the 1980s and 1990s.

Monetary and Banking indicators are generally related to the level of output in the short run. Easy liquidity conditions are important for smooth transactions, which is an important factor in determining output. Currency with the public is important from this point of view. Bank credit results in investment and also in meeting the working capital requirements of business firms. Aggregate deposits are not likely to be high in case of increased economic activities but they form the resource base for banks' lending and have a long lead period of five quarters.

In the case of external sector variables, exports provide incentive to producing units that are directly or indirectly related to exports. Many imported items contribute to domestic productive activities. Non-oil imports include import of investment goods and also items that are imported for value addition and result in re-exports. Oil imports are not taken for the reason that international oil prices are highly volatile and energy prices are regulated in the country, which results in subsidisation. For the same reasons, WPI for Fuel items is not considered. In any case, the price changes in energy items get absorbed immediately by the other commodities where they are inputs and are reflected in prices of other products. The international demand is measured by the US GDP for reasons stated in previous section.

Certain series, (*e.g.*, merchant shipping entered & cleared) are found to be good leading indicators but are not selected in CILI as publication time lag for those series is very high. Some other variables relating to the organised business sector, like, stock prices and registration of new companies may logically serve as good leading indicators in ideal conditions. However, due to major deregulations in the private sector in the 1990s, they could not be considered. The professional practices relating to the functioning of capital markets are in the intermediate stage and an exhaustive regulatory framework is being put in place in the present process of economic reforms. In the light of increasing depth and gradual maturity in capital market in the current process, it may take some more time before capital market indicators can be considered for the purpose of the CILI.

Prices have a very significant role in the context of business cycles analysis. A high anticipated inflation forces consumers to buy goods and services to avoid even higher prices. Long-term investments are deferred and incentives to acquire savings are reduced. Despite the prevalence of administered price regime in the case of several important items for a very long period, price variables in India contained vital information that are useful in analysing the state of the economy and the impact of macro-economic policies. An analysis of variations of inflation rates over the years shows a very clear emerging pattern in the movement of price variables.

A limited analysis of cyclical movements in commodity price variables and their relationship with industrial cycles is carried out using quarterly data for the period 1950-2000. For output series

IIP-*General* is used which is closely related with the IIP-*Manufacturing*. Data on four commodity groups, *viz.* (i) Food Articles, (ii) Industrial Raw Materials, (iii) Fuel Items and (iv) Manufactured Products in the WPI basket have been used in addition to the aggregate WPI.

Table 5 : Coefficient of Correlation of among Cyclical components of Commodity Groups of WPI

(based on quarterly data)

Variable	WPAL	WPFD	WPIR	WPFL	WPMF
WPMF	0.84	0.43	0.72	0.54	1.00
WPFL	0.62	0.45	0.31	1.00	
WPIR	0.80	0.51	1.00		
WPFD	0.82	1.00			
WPAL	1.00				

Table 5 presents the coefficient of correlation among the cyclical components of various commodity groups. As expected, the cyclical components of prices of different commodity groups are highly correlated. Cross-correlation of cyclical components of price variables with the cyclical component of first & second leading quarters, current and first and second lagging quarters of IIP-*General* for the 50-year period 1950-2000 and five intervening decades are given in Table 6.

Analysing the whole period first, all the price variables considered here are found to be counter-cyclical to IIP-*General*. The negative relationship of IPGN with WPAL is an amalgam of its relationship with the WPI component commodity groups. Prices have positive relationship with future output in the 1990s implying price incentive is an important factor to increase industrial production in a liberalised regime that allows market-determined prices in most cases. In the whole period, cyclical component of food prices is negatively related to the cyclical IPGN with the current correlation coefficient being -0.49. Industrial raw materials has the most insignificant relationship (correlation coefficient -0.07)

Table 6 : Cross-Correlation of Cyclical Components of Price Variables with the Current, Leading and Lagging Cyclical Component of IIP - *General*

(using Quarterly data for 1950-2000)

Period	IIP(-2)	IIP(-1)	IIP	IIP(+1)	IIP(+2)
WPI All Commodities					
1950-60	-0.09	-0.11	-0.16	-0.22	-0.30
1960-70	-0.25	-0.32	-0.35	-0.43	-0.51
1970-80	-0.62	-0.69	-0.70	-0.63	-0.47
1980-90	-0.27	-0.30	-0.24	-0.16	-0.12
1990-00	0.06	-0.02	-0.06	0.02	0.14
1950-00	**-0.28**	**-0.32**	**-0.33**	**-0.33**	**-0.31**
WPI- Food Articles					
1950-60	-0.29	-0.39	-0.47	-0.50	-0.50
1960-70	-0.38	-0.46	-0.47	-0.44	-0.39
1970-80	-0.36	-0.45	-0.52	-0.53	-0.46
1980-90	-0.47	-0.64	-0.70	-0.63	-0.47
1990-00	-0.10	-0.32	-0.43	-0.41	-0.32
1950-00	**-0.32**	**-0.43**	**-0.49**	**-0.48**	**-0.43**
WPI – Industrial Raw Materials					
1950-60	0.15	0.17	0.15	0.09	-0.03
1960-70	0.40	0.30	0.14	-0.10	-0.37
1970-80	-0.39	-0.50	-0.57	-0.58	-0.49
1980-90	0.18	0.08	0.00	-0.07	-0.16
1990-00	0.15	0.23	0.30	0.37	0.42
1950-00	**0.01**	**-0.02**	**-0.07**	**-0.12**	**-0.18**
WPI – Fuel, Power, Light & Lubricants					
1950-60	-0.25	-0.42	-0.58	-0.75	-0.87
1960-70	-0.07	0.07	0.21	0.24	0.17
1970-80	-0.61	-0.52	-0.40	-0.25	-0.07
1980-90	-0.05	-0.16	-0.25	-0.31	-0.34
1990-00	-0.41	-0.50	-0.55	-0.57	-0.52
1950-00	**-0.32**	**-0.32**	**-0.30**	**-0.27**	**-0.22**
WPI – Manufactured Products					
1950-60	0.18	0.20	0.15	0.03	-0.12
1960-70	-0.01	0.02	0.00	-0.15	-0.39
1970-80	-0.73	-0.78	-0.76	-0.65	-0.46
1980-90	-0.21	-0.11	0.04	0.16	0.18
1990-00	0.28	0.32	0.36	0.46	0.52
1950-00	**-0.22**	**-0.21**	**-0.19**	**-0.17**	**-0.15**

in the whole period but on a closer look across decades it is found that there is a distinct pattern that gets cancelled out in the aggregate analysis.

The 1990s are found to be different from preceding decades especially in the case of the prices of industrial raw materials and manufactured products. The negative relationship of earlier decades was replaced by a new positive relationship between output and prices. The cross-correlation coefficient between cyclical WPIR and second lead of cyclical IPGN changed from -0.49 in 1970s and -0.16 in 1980s to 0.42 in 1990s. The high correlation in 1990s clearly implies that demand has become a major factor in determining the prices of industrial raw materials after industrial liberalisation. In contrast to the general price indices for consumer and producer goods, prices of industrial commodities and raw materials traded in the organised auction markets show high sensitivity to business cycles, often turning down early in slowdowns as well as contractions in the developed countries. In the Indian case, the prices of manufactured products have even stronger positive relationship with industrial output during the 1990s. The correlation between cyclical WPMF and second lead of cyclical IPGN changed from -0.46 in 1970s to 0.18 in 1980s and further to 0.52 in 1990s. This shows that liberalisation of the industrial sector has brought the demand factor in a big way in determining the prices of these commodity groups.

An analysis of cyclical component data shows that the manufactured prices have much lesser cyclical amplitude than the food prices, which has maximum amplitude. The cyclical amplitude of industrial raw material prices falls in between the two. Frequently, the cyclical movements in the prices of industrial raw materials precede the cyclical movements in manufactured prices. This again emphases on the role of demand factors in determining output. Therefore, price indices relating to different commodity groups work as leading indicators with different lags in Indian context.

Section VI

Conclusions

Business cycle analysis is likely to become increasingly important as the Indian economy goes through the economic liberalisation process in the next few years. This study shows that the major output variables in the non-agricultural sector of the Indian economy have roughly similar cyclic fluctuations. The detection of turning points of cyclical fluctuations is of crucial importance for policy-makers and business investors.

An attempt has been made here to suggest a Composite Index *of Leading Indicators (CILI) that is able to predict these turning* points six months in advance. CILI is constructed for IIP-*Manufacturing*, which is roughly coincident with the all the major output variables in non-agricultural sector of the economy.

Non-availability of most of the conventional leading indicators (used in developed countries) and the absence of regular time series information on business expectations for India rendered the task difficult and circumscribed the choice of variables. The forecasting performance of CILI in predicting the cyclical turns in the short-run has been found to be highly reliable.

In the recent years, some agencies like the RBI, NCAER, CII and some private agencies have taken initiatives to conduct business expectations surveys. Also, regulatory changes were made to ensure more transparency in the operations of firms and many corporate sector variables are now available on a quarterly basis. These developments would provide useful indicators at higher frequency and go a long way in giving impetus to study of business cycles in the Indian economy.

Appendix Table 1 : Annual Data on Selected Macroeconomic Variables (1950-97)

Years	Variables									
	GDPR	PFCE	GDCF	NAGR	DTRD	MANF	GVAD	SALE	IPGN	IPMF
1950-51	42871	36937	6705	19130	3653	4877	100.0	100.0	7.4	9.6
1951-52	43872	38610	7852	19777	3737	5031	120.0	130.8	8.3	10.7
1952-53	45117	39940	5174	20262	3868	5206	114.2	125.7	8.7	11.0
1953-54	47863	42403	5906	21094	4015	5609	120.3	116.0	8.8	11.3
1954-55	49895	43789	6549	22339	4295	6002	131.3	124.0	9.6	12.3
1955-56	51173	44241	9142	23855	4612	6472	149.0	137.7	11.0	13.2
1956-57	54086	46230	11755	25283	4938	6958	168.9	153.9	11.9	14.3
1957-58	53432	45298	11459	25923	5043	7226	173.1	168.1	12.6	14.6
1958-59	57487	49403	9441	27206	5254	7584	186.9	177.1	12.8	14.9
1959-60	58745	49882	10152	28769	5585	8099	213.7	194.0	13.7	15.9
1960-61	62904	52714	12348	30909	6096	8771	238.7	215.5	15.6	17.7
1961-62	64856	53631	11325	32834	6486	9520	259.1	236.0	16.9	19.2
1962-63	66228	54374	13189	34843	6826	10213	284.2	258.2	18.5	20.9
1963-64	69581	56695	13876	37462	7326	11179	315.3	288.9	20.2	22.9
1964-65	74858	60313	15189	39776	7864	11952	347.1	315.8	22.0	24.9
1965-66	72122	60206	16888	40914	7914	12063	375.4	348.0	23.2	25.7
1966-67	72856	61333	17751	42092	8107	12158	414.6	389.0	23.3	26.0
1967-68	78785	64780	16227	43446	8402	12205	441.7	420.1	23.6	25.8
1968-69	80841	66999	15296	45558	8765	12881	470.3	455.9	25.2	27.4
1969-70	86109	69028	17581	48558	9233	14263	523.6	506.9	27.1	29.1
1970-71	90426	71522	18928	50212	9729	14598	593.7	572.3	28.2	30.4
1971-72	91339	73206	19899	51880	9919	15075	655.9	641.0	29.8	32.0
1972-73	91048	73647	18623	53569	9956	15666	732.0	711.5	30.9	33.2
1973-74	95192	75654	23664	55014	10377	16363	822.9	773.4	31.2	33.5
1974-75	96297	75747	21333	56731	10851	16840	1029.6	979.1	32.2	34.1
1975-76	104968	80063	22014	60302	11866	17195	1068.9	1091.7	34.3	36.0
1976-77	106280	82165	24175	64195	12269	18703	1155.6	1229.3	37.6	39.3
1977-78	114219	88706	26311	67910	13293	19867	1252.3	1344.8	39.1	41.0
1978-79	120504	94041	31768	73129	14452	22321	1422.6	1494.1	42.0	44.1
1979-80	114236	91379	28401	72913	13985	21602	1660.4	1724.2	41.4	43.2
1980-81	122427	99292	30880	75758	14713	21644	1893.6	2019.0	43.1	44.7
1981-82	129889	103848	30767	80483	15671	23382	2190.0	2408.7	47.1	48.3
1982-83	133915	107071	30103	85112	16546	24908	2374.5	2618.2	48.6	49.0
1983-84	144865	115057	31378	90785	17417	27377	2566.9	2825.1	51.9	51.7
1984-85	150433	119464	31018	96372	18173	29153	2970.0	3262.9	56.3	55.8
1985-86	156566	124054	36641	102348	19649	30320	3431.5	3706.7	61.2	61.3
1986-87	163271	130262	36259	109990	20852	32445	3699.8	4032.9	66.8	67.0
1987-88	170322	135129	42657	116843	21801	34818	4138.1	4440.2	71.7	72.3
1988-89	188461	143468	49857	126247	23385	37865	4924.4	5323.8	77.9	78.6
1989-90	201453	149738	52698	138190	25231	42285	6093.0	6484.4	84.6	85.3
1990-91	212253	155454	62257	146600	26580	44863	7140.0	7554.3	91.6	93.0
1991-92	213983	158179	52271	149865	26827	43200	8560.8	8959.4	92.1	92.3
1992-93	225240	164585	56691	157231	28653	45005	9613.6	10052.5	94.3	94.3
1993-94	239145	172322	59412	168632	30923	48770	11311.0	11600.6	100.0	100.0
1994-95	257700	182385	77636	183567	34647	54570	13814.7	14048.3	108.4	108.5
1995-96	276132	191973	84584	204225	39968	62207	17095.8	17377.7	122.3	123.5
1996-97	296845	203174	91325	219281	43313	66785	18040.7	19185.0	129.0	131.8

Appendix Table 2 : Quarterly Data on IIP-*General* and Prices Indices (1950-2000) *(Contd.)*

Quarter	IPGN	WPAL	WPFD	WPIR	WPFL	WPMF
Mar-50	7.70	15.85	19.16	12.15		18.03
Jun-50	7.63	15.99	19.70	12.07		18.09
Sep-50	7.54	16.62	20.94	12.70		18.47
Dec-50	7.88	16.73	20.87	13.03		18.57
Mar-51	8.30	17.29	20.29	14.20		19.57
Jun-51	8.57	18.58	20.27	17.01		21.13
Sep-51	8.61	17.88	20.12	14.90		20.65
Dec-51	8.80	17.71	19.81	14.43		20.67
Mar-52	9.20	16.58	18.19	12.82		19.99
Jun-52	9.28	15.17	16.97	10.58		18.71
Sep-52	9.20	15.61	18.14	11.09		18.95
Dec-52	9.76	15.50	17.44	10.78		19.06
Mar-53	9.69	15.51	17.74	10.92		18.80
Jun-53	9.90	16.10	18.78	11.63		19.10
Sep-53	9.85	16.56	19.84	11.94		19.35
Dec-53	10.04	15.90	18.50	11.15		19.13
Mar-54	10.05	15.97	18.43	11.70		19.28
Jun-54	10.47	15.99	17.86	11.39		19.61
Sep-54	10.95	15.63	17.38	10.53	11.46	19.12
Dec-54	11.07	15.10	16.17	10.63	11.48	18.88
Mar-55	11.39	14.56	14.95	10.58	11.38	18.92
Jun-55	11.94	14.05	14.32	9.90	11.31	18.64
Sep-55	11.96	14.47	15.17	10.20	11.14	18.52
Dec-55	11.81	14.51	15.06	10.38	11.20	18.65
Mar-56	11.97	15.13	15.73	11.33	11.38	19.05
Jun-56	13.70	15.89	16.91	11.90	11.67	19.30
Sep-56	13.43	16.61	17.96	12.14	12.49	19.99
Dec-56	12.73	16.96	18.33	12.41	12.61	20.39
Mar-57	13.05	16.76	17.99	12.49	12.60	20.22
Jun-57	12.69	17.10	18.60	12.61	13.03	20.34
Sep-57	12.33	17.47	19.26	12.56	13.59	20.65
Dec-57	12.83	17.05	18.52	12.17	13.64	20.65
Mar-58	13.49	16.57	17.73	11.81	13.57	20.51
Jun-58	12.53	17.15	18.90	12.06	13.63	20.50
Sep-58	12.79	18.19	20.88	12.49	13.73	20.64
Dec-58	13.18	17.90	20.45	12.05	13.61	20.66
Mar-59	14.04	17.71	19.95	12.16	13.69	20.74
Jun-59	13.38	17.91	20.19	12.51	13.76	20.73
Sep-59	14.26	18.40	21.07	12.74	13.71	20.89
Dec-59	15.43	18.63	21.10	13.09	13.82	21.36
Mar-60	15.97	18.72	20.50	13.87	13.88	21.97
Jun-60	15.25	19.19	20.82	14.56	14.03	22.58
Sep-60	15.51	19.65	21.57	14.52	14.16	23.07
Dec-60	16.69	19.75	20.83	15.62	14.23	23.72
Mar-61	17.55	19.91	20.32	16.66	14.37	24.24
Jun-61	16.47	19.79	20.62	16.00	14.47	23.92
Sep-61	16.78	19.95	21.45	15.27	14.44	23.69
Dec-61	16.68	19.47	20.83	14.41	14.43	23.66
Mar-62	17.77	19.45	20.73	14.50	14.51	23.69
Jun-62	17.58	20.13	21.87	14.61	14.69	24.16
Sep-62	18.01	20.74	22.98	14.94	14.81	24.49
Dec-62	18.47	20.55	22.51	14.74	14.81	24.55
Mar-63	19.27	20.29	21.69	14.54	15.40	24.67
Jun-63	18.89	21.16	23.06	14.84	16.97	25.15

Appendix Table 2 : Quarterly Data on IIP-*General* and Prices Indices (1950-2000) *(Contd.)*

Quarter	IPGN	WPAL	WPFD	WPIR	WPFL	WPMF
Sep-63	19.77	21.70	24.29	15.03	17.02	25.26
Dec-63	20.52	21.74	24.38	14.93	17.10	25.33
Mar-64	20.77	22.07	24.74	15.50	17.21	25.55
Jun-64	19.66	22.81	26.13	16.34	17.29	25.75
Sep-64	21.26	24.22	28.89	17.65	17.34	25.98
Dec-64	21.78	24.62	29.43	17.75	17.42	26.64
Mar-65	22.22	24.52	28.74	18.00	17.54	26.97
Jun-65	21.71	24.64	28.38	18.38	17.70	27.55
Sep-65	22.16	25.88	30.73	19.65	17.69	27.91
Dec-65	22.35	26.31	30.91	20.81	17.85	28.40
Mar-66	22.78	26.67	30.93	21.10	18.49	29.15
Jun-66	22.58	28.06	33.23	22.64	19.21	29.74
Sep-66	23.00	29.22	35.19	24.07	19.44	30.20
Dec-66	23.47	29.58	36.03	23.54	19.53	30.52
Mar-67	23.38	31.02	38.66	25.06	19.64	31.03
Jun-67	22.96	32.28	41.60	24.76	19.82	31.41
Sep-67	23.53	33.86	46.06	23.34	20.43	31.53
Dec-67	23.52	33.43	44.60	23.80	20.98	31.60
Mar-68	25.01	32.00	41.50	22.24	20.89	31.70
Jun-68	23.91	32.10	41.89	21.49	21.26	31.76
Sep-68	25.11	33.22	43.36	23.41	21.48	32.46
Dec-68	25.50	32.74	40.89	24.77	21.53	33.15
Mar-69	26.68	32.07	38.52	25.00	21.70	33.82
Jun-69	26.06	32.99	40.02	26.38	22.14	34.11
Sep-69	26.64	34.24	42.36	28.06	22.35	34.23
Dec-69	27.37	33.40	40.56	26.39	22.47	34.79
Mar-70	28.36	34.31	41.47	27.83	22.75	35.50
Jun-70	27.73	35.12	42.38	29.26	23.20	36.10
Sep-70	27.54	35.83	43.45	29.81	23.38	36.64
Dec-70	28.30	35.70	42.73	29.65	23.45	37.15
Mar-71	29.40	35.81	41.92	30.05	23.55	38.20
Jun-71	28.33	36.65	42.80	29.48	23.98	39.00
Sep-71	28.84	38.07	44.10	30.66	24.88	40.71
Dec-71	30.07	37.47	42.31	29.64	24.88	40.65
Mar-72	31.58	38.24	43.22	29.39	25.31	41.76
Jun-72	29.77	39.24	44.85	28.96	25.63	43.01
Sep-72	30.53	41.45	47.72	30.81	25.67	45.58
Dec-72	31.50	42.11	48.18	33.58	25.78	45.89
Mar-73	31.79	42.86	49.07	36.40	25.95	46.09
Jun-73	29.80	45.52	53.00	39.86	26.59	48.41
Sep-73	31.36	48.56	57.71	44.09	27.12	50.88
Dec-73	32.42	50.54	59.41	45.40	30.85	52.73
Mar-74	32.68	54.45	62.74	54.63	37.67	54.60
Jun-74	30.79	59.26	68.86	57.04	44.86	58.81
Sep-74	31.83	63.91	76.02	59.75	45.83	63.74
Dec-74	32.59	63.44	74.20	56.23	47.10	64.39
Mar-75	34.27	62.63	74.34	53.80	47.80	63.11
Jun-75	31.06	63.09	74.11	52.39	48.27	64.52
Sep-75	33.44	63.06	72.58	51.01	50.99	64.94
Dec-75	34.70	61.71	69.14	50.35	52.38	63.74
Mar-76	37.61	58.63	63.16	49.78	53.55	60.30
Jun-76	35.37	60.19	63.89	52.25	53.69	62.39
Sep-76	36.36	63.57	66.84	57.77	53.90	66.22
Dec-76	38.00	63.14	65.54	59.62	54.13	65.37

Appendix Table 2 : Quarterly Data on IIP-*General* and Prices Indices (1950-2000) *(Contd.)*

Quarter	IPGN	WPAL	WPFD	WPIR	WPFL	WPMF
Mar-77	41.02	64.63	68.56	64.37	54.29	65.44
Jun-77	37.60	66.46	73.63	64.32	54.42	66.64
Sep-77	37.68	67.10	75.12	63.77	54.64	67.29
Dec-77	39.21	65.77	73.63	60.50	54.64	66.23
Mar-78	42.03	65.15	73.31	59.91	55.39	65.10
Jun-78	40.45	65.22	73.60	59.22	56.62	64.92
Sep-78	40.80	66.52	75.27	59.93	57.40	66.36
Dec-78	42.10	66.53	73.46	60.81	57.55	67.03
Mar-79	43.99	66.36	71.56	62.17	57.04	67.42
Jun-79	40.46	70.58	75.20	65.18	59.19	72.86
Sep-79	40.81	77.34	81.52	74.15	65.76	79.21
Dec-79	41.33	79.69	80.63	79.33	69.07	82.14
Mar-80	43.21	82.23	80.58	85.45	70.70	85.15
Jun-80	39.49	85.63	83.01	87.93	73.92	89.53
Sep-80	41.66	92.83	87.94	90.94	83.06	98.57
Dec-80	44.26	92.63	90.48	92.73	83.42	96.26
Mar-81	47.00	95.04	92.57	97.96	91.13	96.50
Jun-81	44.17	98.60	95.11	98.89	93.71	101.67
Sep-81	45.94	102.13	102.73	102.66	101.54	101.81
Dec-81	47.99	100.33	101.45	100.47	102.36	99.16
Mar-82	50.38	98.93	100.71	97.97	102.39	97.36
Jun-82	46.19	102.13	103.90	99.26	104.27	101.90
Sep-82	46.65	105.47	114.50	101.84	106.27	103.47
Dec-82	49.03	105.50	111.77	102.59	107.00	104.00
Mar-83	52.63	106.60	114.17	102.91	108.67	104.80
Jun-83	47.83	110.00	121.83	103.98	110.90	107.77
Sep-83	48.62	112.97	129.13	107.53	111.57	109.63
Dec-83	53.04	113.73	129.37	109.85	112.13	110.23
Mar-84	58.07	114.70	125.87	112.69	115.47	111.67
Jun-84	51.95	117.17	128.50	115.85	116.43	114.20
Sep-84	54.11	121.23	135.97	120.14	116.87	117.87
Dec-84	56.78	121.00	132.80	119.26	117.20	118.50
Mar-85	62.57	121.00	129.77	117.81	118.67	119.53
Jun-85	56.78	124.20	131.20	115.57	126.67	123.90
Sep-85	58.06	125.70	137.73	113.56	128.03	124.80
Dec-85	63.51	125.23	133.90	115.41	129.70	124.43
Mar-86	66.62	126.63	133.43	119.21	135.00	124.97
Jun-86	60.23	129.87	143.40	120.37	137.63	126.83
Sep-86	62.99	133.27	150.80	125.69	138.20	128.80
Dec-86	67.73	133.73	152.37	125.54	138.30	129.43
Mar-87	76.45	134.00	144.60	126.12	140.10	131.60
Jun-87	66.92	137.40	151.63	132.00	141.37	133.83
Sep-87	69.20	143.13	161.70	144.69	142.00	137.43
Dec-87	71.91	145.63	165.77	148.21	142.50	139.47
Mar-88	78.84	148.07	165.37	146.27	147.50	143.40
Jun-88	75.42	151.00	168.10	143.95	149.87	147.80
Sep-88	73.36	154.40	179.40	140.33	149.97	151.27
Dec-88	79.04	155.57	183.40	140.56	150.37	151.97
Mar-89	84.45	156.13	177.33	136.24	154.47	155.20
Jun-89	76.81	160.27	175.73	138.05	155.40	162.23
Sep-89	78.03	166.20	187.03	141.88	155.97	168.17
Dec-89	85.70	167.47	179.10	147.88	156.80	171.07
Mar-90	98.09	168.97	175.43	153.58	158.40	172.97
Jun-90	86.52	174.70	188.83	157.60	165.70	176.53

Appendix Table 2 : Quarterly Data on IIP-*General* and Prices Indices (1950-2000) *(Concl.)*

Quarter	IPGN	WPAL	WPFD	WPIR	WPFL	WPMF
Sep-90	86.35	180.13	199.67	164.35	166.93	180.77
Dec-90	89.68	185.00	202.57	168.44	182.70	184.47
Mar-91	104.15	190.97	211.33	176.10	187.83	189.27
Jun-91	84.47	195.33	218.13	181.48	189.37	193.07
Sep-91	86.42	207.47	242.50	190.66	195.67	203.40
Dec-91	89.84	211.93	249.33	195.40	199.50	206.63
Mar-92	105.77	216.47	254.63	197.89	210.90	210.67
Jun-92	89.11	221.70	263.80	189.49	213.90	218.77
Sep-92	89.65	228.70	275.20	196.35	217.57	225.00
Dec-92	94.92	231.83	273.53	192.15	234.90	228.90
Mar-93	103.71	232.50	271.30	190.90	241.97	229.77
Jun-93	91.76	237.13	274.17	194.68	251.40	234.23
Sep-93	96.92	247.00	289.27	208.88	257.33	242.17
Dec-93	101.30	251.83	292.30	216.92	266.30	245.90
Mar-94	110.01	255.03	281.90	226.71	274.63	250.57
Jun-94	100.40	265.27	299.53	239.46	277.73	259.23
Sep-94	102.97	272.20	315.60	241.30	279.67	265.63
Dec-94	110.23	276.93	317.43	248.13	281.20	271.30
Mar-95	120.17	284.30	318.23	265.92	283.07	278.93
Jun-95	113.87	290.90	328.93	264.70	284.47	287.37
Sep-95	117.17	295.90	337.63	267.14	284.30	292.87
Dec-95	122.73	298.33	339.67	269.64	284.37	295.83
Mar-96	135.27	298.23	336.40	267.49	288.53	296.47
Jun-96	125.80	304.47	359.30	269.59	295.20	298.60
Sep-96	123.83	314.37	371.13	275.63	328.13	304.60
Dec-96	128.37	318.87	383.90	274.43	332.93	308.03
Mar-97	138.17	320.63	385.97	275.97	340.40	308.67
Jun-97	131.83	322.70	380.63	274.99	349.20	312.87
Sep-97	132.83	326.40	382.70	278.76	356.17	316.10
Dec-97	138.87	332.53	387.93	285.00	377.60	319.67
Mar-98	146.83	337.43	400.53	293.22	380.00	321.80
Jun-98	137.67	343.93	419.87	296.92	380.57	326.30
Sep-98	137.53	353.80	446.07	307.15	380.20	332.90
Dec-98	143.33	357.90	463.07	310.41	382.07	333.67
Mar-99	153.43	354.37	436.97	313.44	382.33	334.63
Jun-99	145.93	356.77	448.60	306.16	392.00	335.73
Sep-99	147.37	362.33	465.03	310.29	401.70	337.30
Dec-99	156.63	367.83	466.73	314.67	436.00	338.83
Mar-00	168.10	364.73	448.20	313.41	440.13	338.63

Appendix Table 3 : Quarterly Data on CILI Component Variables *(Contd.)*

	IPMF	IPMI	IPBM	FDST	EMAP	WPFD	WPNF	WPMI
Mar-80	45.10	44.53		15346		80.57	85.37	85.60
Jun-80	41.10	39.50		15650		83.00	86.30	90.70
Sep-80	43.50	38.00		13574	15644.67	87.97	89.13	94.03
Dec-80	45.93	42.63		11784	16072.00	90.50	91.50	94.80
Mar-81	48.43	52.63		10772	16202.00	92.57	96.57	100.37
Jun-81	45.13	46.67	41.93	12367	16398.67	95.10	97.90	100.53
Sep-81	47.63	45.27	43.43	11378	17183.33	102.73	103.60	101.03
Dec-81	49.07	52.40	47.27	10708	17632.00	101.47	99.93	101.37
Mar-82	51.37	59.10	45.87	11383	17974.00	100.73	98.53	97.00
Jun-82	46.60	52.40	42.47	13438	18153.00	103.90	97.47	103.00
Sep-82	47.13	51.17	44.67	13201	18971.67	114.50	101.10	103.40
Dec-82	49.33	57.37	49.80	12111	19486.67	111.77	102.20	103.40
Mar-83	52.70	67.57	48.93	11837	20011.33	114.17	102.60	103.57
Jun-83	48.03	56.37	36.83	14567	20379.33	121.83	105.73	100.30
Sep-83	48.37	58.60	39.97	15102	21082.00	129.13	111.00	100.30
Dec-83	52.60	66.67	42.93	14773	21733.00	129.37	114.40	100.37
Mar-84	57.87	73.77	49.90	15328	22483.67	125.87	118.53	100.50
Jun-84	51.00	65.47	41.43	19980	22708.00	128.50	121.23	104.60
Sep-84	54.20	61.53	47.07	20928	23349.00	135.97	127.57	104.63
Dec-84	56.13	69.90	48.17	21612	23595.00	132.80	126.17	104.83
Mar-85	62.13	81.00	54.73	21795	23750.00	129.77	123.40	106.13
Jun-85	56.77	65.73	46.70	26931	24225.33	131.20	119.77	106.80
Sep-85	58.47	63.57	50.23	25949	25357.33	137.73	116.77	106.87
Dec-85	64.03	73.30	53.97	24172	26119.33	133.90	119.93	105.97
Mar-86	65.77	86.83	57.87	22526	26787.33	133.43	125.33	106.43
Jun-86	59.70	70.13	45.50	26111	27518.00	143.40	126.67	107.23
Sep-86	63.17	68.70	51.97	25267	28865.67	150.80	134.50	107.30
Dec-86	67.70	78.63	61.27	23597	29877.67	152.37	134.20	107.43
Mar-87	77.43	90.00	67.40	21236	30488.00	144.60	141.03	94.97
Jun-87	67.23	74.10	51.93	23252	30383.33	151.63	146.77	101.17
Sep-87	69.97	72.10	57.90	19094	30831.33	161.70	165.50	101.23
Dec-87	72.33	81.83	63.37	14007	30454.33	165.77	170.70	101.23
Mar-88	79.60	90.93	68.67	11248	29802.67	165.37	169.20	98.40
Jun-88	76.27	78.70	60.67	12156	29340.33	168.10	165.60	98.73
Sep-88	74.73	75.70	62.13	9261	29889.00	179.40	160.40	98.40
Dec-88	79.10	89.47	66.57	8718	30052.33	183.40	160.80	98.30
Mar-89	84.20	100.17	69.17	8365	30248.33	177.33	154.17	98.80
Jun-89	76.20	87.07	57.63	11701	30351.67	175.73	156.77	98.97
Sep-89	78.07	83.57	60.60	10857	32040.00	187.03	161.83	100.23
Dec-89	85.93	92.57	67.47	11096	32592.67	179.10	170.53	100.57
Mar-90	101.10	102.47	70.73	12170	33194.00	175.43	174.80	109.27
Jun-90	87.30	91.17	64.40	18318	33431.33	188.83	180.80	109.17
Sep-90	87.93	84.90	66.60	18121	34250.33	199.67	190.87	109.00
Dec-90	91.00	94.37	73.87	18431	34488.00	202.57	196.90	109.00
Mar-91	106.03	113.23	78.63	18414	34833.00	211.33	208.23	109.00
Jun-91	84.07	87.87	71.43	20615	35019.33	218.13	215.67	110.10
Sep-91	86.73	83.40	72.93	17507	35835.67	242.50	227.23	114.30
Dec-91	88.40	98.57	76.30	14759	36269.67	249.33	234.10	114.60
Mar-92	107.10	112.90	79.93	13342	36559.33	254.63	237.77	114.63
Jun-92	87.87	95.10	71.23	15310	36756.67	263.80	225.30	114.70
Sep-92	89.37	84.23	71.43	11887	37092.67	275.20	234.77	116.13

Appendix Table 3 : Quarterly Data on CILI Component Variables *(Contd.)*

	IPMF	IPMI	IPBM	FDST	EMAP	WPFD	WPNF	WPMI
Dec-92	93.90	98.07	76.77	12071	36823.00	273.53	228.43	116.40
Mar-93	101.87	116.87	80.47	14442	36504.00	271.30	226.17	117.27
Jun-93	89.30	89.43	75.73	24167	36132.67	274.17	228.07	124.97
Sep-93	96.27	88.10	104.80	24525	36476.67	289.27	243.93	135.70
Dec-93	101.13	100.87	95.70	23026	36313.67	292.30	255.70	135.97
Mar-94	107.10	119.37	87.03	25137	36255.67	281.90	268.67	139.10
Jun-94	100.87	93.97	107.20	30081	35967.00	299.53	287.00	140.20
Sep-94	103.00	101.60	109.47	29568	36734.33	315.60	288.63	142.47
Dec-94	109.60	113.80	115.67	31327	36778.67	317.43	297.70	144.63
Mar-95	120.70	121.17	120.20	29276	36689.33	318.23	322.83	147.07
Jun-95	113.80	112.17	119.90	34633	36506.00	328.93	319.43	150.40
Sep-95	118.30	111.80	127.80	32186	37140.67	337.63	321.37	153.93
Dec-95	124.17	117.37	130.03	29904	37086.67	339.67	324.73	154.60
Mar-96	137.63	130.13	146.33	25142	36881.67	336.40	321.30	155.13
Jun-96	128.67	111.23	131.23	26932	36780.33	359.30	324.33	155.30
Sep-96	126.57	109.10	139.07	22499	37615.33	371.13	332.30	157.30
Dec-96	130.43	116.87	141.57	20563	37615.33	383.90	330.20	157.97
Mar-97	141.37	125.20	147.50	17420	37622.00	385.97	332.23	158.50
Jun-97	134.67	116.80	138.63	20626	37778.67	380.63	330.97	158.10
Sep-97	135.83	114.53	141.53	16557	38941.33	382.70	335.43	160.43
Dec-97	142.07	124.43	145.77	18418	39114.67	387.93	341.77	166.47
Mar-98	149.67	134.00	147.90	18404	39123.00	400.53	353.93	166.47
Jun-98	140.43	116.43	138.27	26347	39351.33	419.87	358.93	167.43
Sep-98	141.07	114.00	140.27	26136	40136.33	446.07	377.10	161.10
Dec-98	147.03	122.67	136.53	24800	40173.33	463.07	382.50	159.87
Mar-99	157.80	127.90	144.40	23627	40151.33	436.97	386.97	159.90
Jun-99	150.23	115.10	138.30	28810	40294.00	448.60	373.77	165.00
Sep-99	151.23	116.47	147.30	31003	41006.00	465.03	376.17	172.73
Dec-99	162.97	122.23	146.70	31117	40697.00	466.80	380.27	177.70
Mar-00	174.90	130.10	153.33	31460		448.20	376.73	181.20

Appendix Table 3 : Quarterly Data on CILI Component Variables *(Contd.)*

	WPMF	EXPR	MNOL	CWP	AGDP	CRDT	MMTL	USGP
Mar-80	85.00	732.33			31759	21537		4926.8
Jun-80	89.37	714.00		12052	33377	22068		4829.0
Sep-80	98.37	725.33		11644	34484	22060		4823.3
Dec-80	96.07	756.67		12591	36900	24235		4910.1
Mar-81	96.33	705.33		13463	37988	25371		5003.6
Jun-81	101.47	718.33		13937	40549	26551		4969.3
Sep-81	101.63	682.67		13229	41585	27164		5030.0
Dec-81	98.97	725.33		13779	44123	29513		4972.5
Mar-82	97.20	831.00		14537	43733	29681		4894.6
Jun-82	101.90	828.67		15549	46128	30180		4916.9
Sep-82	103.47	728.00		14845	47565	30569		4893.5
Dec-82	104.00	741.33		15628	52077	34812		4896.1
Mar-83	104.80	768.67		16659	51358	35493		4948.5
Jun-83	107.77	786.67		17948	54039	36006		5063.6
Sep-83	109.63	769.00		17021	56222	36777		5152.6
Dec-83	110.23	791.67		18070	61226	40280		5257.6
Mar-84	111.67	865.00		19533	60596	41294		5370.1
Jun-84	114.20	802.33		21013	64620	43613		5465.9
Sep-84	117.87	843.67		20551	65860	43506		5513.6
Dec-84	118.50	860.67		21742	71711	47951		5555.9
Mar-85	119.53	872.67		22664	72244	48953		5602.4
Jun-85	123.90	737.00		23927	77075	50921		5646.6
Sep-85	124.80	732.00		22542	78795	50559		5731.4
Dec-85	124.43	771.67		23905	85457	53860		5778.8
Mar-86	124.97	794.00		25160	85404	56067		5831.1
Jun-86	126.83	760.67		26658	91828	57229		5856.0
Sep-86	128.80	800.00		25382	93598	57009		5911.3
Dec-86	129.43	795.67		26746	102401	61608		5944.3
Mar-87	131.60	890.00		28585	102724	63308		5990.7
Jun-87	133.83	973.00		30463	107898	64213		6056.1
Sep-87	137.43	957.33		29932	110299	64598		6108.3
Dec-87	139.47	946.67		31573	118608	68950		6215.4
Mar-88	143.40	1151.33		33650	118045	70536		6257.0
Jun-88	147.80	1070.33	1317.00	35553	126323	72436	51162	6331.0
Sep-88	151.27	1083.33	1347.00	33508	130870	75337	70422	6363.1
Dec-88	151.97	1108.67	1423.00	35417	142005	82162	101094	6445.0
Mar-89	155.20	1375.67	1440.33	38415	140150	84719	113322	6522.4
Jun-89	162.23	1249.67	1397.00	40827	147854	89080	106740	6556.9
Sep-89	168.17	1284.33	1396.00	39720	157504	92518	101061	6586.8
Dec-89	171.07	1382.00	1493.33	43454	161913	95967	109659	6608.7
Mar-90	172.97	1611.33	1540.00	46568	166959	101453	109152	6689.2
Jun-90	176.53	1417.67	1477.00	49140	173089	104011	84198	6705.4
Sep-90	180.77	1467.33	1468.67	47476	178942	103066	104943	6695.4
Dec-90	184.47	1494.33	1599.67	50173	185739	109449	150795	6643.9
Mar-91	189.27	1656.67	1490.00	53048	192541	116301	99798	6616.2
Jun-91	193.07	1366.67	1227.33	56785	199108	117261	92790	6658.4
Sep-91	203.40	1422.00	1096.67	53823	209189	115942	73575	6680.2
Dec-91	206.63	1477.33	1195.33	59106	220767	119804	99519	6721.7
Mar-92	210.67	1657.67	1206.67	61098	230758	125592	83091	6792.9
Jun-92	218.77	1359.33	1377.67	63853	243014	133644	90686	6859.3
Sep-92	225.00	1511.67	1423.33	61763	249016	135621	100369	6912.1

Appendix Table 3 : Quarterly Data on CILI Component Variables *(Concl.)*

	WPMF	EXPR	MNOL	CWP	AGDP	CRDT	MMTL	USGP
Dec-92	228.90	1521.33	1324.67	64585	262609	143379	92683	7000.0
Mar-93	229.77	1768.67	1223.67	68273	268572	151982	73369	6986.9
Jun-93	234.23	1727.33	1285.00	74397	278389	154685	92184	7024.0
Sep-93	242.17	1745.67	1297.33	72905	286408	151984	94334	7050.8
Dec-93	245.90	1799.33	1458.33	78259	300619	158507	120768	7155.0
Mar-94	250.57	2139.67	1812.33	82301	315132	164418	125604	7218.5
Jun-94	259.23	1904.67	1514.33	90603	327686	164714	130377	7319.8
Sep-94	265.63	2064.00	1886.00	85415	352653	177808	153466	7360.5
Dec-94	271.30	2231.67	1979.33	94906	358745	187965	163538	7452.3
Mar-95	278.93	2574.00	2133.67	100681	386859	211560	192048	7480.4
Jun-95	287.37	2389.33	2135.67	110612	376144	208688	184351	7496.0
Sep-95	292.87	2505.67	2514.00	107368	398599	221789	181908	7555.0
Dec-95	295.83	2691.00	2454.33	113786	402908	232752	240908	7616.8
Mar-96	296.47	3024.33	2633.33	118258	433819	254015	220251	7671.4
Jun-96	298.60	2737.67	2287.33	127179	440450	249025	225185	7800.5
Sep-96	304.60	2642.33	2221.00	119735	464418	252108	224326	7843.3
Dec-96	308.03	2688.00	2296.00	129385	471018	259696	214041	7937.5
Mar-97	308.67	2966.67	2839.33	132087	505599	278401	282304	8033.4
Jun-97	312.87	2711.33	2491.33	144350	518980	275669	214625	8134.8
Sep-97	316.10	2895.33	2643.00	135382	546548	279734	223706	8214.8
Dec-97	319.67	2728.67	2692.00	144443	558610	289504	254112	8277.3
Mar-98	321.80	2991.33	3127.67	145579	605410	324079	237605	8412.7
Jun-98	326.30	2496.33	2862.67	158117	612687	318831	201209	8457.2
Sep-98	332.90	2927.00	3261.00	151487	661659	330690	224356	8536.0
Dec-98	333.67	2672.33	2937.33	162444	671912	338168	191152	8659.2
Mar-99	334.63	3118.00	2941.67	169382	714025	368837	194711	8737.9
Jun-99	335.73	2628.33	2776.67	184983	729417	365617	171615	8778.6
Sep-99	337.30	3069.00	3228.00	176879	765705	380658	197124	8900.6
Dec-99	338.83	3228.33	3153.33	192999	788099	410464	210602	9050.9
Mar-00	338.63	3200.33	3008.00	192993	841967	449565		

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Why Should Government Be Indifferent to Inflation?

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This paper questions the argument that government is indifferent to inflation since it improves the buoyancy of revenue more than it affects the elasticity of expenditure and narrows the fiscal gap. Employing a partial equilibrium framework for the period 1970-71 to 1997-98, the results indicate that inflation would enlarge the fiscal gap except in the unlikely case of inflation enhancing growth. The best policy option when the fiscal gap overshoot the target is to keep inflation stable and activate discretionary fiscal actions.

Introduction

The consequences of inflation for growth has been an enduring theme in economic literature. Empirical evidence suggests that while inflation produces an adverse impact on the growth process in the long run, the prognosis is not so clear in the short-run. The disposition, supported by same evidence is that there exists a trade-off between inflation and growth. This has prompted the search for the existence of some threshold rate of inflation, the breaching of which lead to pronounced and serious negative effects [Rangarajan, (1998), Vasudevan (1998)].

Given this limited consensus on potentially adverse impact of inflation on the economy, will the Government be indifferent to inflation? Since the eighties, empirical evidence has been put forward to question the Aghevli-Khan (1978) hypothesis of bi-directional causation between fiscal deficits and inflation on the premise that governments receipts adjust faster to inflation than expenditures [Heller (1980)]. In the Indian context, it has been argued that "inflation is deficit reducing. It improves the buoyancy of government revenues more than it affects the elasticity of expenditures. This is because most revenues, like taxes are on ad

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valorem basis. Expenditures on the other hand are not fully indexed and even if they are, the indexation is never instantaneous. Also, with a high rate of inflation, the nominal growth of GDP will be higher even if the real rate of growth remains the same.... and fiscal target .... an important yardstick of the success can be accommodated. This might be the reason why the government is letting inflation alone". (Business Standard (BS) January 9, 1997 and August 12, 1998).

The purpose of this paper is to assess the validity of the above proposition by drawing from the literature and through empirical verification. Essentially, this involves the examination of two testable propositions *i.e.* (i) that inflation improves buoyancy of revenue more than the elasticity of expenditure (ii) that the fiscal deficit declines as inflation rises. The rest of the paper is organised in the following manner : Section I reviews the treatment of the proposition in the literature. Section II lays out the theoretical framework for examining the hypothesis set out earlier under alternative scenarios of the impact of inflation on growth. Section III presents estimates of the structural parameters which are then applied to the theoretical conditions developed in the preceding Section. Section IV contains concluding observations.

Section I

The Literature and the Propositions

Both inflation and growth impact expenditures and receipts of government and, consequently, the fiscal deficit. The causality is not uni-directional. High fiscal deficit also leads to rise in inflation and interest rate which would hamper growth. On the other hand, when the economy is in slump, fiscal expansion may help in the revival of growth. Further fiscal deficit incurred for public investment and for public consumption would have different influences on growth and inflation and also on the external balance. In a developing country context, a considerable amount of attention has been devoted in the literature to the phenomenon of deficit induced inflation followed by inflation induced deficit [Aghevli and

Khan (1978)]. Since government expenditures adjust more rapidly than receipts to a given change in the price level, inflation widens the fiscal deficit. Monetary accommodation of the higher deficit leads to larger money supply which exacerbates inflation and widens the deficit further. The hypothesis, however, has not found universal acceptance. Heller (1980) found the opposite result in a cross country study, *i.e.*, receipts adjusting more rapidly than expenditure [for a survey see Jadhav (1994)]. This is not surprising since response of expenditure and receipts to inflation would depend upon factors such as tax system and its effective enforcement, the nature of the economy and host of other factors which are country and time specific, and therefore, vary across time and space.

In the Indian context, the hypothesis of inflation induced deficit is vindicated by number of studies which found a quicker response of government expenditure to inflation than government receipts [Rangarajan, et al (1989), Jadhav and Singh (1990), Rangarajan and Arif (1990) and Bhattacharya, et al (1994)]. Jadhav (1994) even confirms the validity of growth induced deficits. These studies, though uniform in their focus on the period *i.e.*, 1970-71 to 1990-91 differ in the estimates of structural parameters. Besides differences in aggregation or disaggregation of government expenditure in the defined functional relationship, they also diverge in the type of approach adopted. Rangarajan et al (1989) and Bhattacharya et al (1994) employed long-run relationships while the other studies examined short-run relationships. This difference in postulation is crucial. Even though inflation induces deficits in the long-run, it is possible that in the short-run receipts adjust faster to inflation than expenditures and reduce deficit. In these studies, however, the long-run and the short-run behaviour was identical. In studies incorporating the post-reform period, Khundrakpam (1996, 1998) also found evidence of inflation induced deficits in long-run relationships.

With *ad valorem* nature of indirect taxes and lack of instantaneous adjustment in a significant portion of expenditure (as pointed out by BS), why should government expenditures respond more to inflation than government receipts? Besides the collection lag in the receipts - pointed out by Jadhav (1994), the following factors may have been important: a) the price rise may emanate from goods which are not in the tax net or are only marginally taxed, such as agricultural goods; b) fiscal subsidies; c) cost push inflation, the full impact of which is not passed on to the consumer in order to contain decline in demand; the price rise would reduce profit and corporate tax, but not yield excise duty to compensate; d) leakages like tax avoidance; e) customs duty collections with respect to domestic prices, by raising imports, would increase subsequently [Bhattacharya, et al (1994)]; when there are import restrictions, this may be dampened. These factors are policy and time variant. Furthermore, there are interest payments which form significant proportion of expenditure and are far more insensitive to inflation and growth than other components. Owing to this nature of interest payments, the concept of operational deficit has been employed in the literature. The studies referred to above, however, do not consider interest payment explicitly in their elasticity estimates. Various tax and expenditure reforms undertaken during the '90s may have also brought about a change in the relationships.

Thus, in the long-run (unlike the proposition and inference drawn by BS), the Government should be adverse to inflation given all its other adverse consequences on the economy besides the worsening of the fiscal gap. In the short-run the proposition that government receipts respond more to inflation than government expenditure appears valid. But can it be inferred that such a situation will necessarily reduce fiscal deficit so that a government with myopic foresight obtains short-run fiscal gains from inflation? The next section examines this argument under a theoretical proposition that fiscal deficit will not necessarily decline even if inflation has the tendency to reduce fiscal gap in the short-run as this would depend upon the existing state of the fiscal balance and the relative degree of responses of the variables concerned.

Section II

A Theoretical Framework[1,2]

In view of the inconclusive views on the impact of inflation on growth, empirical analysis would need to evaluate the response of the fiscal regime to various alternative combinations of growth and inflation. Let 'G' stand for total expenditure, 'R' for receipts, 'P' for price (wholesale, average of weeks), 'Y' for real GDP at factor cost and their lower case letters for rate of change in the respective variables. Other notations are 'a' and 'q' for price elasticities, 'c' and 'm' for income elasticities, 'd' and 'n' for adjustment lags for expenditure and receipts respectively.

II.1. Inflation With No Impact on Growth

In such situations, the change in expenditure and receipts effected by the price rise are a*p*G(-1) and q*p*R(-1) respectively. This would reduce fiscal gap if,

$$\frac{a}{q} < \frac{R(-1)}{G(-1)} \qquad (1)$$

i.e., the ratio of price elasticity of expenditure to revenue must be less than the ratio of revenue to expenditure. When fiscal gap is large, even if price elasticity of receipts is greater than expenditure the gap can still widen with inflation, since a smaller percentage increase in expenditure can be larger than a higher percentage increase in receipts. Thus, price elasticity of revenue being greater than expenditure is not a sufficient condition for inflation to be deficit reducing. This argument can also be applied to long-run relationship. Here, however, faster rise in receipts than expenditure will, over a long period of time, close fiscal gap.

If the fiscal deficit declines, its ratio to GDP would also decline since nominal GDP rise due to inflation. When the gap rises, however, the rise in nominal GDP would still reduce its ratio to GDP if $- q + n*r(-1) < - a + d*g(-1)$. In the context of deficit reducing effect of inflation $q > a$, the condition gets reduced to

$$d^*g(-1) - n^*r(-1) > 0 \qquad (2)$$

i.e., the unfulfilled portion of the growing expenditure must be greater than unfulfilled portion of growing receipts. But deficit reducing effect of inflation does not guarantee that the above condition will always be satisfied. Thus, it does not necessarily follow that inflation would reduce fiscal deficit to GDP ratio if receipts are more price responsive than expenditure since the outcome also depends upon the evolution of expenditure and receipts and their adjustment to desired levels.

II.2 Inflation With Positive Impact on Growth

Under such situations the condition required for fiscal deficit to decline is

$$\frac{(a + c)}{(q + m)} < \frac{R(-1)}{G(-1)} \qquad (3)$$

The logic is the same as in Sub-section II.1. Even if inflation improves growth and their combined elasticity of receipts is more than expenditure, fiscal deficit need not decline if it is initially too large. A smaller percentage change in expenditure could be larger than a higher percentage change in receipts and enlarge fiscal gap. If growth induces deficit *i.e.*, $c > m$, then it is all the more likely that the deficit will rise.

Similarly, if the fiscal deficit declines, its ratio to GDP will automatically fall since nominal GDP rises. If the fiscal gap enlarges there is no guarantee that fiscal deficit to GDP ratio would decline as the required condition,

$$\frac{(a + c - d^*g(-1) + n^*r(-1))}{(q + m + d^*g(-1) - n^*r(-1))} < 1 \qquad (4)$$

which for higher combined income and price elasticity of receipts than expenditure *i.e.*, $(a + c) < (q + m)$, or $d^*g(-1) > n^*r(-1)$, is not ensured by $q > a$. Thus, by (4), there is no guarantee that fiscal deficit to GDP ratio would decline even if both inflation and growth reduce deficit *i.e.*, $(a + c) < (q + m)$. Alternatively it is possible for the ratio to improve even if inflation is deficit inducing $(a > q)$ provided it enhances growth which is highly deficit reducing $(m >> c)$. When growth also induces deficit the plausibility of the ratio rising increases.

II.3 Inflation With Negative Impact on Growth

Rise in inflation associated with decline in income growth will capture the fiscal outcome under any of the following situations: a) stagflation sets in; b) real growth declines and inflation is allowed to rise to harness its deficit reducing effects. In such situations, the fiscal deficit would decline if,

$$\frac{(c - a)}{(m - q)} > \frac{R(-1)}{G(-1)} \text{ or } > \frac{(a - c)}{(q - m)} \qquad (5)$$

i.e., the ratio between the net elasticity of price rise and induced fall in income elasticities of expenditure and receipts must be less than receipts to expenditure ratio. Note that less net response of expenditure than receipts does not guarantee reduction of fiscal deficit since a smaller change in expenditure, when larger than the change in receipts, can cause the deficit to expand. Thus, when inflation negatively impact growth, deficit reducing effect of inflation $(q > a)$ does not guarantee reduction of fiscal deficit as decline/rise in growth could be highly deficit inducing/reducing $(m >> c)$. If there is the phenomenon of growth induced deficit $(c > m)$, the possibility of a decline in the deficit would increase. However, it would be insensible to trade-off inflation for growth just for fiscal gains.

If (5) is not satisfied and the fiscal deficit rises, for inflation less than or equal to fall in growth, its ratio to GDP would also enlarge since nominal GDP falls. And for inflation rising more than the fall in growth, reduction in fiscal deficit would automatically reduce its ratio to GDP since nominal GDP rises; but for fiscal deficit falling/rising alongwith declining/increasing nominal GDP, the ratio would fall if,

$$\frac{p}{y} > \frac{[(m - c) + d^*g(-1) - n^*r(-1)]}{[(q - a) + d^*g(-1) - n^*r(-1)]} \qquad (6)$$

which can be reduced to

$$\frac{(m - c)}{(q - a)} < 1 \qquad (7)$$

that is, if inflation is more deficit reducing than growth, fiscal deficit to GDP ratio would decline. Conversely, even if receipts respond more to inflation than expenditure, receipts also may respond more than expenditure to the income decline induced by inflation so that fiscal deficit to GDP ratio worsens. On the other hand, when both inflation and growth induce deficit ($(q - a) > 0$ and $(m - c) < 0$), fiscal deficit to GDP ratio would always fall since (7) will always be satisfied. As mentioned above, however, this will not be a justifiable trade-off as other adverse economic consequences associated with inflation and decline in growth would far outweigh the fiscal gain. If growth is also deficit reducing then there might not be any fiscal gain at all, and even if there is, the extent of trade-off which can be obtained from (6) could be so large that it is best avoided.

Section III

Estimates of Structural Parameters

Short-run double log linear functions based on the data on total expenditure (including interest payments) and receipts of central government during 1970-71 to 1997-98 (R.E.) are estimated.

The results which are statistically significant and satisfy the relevant properties are:

$$\log G = \underset{(-2.05)}{-3.86} + \underset{(8.01)}{0.7193} \log G(-1) + \underset{(2.28)}{0.482} \log Y$$

$$+ \underset{(2.30)}{0.249} \log P - \underset{(-2.78)}{0.117} DG$$

$\bar{R}^2 = 0.998$ Durbin's h = -0.55 F- statistics = 3612 (8)

$$\log R = \underset{(-3.66)}{-8.06} + \underset{(4.27)}{0.4756} \log R(-1) + \underset{(3.90)}{0.995} \log Y$$

$$+ \underset{(3.35)}{0.3229} \log P - \underset{(-2.95)}{0.116} DG$$

$\bar{R}^2 = 0.998$ Durbin's h = 0.73 F-statistics = 4052 (9)

where 'G' is total expenditure, 'R' is receipts, 'P' is price (wholesale, average of weeks), 'Y' is real GDP at factor cost, 'DG' is a shift dummy representing the expenditure reduction measures undertaken during the post-reform period of 1991-92 to 1997-98 and 'DR' is dummy to adjust for tax reform measures for the period 1993-94 to 1997-98.

The short-run price elasticity of receipts (0.323) is higher than that of expenditure (0.249). However, the income elasticity of receipts (0.995) is far higher than that of expenditure (0.482). Unlike in the short-run, the long-run price elasticity of expenditure (0.888) is higher than that of receipts (0.616) while the income elasticity of revenue (1.90), like in the short-run, is higher than that of expenditure (1.72). In a single year about 52.0 per cent of the desired adjustment in receipts is achieved while for expenditure it is about 28.0 per cent only. The long-run behaviour probably follow from the nature of budgetary practices where expenditure is first determined by the existing level and the fresh expenditure proposals from each Ministries which, *ceteris paribus,* is sought to be financed by receipts expected from the assumed rate of inflation, GDP growth and net borrowing. Then to keep the net borrowing at a targeted level additional resource mobilization measures are sought.[3]

Therefore, inflation in the long-run would widen fiscal gap while growth would narrow it *i.e.,* there is evidence of inflation induced deficit but no growth induced deficit as pointed out by Jadhav (1994).

The relevant parameters obtained from the estimates in (8) and (9) are: a = 0.249, q = 0.323, c = 0.482, m = 0.995, d = 0.719 and n = 0.476.

By condition (1) when real GDP growth remains the same, inflation can reduce fiscal deficit if $a/q < R(-1)/G(-1)$ which, on substituting the value of parameters, requires $R(-1)/G(-1) > 0.771$. During 1970-71 to 1997-98 R(-1)/G(-1) ranged between 0.56 (in 1986-87) to 0.74 (in 1974-75). In the 1990s, the ratio hovered somewhere around 0.60. Therefore, even though short-run price elasticity of receipts is greater than that of expenditure, inflation would increase expenditure more than it would increase receipts and widen the fiscal gap since expenditure are far larger than receipts. However, by condition (2), fiscal deficit to GDP ratio would fall if $d*g(-1) - n*r(-1) > 0$, which on substituting the relevant values is satisfied in all the years, except in 1973-74, 1977-78, 1987-88 and 1991-92. If the less strict condition *i.e.,* $d*g(-1) - n*r(-1) > (a - q)$ is employed, the ratio would decline in all the years except perhaps 1991-92 when economic reform was initiated.

Table 1 : Value of Relevant Indicators During 1970-71 to 1997-98

(in Rs. crore)

Year	G (1)	R (2)	R/G (3)	d*g(-1) (4)	n*r(-1) (5)	(4)-(5) (6)	m-c+(6) (7)	l-a+(6) (8)	(7)/(8) (9)	ΔP (10)
1970-71	4725	3316	0.70							
1971-72	5722	3996	0.70	0.15	0.10	0.05	0.57	0.13	4.43	0.071
1972-73	6650	4545	0.68	0.12	0.07	0.05	0.56	0.13	4.51	0.097
1973-74	6852	5032	0.73	0.02	0.05	-0.03	0.48	0.04	10.79	0.22
1974-75	8782	6478	0.74	0.20	0.14	0.07	0.58	0.14	4.14	0.29
1975-76	10987	7958	0.72	0.18	0.11	0.07	0.58	0.15	4.01	0.002
1976-77	12400	8618	0.70	0.09	0.04	0.05	0.57	0.13	4.46	0.028
1977-78	13271	9592	0.72	0.05	0.05	0.00	0.51	0.07	7.21	0.044
1978-79	16157	11003	0.68	0.16	0.07	0.09	0.60	0.16	3.74	0.006
1979-80	17453	11061	0.63	0.06	0.00	0.06	0.57	0.13	4.40	0.219
1980-81	20783	12484	0.60	0.14	0.06	0.08	0.59	0.15	3.93	0.217
1981-82	23806	15140	0.64	0.10	0.10	0.00	0.52	0.08	6.68	0.087
1982-83	28134	17507	0.62	0.13	0.07	0.06	0.57	0.13	4.37	0.049
1983-84	32747	19717	0.60	0.12	0.06	0.06	0.57	0.13	4.33	0.075
1984-85	40965	23549	0.57	0.18	0.09	0.09	0.60	0.16	3.71	0.065
1985-86	49901	28044	0.56	0.16	0.09	0.07	0.58	0.14	4.14	0.044
1986-87	59292	32950	0.56	0.14	0.08	0.05	0.57	0.13	4.48	0.058
1987-88	64081	37037	0.58	0.06	0.06	0.00	0.51	0.07	7.01	0.082
1988-89	74514	43592	0.59	0.12	0.08	0.03	0.55	0.11	5.11	0.075
1989-90	87928	52097	0.59	0.13	0.09	0.04	0.55	0.11	4.97	0.074
1990-91	99586	54954	0.55	0.10	0.03	0.07	0.58	0.14	4.07	0.103
1991-92	102356	66031	0.65	0.02	0.10	-0.08	0.44	0.00	-224.41	0.137
1992-93	114301	74128	0.65	0.08	0.06	0.03	0.54	0.10	5.41	0.101
1993-94	135710	75453	0.56	0.13	0.01	0.13	0.64	0.20	3.19	0.084
1994-95	148787	91083	0.61	0.07	0.10	-0.03	0.48	0.04	10.83	0.108
1995-96	170387	110130	0.65	0.10	0.10	0.00	0.52	0.08	6.57	0.077
1996-97	193012	126279	0.65	0.10	0.07	0.03	0.54	0.10	5.40	0.064
1997-98	224859	138514	0.62	0.12	0.05	0.07	0.59	0.15	4.00	0.048

Note: R = revenue, G = expenditure,

ΔP = change in price (WPI average of weeks) and other notations are as defined in the text.

If inflation also has the effect of improving growth as it is assert to be within some threshold, fiscal gap would most likely reduce since $(a + c)/(q + m) = 0.555$, as required by condition (3), is lower than $R(-1)/G(-1)$ in all the years except the crisis year of 1990-91. The fiscal deficit to GDP ratio would also decline since $d*g(-1) - n*r(-1) > 0$ in all but the four years mentioned above. However, with the less strict condition $- d*g(-1) + n*r(-1) < d*g(-1) - n*r(-1) + 0.587$, after substituting the values of elasticity in (4), the ratio would fall even for 1991-92.

However, inflation has hardly been within the suggested threshold level except during the late '70s (Table-1). Therefore, any increase in inflation from the actual during this period would have most likely reduced growth. A widening of the fiscal deficit is more likely to occur when inflation hampers growth since, as estimated, growth impact more on receipts than expenditure. In situations characterised by inflation combined with fall in income, the fiscal deficit would decline if $\{(c - a)/(m - q)\} > R(-1)/G(-1)$ by condition (5), which on the substitution of parametric values yields $0.347 > R(-1)/G(-1)$. Even the lowest $R(-1)/G(-1)$ ratio of 0.56 (in 1986-87) during the period of study was far higher. Therefore, in the Indian context inflation would increase fiscal deficit and cannot substitute decline in growth rate to counteract widening of fiscal deficit. Regardless of rise or fall in fiscal deficit, its ratio to GDP may rise or fall depending upon the change in nominal GDP. Using (7) it would fall if $(m - c)/(q - a) < 1$ which on substituting the values of the parameters give an absurd value $6.93 < 1$. Thus in the Indian context, there is no guarantee that inflation accompanied by decline in real growth would contain fiscal deficit to GDP ratio. Instead it is likely to widen further. However, there may be some inflation rate which more than offsets the decline in income growth and by raising nominal GDP, reduces the ratio of the deficit to GDP. On estimation of (6) i.e., $p/y > [(m - c) + d*g(-1) - n*r(-1)]/[(1-a) + d*g(-1) - n*r(-1)]$ the required rise in inflation is estimated to be 3.19 times (1993-94) to 10.83 times (1994-95) of the fall in real growth. Such a rise besides being impractical is likely to turn out to be self defeating given the evidence that growth decelerates faster at higher rates of inflation (see Kannan and Joshi, 1998).

Section IV

An Assessment

Ceteris Paribus, a higher short-run price elasticity of receipts than expenditure is not a sufficient condition for inflation to be always deficit reducing. For that matter, even when inflation improves growth which induces fiscal surplus *i.e.*, when inflation impacts revenue more than expenditure, the fiscal gap need not narrow if the size of government expenditure exceeds that of revenue significantly. On the other hand, when price induces fiscal surplus and growth induces fiscal deficit and the former is adverse to the latter, rise in inflation would reduce fiscal deficit to GDP ratio. However, it would be nonsensical to trade inflation for growth on the ground of fiscal gains only. In the case of deficit reducing effect of both inflation and growth, with the latter far more pronounced than the former as in the Indian context in the short-run, inflation is likely to worsen the fiscal deficit by impacting adversely on growth.

In the Indian context, inflation induces deficit in the long-run and has the tendency to reduce it in the short-run while growth reduces deficit in both the short and long run. In the more likely situation under which inflation is already high or at threshold levels, a rise in the rate of inflation would enlarge the fiscal gap.

Thus the assertion that when the fiscal deficit goes off-target, the government would be unconcerned with the inflation upsurge, has neither sound theoretical nor empirical basis. Such policy indifference to inflation would not only worsen the fiscal deficit in the long-run but also in the short-run. The policy implication which follow is that when growth suffers for exogenous reasons, discretionary fiscal options should be activated to contain any rise in fiscal gap rather than letting inflation rise. In other words, if the best attainable growth rate of GDP at the optimal level of inflation cannot help achieve the desired fiscal targets, then only deliberate corrections would ensure fiscal stability.

Notes

1. For detailed derivation of this section see Appendix at the end.

2. Since the issue is reduction of fiscal deficit, the derivation of necessary conditions is set in the background of an existing fiscal deficit.

3. In this budgetary process, the size of revenue do not solely determine the size of expenditure. Partly reflecting this, Das and Das (1998) testing for temporal causality between government taxes and spending by applying error correction model find that at the Centre the causality is bi-directional in nominal terms but in real terms the direction is from spending to taxes.

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Appendix

Let the relationship between price and real GDP with expenditure and receipts be represented by double log linear equations written, respectively, as

$$\log G = \log C + d \log G(-1) + a \log P + c \log Y + u \quad \text{and}$$
$$\log R = \log C + n \log R(-1) + q \log P + m \log Y + u$$

where 'G' is total expenditure, 'R' is receipts, 'P' is price (wholesale, average of weeks), 'Y' is real GDP at factor cost, 'C' is a constant, 'u' is error term and (-1) denoting lag for partial adjustment. 'a' and 'q' are price elasticity and 'c' and 'm' are income elasticity of total expenditure and receipts, respectively. 'd' and 'n' determine the speed at which expenditure and receipts adjust to their equilibrium positions.

Differentiating above with respect to time, we get

$$[G - G(-1)]/G(-1) = g = a*p + c*y + d*g(-1) \quad \text{and}$$
$$[R - R(-1)]/R(-1) = r = q*p + m*y + n*r(-1)$$

with the lower case letters denoting rate of change in the respective variables. Finally, the above can be transformed to estimable equations for 'G' and 'R, written as,

$$G = (1 + a*p + c*y + d*g(-1))G(-1) \quad \text{and}$$
$$R = (1 + q*p + m*y + n*r(-1))R(-1)$$

For simplicity and to reduce use of notations, let us assume that initially both inflation and real GDP growth are zero. Then, *ceteris paribus*, expenditure and receipts would change as

$$Gi = [1 + d*g(-1)]*G(-1) \qquad (1)$$
$$Ri = [1 + n*r(-1)]*R(-1) \qquad (2)$$

1. Inflation With No Impact on Growth:

Now, let price increase by 'p' which has no effect on growth. The expenditure and revenue would now write as,

$$Gr = (1 + a*p + d*g(-1))G(-1) \quad (3)$$

and

$$Rr = (1 + q*p + n*r(-1))R(-1) \quad (4)$$

The changes in expenditure and revenue (3) - (1) and (4) - (2), respectively are 'a*p*G(-1)' and 'q*p*R(-1)', and would reduce fiscal deficit if a*p*G(-1) < q*p*R(-1).

$$\text{or, } \frac{a}{q} < \frac{R(-1)}{G(-1)} \quad (5)$$

condition given in (1) in the text.

The corresponding nominal GDP at factor cost are given as, Yi = Y(-1) and Yr = (1 + p)*Y(-1)

$$\text{Defining } \delta G = \frac{Gr}{Yr} - \frac{Gi}{Yi} = \frac{Gr}{(1 + p)*Y(-1)} - \frac{Gi}{Y(-1)} \text{ we get,}$$

$$\delta G = \frac{(Gr - Gi) - p*Gi}{(1 + p)*Y(-1)} \quad (6)$$

From (1) and (3), Gr - Gi = a*p*G(-1) which with the value of Gi in (1) on substitution in (6) gives,

$$\delta G = \frac{p*[a - 1 - d*g(-1)]*G(-1)}{(1 + p)*Y(-1)} \quad (7)$$

Similarly,

$$\delta R = \frac{Rr}{Yr} - \frac{Ri}{Yi} = \frac{p*[q - 1 - n*r(-1)]*R(-1)}{(1 + p)*Y(-1)} \quad (8)$$

Fiscal deficit to GDP ratio would improve if (7) < (8) or, p*[a - 1 - d*g(-1)]*G(-1) - p*[q - 1 - n*r(-1)]*R(-1) < 0, the denominator being the same, which after changing sides and on simplification yields,

$$\frac{R(-1)}{G(-1)} < \frac{1 - a + d*g(-1)}{1 - q + n*r(-1)} \quad (9)$$

Since R(-1)/G(-1) > 0, RHS in (9) must be positive, otherwise there is contradiction. Fiscal deficit imply R(-1)/G(-1) < 1, which imply (9) is necessarily satisfied if,

$$1 < \frac{1 - a + d*g(-1)}{1 - q + n*r(-1)}$$

$$\text{or, } - q + n*r(-1) < - a + d*g(-1) \quad (10)$$

Where q > a, (10) is always satisfied for d*g(-1) - n*r(-1) > 0, the condition given in (2) in the text.

2. Inflation with Positive Impact on Growth :

Let price rise by 'p' improve growth by 'y'. Government expenditure (Gr) and revenue (Rr) would now write as,

$$Gr = [1 + a*p + c*y + d*g(-1)]*G(-1) \quad (11)$$
$$Rr = [1 + q*p + m*y + n*r(-1)]*R(-1) \quad (12)$$

Deducting (1) from (11) and (2) from (12),

$$Gr - Gi = (a*p + c*y)*G(-1) \tag{13}$$
$$Rr - Ri = (q*p + m*y)*R(-1) \tag{14}$$

Fiscal deficit would decline if (13) < (14), i.e.,

$$(a*p + c*y)*G(-1) < (q*p + m*y)*R(-1)$$

$$\text{or, } \frac{p}{y} < \frac{m*R(-1)-c*G(-1)}{a*G(-1)-q*R(-1)} \text{ or, } \frac{y}{p} < \frac{q*R(-1) - a*G(-1)}{c*G(-1) - m*R(-1)} \tag{15}$$

Since both p/y and y/p are > 0, RHS in both the forms of presentation in (15) must be positive, otherwise there is contradiction.

Thus, for p/y < = 1 and y/p < = 1 which combined yield p/y > 0, (15) is always satisfied if

$$1 < \frac{m*R(-1) - c*G(-1)}{a*G(-1) - q*R(-1)} \text{ or, } 1 < \frac{q*R(-1) - a*G(-1)}{c*G(-1) - m*R(-1)}$$

both of which give (a + c)*G(-1) < (m + q)*R(-1)

$$\text{or, } \frac{(a + c)}{(q + m)} < \frac{R(-1)}{G(-1)} \tag{16}$$

the condition given in (3) in the text.

When both 'p' and 'y' rise, the nominal GDP at factor cost would write as,

Yi = Y(-1) and Yr = (1 + p + y)*Y(-1), then

$$\delta G = \frac{Gr}{Yr} - \frac{Gi}{Yi} = \frac{Gr}{(1+p+y)*Y(-1)} - \frac{Gi}{Y(-1)} = \frac{(Gr-Gi)-(p+y)*Gi}{(1+p+y)*Y(-1)} \tag{17}$$

Substituting (13) and putting the value of Gi in (1) in (17), we get,

$$\delta G = \frac{(a*p + c*y)*G(-1) - (p + y)*(1 + d*g(-1))*Gi}{(1 + p + y)*Y(-1)}$$

$$\text{or, } \delta G = \frac{[\{p*(a-1-d*g(-1)\} + y*\{c-1-d*g(-1)\}]*G(-1)}{(1 + p + y)*Y(-1)} \quad (18)$$

Similarly,

$$\delta R = \frac{[\{p*(q-1- n*r(-1)\} + y*\{m-1- n*r(-1)\}]*R(-1)}{(1 + p + y)*Y(-1)} \quad (19)$$

Fiscal deficit to GDP ratio would improve if $\delta G - \delta R < 0$ i.e.,

$$[\{p*(a-1- d*g(-1)\} + y*\{c-1-d*g(-1)\}]*G(-1) - [\{p*(q-1-n*r(-1)\} + y*\{m-1-n*r(-1)\}]*R(-1) < 0$$

since the denominator in (18) and (19) are the same.

Changing sides and eliminating the common factors gives,

$$[\{p*(1-q+n*r(-1)\} - y*\{m-1-n*r(-1)\}]*R(-1) < [\{p*(1-a+d*g(-1)\} - y*\{c-1- d*g(-1)\}]*G(-1)$$

$$\text{or, } \frac{R(-1)}{G(-1)} < \frac{p*(1-a+d*g(-1)) - y*(c-1-d*g(-1))}{p*(1-q+n*r(-1)) - y*(m-1-n*r(-1))} \quad (20)$$

Since $R(-1)/G(-1) > 0$, RHS in (20) must be positive, otherwise there is contradiction. Fiscal deficit imply $R(-1)/G(-1) < 1$, which imply (20) is necessarily satisfied if,

$$1 < \frac{p*(1-a+d*g(-1)) - y*(c-1-d*g(-1))}{p*(1-q+n*r(-1)) - y*(m-1-n*r(-1))}$$

$$\text{or, } \frac{p}{y} < \frac{(m - c + d^*g(-1) - n^*r(-1))}{(a - q - d^*g(-1) + n^*r(-1))} \qquad (21)$$

which is obtained after cross multiplication, collecting terms and simplification.

Since $p/y > 0$, RHS in (21) must be positive, otherwise there is contradiction.

Using the same argument used in deriving (16), for $p/y > 0$ (21) is always satisfied if

$$1 < \frac{(m - c + d^*g(-1) - n^*r(-1))}{(a - q - d^*g(-1) + n^*r(-1))}$$

or, $(a - q - d^*g(-1) + n^*r(-1)) < (m - c + d^*g(-1) - n^*r(-1))$ which on simplification gives,

$$\frac{(a + c - d^*g(-1) + n^*r(-1))}{(q + m + d^*g(-1) - n^*r(-1))} < 1 \qquad (22)$$

the condition given in (4) in the text.

If, $(a + c) < (m + q)$, (22) is always satisfied when $d^*g(-1) - n^*r(-1)) > 0$ since the numerator would always be less than the denominator.

3. Inflation With Negative Impact on Growth

Let price increase by 'p' lead to decline in growth by 'y' then,

$$Gr = [1 + a^*p - c^*y + d^*g(-1)]^*G(-1) \qquad (23)$$
$$Rr = [1 + q^*p - m^*y + n^*r(-1)]^*R(-1) \qquad (24)$$

Deducting (1) from (23) and (2) from (24),

$$Gr - Gi = (a*p - c*y)*G(-1) \quad (25)$$
$$Rr - Gi = (q*p - m*y)R(-1) \quad (26)$$

Fiscal deficit would decline if (25) < (26), i.e.,

$$(a*p - c*y)*G(-1) < (q*p - m*y)*R(-1)$$

$$\text{or, } \frac{p}{y} < \frac{c*G(-1) - m*R(-1)}{a*G(-1) - q*R(-1)} \quad (27)$$

Since p/y > 0, RHS in (27) must be positive, otherwise there is contradiction.

Using the same argument given in deriving (16) for p/y > 0 (27) is always satisfied if,

$$1 < \frac{c*G(-1) - m*R(-1)}{a*G(-1) - q*R(-1)}$$

$$\text{or, } a*G(-1) - q*R(-1) < c*G(-1) - m*R(-1)$$

$$\text{or, } \frac{(c - a)}{(m - q)} > \frac{R(-1)}{G(-1)} > \frac{(a - c)}{(q - m)} \quad (28)$$

which is given at (5) in the text.

The nominal GDP will now write as Yr = (1 + p - y)*Y(-1) and Yi = Y(-1)

$$\delta G = \frac{Gr}{Yr} - \frac{Gi}{Yi} = \frac{Gr}{(1+p-y)*Y(-1)} - \frac{Gi}{Y(-1)} = \frac{(Gr-Gi) - (p-y)*Gi}{(1+p-y)*Y(-1)} \quad (29)$$

Substituting (25) in (29), we get,

$$\delta G \frac{(a*p-c*y)*G(-1) - (p-y)*Gi}{(1 + p - y)*Y(-1)} \quad (30)$$

The numerator in (30) on substituting the value of Gi in (1) is,

(a*p-c*y)*G(-1) - (p-y)*{1+d*g(-1)}*G(-1) which on simplification yields
G(-1)*[p{a-1-d*g(-1)} + y{1-c+d*g(-1)}]

Similarly the numerator for $\delta R = \frac{(q*p-m*y)*R(-1)-(p-y)*Ri}{(1 + p - y)*Y(-1)}$ is obtained as,

R(-1)*[p{q-1-n*r(-1)} + y{1-m+n*r(-1)}]

Since the denominator are the same, fiscal deficit to GDP ratio would decline if,

G(-1)*[p{a-1-d*g(-1)} + y{1-c+d*g(-1)}] - R(-1)*[p{q-1-n*r(-1)} + y{1-m+n*r(-1)}] < 0

or, R(-1)*[p{1-q+n*r(-1)}-y{1-m+n*r(-1)}] < G(-1)*[p{1-a+d*g(-1)}-y{1-c+d*g(-1)}]

$$\text{or, } \frac{R(-1)}{G(-1)} < \frac{p\{1-a+d*g(-1)\} - y\{1-c+d*g(-1)\}}{p\{1-q+n*r(-1)\} - y\{1-m+n*r(-1)\}} \quad (31)$$

R(-1)/G(-1) > 0, therefore, RHS in (31) must be positive, otherwise there is contradiction. Since fiscal deficit implies R(-1)/G(-1) < 1, which means (31) is necessarily satisfied if,

$$1 < \frac{p\{1-a+d*g(-1)\} - y\{1-c+d*g(-1)\}}{p\{1-q+n*r(-1)\} - y\{1-m+n*r(-1)\}}$$

$$\text{or, } \frac{p}{y} < \frac{(c-m) - d*g(-1)+n*r(-1)}{(a-q) - d*g(-1)+n*r(-1)} \tag{32}$$

which is obtained after cross multiplication, collecting terms and simplification.

Since p/y > 0, RHS in (32) must be positive, otherwise there is contradiction.

Using the same argument given above, for p/y > 0, (32) is always satisfied if,

$$1 < \frac{(c-m) - d*g(-1)+n*r(-1)}{(a-q) - d*g(-1)+n*r(-1)}$$

which is given in (6) in the text which on simplification gives,

$$\frac{(m - c)}{(q - a)} < 1 \tag{33}$$

which is given at (7) in the text.

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SPECIAL NOTES

Potential Output and Output Gap : A Review

Kshitija Donde & Mridul Saggar*

'Potential Output' and 'Output Gaps' are often regarded as important variables in the design and conduct of the monetary policy in the short-run. This article provides a brief review of the literature in this area, bringing to fore its policy relevance. Alternative methods of estimating potential output, as also their limitations, are discussed along with an explanation why these different techniques may yield different results. Based on the preliminary empirical results obtained from an ongoing research project on this issue, applications of the HP and the Kalman filters are provided to the Indian data. 'Permanent' and 'cyclical' components in the GDP and the IIP series are obtained using these two alternative detrending procedures. They quite satisfactorily explain the upturns and the downturns in the economy in the period under consideration. Considering the GDP time-series for the period spanning 1950-51 to 2000-01, the potential output for the Indian economy using HP filter is currently placed at 6.3 per cent. The potential output for industry is currently placed higher at around 7.5 percent using either the HP or the Kalman filters. The estimates of output gap for GDP growth in India have ranged in a small band of ±1.3 percentage points after the reforms in 1991, indicating a more stable non-inflationary growth environment. The estimates also show that there has been marked increase in the permanent component of output in the last two decades. The paper argues that it is possible that the potential output be raised further with appropriately induced policy shocks.

This paper, reviews the literature on 'potential output' and 'output gap', as it has evolved in the context of business cycle literature and as it has matured in the context of present debate on instrument rules for the conduct of monetary policy. Section I of this paper defines these concepts and explains their importance for theory and practice of macroeconomic stabilisation. Section II discusses the alternative methods of estimating them, their specific interpretations and their limitations and also why they may yield different estimates. Section III provides empirical estimates for

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India for the Gross Domestic Product (GDP) at factor cost at constant prices and the Index of Industrial Production (IIP) for India using Hodrick-Prescott (HP) for the former and both HP and the Kalman filters for the latter. The results obtained for these two filters for the IIP series are also compared. The section also provides an idea of how the estimates of potential output in various sectors might have changed over the years, bringing to fore the role of policy as well as exogenous shocks in determining not just the output gap, but also potential output. Section IV is by way of conclusion and provides suggestions for further research in this area.

Section I

Theoretical Overview

An assessment of potential output and output gap is of substantial importance in macroeconomic literature. More importantly, these measures are widely used in the design and conduct of monetary policy. Broadly, potential output can be defined as the full-employment level of output. It represents the steady-state level of output associated with the long-run supply curve i.e. the level to which the GDP reverts as the transitory effects of macroeconomic disturbances dissipate (Kuttner, 1994). Potential output represents the permanent component of a time series as distinct from its transitory component. Therefore, in a sense, potential output is one that is not subjected to inflationary disturbances and can, therefore, depend on the Non-accelerating inflation rate of unemployment (NAIRU), depending upon what method is used to estimate potential output. 'Output gap', which represents the deviation of actual output from its potential level is, therefore, of vital importance in the formulation of macroeconomic policies. Macroeconomic policies generally try to influence the level of the output gap in some manner. In particular, the monetary and the fiscal policies affect actual output, while the structural policies affect the potential output.

The measures of output gap are often used in the estimation of gap models. There is considerable evidence from the industrial countries that output gap is an important determinant of inflation. It is generally accepted that inflation is closely related to the pace of economic activity. The change in inflation rate is related to the level of the output gap. Thus, inflation will generally tend to rise if the gap is positive and vice-versa. This phenomenon is termed as the *overheating of the economy*. In these economies, the measures of potential output and output gap are often used in studies about the leading indicators of inflation. These models are popularly known as 'gap models' in economic literature.

Apart from their noted use in the gap models, the measures of output gap are also used in the estimation of the short-run Phillips curve or the expectations-augmented Phillips curve. In this context, the policy makers became interested in the various measures of the output gap since the 1960s with the introduction of the short-run Phillips curve in economic literature. With the arrival of the rational expectations school, the efficacy of the anticipated monetary policy was strongly questioned. According to this school of thought, only the unanticipated changes in the monetary policy have real effects on the system. The short-run Phillips curve essentially traces this relationship between unanticipated inflation and the output gap. Inflation above the anticipated level will essentially raise the real output above its potential or the trend level. This relationship has been extensively exploited for a long time by the central banks all over the world since then.

However, of late the role of the monetary policy in effecting even short-run changes in the real output in case of the developed economies has been strongly questioned. As a consequence, in these economies, price stability has become the single-most important objective of the monetary policy. But the central banks in the developing economies often confront a different situation. The information asymmetry and the structural rigidities present in these economies leave considerable scope for manoeuvering the monetary policy stance to impact the real economy. On account of the peculiar structural features of these economies, not only the unanticipated, but also the anticipated policy has significant real effects. In this regard, the estimates of the output gap assume great importance for the policy makers as it tells them about the cyclical pattern of output. However, the design and the conduct of the monetary policy cannot be undertaken in a mechanical fashion tying instruments to rules based on output gap. There is far too much uncertainty about the estimates in the first place and about the lags in monetary policy in the second. A meaningful application of monetary policy instrument rules, such as the Taylor rule is therefore not possible in practice. Nevertheless, estimates of potential output and output gap, when taken along with several other indicators provide useful information for altering policy stance.

Although, the literature on the policy-effectiveness proposition suggested shocking the nominal variables in order to effect a change in the real variables, it seemed quite an unreasonable idea to implement in practice. In the mean time new literature emerged wherein the idea about pursuing a monetary policy based on the 'rules approach' was strongly advocated. The principal economic argument for the 'rules' based policy comes from the analysis of strategic behaviour. It is a general proposition that a player in a game has much to gain from his ability to commit in advance. Kydland and Prescott (1977), Barro and Gordon (1983) and others applied this principle to monetary policy. They pointed out that if only the surprise elements in monetary policy raise output, then the government could try to create a new surprise each year. But the public will be able to see what the government is doing. As a result, in the long run these surprises will lead to higher expected inflation and higher actual inflation, but not actual output. By committing to a particular target in advance the government can lower expected inflation and achieve a better performance. Among the rules based approaches, one of the important approaches is the one based on nominal income targeting. According to this view, the focus of the monetary policy is to keep the nominal income on a smooth path. To this end, this policy attempts at minimizing the variance of the nominal GDP around a trend. Thus, the estimates of potential output are widely used in this context too. Estimates of potential output and output gap are thus widely used for operational policy purposes.

Section II

Methods of Estimating the Output Gap

The output gap as explained above is the difference between actual and potential output:

$$Gap_t = y_t - y^T_t$$

Where *gap* is the output gap, y is output and y^T is potential output. In this form, a positive number for the gap indicates excess demand and a negative number indicates greater capacity. The output gap represents transitory movements from potential output. Given that potential output is not observed, it has to be estimated.[1]

A large number of different approaches have been adopted in the literature to measure potential output and output gap. A brief overview of these approaches is provided below:

II.1 The Production Function Approach

The estimates of potential output from the production function approach are often used for growth accounting purposes. This method provides estimates of potential output as that which would be obtained if all the factors of production were fully employed in the sense that NAIRU prevails in the economy. An alternative measure can be obtained by measuring the slack in employment on the basis of the estimate for non-accelerating wage rate of unemployment (NAWRU). The approach attempts to explain the growth in output in terms of the contribution made by the individual factors of production as well as the Total Factor Productivity (TFP). The TFP in this case is derived by smoothening the residuals after subtracting the contributions of inputs. Potential output is modelled to depend on trend labour input and not on labour input in itself. The trend labour force is seen as dependent on labour force, participation rate and the NAIRU. Production function approach using the conventional

Cobb-Douglas production function was applied by Giorno, *et al.* (1995). More recently, Thomas (1999) employed the production function approach to OECD countries. Production function approach in contrast to detrending methods, provide useful information on sources of changes in potential output. However, the limitation is that estimating the production frontier at the macro-level is often not very advantageous on account of high degree of aggregation of the data and also its poor quality. It is almost impossible to capture the qualitative differences in inputs in economy-wide data. The estimates critically hinge on the estimates of NAIRU. End-sample biases are large in case of this technique, In a way, production function approach may also depend on some detrending of the variables that explain changes in potential output. Furthermore, large errors in estimating the input use, generally affects the reliability of estimates of output gap limiting its usefulness for policy purposes.

In view of the limitations cited above, pure time series detrending approaches have become more popular for the estimation of potential output. They attempt at estimating the 'permanent' and the 'cyclical' components in the output series. The estimates obtained using these approaches do not convey much as regards the 'potential' of the economy in terms of maximum feasible output, but is merely an *ex-post* analysis to data using certain detrending procedures. Estimates of potential output using detrending procedure measure the trend output that would prevail in absence of cyclical influences. Therefore, they could be very different from those obtained using production functions. It is for this reason that the estimates obtained from the pure time series detrending procedure are often used for operational policy purposes eg. relating the cyclical component of output to other macro-economic variables like money supply, inflation rate, etc. On account of the problems with the production frontier method discussed above and since the purpose of the study from the monetary policy viewpoint is not growth accounting but macro-economic stabilisation, we later make use of the detrending filters to provide illustrative estimates of potential output and output gap for India.

II.2 Linear Trend Method

The linear trend method, though archaic, is the easiest method to calculate potential output or the output gap. It involves a simple linear trend estimation through a regression using ordinary least square (OLS) technique. Deviations from the trend imply output gap for this simple method. The results are hyper-sensitive to sample selections because of the end-sample biases. For example, if the regression estimate begins say at the peak of the boom and ends at a deep recession, the regression slope would be under-estimated. Since one can never be sure as to at which point the economy was in balance, there would be considerable uncertainty about estimates of output gaps. Detrending methods seek to measure potential output, whereas linear trend method would require its prior knowledge if we are to be sure that end periods are not influenced by cycles. Yet another problem with linear trend is that output time series are stochastic and even when linear trend is removed, the residual series is still non-stationary. The output series in this sense will not be mean reverting and suffer from large persistence. There has been some evidence that output series may be fractionally integrated with sum of autocorrelation coefficients summing to unity, in which case too linear trend method would yield spurious cycles.

II.3 The Hodrick-Prescott (HP) Filter

Traditionally, economists used deterministic trend filters such as the linear trend method discussed above or the quadratic trend models for measuring the trend output. There were several problems with the traditional approach to detrending the data. The most important among them was the assumption made by these models about the deterministic nature of the trend. In the 1980s path-breaking work by Nelson and Plosser (1982) revealed that most macroeconomic variables exhibit a stochastic trend and are essentially random walks. Thus, if the output is integrated of order one i.e., it follows a stochastic trend, then the residual from removing the deterministic trend is still non-stationary. This would violate the usual assumption that the output-gap is a mean-reverting variable. Around the same time, the HP filter was developed and presented in a working paper published in 1981, but the method did not quite get the warranted attention till it was published formally over a decade later. Therein, Hodrick and Prescott (1993) provided a formal documentation of the method to features of aggregate economic fluctuations or business cycles for the United States.

The HP filter is basically a moving average approach. It uses a running window on the data in order to smoothen it. The advantage of the HP filter over the simple linear filter is that it renders output gap stationary over a wide range of smoothing values and that it allows the trend to change over time.

The Hodrick Prescott (HP) filter sets the potential component of output to minimize the loss function L,

$$L = \sum_{t=1}^{s} \left(y_t - y_t^T\right)^2 + \lambda \sum_{t=2}^{s-1} \left(\Delta y_{t+1}^T - \Delta y_t^T\right)^2$$

where subscript t denotes the time, superscript s denotes the sample size, y is the actual output, y^T is the trend output, λ is the smoothing parameter and Δ denotes the first difference. The first term penalizes the bad fitting, while the second term penalizes the lack of smoothness. The smoothness parameter λ regulates the trade-off between these two terms. For $\lambda = 0$, the best fit is obtained, while for $\lambda = \infty$, the plot becomes a deterministic linear trend. The minimi-zation is done subject to the constraint that the two decomposed terms add up to the original time series. The HP filter is a linear filter. The HP filtering to obtain cyclical component is typically done to time series that is deseasonalised using X11 or X12 methods.

HP filters suffer from two major deficiencies.[2] The first is the somewhat arbitrary smoothing parameter. Typically, λ is set to 100 for annual time series, while a λ-value of 1600 has been advocated for monthly and quarterly time series. In our applications of the HP filter later in this paper we employ these values. As stated above, λ is the smoothing parameter. However.

the validity of these parameters critically hinge on the length of business cycles.[3] Changing the value of λ affects how responsive potential output is to movements in actual output. Therefore, a practical way of obviating this problem is to see the sensitivity of the results to a relatively wide range of λs and check the time series and economic properties of the decomposed series. The second deficiency relates to the sensitivity of the estimates to the sample selection, as the results suffer from end-sample biases. Again, it would be a useful practical strategy to check the estimates of potential output for different sample periods and to avoid choice of sample period that begins or ends at a time when business cycle is at peak or trough or large positive or negative output gaps are perceived. The problem is that empirically one cannot know whether the output gap is large or not at the end points unless we know the estimates of potential output, whereas limiting the uncertainty about the estimate of the latter critically hinges on the end-period output gap. Therefore, it becomes a kind of a chicken and egg problem when one sets out using the HP filter. The multivariate versions of HP filters or the modifications to the univariate version of the original HP filter have been tried to overcome some of the associated difficulties with the HP filter.

II.4 The Unobserved Components Method Using Beveridge Nelson Decomposition

A major difficulty in estimating potential output is that it is unobservable or relates to other macroeconomic unobservable variables like the NAIRU or NAWRU that are also unobservable. This difficulty led to the development of unobserved components methods which seek to exploit information from other observable variables. For this, state space system is specified making observed variables a function of unobserved state variables. Beveridge-Nelson decomposition or the Kalman filters are popularly used to handle this.

Theoretically, Beveridge-Nelson (1981) considered a time series as an ARIMA (p,d,q) model comprising of a deterministic trend, stochastic trend and a cyclical component and provided a general procedure for the decomposition of a non-stationary time series.

The permanent component of output is viewed as a sum of a deterministic component and a stochastic trend component and is therefore, stochastic in nature. It is a random walk with a drift. They define the permanent component as the sum of current information and all that can be forecasted about future changes which can be culled out from the past profile of changes in output movement. The transitory or the cyclical component is a stationary process with mean zero. The empirical results obtained from Beveridge-Nelson decomposition crucially depends on the Box-Jenkins identification of an ARIMA (p,d,q) model for estimating permanent and transitory components of output series. For identification, autocorrelation and partial autocorrelation functions of first differenced data series are examined and a suitable model is chosen using the model selection criterion including Akaike and Schwartz-Bayes information criterion. Yet another limitation of the Beveridge-Nelson model is that shocks to cyclical and stochastic components are correlated.

II.5 The Unobserved Component Method Using Kalman Filters

As stated earlier, the HP filter is often criticized on the ground that it fails to take into account the structural changes in the data. Kalman filter tries to resolve this problem associated with the HP filter. The Kalman Filter is a recursive method, where each observation on permanent output is forecasted first on the basis of the past values of the data series. This forecasted observation on permanent output is further updated as new data on the measured output arrives. Thus given a structural change in the data, the forecast error would become very large, and in an attempt at minimizing the forecast error the earlier forecasted value of permanent output will be so corrected to account for any structural change present in the data.

Later in this paper, we obtain the permanent and the transitory components represented as unobservable components model and estimated by using the Kalman filter. Following Brouwer (1998), in that unobservable components model, we observe the actual income y_t which is assumed to consist of an unobserved permanent component π_t plus a white noise error ξ_t

$Y_t = \pi_t + \xi_t$

The Kalman filter provides an optimal updating scheme for the unobservable π_t based on the information about measured income as it sequentially becomes available. With this interpretation, the unobservable components model provides a method of generating an expectations series for the permanent income π_t.

The unobserved components models discussed above are 'non-standard', that is one cannot apply least - squares procedures directly in estimating the parameters of these equations. However, each of the above models can be 'rewritten' in terms of two distinct types of equations (called the *measurement* and the *transition* equaticns) which together are called the *state-space* form. The Kalman filter can be applied to the set of state-space form equations to yield a set of recursive equations; which are then used to generate a series for v_t i.e. one step - ahead prediction errors and its variance which will contain the unknown parameter to be estimated. Subsequently, standard maximum likelihood procedures are used to estimate the unknown parameters. The Kalman filter is based on the Bayes theorem. Bayes theorem allows one to combine prior information with data to yield an optimum posterior estimator.

In a way the Kalman filter mimicks a learning process. It may be interpreted as a form of adaptive expectations where the adjustment parameter is updated each period, based on new information.

The methodology of the Kalman filter is discussed in greater detail in the appendix. In our application of the filter for estimating the potential or the permanent output, we use the monthly data. This exercise cannot be performed with the annual data on account of insufficient observations.

II.6 The Band-Pass (BP) Filters

BP filters have recently gained popularity after Baxter and King (1995) developed approximate band-pass-filters that are generally considered optimal. BP filters have a series of properties that make their use attractive for applications to business cycles. They extract specified range of periodicity, leaving the properties of the extracted components unaffected and they avoid phase shifts. Its application yields a stationary time series and eliminates any quadratic trends from the series. Through a specified loss function it provides an optimal approximation of the series. The method yields business cycle component by eliminating a slow moving trend component and very high frequency irregular components. The BP filter uses the low-pass filter, such as the HP, to construct a band-pass filter. The filter knocks out the frequencies that lie outside the band of interest, rather than knocking out the low or the high frequencies alone. The BP filter exploits both the frequency domain and time domain techniques.[4]

II.7 The Macro-modelling Approach

Potential output has also been estimated through development of a full-scale macroeconometric model or smaller models that provides a system of equations in which simultaneous equations for at least goods market, labour market and prices are used to provide estimates of NAIRU or the potential output. Adams and Coe (1990) developed one such model and estimate it as a 3SLS model. Kuttner (1994) specified a bivariate model of output and inflation and derive output gap through common cycles with inflation. Apel and Jansson (1997) model a Phillips curve and an Okun Laws relationship and generate both the potential output and NAIRU using this specification.

II.8 The Structural Vector Autoregression (SVAR) Approach

SVAR models have alternatively been used as a meaningful method of providing estimates of potential output. Following Blanchard and Quah (1989), these models have effectively captured both the supply side and demand side disturbances. The supply side disturbances are generally assumed to have a permanent impact on output, while the demand side shocks translate into transitory or cyclical movements (Cerra and Saxena, 2000). The

SVAR framework also enables us to trace the impact of nominal shocks, such as those in prices, exchange rates and interest rates on permanent and transitory components of output. Compared with pure detrending techniques, SVAR enables us to impose explicit long-run restrictions that lay down a theoretical basis for the estimates. In practice, these restrictions are less restrictive than those imposed in detrending techniques where the permanent output is constrained to a random walk.

Several other methods have also been tried in the literature. The Running Median Smoothing (RMS) (Tukey, 1977) and the wavelets filter (Donoho and Johnstone, 1992) are among those which have received some recent attention. Scacciavillani and Swagel (1999) may be cited as an example of their application to Israel. They find that empirical results are highly sensitive to the choice of filters, but argue for use of RMS on grounds of their statistical superiority.

Section III

Empirical Estimates of the Potential Output & Output Gap for the Indian Economy

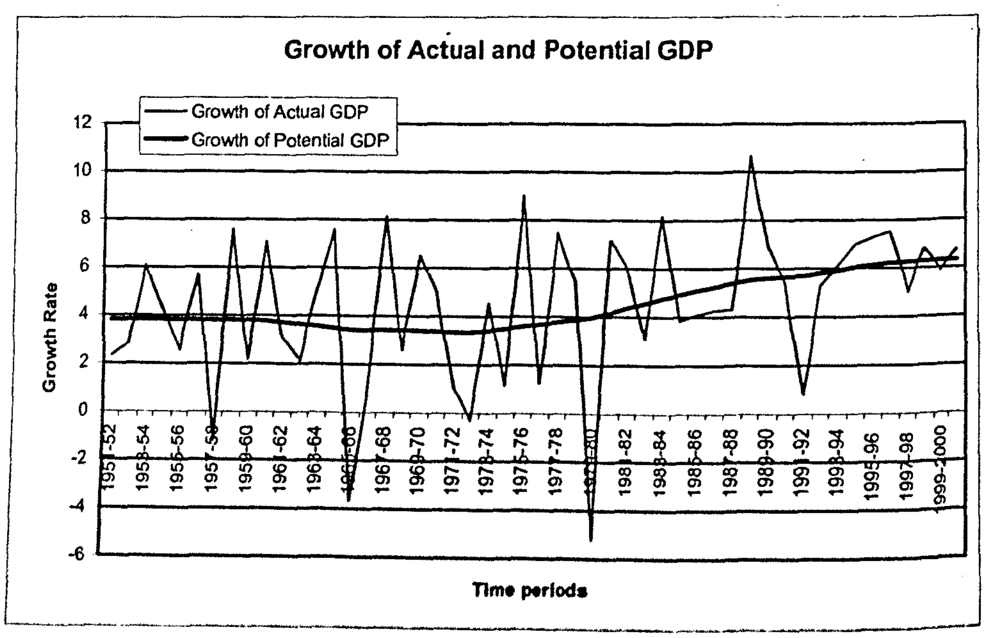
In this section we provide an illustrative application of two of the filters - HP and Kalman - to the Indian economy. These preliminary results are obtained from an ongoing project on this issue which is examining various aspects of business cycle fluctuations in the Indian context with a view to obtaining reliable estimates of output gaps that can be considered for monetary policy reaction either through instrument linked rules or otherwise through some discretion. The HP filter is applied to the annual data for the real GDP at factor cost for the period 1950-51 to 2000-01. For the terminal year the GDP growth is anticipated at 6.75 per cent.[5] The HP filter is also applied to the index of industrial production for a monthly frequency covering the period 1982:4 to 2000:3 and the results of this moving average approach are compared with that obtained from the time-varying parameters approach using Kalman filter for this series.

The time series for GDP as well as IIP were obtained by appropriately splicing these data series for different base. In order to tackle the presence of strong seasonality in these data series, X-11 method was used to obtain seasonal components and to do away with the element of seasonality in the data. The deseasonalised series was used to obtain the empirical estimates.

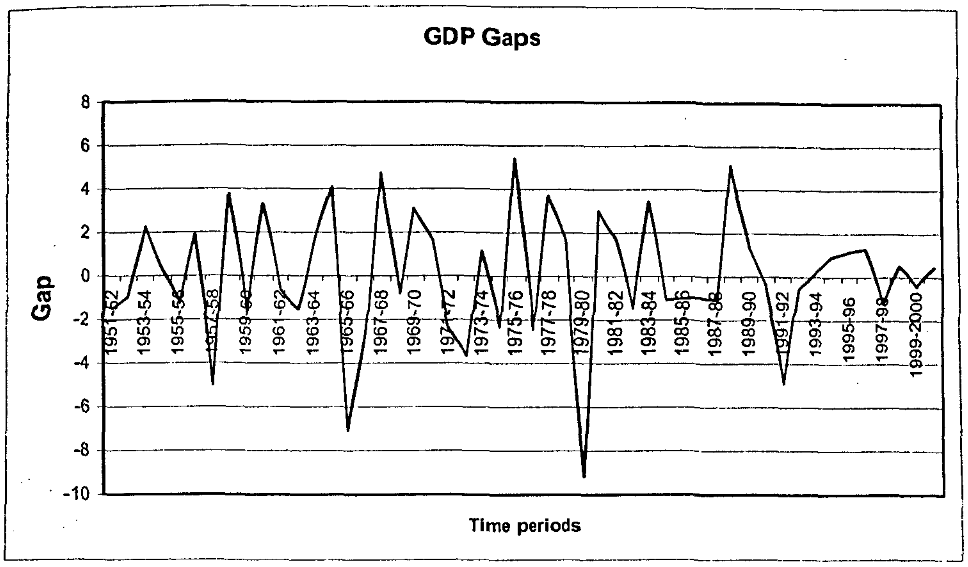
III.1 The HP Filter Applied to GDP

The estimates of potential output derived from the HP trend using the monthly as well as the annual data are presented in Graph-1 below. The results reported are for λ value of 100 in case of the annual and 1600 in case of the monthly data, but are not very sensitive to alternative values attempted for a very wide range of λ. Therefore, we report results for the typical values of the smoothing parameters as suggested by Kydland and Prescott (1990). Although, these values were initially suggested in context of the United States data, they have now largely become the norm for other countries as well as they conform to the generally accepted length of a cycle ranging from 2 to 8 years.

GRAPH-1:



GRAPH-2:

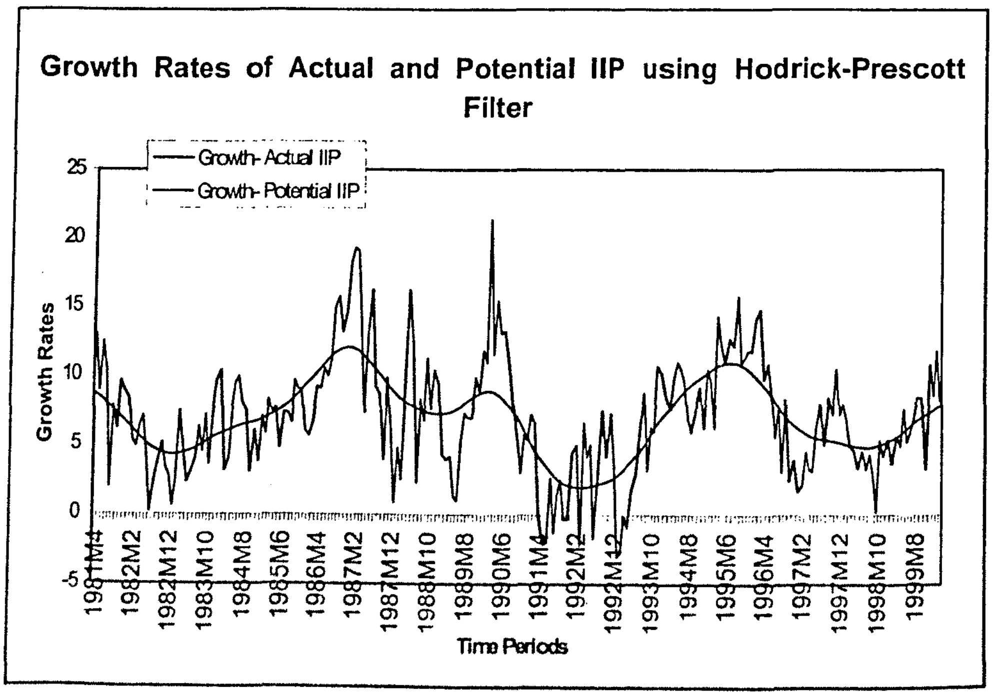


Estimates of the potential output for GDP show that potential output that ranged between 3.3-4.0 per cent during the first three decades of planning, began to improve subsequently (Graph-1). It crossed the 5.0 per cent mark in the mid-1980s and 6.0 per cent mark in the mid-1990s registering a sustained increase in the permanent component of the output over last two decades. The clear stagnation in overall trend output in the period 1950-51 to 1979-80 may have been due to lack of technology breakthrough in agriculture before the mid-sixties and the industrial stagnation thereafter. Large output gaps were observed on several occasions prior to reforms initiated in mid-1991 (Graph-2). Actual growth rate exceeded potential growth rate by over 3-percentage points on 10 occasions, while it fell below the potential by over 3-percentage points on four occasions. No such transitory swings are observed in the post-reform period when the output gaps have been contained within ±1.3 percentage points. This reflects a more stable non-inflationary growth environment after the reforms. The potential GDP growth is currently placed at 6.3 per cent with a moderate output gap of 0.4 per cent.

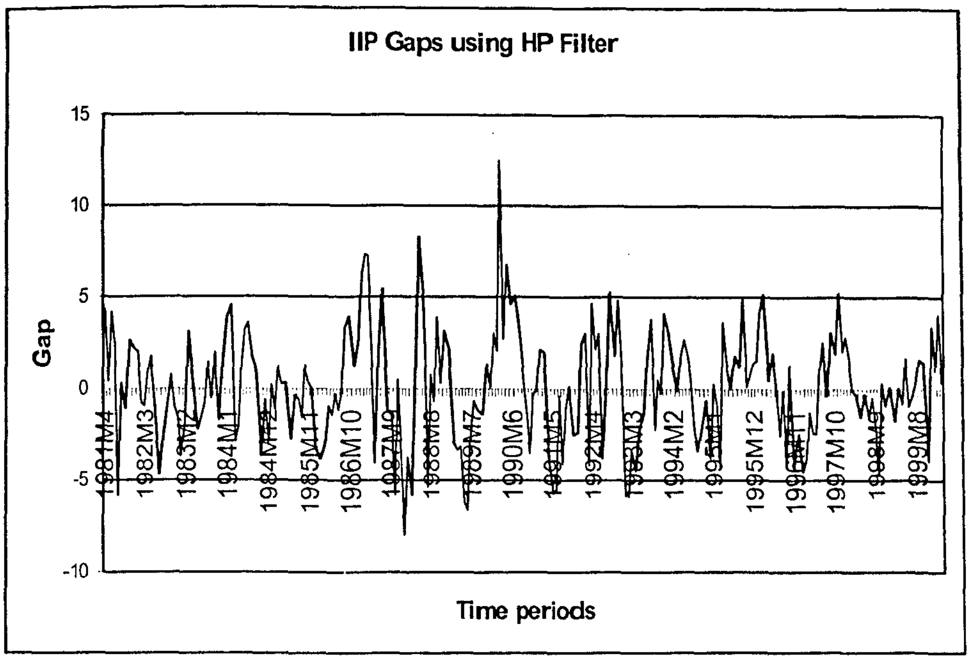
III.2 The HP & the Kalman Filters Applied to IIP

Applying HP technique to a monthly frequency to IIP series for the period 1982:4 to 2000:3 show that the potential growth of industry declined from a high rate of around 8.0 per cent in the early 1980s to 4.0-5.0 per cent during 1982:7 to 1983:8 before recuperating and surpassing the earlier rate, touching a peak of 12.0 per cent in December 1986 and January 1987 (Graph-3). It declined, thereafter and stayed in a 7.0-9.0 per cent band during 1988:1-1990:9 but dropped sharply to about 2.0-3.0 per cent in the wake of policy shocks such as credit compression that were necessary to combat the balance of payment crisis of the mid-1991.[6] The potential output recovered subsequently and was back in 7.0-9.0 per cent range during 1994. It exceeded 10.0 per cent in 1995 before declining again to below 6.0 per cent between 1997:2 to 1999:5. The potential output is currently back at around 7.5 per cent with a moderate positive output gap (Graph-4).

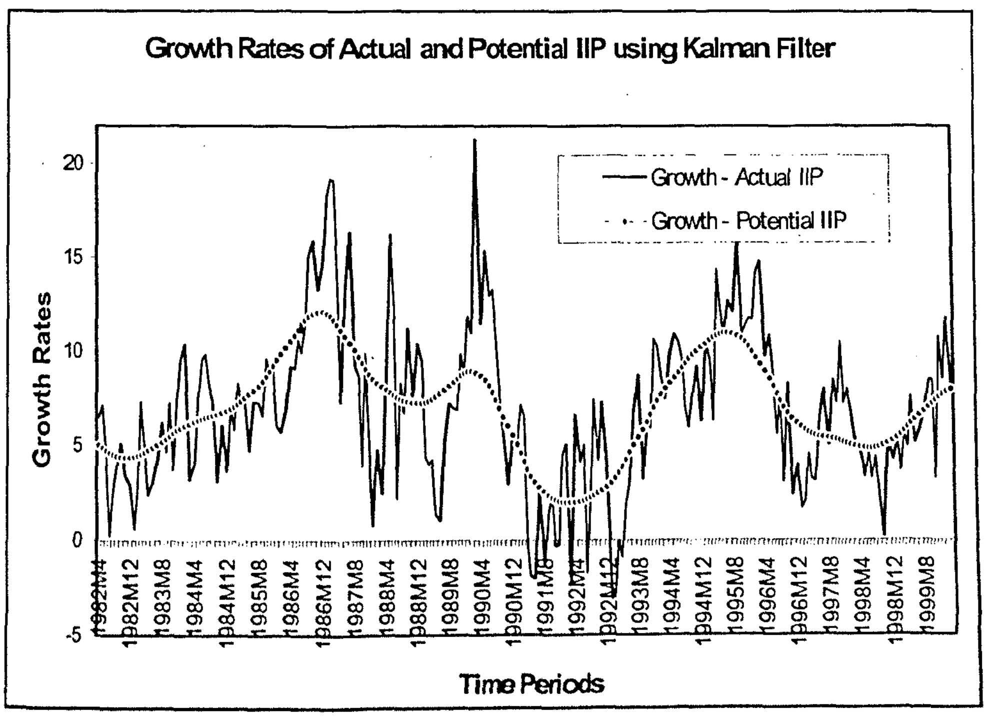
GRAPH-3:



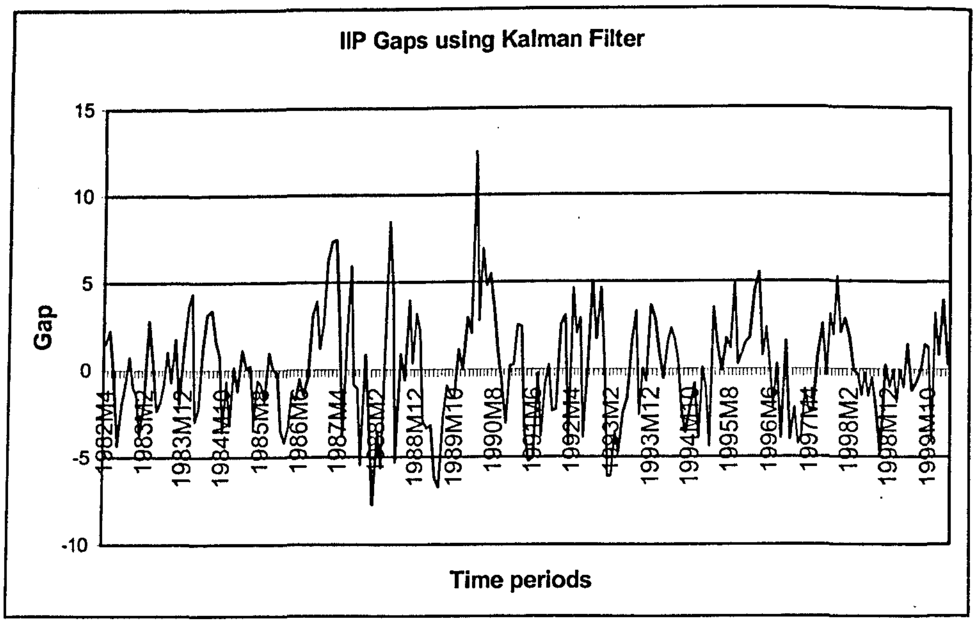
GRAPH-4:



GRAPH5:



GRAPH-6:



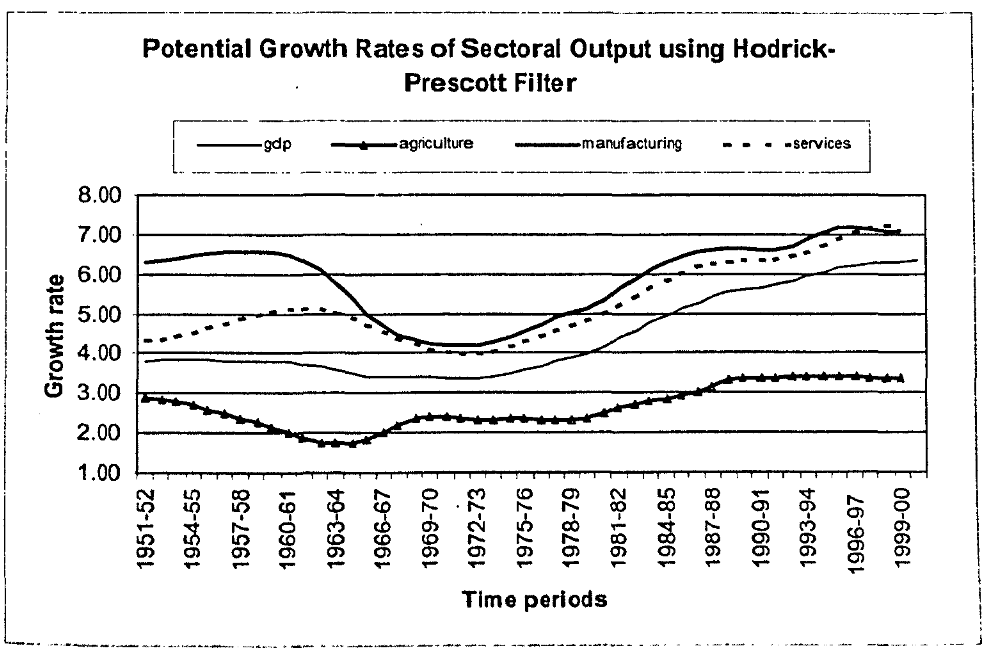
The output gap results from the Kalman filter are not very different from that from the HP filter, though there are some periods of small systematic differences. The estimates of Kalman filter are provided in Graphs-5 & 6.

III.3 Structural Transformation and Potential Output

It is not often realized that the permanent component of output does not in any way imply a zero or even a static rate of growth. The permanent component is merely that part of an output which in a given year is arid of cyclical influences. In effect while monetary policy primarily seeks to be countercyclical, empirical evidence above suggests that it can have pronounced effect on potential output itself. Furthermore, other policy shocks and exogenous events also have a role to play in determining the potential output. This is partly the result of the filtering process that involves updation through first differences or in some other recursive manner and partly the effect of the short-run influences on the long-run trend component. As a consequence, we found substantial changes in potential output itself for the GDP as also for the IIP.

Using annual GDP data with its sectoral components, we find considerable shifts in potential output that are considerably reflected in the structural transformation of the Indian economy (Graph-7). Potential output for the agriculture sector hovered at around 2.8 per cent in the early 1950s, but dropped to below 2.0 per cent in the first half of the 1960s. Following the introduction of the new technology the potential output for agriculture increased at a slow rate and touched 3.0 per cent by the mid-1980s, improving further to 3.4 per cent by the end of that decade. Saggar and Raghavn (1989) state that the growth after the introduction of new technology came primarily from yield improvement, while area under cultivation stagnated. They also argue that the impressive improvement in agriculture output during the 1980s was substantially the result of technological and institutional support to rice production in the Eastern India. It appears that the potential output improvement in the agricultural sector at least in part may be due to technology shocks aided by institutional support.

GRAPH-7:



The potential output in industry improved from 6.3 per cent at the start of the planning era in 1951-52 to 6.7 per cent by the end of that decade, but declined thereafter falling to below 5.0 per cent during 1966-67 to 1976-77. The decline of potential output in industry may have been due to a combination of factors. Nayyar (1978) argued that demand factors had a large role to play in the sluggishness of industrial output. Rangarajan (1982) is of the view that during this period one could easily identify six or seven years where deceleration can be traced to supply side bottlenecks. Pattanaik and Rao (1977) traced the decline to fiscal shock of decline in public expenditure. Shetty (1978) argued that structural deterioration had set in the economy that also resulted in decline in industry. The results using HP filter show that the decline had occurred not just in growth of actual industrial output, but also of potential industrial output. Therefore, demand factors are less likely to have been responsible for the industrial stagnation of the mid-1960s. Structural or supply side factors could have caused a decline in potential output. Potential output of industry has recovered substantially after mid-1970s and has remained above 6.5 per cent after the mid-1980s and is currently placed at 6.8 per cent in terms of GDP originating from industry. Based on monthly IIP series, it is currently placed still higher at around 7.5 per cent. The improvement in potential output has mainly been led by significant growth in potential output of services sector. After stagnating at slightly above 4.0 per cent for the most part till 1980, potential growth rate for GDP from services sector improved through the last two decades and is currently placed at 7.2 per cent higher than the 6.8 per cent potential industrial growth rate.

The sectoral developments have also influenced output gaps. Starting with the years 1970-71 and 1971-72, the positive output gap is mainly attributed to the advances made in the agricultural sector in the period following the green revolution. During this period, there was a rapid increase in the agricultural production to the tune of nearly 35 per cent in a span of 3-4 years. The output remained around 0.23 per cent above potential during this period. However, a downswing seems to have begun following 1972-73. This downswing lasted for a period of 3-4 years. During this period the output decelerated to 0.22 per cent below potential. A number of factors accounted for the deceleration in output. There was nearly an 8 per cent drop in the agricultural output in the year 1972-73. Besides, the war of 1970-71 caused a manifold increase the current expenditure of the government. In order, to curb the burgeoning fiscal deficit, the capital expenditure of the government had to be severely curbed. The oil price shock of 1974 seems to have further aggravated the problem. All these factors put together could be held together for the downswing (Joshi and Little; 1994, 1996). Following 1979-80, once again, the output slipped below potential. This period is marked by both internal and external shocks. The drought of 1979 was the worst since independence. The external shock came in the form of an oil price hike. As a result the terms of trade deteriorated by about 33 per cent during 1979 and 1980. Besides, there was an accompanying world recession that kept the exports sluggish. During this period not only did the capital expenditures of the government remain low, but the increasing fiscal deficits also crowded out the private sector investment. Besides these, the economy was plagued with a range of structural bottlenecks during this period. There was an inadequate supply of coal and also a decline in its quality. The shortage in coal and the water supplies (due to the drought) led to a drop in the power supplies. All of the above factors gave rise to recessionary tendencies in the manufacturing industry. The output remained about 0.15 per cent below potential.

The economy recovered marginally during the mid-1980s. On account of the increase in the export incentives and the depreciation in the real exchange rate by about 30 per cent between 1985-86 to 1989-90, the exports seem to have done quite well during this period. The dollar value of the exports increased by about 14 per cent a year. The volume of exports grew by about 12 per cent. Despite the good performance, the output still remained around 0.04 per cent below potential.

India slipped into another crisis in the year 1991 following the Gulf war. Fiscal profligacy of the 1980s may have been largely responsible for the adverse absorption impact. The government finances worsened; as a result there was a heavy reliance on both domestic as well as external debt. This worsened the current account deficit and even a temporary shock like the Gulf war was enough to trigger a full-scale crisis. As a result of the 1991 shock a massive program of fiscal retrenchment and a credit squeeze were undertaken. A two-step 19 per cent devaluation of the rupee exchange rate with the US dollar was effected in mid-1991. Both, the agricultural and the manufacturing output declined during this period. Agricultural output declined on account of the erratic weather, while the industrial sector suffered because of the agricultural setback, severe import controls, credit compression and the fiscal contraction.

However, the economy recovered remarkably since 1993-94. This recovery is mainly attributed to the range of reforms and reconstruction measures undertaken in the years following the 1991 crisis that may have had a pronounced impact on potential output as well as output gap. The recover seems to have taken place mainly on account of an increase in exports, a decline in tariffs on capital goods, a fall in corporate taxes and a favourable climate for investment that was generated by a host of policy measures.

Section IV

Conclusion

This paper attempted to review alternative techniques for estimating potential output and output gap and provide illustrative application for India using the HP filter to GDP and the IIP. In addition, Kalman filter was applied to the IIP time series. The results obtained by us by and large satisfactorily explain the upswings and the downswings in the economy in the period under consideration. However, it may be mentioned that the results need to be interpreted with considerable caution. First, it needs to be recognised that the estimates of potential output do not in any way tell about the production possibility curve facing the Indian economy in the sense that the estimates do not reflect the maximum feasible output with full employment. We have not imposed the NAIRU concept anywhere in our methods, which are merely based on detrending procedure and in that sense reflects a smoothening that yields a time series that is rid of cyclical influences. There are reasons to believe that if the current structural changes and reforms are pushed further, these policy shocks could take the potential growth rate of the Indian economy to 8-10 per cent mark in near future as against the current estimate of potential growth rate of 6.3 per cent. Second, it should be recognised that business cycle conditions differ in developing countries than in developed countries. Agenor, et. al., (1999) strongly argue that though the techniques could be applied at sectoral levels, the transitory component of agricultural output in the context of developing countries can not be interpreted as representing business cycles. We, therefore, do not place much credibility on estimates of output gap as may be obtained using HP filter in the Indian context. Taylor (1994) and Coe and McDermott (1996) provide further evidence on the limitations with which gap model might be working in Asia. Roldos (1997) also allude to the different nature of cycles in the developing countries. Third, it may be added that even in the context of developed countries it has been questioned whether transitory deviations from trend or the NAIRU represents business cycle components (Cambell and Mankiw, 1987a,b).[7] It need to be recognised that indicators of aggregate capacity utilisation such as the NAIRU or the output gap are measured with considerable margins of uncertainty (Smets, 1998; Taylor, 1999). We found that different techniques used in the literature yield different estimates that often need to be interpreted differently. In view of this their use in monetary policy formulation has to recognise the underlying uncertainty. Instrument rules, such as the Taylor rule, using output gap measures or nominal income targetting through the McCallum rule are unlikely to work in practice and considerable discretion may be necessary. We, therefore, suggest that measures of potential output and output gaps should be used as an indicator along with other indicators while framing monetary policies. In view of the methodological limitations explained above, further research would be necessary to obtain more reliable estimates of output gaps for practical policy use.

Appendix

Given below is an intuitive account of the Kalman filter. Consider an agent who has sequential observations on his measured income y_t which he views as consisting of an *unobserved* permanent component π_t and a zero mean (unobserved) 'surprise' element s_t. The agent has an initial or prior estimate of π_0 and wishes to update this estimate, as the information on measured income becomes available.

The agent here faces a signal extraction problem. Given a change in the measured income he has to allocate a part of the income to permanent income and a part to transitory income. Clearly to solve this problem the agent must have some view or model of how permanent income varies over time. For expositional reasons we assume that the *transition equation* describing the evolution of π_t is a random walk with a drift. Our final assumption is that the agent perceives that a fraction k_t of the surprise st in measured income, as permanent income and $(1-k_t)s_t$ is considered to be an addition to transitory income. The coefficient k_t varies through time and for the moment we assume the value of k_t to be known by the agent. The Kalman filter provides a method of estimating and optimally updating k_t.

Let us now consider the model assumed by the agent
The measurement equation is:

$$Y_t = \pi_t + (1-k_t)s_t \qquad \text{....(1)}$$

The transition equation is:

$$\pi_t = g + \pi_{t-1} + k_t s_t \qquad \text{....(2)}$$

with

$$E_{t-1}s_t = s^e_t|_{t-1} = 0;$$

$$E(\pi_t s_{t-j}) = 0 \ (j = 0, \alpha)$$

The measurement equation has the measured income y_t as the sum of permanent π_t and transitory income $(1-k_t)s_t$, while the transition equation represents the assumed evolution of π_t through time.

Substituting equation (2) in (1) we get;

$$Y_t = \gamma + \pi_{t-1} + s_t \qquad ......(3)$$

Multiplying (3) by k_t and substituting in (2) for $k_t s_t$ we obtain the updating equation for π_t in the form of a variable parameter adaptive model.

$$\pi_t = \gamma + \pi_{t-1} + k_t (y_t - \pi_{t-1}) \qquad ....(4)$$

Thus given an initial estimate of the permanent income π_0 knowing k_t and y_t, the updating equation (4) can be used to give all future values of permanent income.

Thus the prime task here is to get an estimate for k_t. This is obtained by making use of the Kalman Filter.

Now returning to the signal extraction problem, let us assume that ε_t is the shock to measured income and ξ_t is a shock to permanent income. Assume for simplicity that the agent knows the values of $\sigma_{2\varepsilon}$ and σ^2_ξ. Assume also that with information on y upto period $t-1$ (which could be time 'zero') he has formed a prior estimate of the unobservable permanent income for time t, namely $\pi_t|_{t-1}$. The key question is how the agent optimally uses information to update his estimate of π once new information on y_t arrives. To gain some intuitive insights consider the two polar cases $\sigma^2_\varepsilon = 0$ and $\sigma^2_\xi = 0$. In the first case there is no measurement noise ($y_t = \pi_t$) and we would expect all of his forecast error

$$Vt = (y_t - y_{t|t-1}) = (y_t - \pi_{t-1})$$

To be included in his estimate of permanent income, that is,

$$\pi_t = \pi_{t|t-1} + (y_t - y_{t|t-1})$$

The converse applies for $\sigma^2_\xi = 0$ and here $\pi_t = \pi_{t-1}$. In the intermediate case (σ^2_ε, $\sigma^2_\xi \neq$) the proportion of the forecast error added to $\pi_{t|t-1}$ will depend on the agent's perception of The *relative* variance of σ^2_ε and Var ($\pi_{t|t-1}$). The latter is equal to the sum of his prior estimate of the variance π (say σ^2_0) and his sampling error for π, (i.e σ^2_ξ). Hence if the updating equation is

$$\pi_t = \pi_{t|t-1} + k_t(y_t - y_{t|t-1}) \qquad \ldots(5)$$

then we might expect

$$k_t = (\sigma^2_0 + \sigma^2_\xi)/(\sigma^2_\varepsilon + (\sigma^2_0 + \sigma^2_\xi)$$

It is easily seen that $k = 1$ for $\sigma^2_\varepsilon = 0$ and $k = 0$ for $\sigma^2_\xi = \sigma^2_0 = 0$. The adjustment parameter k_t is known as the Kalman gain and the above equation will be seen to be the updating equation for the 'unobservable' permanent income variable. Given an initial estimate of $\pi_{1|0}$ and knowing k_t, equation (5) provides a recursion formula for updating pt as new information on y_t arrives.

Notes

1. De Masi (1997) provides a good account of the theoretical and practical insights into these concepts.

2. See also Canova(1998) for a critique on the HP filter.

3. Burns and Mitchell (1944) had found the length of business cycle in the US to vary between 2 and 8 years and the indicated λ parameters are consistent with cycles of such duration. Alternative values of λ have been suggested in literature. Li, et al. (1994), for instance use $\lambda = 10$ for annual and $\lambda = 10{,}000$ for quarterly data.

4. Mall (2000) makes an application of the technique to the Indian data. For further details on business cycles in India, see Dua (2000).

5. This is the mid-point of the RBI projection of a real GDP growth of 6.5-7.0 per cent for 2000-01 as stated in the Monetary and Credit Policy for the year.

6. Such a steep drop in potential output for industry could be a statistical overstatement as using annual GDP data for industry instead of monthly IIP data does not show any drop in the permanent component of the industrial output for 1991-92 and 1992-93, with potential industrial growth rate remaining at 6.7 per cent.

7. See also Mankiw (1994).

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Potential Growth in India: Viable Alternative to Time Series Approaches

Sarat Chandra Dhal*

This note estimates potential growth rate for the Indian economy within the framework of warranted growth and production function approach. The empirical estimate of potential growth rate range between 8-10 per cent for given saving rate and alternative measures of capital stock-output ratio. The estimates are higher than the conventional estimate by 2-4 percentage points.

Introduction

Most empirical studies of economic growth estimate potential output as the trend component of gross domestic product (GDP) using a suitable time series based detrending procedure. The 'potential growth rate' is derived as the annual percentage increase in the estimated underlying trend component of output. Theoretically, the mechanical univariate filtering technique derives justification from business cycle literature. However, it needs to be pointed out that the rate of growth of potential output estimated in this mechanistic manner can be justified *only under* certain crucial assumptions that may not necessarily characterise the growth processes as they respond to changes in technology and policy regimes.

First and foremost, the observed values of GDP reflect realised output. If the economy records realised output at close to its capacity level for most of the sample period, the estimated trend component of output will adequately reflect potential output. Otherwise, the detrending procedure may produce either an overestimate or an underestimate of the potential output depending upon whether the economy realises capacity output levels over a greater (lesser) part of the sample horizon. A mature economy will

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tend to move along the capacity growth trajectory. On the contrary, a developing economy characterised by several structural constraints may realise output below the capacity level. In this context, estimation of trend output and trend growth rate from observed GDP series alone may not adequately reflect potential output and capacity growth rate of the economy.

Secondly, according to business cycle literature, the growth trend will follow the underlying path of cyclical output. The trend growth rate itself will accelerate or decelerate depending upon whether economic activity is in an upswing or downswing, respectively Beveridge and Nelson (1981). Furthermore, as in the Indian context, short term fluctuations in agricultural production and thereby, in GDP can be largely attributed to erratic monsoon, natural calamities and several other unforeseen factors which can not be construed as a part of the business cycle[1].

Thirdly, growth theory, particularly the stages-of-growth school, characterise growth as an evolutionary process. In the early and intermediate stages of this process, a developing economy accumulates capital rapidly by increasing saving rates over time. Under these conditions, the economy may not realise output equivalent to its potential level. Given the process of rapid capital accumulation and capacity augmentation that is going on, the underlying growth trend may keep on accelerating over time.

Fourthly, there is some perception that GDP estimation in the Indian context has been a gross underestimate of actual economic activities. The main reason is that there are no reliable information and estimates about the large unorganised sector which accounts for a sizable amount of economic activity.[2]

This note attempts an empirical evaluation of the potential growth rate for the Indian economy using information on the proximate determinants of growth i.e., saving rate and capital intensity of production. Two alternative approaches to estimating full capacity growth for the Indian economy are adopted-the Harrod-Domar warranted or capacity growth rate and the Neoclassical production function approach.

The note also demonstrates that the application of detrending time series techniques within the theoretical framework of growth theory yields in more meaningful estimates of potential growth. It needs to be mentioned, however, that the empirical estimates of potential growth rate in this note are entirely aggregative in nature and it can not be equated with optimal growth rate which is defined with respect to general equilibrium approach based on a material balance perspective at a disaggregated level encompassing sectoral equilibrium.

The Framework of Warranted Growth

In the Harrod-Domar model, the concept of capacity or warranted growth rate (g_p) is determined by the underlying long term saving rate (s_p) and capital intensity (v_p) of production in the form of

$$g_p = s_p / v_p \neq g_a$$

where g_a is the actual growth rate (i.e., $y_t/y_{t-1} - 1$). For the product market to be in equilibrium, the actual growth rate should be equal to the warranted growth rate, failing which the economy will never come back to its long run equilibrium path. This knife-edge problem was based on the assumption that s_p and v_p are fixed and constants, and therefore, it follows that the warranted growth rate g_p is unique. The uniqueness of warranted growth rate is tenable in the context of an advanced economy where there is little scope for augmenting the long term saving rate and/or for bringing sharp innovations to the capital intensity of production. On the contrary, for a developing economy, as explained earlier, there exists considerable scope for augmenting both the saving propensity and capital intensity over long time horizons. Conse-quently, for a developing economy, the potential growth rate can be expected to accelerate over a medium to long term horizon. In other words, the capacity growth trajectory for a developing economy will be time varying in nature. More specifically, the parameters s_p and v_p may track along a long run trend path. However, s_p and v_p and consequently g_p are not observable. Empirically, therefore, the underlying potential growth rate can be estimated from the underlying trend in the saving rate and the capital-output ratio. This can be explained as follows:

g_p = g (trend) = s (trend) / v **(trend)**

In functional form, the relationship is given as

$$g(x) = s(x) / v(x)$$

where **x** denotes time horizon. If **s(x)** and v(x) tend to limiting values of *l* and *m* in the neighborhood of **x** = **a**, then it can be shown that

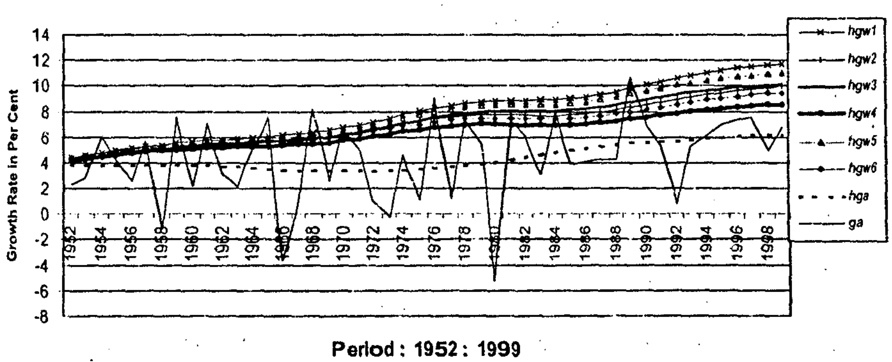
$$\lim_{x \to a} g(x) = \lim_{x \to a} [s(x)/v(x)] = l/m$$

On the empirical plane, a trend filtering technique is employed to the variable growth rate which is derived as the ratio of actual saving rate and observable capital-output ratio i.e., g_w (= s/v) such that the deviations from trend follow a normal distribution with zero mean and constant variance. Following the recent literature on time series techniques, Hodrick-Precsott (HP) filter is applied for measuring the underlying trend component of the series g_w (=s/v). *It may be noted here that the derived growth rate g_w is not equal to actual growth rate of output g_a* (Table 1).

The series 'v' here relates to ratio of capital stock (K_t) to GDP at constant (1980-81) prices.[3] Theoretically, 'v' should be defined in terms of ratio of usable capital stock at the beginning of the year t (i.e., equivalent to the end of the period t-1) to output produced in the end of period t. Empirically, 'v' should be appropriately defined as equal to K_{t-1}/Y. Many empirical studies use a smoothed incremental capital-output ratio as the underlying measure of 'v', but such on approach will produce misleading results. The incremental capital (or investment) in period 't' can not be considered as part of capital used for production in the year 't'. The data on saving rate are directly available from the National Accounts Statistics and various issues of Economic Survey. It is assumed that the saving rate being a ratio indicator is not affected by nominal bias.

Various alternative measures of the average capital output ratio shown in Table 1(a) are worthy of consideration and therefore, experimented with. The resulting underlying growth rate as implied by the theoretical definition of warranted growth rate over time using HP trend-cycle decompo-sition is shown along with the actual growth rate of output in Table 1(b) and Graph-1. For comparison, Table 1(b) also provides the trend component of actual growth rate hga(T) if HP filter is used for actual growth rate series. Table 2 shows that the HP filtering technique has produced efficiently smoothed trend paths in warranted growth rate as the deviations from the underlying trend path are normally distributed, which is verified by Dornik-Hansen test.[4]

Graph 1: Alternative Measures of Potential Growth Rate



The empirical results show that the estimated potential growth rate corresponding to the conventional approach i.e., trend growth rate estimated from the trend output using actual GDP data comes to about 6.18 per cent for the year 1999-2000. It is approximately 6 per cent for the period of 1992-93-1999-2000. On the contrary, estimates of warranted growth rate range between 8.5-11.7 per cent for alternative measures of average capital-output ratio. The potential growth rate turns out to be highest at about 11-11.5 per cent for the 1990s in two cases i.e., (I) with 'v' defined as the ratio of net fixed capital stock to GDP at constant prices and the corresponding trend growth denoted by hgw1 in Table-1(b) and (II) with 'v' as the ratio of gross fixed capital stock to gross domestic product at constant prices and the corresponding trend growth rate shown as hgw5 in the same Table-1(b). However, the more plausible measure of capital-output ratio is the ratio of net fixed capital stock to net domestic product or net capital stock to net domestic product at constant prices. Corresponding to these measures, the underlying warranted growth rates i.e., hgw3 and hgw4 are estimated at about 8.5-10 per cent.[5] There are only few occasions when the economy has achieved output close to its potential.

Production Function Approach

The neoclassical production function approach postulates that the potential growth rate can be estimated as the weighted estimate of labour force growth and usable capital stock growth. The analytical framework can be formalised as follows.

Let the generalised production function take the form of a Cobb-Douglass function.

$$Y = A\ K^{k-\alpha}\ L^{\alpha}$$

Where A characterises the level of technology, α is classify of output with respect to labour and β = k-α is elasticity of output with respect to capital, k represents return to scale. Usually, k is set to unity under the assumption of constant return to scale. Under the assumption of constant returns to scale along with a constant labour force growth rate, it can be shown that per capita growth rate and per capita capital stock should grow at the same rate. However, most analyses ignore the possibility of increasing returns to scale. If the economy moves along production processes with increasing returns to scale, then per capita growth rate will be higher than per capita capital stock growth. In the case of increasing return to scale, the coefficient β will be higher than unity. For instance, if β is about 1.5, and capital accumulation grows at the rate of 6-7 per cent, then output shall grow at the rate of 9-10.5 per cent.

The long run version of the production function is estimated here by using co-integration technique. Since data on unorganised employment are not available, the labour force variable here represents employment in the organised sector. The parameters of the production function are estimated using the data available for the sample period of 1970-1999. Over this sample period, the stochastic nature of the output, labor force and capital stock has been investigated using DF and ADF unit root tests. The results are summarised in Table 2. On the basis of maximum Akaike information criterion value, the labor force variable is stationary following DF and ADF tests based on deterministic trend captured by a constant term but no time trend. The result is in line with the fact that labor force growth is constant in the long run. The output and capital stock variable are not stationary series in their logarithm level form. They are stationary in the first difference form. Therefore, the cointegration space shall encompass output and capital stock. In other words, the long run output growth will depend upon long run capital stock. Alternatively, it implies that labour supply in a developing economy with high population is not a constraint for long run growth.

Next, the cointegrating relationship is investigated using Johansen's technique. The results are summarised in Table 3. Both the trace and maximum eigen value test statistics suggest that there can be only one cointegrating relationship of the following form.

$$\mathbf{LnY = \underset{(0.05)}{1.33}\, LnK - \underset{(0.25)}{0.68}}$$

The estimated long run elasticity of output with respect to capital stock is 1.33 with asymptotic standard error very low at 0.05 and it is statistically different from unity. The test of restricting this coefficient to unity had to be rejected with the computed $\chi^2(1)$ statistic at 17.68 being highly significant at 1 per cent level of significance. Thus, the estimated long run relationship implies that if capital stock grows at a trend rate of g_k, then the trend growth rate of output (g_y) will be 1.33 times g_k. The implied trend growth rate of output can be estimated by multiplying the trend growth rate of capital stock with a constant elasticity coefficient 1.33.[6] The trend growth rate of capital stock is, again, captured through the HP filter. The implied output growth rate is shown in Table 4. The potential growth rate of GDP is estimated at 8.9 per cent by the end of 1999-2000.

Conclusion

This note has endeavored to provide an alternative framework to conventional time series techniques for estimating the underlying or potential growth rate for the Indian economy. Given the recent trend in saving rate and the capital intensity of production, the estimates of potential growth rate for the Indian economy range between 8-10 per cent which is higher than the conventional estimates by about 2-4 percentage points. This has important implications for the conduct of macroeconomic policies designed to close the output gap.

Notes :

1. See Campbell and Mankiw (1987a,b), Coe and McDermott (1996) and Smets (1998) point out the limitation of characterising detrended output gap as business cycle phenomenon.

2. The National Accounts Statistics of India : 1950-51 to 1996-97, Economic and Political Weekly Research Foundation (1998), provides a summary discussion on various sources of errors in GDP estimation. For further references, see Bhagawati (1993), Bhagawati and Srinivasan (1984), Asthana (1998) and Mehta (1998) among others.

3. For arriving at total capital stock, inventory data were accumulated and then added to fixed capital for the period 1951-79. The National Accounts Statistics provides data on fixed capital stock for the same period. For the remaining period, data are available for fixed capital as well as total capital stock.

4. Among various alternative detrending techniques defined over time domain, Hodrick-Prescott filter is widely used in empirical studies. However, one of the limitation of the technique is that it involves an arbitrary choice of smoothing parameter. Canova (1998) provides a critique of Hodrick-Prescott filter. Nevertheless, *for an appropriate choice of the smoothing parameter, it requires that the detrended series, usually referred to the cyclical component, must be stationary and normally distributed with zero mean and constant variance.* This statistical condition forms a part of regularity conditions of economic cycles in Lucasian sense. In terms of economic logic, it

implies that on an average the series under consideration will tend to move along the long term trend path since expectation about short run fluctuatioins, on average, tend to zero. *However, many empirical studies neglect this aspect while studying economic cycles.* On the empirical ground, the normality test can be carried out preferably through Jarque-Berra Test and Doornik-Hansen Tests. The later is capable of undertaking univariate as well as multivariate normality tests. The test statistic named as EP-statistic follows chi-square distributioin with two degrees of freedom as shown in Doornik-Hansen (1994).

5. Of late, there is a growing optimism on the part of several official as well as non-official organisations about the high growth trajectory at about 8-10 per cent for the Indian economy. The Asian Development Bank has projected higher growth for the Indian Economy in its Asian Development Report 1999-2000.

6. Experiment with alternative measures of capital stock in cointegraption exercise did not produce significantly different value for β.

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Table 1 (a) : Alternative Measures of Capital-Output Ratios (Contd.)

Year	GDPMP (current prices)	GDPFC81 (constant prices)	NDPFC81 (constant prices	DEPN	Saving Rate (sr)	Net Fixed Capital Stock (nfcs)	Net Capital Stock (ncs)	Gross Fixed Capital Stock (gfcs)	Gross Capital Stock (gcs)
1951	9366	42871	40681	2190	10.41	96061	96360	98251	98550
1952	9966	43872	41585	2287	10.08	99106	100584	101393	102871
1953	9774	45117	42728	2389	8.25	101600	102286	103989	104675
1954	10638	47863	45388	2475	8.67	104486	105246	106961	107721
1955	10073	49895	47256	2639	10.46	107827	108867	110466	111506
1956	10258	51173	48342	2831	13.94	112107	114313	114938	117144
1957	12217	54086	51039	3047	13.09	117142	121190	120189	124237
1958	12598	53432	50179	3253	10.87	122473	127299	125726	130552
1959	14034	57487	54045	3442	10.04	127060	132501	130502	135943
1960	14793	58745	55086	3659	11.93	131693	137746	135352	141405
1961	16201	62904	58974	3930	12.73	137556	145402	141486	149332
1962	17177	64856	60665	4191	12.18	142937	150898	147128	155089
1963	18476	66228	61736	4492	13.40	149482	158487	153974	162979
1964	21237	69581	64791	4790	13.31	156655	166113	161445	170903
1965	24765	74858	69679	5179	12.66	164136	173799	169315	178978
1966	26145	72122	66518	5604	14.50	172131	182796	177735	188400
1967	29571	72856	66853	6003	15.26	179367	192643	185370	198646
1968	34611	78785	72459	6326	12.99	186313	200074	192639	206400
1969	36674	80841	74181	6660	12.81	192409	205385	199069	212045
1970	40387	86109	79137	6972	14.97	199015	212980	205987	219952
1971	43163	90426	83172	7254	15.71	205523	221743	212777	228997
1972	46257	91339	83733	7606	16.23	212268	230681	219874	238287
1973	51005	91048	83042	8006	15.36	220539	238954	228545	246960
1974	62007	95192	86807	8385	18.44	227921	251539	236306	259924
1975	73235	96297	87528	8769	17.38	234667	261751	243436	270520
1976	78761	104968	95741	9227	18.95	243557	273062	252784	282289
1977	84894	106280	96537	9743	21.24	252673	284292	262416	294035
1978	96067	114219	103986	10233	21.06	262367	296121	272600	306354
1979	104190	120504	109668	10836	23.17	273681	314801	284517	325637
1980	114356	114236	102794	11442	21.60	283892	329719	295334	341161
1981	136013	122427	110340	12087	21.16	295422	338093	307509	350180
1982	159760	129889	117101	12788	19.78	309042	359522	321830	372310
1983	178132	133915	120320	13595	18.96	324054	379220	337649	392815
1984	207589	144865	130396	14469	18.93	338293	396067	352762	410536
1985	231343	150433	134985	15448	18.23	353405	413644	368853	429092
1986	262243	156566	140226	16340	19.80	368846	435562	385186	451902
1987	292949	163271	145978	17293	18.71	385784	456705	403077	473998
1988	333201	170322	151988	18334	20.90	403298	474616	421632	492950
1989	395782	188461	168985	19476	21.39	421776	500302	441252	519778
1990	456821	201453	180686	20767	22.41	441073	524133	461840	544900
1991	535534	212253	190218	22035	24.27	463379	551493	485414	573528
1992	616799	213983	190553	23430	22.90	485137	574838	508567	598268
1993	705918	225240	200381	24859	21.99	507967	602101	532826	626960
1994	859220	239145	207242	31903	22.53	533710	626856	565613	658759
1995	1009906	255832	221457	34375	24.96	567776	669551	602151	703926
1996	1181961	274540	237112	37429	25.46	603089	715296	640518	752725
1997	1361952	295169	254820	40349	23.32	638759	756040	679108	796389
1998	1515646	309991	267048	42943	24.70	695010	805010	737953	847953
1999	1762609	331115	285242	45873	22.33	750645	860645	796519	906519

Table 1 (a) : Alternative Measures of Average Capital-Output Ratios (Contd.)

Year	Measures of Capital-output Ratios					
	fkorg (nfcs/gdp)	skorg (ncs/gdp)	fkorn (nfcs/ndp)	skorn (ncs/ndp)	gfkor (gfcs/gdp)	gskor (gcs/gdp)
1951						
1952	2.19	2.20	2.31	2.32	2.24	2.25
1953	2.20	2.23	2.32	2.35	2.25	2.28
1954	2.12	2.14	2.24	2.25	2.17	2.19
1955	2.09	2.11	2.21	2.23	2.14	2.16
1956	2.11	2.13	2.23	2.25	2.16	2.18
1957	2.07	2.11	2.20	2.24	2.13	2.17
1958	2.19	2.27	2.33	2.42	2.25	2.33
1959	2.13	2.21	2.27	2.36	2.19	2.27
1960	2.16	2.26	2.31	2.41	2.22	2.31
1961	2.09	2.19	2.23	2.34	2.15	2.25
1962	2.12	2.24	2.27	2.40	2.18	2.30
1963	2.16	2.28	2.32	2.44	2.22	2.34
1964	2.15	2.28	2.31	2.45	2.21	2.34
1965	2.09	2.22	2.25	2.38	2.16	2.28
1966	2.28	2.41	2.47	2.61	2.35	2.48
1967	2.36	2.51	2.57	2.73	2.44	2.59
1968	2.28	2.45	2.48	2.66	2.35	2.52
1969	2.30	2.47	2.51	2.70	2.38	2.55
1970	2.23	2.39	2.43	2.60	2.31	2.46
1971	2.20	2.36	2.39	2.56	2.28	2.43
1972	2.25	2.43	2.45	2.65	2.33	2.51
1973	2.33	2.53	2.56	2.78	2.41	2.62
1974	2.32	2.51	2.54	2.75	2.40	2.59
1975	2.37	2.61	2.60	2.87	2.45	2.70
1976	2.24	2.49	2.45	2.73	2.32	2.58
1977	2.29	2.57	2.52	2.83	2.38	2.66
1978	2.21	2.49	2.43	2.73	2.30	2.57
1979	2.18	2.46	2.39	2.70	2.26	2.54
1980	2.40	2.76	2.66	3.06	2.49	2.85
1981	2.32	2.69	2.57	2.99	2.41	2.79
1982	2.27	2.60	2.52	2.89	2.37	2.70
1983	2.31	2.68	2.57	2.99	2.40	2.78
1984	2.24	2.62	2.49	2.91	2.33	2.71
1985	2.25	2.63	2.51	2.93	2.34	2.73
1986	2.26	2.64	2.52	2.95	2.36	2.74
1987	2.26	2.67	2.53	2.98	2.36	2.77
1988	2.27	2.68	2.54	3.00	2.37	2.78
1989	2.14	2.52	2.39	2.81	2.24	2.62
1990	2.09	2.48	2.33	2.77	2.19	2.58
1991	2.08	2.47	2.32	2.76	2.18	2.57
1992	2.17	2.58	2.43	2.89	2.27	2.68
1993	2.15	2.55	2.42	2.87	2.26	2.66
1994	2.12	2.52	2.45	2.91	2.23	2.62
1995	2.09	2.45	2.41	2.83	2.21	2.57
1996	2.07	2.44	2.39	2.82	2.19	2.56
1997	2.04	2.42	2.37	2.81	2.17	2.55
1998	2.06	2.44	2.39	2.83	2.19	2.57
1999	2.10	2.43	2.44	2.82	2.23	2.56

Table 1 (a) : Alternative Measures of Average Capital-Output Ratios (Concld.)

Year	Measures of Warranted Growth						Actual Growth (ga)
	Warranted Growth (gw1) (sf/fkorg)	Warranted Growth (gw2) (sr/skorg)	Warranted Growth (gw3) (sr/fkorn)	Warranted Growth (gw4) (sr/skorn)	Warranted Growth (gw5) (sf/gfkor)	Warranted Growth (gw6) (sr/gskor)	
1951							
1952	4.61	4.59	4.37	4.35	4.50	4.49	2.33
1953	3.75	3.70	3.56	3.50	3.67	3.62	2.84
1954	4.08	4.06	3.87	3.85	3.99	3.96	6.09
1955	5.00	4.96	4.73	4.70	4.88	4.85	4.25
1956	6.62	6.55	6.25	6.19	6.46	6.40	2.56
1957	6.31	6.19	5.96	5.84	6.16	6.04	5.69
1958	4.96	4.79	4.66	4.50	4.83	4.68	-1.21
1959	4.71	4.53	4.43	4.26	4.59	4.42	7.59
1960	5.52	5.29	5.17	4.96	5.37	5.16	2.19
1961	6.08	5.82	5.70	5.45	5.92	5.66	7.08
1962	5.75	5.44	5.37	5.08	5.59	5.29	3.10
1963	6.21	5.88	5.79	5.48	6.03	5.72	2.12
1964	6.19	5.84	5.77	5.44	6.01	5.68	5.06
1965	6.05	5.70	5.63	5.31	5.87	5.54	7.58
1966	6.37	6.02	5.88	5.55	6.18	5.84	-3.65
1967	6.46	6.08	5.93	5.58	6.26	5.90	1.02
1968	5.71	5.31	5.25	4.89	5.52	5.15	8.14
1969	5.56	5.17	5.10	4.75	5.37	5.02	2.61
1970	6.70	6.27	6.16	5.77	6.47	6.08	6.52
1971	7.14	6.67	6.57	6.14	6.90	6.46	5.01
1972	7.21	6.69	6.61	6.13	6.97	6.47	1.01
1973	6.59	6.06	6.01	5.53	6.36	5.87	-0.32
1974	7.96	7.34	7.26	6.70	7.68	7.11	4.55
1975	7.34	6.65	6.67	6.05	7.08	6.44	1.16
1976	8.48	7.60	7.73	6.93	8.17	7.35	9.00
1977	9.27	8.27	8.42	7.51	8.93	8.00	1.25
1978	9.52	8.46	8.67	7.70	9.17	8.18	7.47
1979	10.64	9.43	9.68	8.58	10.24	9.11	5.50
1980	9.01	7.84	8.11	7.05	8.67	7.58	-5.20
1981	9.13	7.86	8.23	7.08	8.77	7.59	7.17
1982	8.70	7.60	7.84	6.85	8.35	7.34	6.10
1983	8.22	7.06	7.38	6.35	7.89	6.82	3.10
1984	8.46	7.23	7.62	6.51	8.12	6.98	8.18
1985	8.11	6.92	7.27	6.21	7.77	6.68	3.84
1986	8.77	7.50	7.86	6.71	8.41	7.23	4.08
1987	8.28	7.01	7.40	6.27	7.93	6.76	4.28
1988	9.23	7.79	8.23	6.95	8.83	7.51	4.32
1989	10.00	8.49	8.96	7.62	9.56	8.18	10.65
1990	10.70	9.02	9.60	8.09	10.23	8.69	6.89
1991	11.68	9.83	10.47	8.81	11.16	9.46	5.36
1992	10.58	8.89	9.42	7.91	10.10	8.54	0.82
1993	10.21	8.62	9.08	7.67	9.74	8.28	5.26
1994	10.61	8.95	9.19	7.76	10.11	8.60	6.17
1995	11.96	10.19	10.36	8.82	11.29	9.69	6.98
1996	12.31	10.44	10.63	9.02	11.61	9.93	7.31
1997	11.41	9.62	9.85	8.31	10.75	9.14	7.51
1998	11.99	10.13	10.33	8.73	11.28	9.62	5.02
1999	10.64	9.18	9.16	7.91	10.02	8.72	6.81

Table 1(b) : Trends in Actual Growth Rate and Warranted Growth Rate (Contd).

	Actual Growth	Underlying Trend in Actual Growth (HP Filter)		Alternative Measures of Warranted Growth Rate (gw)					
Year	ga	hga	hga(T)	gw1	gw2	gw3	gw4	gw5	gw6
1952	2.33	3.82	3.44	4.61	4.59	4.37	4.35	4.50	4.49
1953	2.84	3.82	3.55	3.75	3.70	3.56	3.50	3.67	3.62
1954	6.09	3.84	3.66	4.08	4.06	3.87	3.85	3.99	3.96
1955	4.25	3.83	3.73	5.00	4.96	4.73	4.70	4.88	4.85
1956	2.56	3.82	3.78	6.62	6.55	6.25	6.19	6.46	6.40
1957	5.69	3.82	3.82	6.31	6.19	5.96	5.84	6.16	6.04
1958	-1.21	3.81	3.85	4.96	4.79	4.66	4.50	4.83	4.68
1959	7.59	3.82	3.88	4.71	4.53	4.43	4.26	4.59	4.42
1960	2.19	3.81	3.88	5.52	5.29	5.17	4.96	5.37	5.16
1961	7.08	3.78	3.86	6.08	5.82	5.70	5.45	5.92	5.66
1962	3.10	3.72	3.81	5.75	5.44	5.37	5.08	5.59	5.29
1963	2.12	3.65	3.74	6.21	5.88	5.79	5.48	6.03	5.72
1964	5.06	3.58	3.66	6.19	5.84	5.77	5.44	6.01	5.68
1965	7.58	3.50	3.58	6.05	5.70	5.63	5.31	5.87	5.54
1966	-3.65	3.42	3.50	6.37	6.02	5.88	5.55	6.18	5.84
1967	1.02	3.41	3.48	6.46	6.08	5.93	5.58	6.26	5.90
1968	8.14	3.42	3.49	5.71	5.31	5.25	4.89	5.52	5.15
1969	2.61	3.42	3.49	5.56	5.17	5.10	4.75	5.37	5.02
1970	6.52	3.41	3.47	6.70	6.27	6.16	5.77	6.47	6.08
1971	5.01	3.38	3.43	7.14	6.67	6.57	6.14	6.90	6.46
1972	1.01	3.34	3.40	7.21	6.69	6.61	6.13	6.97	6.47
1973	-0.32	3.35	3.40	6.59	6.06	6.01	5.53	6.36	5.87
1974	4.55	3.40	3.46	7.96	7.34	7.26	6.70	7.68	7.11
1975	1.16	3.49	3.56	7.34	6.65	6.67	6.05	7.08	6.44
1976	9.00	3.60	3.67	8.48	7.60	7.73	6.93	8.17	7.35
1977	1.25	3.69	3.76	9.27	8.27	8.42	7.51	8.93	8.00
1978	7.47	3.78	3.86	9.52	8.46	8.67	7.70	9.17	8.18
1979	5.50	3.87	3.95	10.64	9.43	9.68	8.58	10.24	9.11
1980	-5.20	3.98	4.06	9.01	7.84	8.11	7.05	8.67	7.58
1981	7.17	4.16	4.23	9.13	7.86	8.23	7.08	8.77	7.59
1982	6.10	4.36	4.43	8.70	7.60	7.84	6.85	8.35	7.34
1983	3.10	4.56	4.62	8.22	7.06	7.38	6.35	7.89	6.82
1984	8.18	4.76	4.80	8.46	7.23	7.62	6.51	8.12	6.98
1985	3.84	4.93	4.96	8.11	6.92	7.27	6.21	7.77	6.68
1986	4.08	5.10	5.12	8.77	7.50	7.86	6.71	8.41	7.23
1987	4.28	5.26	5.27	8.28	7.01	7.40	6.27	7.93	6.76
1988	4.32	5.41	5.41	9.23	7.79	8.23	6.95	8.83	7.51
1989	10.65	5.54	5.53	10.00	8.49	8.96	7.62	9.56	8.18
1990	6.89	5.61	5.60	10.70	9.02	9.60	8.09	10.23	8.69
1991	5.36	5.66	5.65	11.68	9.83	10.47	8.81	11.16	9.46
1992	0.82	5.70	5.71	10.58	8.89	9.42	7.91	10.10	8.54
1993	5.26	5.79	5.81	10.21	8.62	9.08	7.67	9.74	8.28
1994	6.17	5.90	5.95	10.61	8.95	9.19	7.76	10.11	8.60
1995	6.98	6.01	6.10	11.96	10.19	10.36	8.82	11.29	9.69
1996	7.31	6.09	6.25	12.31	10.44	10.63	9.02	11.61	9.93
1997	7.51	6.15	6.39	11.41	9.62	9.85	8.31	10.75	9.14
1998	5.02	6.17	6.51	11.99	10.13	10.33	8.73	11.28	9.62
1999	6.81	6.18	6.63	10.64	9.18	9.16	7.91	10.02	8.72

Table 1 (b) : Trends in Actual Growth Rate and Warranted Growth Rate (Concld.)

Year	Underlying Long Term Trend in Warranted Growth (Hodrick-Prescott Filter)							
	hgw1	hgw2	hgw3	hgw4	hgw5	hgw6	hgks	hgks1
1952	4.37	4.38	4.16	4.16	4.28	4.28	4.03	3.30
1953	4.57	4.55	4.34	4.31	4.47	4.45	4.05	3.51
1954	4.77	4.72	4.52	4.47	4.66	4.61	4.10	3.73
1955	4.96	4.89	4.69	4.62	4.85	4.78	4.19	3.96
1956	5.14	5.04	4.86	4.76	5.02	4.92	4.30	4.17
1957	5.29	5.16	4.99	4.87	5.16	5.04	4.40	4.35
1958	5.42	5.26	5.10	4.95	5.28	5.13	4.48	4.48
1959	5.53	5.34	5.19	5.02	5.38	5.21	4.54	4.58
1960	5.63	5.42	5.28	5.08	5.48	5.28	4.58	4.64
1961	5.73	5.49	5.36	5.14	5.57	5.35	4.61	4.68
1962	5.82	5.56	5.44	5.19	5.66	5.41	4.62	4.68
1963	5.91	5.62	5.51	5.24	5.74	5.47	4.61	4.67
1964	5.99	5.68	5.57	5.28	5.82	5.52	4.58	4.63
1965	6.07	5.74	5.63	5.33	5.89	5.58	4.53	4.57
1966	6.16	5.81	5.70	5.38	5.97	5.64	4.45	4.49
1967	6.27	5.89	5.79	5.44	6.07	5.72	4.37	4.39
1968	6.39	5.99	5.89	5.52	6.19	5.81	4.27	4.29
1969	6.55	6.11	6.02	5.62	6.33	5.93	4.19	4.21
1970	6.74	6.27	6.19	5.75	6.52	6.07	4.15	4.16
1971	6.96	6.44	6.38	5.91	6.73	6.24	4.13	4.14
1972	7.20	6.63	6.59	6.07	6.96	6.42	4.14	4.15
1973	7.47	6.84	6.82	6.25	7.21	6.62	4.18	4.18
1974	7.74	7.04	7.06	6.43	7.46	6.82	4.23	4.24
1975	8.01	7.24	7.30	6.60	7.72	7.01	4.29	4.30
1976	8.26	7.43	7.52	6.76	7.97	7.19	4.37	4.37
1977	8.49	7.58	7.72	6.89	8.18	7.34	4.44	4.45
1978	8.67	7.69	7.87	6.98	8.35	7.44	4.52	4.52
1979	8.79	7.76	7.97	7.03	8.46	7.50	4.59	4.59
1980	8.86	7.77	8.02	7.03	8.52	7.51	4.65	4.65
1981	8.88	7.75	8.03	7.00	8.54	7.49	4.69	4.69
1982	8.90	7.72	8.03	6.97	8.55	7.45	4.74	4.73
1983	8.91	7.69	8.04	6.93	8.56	7.43	4.77	4.75
1984	8.96	7.69	8.06	6.93	8.60	7.43	4.79	4.76
1985	9.04	7.73	8.13	6.95	8.67	7.46	4.80	4.76
1986	9.17	7.81	8.24	7.02	8.79	7.54	4.81	4.77
1987	9.35	7.94	8.38	7.12	8.96	7.66	4.83	4.77
1988	9.58	8.11	8.57	7.26	9.17	7.82	4.86	4.79
1989	9.83	8.32	8.78	7.42	9.40	8.00	4.90	4.83
1990	10.10	8.53	8.99	7.59	9.64	8.20	4.96	4.89
1991	10.35	8.74	9.19	7.75	9.87	8.40	5.03	4.97
1992	10.59	8.94	9.36	7.90	10.09	8.58	5.12	5.09
1993	10.82	9.13	9.52	8.04	10.28	8.75	5.24	5.25
1994	11.03	9.32	9.66	8.16	10.46	8.91	5.37	5.44
1995	11.22	9.49	9.79	8.28	10.62	9.06	5.50	5.67
1996	11.38	9.64	9.89	8.38	10.76	9.19	5.61	5.91
1997	11.52	9.77	9.97	8.46	10.87	9.30	5.69	6.15
1998	11.64	9.89	10.03	8.52	10.96	9.40	5.74	6.40
1999	11.74	10.00	10.09	8.58	11.04	9.48	5.76	6.65

Table 2 : Normality Test for Detrended Warranted Growth Rate

Doornik-Hansen Normality Test				
Variables	Skewness	Excess Kurtosis	EP-Statistic	significance
Cgw1	0.54	0.16	2.55	0.28
Cgw2	0.41	-0.18	1.72	0.42
Cgw3	0.54	-0.06	3.02	0.22
Cgw4	0.36	-0.47	1.96	0.37
Cgw5	0.57	0.03	3.22	0.20
Cgw6	0.39	-0.29	1.73	0.42

Note : Cgw1 denotes deviation of warranted growth (gw1) from its trend (HP) component denoted by hgw1 and the like for Cgw2, Cgw3, etc.

Table 3 : Test of Unit Root in Variables: GDP, NCS and EMP

GDP : Real Gross Domestic Product, NCS: Real Net Capital Stock, EMP: Employment

	DF Test Statistic (Computed)		ADF(1) Test Statistic (Computed)	
	With intercept*	With intercept** And Trend	With intercept* ADF(1) Test	With intercept** and Trend
LGDP	1.43	1.82	-1.43	-1.03
LNCS	2.00	1.63	-0.73	-1.10
LEMP	-7.47	-4.65	—	—

Note : * : 95% Critical value is -2.89. ** : 95% Critical value is -3.46.

Table 4 : Test of Cointegration Relation : Johansen's Maximum Likelihood Method

Dependent variable : Output and Capital Stock

Null Hypothesis	Alternative	Computed Statistics Max.Eigen	Computed Statistics Trace	95% Critical value Max.Eigen	95% Critical value Trace	90% Critical value Max.Eigen	90% Critical value Trace
R=0	R=1	19.99	23.54	15.87	20.18	13.81	17.88
R=1	R=2	3.54	3.54	9.16	9.16	7.53	7.53

Table 5 : Estimate of Potential Growth Rate (Production Function Approach)

Year	Actual Capital Stock Growth Rate	Trend (HP) Growth of Capital Stock	Implied Long Run Trend Growth of GDP
1971	4.11	4.14	5.50
1972	4.03	4.15	5.51
1973	3.59	4.18	5.56
1974	5.27	4.24	5.63
1975	4.06	4.30	5.72
1976	4.32	4.37	5.81
1977	4.11	4.45	5.91
1978	4.16	4.52	6.01
1979	6.31	4.59	6.11
1980	4.74	4.65	6.18
1981	2.54	4.69	6.24
1982	6.34	4.73	6.29
1983	5.48	4.75	6.32
1984	4.44	4.76	6.33
1985	4.44	4.76	6.33
1986	5.30	4.77	6.34
1987	4.85	4.77	6.35
1988	3.92	4.79	6.37
1989	5.41	4.83	6.42
1990	4.76	4.89	6.50
1991	5.22	4.97	6.61
1992	4.23	5.09	6.77
1993	4.74	5.25	6.98
1994	4.11	5.44	7.24
1995	6.81	5.67	7.54
1996	6.83	5.91	7.86
1997	5.70	6.15	8.18
1998	6.48	6.40	8.51
1999	6.91	6.65	8.85

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Book Reviews

Development as Freedom, *by Amartya Sen,* Alfred A. Knopf Publishers, New York, 1999 pp 366 + xvi; US $27.50.

Amartya Sen's contributions in development economics span over five decades and demonstrate an astonishing unity in diversity - in its uncompromising advocacy of egalitarianism, abiding concern for humanity, the centrality of human freedom and the restoration of an ethical dimension to vital economic problems. Development as Freedom, Amartya Sen's first book since he was awarded the Nobel Prize, once again reflects the coherence and continuity in Sen's economics.

Amartya Sen's research over the years has broadened the scope of development economics quite substantially – by looking beyond conventional indicators like level and distribution of income towards more meaningful indices of quality of life, including health, nutrition, education, housing, life expectancy, infant mortality rates and so on. The distinction drawn by him between 'growth-oriented security strategy' and 'support-led security strategy' has enhanced the understanding of the development process. In 1970, Sen demonstrated that there is a very basic conflict between the rights of people and the fundamental principle of welfare economics, the principle of Pareto Optimality. The book revisits the conflict in the context of the role of development in improving the freedom (both economic and non-economic), enjoyed by the people. The debate in welfare economics in the 1970s, in which Sen was actively involved, adopted two different approaches to rights, *i.e.* independent rights and integrated rights. The theory of independent rights was an attempt to move out of the dilemma of social choice by giving liberal rights priority over social choice. This view regarded rights as desired elements and beyond the scope of value judgement of society. The 'rightness' of rights took precedence over its 'goodness'. In contrast, the integrated approach to rights looked at rights as socially important, at conflict with each other with possible 'trade-offs' between them. Sen's research has largely moved in the 'integrated' approach stream. Sen has written extensively to highlight the advantages of a framework of 'rights inclusive social choice theory' that goes beyond utilitarianism by including the fulfillment and violation of rights as parts of the emerging states of affairs. This book is a step forward towards a more acceptable integrated framework of overall assessment of rights and freedom of people. The book broadens the horizon and scope of development economics by pushing of towards an inter-disciplinary plane.

In its efforts to capture the bi-directional causality between development and freedom, the book contributes to some of the contemporary debates in development economics and development policy.The first of these issues of contemporary concern is the role of democracy in development. Empirical studies in growth economics have tended to demonstrate that the growth rates have a weak but inverse association with the freedoms enjoyed by the people. Cross country empirical studies (Barro, 1998) demonstrated that authoritarian nations did fare better than the democratic ones. This found strong favour with East Asian countries, whose impressive track record has often been accompanied by the denial of unrestricted political freedom. Sen here argues that the intensity of economic needs adds to the urgency of political freedom – through its instrumental role in hearing the economic needs of the people and its constructive role in the creation of social values and norms. The right to express one's opinion and the ability to debate can go a long way in enhancing economic well-being. Sen also stresses that the degree of this linkage is depended upon the range, reach and efficiency of the democratic system. Here, Sen emphasises that the virtues of authoritarian rule is based on very selective information. The positive role of democracy emanates from the checks and balances provided by democracy; a strong opposition and a responsive media can tilt the balance in favour of the masses in a developing country.

The second issue relates to the role of state and markets in economic development. This is an age-old issue and Sen provides a freedom-inclusive perspective of the role of State *vis-à-vis* markets. Sen feels that the far-reaching powers of the market mechanism have to be supplemented by the creation of basic social opportunities. Sen identifies three crucial areas of economic freedom where the State should intervene, ensuring adequate food at reasonable prices thereby ensuring freedom from hunger, encouraging education to give freedom from ignorance which will influence the productivity of human capital and finally, the fulfilment of social needs, through state intervention in health, housing, poverty eradication etc. Another crucial issue highlighted by the author in this context is the interlinkage between economic and political freedom. The author here argues that the ability of the State to ensure peoples' participation in the development process enhances economic freedom in society. Thus Sen stresses the overriding role of the State to attain social objectives.

The third debate concerns the concept of 'agency' in economic development. The 'agency' view argues that if people have the power to influence economic policy, they'll contribute to the growth process through participation. This view of agency is quite akin to the role of human capital in endogenous growth theory, which also seeks to empower the workforce to raise productivity. Sen argues that if economic agents have power to influence decisions regarding the activities they undertake, it improves the efficiency and welfare of a society. In a detailed discussion of women's agency in the book, Sen puts forth the view that if women have the power to influence reproductive choices, not only will it contribute to the decline in population growth in the developing world but at the same time improve child welfare and also reduce the infant mortality rate. Thus, the author underscores the imminent need to ensure female well-being and giving agency to women as key issues in the attainment of 'development as freedom'.

Besides these contemporary concerns, the book also represents a bridge between the present and the past. By pitting the various schools of thought, Classics, Keynesian, Neo-classical and the

Austrian school against each other in the context of the development debate, this book has contributed to a greater understanding of their specific positions.

A fair assessment of the book's utility to the policymakers will be difficult, given the fact that the book ventures into hitherto unexplored terrain. Nevertheless, the book expands the goals of development policy moving it beyond defining development in terms of per capita GDP and by introducing crucial concepts like the freedom of the people as an ultimate goal of development strategy. In doing so, the book may force the policymakers towards a reassessment of the instruments of development in view of the broader set of goals set out in the book. In the final analysis, the book weaves through historical examples, empirical evidence and rigorous analysis into a noteworthy contribution towards an understanding of development as 'a momentous engagement with freedom's possibilities'.

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***Safeguarding Prosperity in a Global Financial System: The Future International Financial Architecture; Report of An Independent Task Force,* sponsored by the Council on Foreign Relations, NY, published by the Institute of International Economics, VA, USA, 1999, pp ix+149.**

A series of financial crises between mid-1997 and early 1998 have generated a perception of deep inadequacies in the international financial system have spurred various initiatives to strengthen financial systems, including banking, capital markets and market infrastructure. This report contains the findings and recommendations of an independent blue ribbon commission on the future international financial architecture. The Independent Task Force on the Future International Financial Architecture met regularly from January through June 1999. Meetings focused on what was "broken," in the existing architecture and how to 'fix' it. The published report under the project directorship of Prof. Morris Goldstein has been developed to cover five chapters and dissenting views.

The report highlights why the international financial architecture matters, including to the United States. It contains a critical assessment of the existing architecture. It argues despite the sorry track record on banking, currency, and debt crises of the past twenty years, it would be a counsel of despair to conclude that little can be done to make crises less frequent and less severe. A market-oriented approach to reform would create greater incentives for borrowing countries to strengthen their crisis prevention efforts and for their private creditors to assume their fair share of the burden associated with resolving crises.

Notwithstanding some dissents (pp125-143) on specific findings and proposals, the following key recommendations were able to command majority support:

A. Greater rewards for joining the "good housekeeping club". The

IMF should lend on more favourable terms to countries that take effective steps to reduce their crisis vulnerability and should publish an assessment of these steps so the market can take note.

B. Capital flows-avoiding too much of a good thing: Emerging economies with fragile financial systems should take transparent and non-discriminatory tax measures to discourage short-term capital inflows and encourage less crisis prone longer-term ones, like foreign direct investment.

C. The private sector: Promote fair burden-sharing and market discipline. All countries should include "collective action clauses' in their sovereign bond contracts. In extreme cases where rescheduling of private debt is necessary, the IMF should provide financial support only if debtor countries are engaged in "good faith" rescheduling discussions with their private creditors, and it should be prepared to support a temporary halt in debt payments. The IMF should also encourage emerging economies to implement a deposit insurance system that places the main cost of bank failures on shareholders and on large, uninsured private creditors, not on small depositors or tax payers.

D. Just say no to pegged exchanged rates: The IMF and the Group of seven leading industrial countries should advise emerging economies against adopting pegged exchange rates and should not provide funds to support unsustainable currency pegs.

E. IMF crisis lending: Less will do more. For country crises, the IMF should adhere consistently to normal lending limits and should abandon huge rescue packages. For systemic crises that threaten the international monetary system, the IMF should turn to its existing credit lines when problems are largely of the country's making and to special contagion funds when the country is an innocent victim.

F. Refocus the IMF and the World Bank back to basics: The

IMF should focus on monetary, fiscal, exchange rate, and financial sector policies, not on longer-term structural reforms. The World Bank should focus on longer-term structural and social aspects of development, not on crisis management or macro-economic advice.

G. Generate political support for the ownership of financial reforms: A global conference of finance ministers should convene to reach a consensus on priorities and timetables for specific actions that countries will take to strengthen national financial systems.

On dissenting views, Paul Volcker and others urge the G3 countries to adopt some variant of exchange rate target zones in the near future. There can be no serious reform of the overall financial architecture without fundamental reform of the way in which the G3 (the dollar, the euro, and the yen) manage the relationships among their exchange rates. More attention needs to be directed toward means of practically achieving grater stability in exchange rates, including those of major countries. George Soros feels obliged to point out a bias that permeates the report. The people, including Soros, who participated in the task force, occupy positions at the centre of the global capitalist system. This colours their views and interests, and the report reflects it. The report does not give sufficient weight to the need to create more level playing field. What is missing from the report in any measure to encourage sound, long-term lending.

There is a substantial area of agreement between the task force and the official sector's recommendations to strengthen the architecture of international financial system. The proposals commonly addressed relate to transparency and accountability, internationally accepted standards of good practice in economic, financial and business activities; capital market liberalisation, the role of the private sector in forestalling and resolving crises: and improvements in financial market supervision. The task force attaches high priority to a refocusing of the mandates of the IMF and the World Bank.

The report has succeeded in presenting a coherent and well-informed analysis and some useful recommendations. The exercise might be considered worthwhile and the product is valuable, particularly for policy making bodies. It is interesting to note that there has recently been a marked improvement in financial market conditions and most of the economies that were affected by the crises have begun to recover. However, recurrent crises in the international financial system have become a fact of life. The bottom line is that there is no substitute for the consistent implementation of sound economic policies. The external economic environment must also be supportive of sound economic policies over time.

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***Microeconomics of Banking*, by Xavier Frexias and Jean-Charles Rochet, The MIT Press, Cambridge, Massachusetts, Year of Publication : 1998, Price $45.95.**

In the last decade, economic theorists have dovetailed their attention towards issues of how financial institutions influence the allocation of funds for investment and the possibilities for economic growth. Although the relationship between the real and the financial sectors of the economy have been discussed during and immediately after the Great Depression, interest in this topic had taken a backseat in the decades following the Second World War. However, over the past two decades or so, the macro-economic consequences of financial sector fragility, in general, and banking sector weaknesses, in particular, have attracted growing attention of policy makers. The worldwide trend towards deregulation of financial sectors, ascendancy of free market philosophy and the widespread banking sector problems of many countries have raised a gamut of questions relating to the linkages between de-regulation, various categories of risks confronting banks and banking crises. Almost around the same time, there have been significant developments in economic theory, *viz.*, those relating to asymmetric information and the economics of contracts. These developments have provided an altogether new perspective towards understanding the microeconomic underpinnings of banking theory and the structural weaknesses that might justify public intervention.

Despite these significant strides in the study of banking sector problems, most earlier textbooks on banking focused on either the management or the monetary aspect and failed to integrate the two into a coherent whole. However, it was increasingly being realized that newer tools of economic analysis could be pro-actively applied towards the study of banks and banking, without sacrificing the focus on either the monetary and/or management aspects. Therefore, there was the need for a book that could fill the void between the rapid economic advances in this area and an analytically tractable way in which these advances could be presented to the financial community, at large. Frexias and Rochet, two eminent contract theorists, makes an attempt to fill this gap by presenting a book that interweaves the present literature on banking and with those of imperfect markets.

The book starts off by describing the basic roles of financial intermediation in the provision of transformation, payments and information processing. In this process, fundamental papers on adverse selection and signalling – Rothschild and Stiglitz (1976) and Leland and Pyle (1977) – and on monitoring by intermediaries, *viz.*, Diamond (1984), are described using simplified models. Subsequently, older models of banking, focusing on perfectly competitive/monopolistic markets, as well as newer issues relating to competition among banks in multiple - (asset and liability) linked markets, are described. Thereafter, the issue of costly state verification models of debt (Gale and Hellwig, 1985), strategic debt repayment initiatives in multi-period setting, including those of sovereign debt, and moral hazard problems in loan markets with asymmetrically informed heterogeneous borrowers are examined.

Equilibrium models of rationing of loans in credit markets arising from the phenomenon of adverse selection are elaborated under the topic on Credit Market. The macroeconomic consequences of possible 'breakdowns' of such imperfect credit markets, and the resulting implications for transmission channels of monetary policy are delineated thereafter, touching upon even very recent models of credit cycles. The liability side and liquidity provision aspects of banking intermediaries, the Diamond Dybvig model of bank runs and the possible solutions to such problems are taken up subsequently. The roles of a central bank, including the provision of deposit insurance and lender of last resort services are also delineated here.

Banking, in the ultimate analysis, in an exercise in risk management and to the extent that banks adopt sound risk management practices, the possibility of adverse outcomes impinging on banks' balance sheets is mitigated. Towards this end, the various facets of risks and risk management practices receive detailed scrutiny in the topic under Risk Management. The impact of various measures that can be undertaken to lower/minimize these risks, *viz.*, capital adequacy, reserve requirements *etc.*, are also elicited here. The book ends with a review and synthesis of the issues regarding the rationales, and instruments of bank regulation. Topics like the scope of bank regulation, universal banking and the resolution of bank failures, constitutes the major focus of the discussion under this head.

Two features of the book stand apart: its brevity, given the wide spectrum of topics covered, and its clarity of exposition, with simplifications (without sacrificing the flavour) relative to the original papers reviewed, wherever required. Also, each Chapter is succeeded by an extensive bibliographical reference for the benefit of the reader in that area. Given the urgent need in university curricula for a course covering recent theoretical developments on advances in the area of banking, the authors need to be amply lauded for producing a textbook with these praise-worthy features.

The panoramic view that the book provides of an extensive volume of models and the extant literature, is also the source of a few minor shortcomings, which, in a sense, constrain it from being an ideal research monograph. Several interesting models in the literature which need to have found a space in the book, are not discussed in detail, and several other recent developments are not covered in its entirety. For instance, in Chapter 6 on the macroeconomic consequences of financial imperfections, the structural models of 'breakdowns' of intermediation might have been contrasted, more explicitly, with less drastic models of credit cycles. Secondly, recent advances in elucidating newer theories of banking (Diamond and Rajan, 1999) have also been neglected. Part of it is understandable: the book was written sometime around end-1997/early-1998 and given the rapid advances in this area over the past two years or so, these developments might have been difficult to envisage. However, the authors would have rendered yeoman service had they pointed out the limitations of the present models, paving the way for future research in those areas. Secondly, given that theoretical models are analytical constructs that capture certain real-world features, it would have been useful if some of these fundamental models were supplemented with numerical examples analyzing their workings. This would have enabled one to have a better grasp of the functioning of the models. A third significant omission is the lack of proper treatment on comparisons between bank versus financial market-dominated economies. Recent developments in this area have observed that while 'banking economies', like the US and the UK, are characterized by high concentration of ownership and long-term relation between banks and industry, the reverse is the case for 'market economies' like France and Germany. What circumstances gives rise to such equilibrium configuration between ownership and finance? These issues, which needed to have been treated in some detail, do not find space in the book. Another significant omission of the book, from the point of view of central banking, is the lack of any empirical evidence to support or review the models. For example, there has been a significant amount of literature in recent years, on the empirical evidence, regarding quantification of bank runs. Similarly, did universal banking in the US before the Glass-Steagall Act of 1932 engender any potential conflict of interests? These, and many such interesting empirical issues, are barely touched upon. Needless to say, confronting theoretical models with such hardcore empirical evidence, would have greatly enhanced the usefulness of the book. Finally, one might mention that the bulk of these models are tailored to advances in banking in developed economies. How, or in what significant way would the results have altered if these were applied to developing country markets? Readers are often at a loss to apprehend these nuances of the models. As a forerunner in this area, the authors need to have taken this into cognizance, in view of the wide readership that the book is expected to enjoy.

These are only minor quibbles, a first book on such a complex and rich set of topics can rarely accomplish so much. One merely hopes the authors will factor these lacunae into account, when they bring out a revised edition. One can however hazard a guess that this marks a beginning of a series of such endeavours, on expositional and critical synthesis of the literature on imperfect financial markets and their macro implications.

All in all, the book marks a substantial beginning in this untreaded area and should be read by bankers, students and teachers alike.

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