SHOCKS, ECONOMIC GROWTH AND THE INDIAN ECONOMY*

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Abstract

This paper analyses the impact of domestic and external shocks on the Indian economy. We have developed a macro-modelling framework that evaluates the impact of two domestic shocks (rainfall shortfall and fiscal profligacy) and three external shocks (oil price hike, world trade shock and capital flow shock) that affect the economy through various channels. Our results show that different shocks have very different impacts on various aspects of the growth process. On balance, it appears that the Indian economy is more resilient to shocks because of reforms. As far as counter shock policies are concerned, all major domestic and external shocks can be countered through contra-cyclical fiscal and monetary policies. In the short run, this may lead to higher inflation due to a tradeoff between growth and inflation in case of certain shocks that are stagflationary. In the long run, counter shock policy must involve higher public investment financed by the lowering of other government expenditure.

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1. INTRODUCTION

Evaluating the impact of domestic and external shocks on the growth of developing economies is of utmost importance, as the consequences of these shocks push millions of people into abject poverty and deprivation. It is in this context that we have studied the impact of domestic and external shocks on the Indian economy. A closer look at the last fifty year's experience reveals that broadly, there are five distinct types of shocks that have affected the performance of the Indian economy, sometimes working in tandem. The first two types, discussed below, are domestic shocks.

1. Drought, i.e., below normal rainfall. Since the agricultural sector is still a significant part of the economy and has strong demand and supply interlinkages with the rest of the economy, this is perhaps the shock that causes maximum damage to the Indian economy.

2. Fiscal profligacy of the government, which is a non-developmental expenditure undertaken due to political economic compulsion or to mitigate the effect of other shocks, leading to a fiscal burden.

The next three types that we discuss are external shocks.

1. Hike in the international price of oil (petroleum). This is a major import item and is highly price inelastic as a result of which it has a strong impact on the economy.

2. Stagnation or fall in world trade. World trade is a strong determinant of Indian exports and hence any fluctuation in this also affects the economy adversely.

3. Sudden capital outflow induced foreign exchange market shock. This is a phenomenon that has precipitated a crisis in many developing economies and India is no exception to that.

Any satisfactory analysis of these shocks has to provide an answer to the following questions:

- What are the sectors where these shocks originate?
- What are the intermediate variables that are affected by these shocks and that in turn pass on these affects to the production (growth) sector of the economy?
- What are the equilibrating variables in the economy that adjust to the disequilibrium created by these shocks?
- How do we quantify all these effects that originate in one sector and then spread to the rest of the economy through multiple channels?
- How do we differentiate between the short term and long term effects of these shocks?
- What are the worst-case scenarios in the eventuality of multiple shocks affecting the economy simultaneously?
- How do we assess the ability of public policy interventions in mitigating these shocks?

The purpose of this study is to analyse the effect of the five types of shocks on the growth in the Indian economy in terms of the issues raised by the above questions. Section 2 discusses the literature on the effect of shocks on growth. Section 3 looks at some macroeconomic data from the Indian economy in order to identify the incidence of these shocks and their impact on other parts of the economy. Section 4 gives a brief description of the methodology of the study. Section 5 describes the model in terms of behavioral equations and identities. Section 6 presents some simulation results that help in evaluating the effect of shocks on the economy. Section 7 concludes the study.

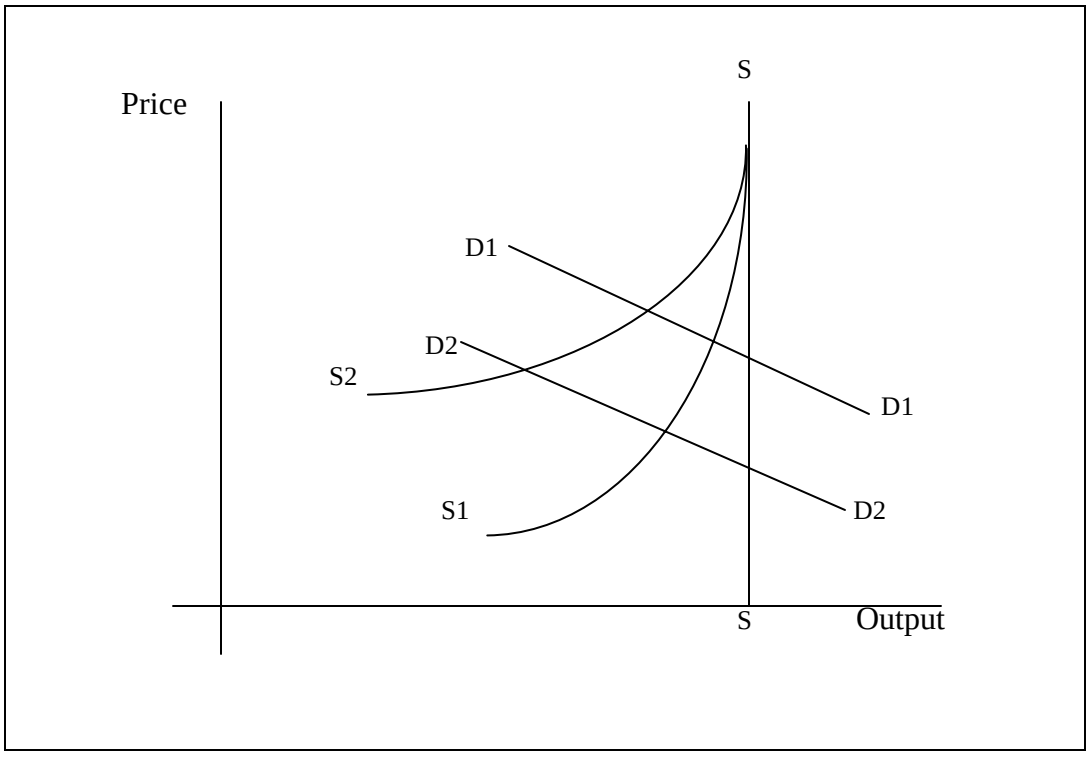
2. ECONOMIC SHOCKS AND THEIR IMPACT ON GROWTH

Although discussions and research on economic shocks have a long history, there has been no attempt in the literature to give a rigorous definition to this term. Loosely defined, an economic shock is an unexpected exogenous disturbance that has a significant

impact on the economic system. Although there may be some shocks that have a positive impact (for example technological breakthroughs), the term is largely used for phenomena that have an adverse impact on the economy. The analysis of shocks became popular after a spate of supply shocks hit the global economy during the seventies. Since then, various kinds of shocks have been historically recorded and the current literature distinguishes between demand and supply shocks, domestic and external shocks, country-specific and global shocks, nominal (monetary) and real shocks, etc.

An important part of the literature focuses on the impact of these shocks on the growth of an economy. According to the neoclassical literature, these shocks cause unpredictable changes in aggregate demand and short run aggregate supply and hence induce fluctuations in the short run growth rate. Nonetheless, this literature questions whether these shocks have any significant long-lasting impact. The impact of demand and supply side shocks on output and prices are represented in Figure 1.

Figure 1



Demand shocks affect the aggregate demand for the economy's output. For example, a global recession may lead to a fall in the demand for a country's exportables. This will shift the demand curve from D1D1 to D2D2. Given the short run supply curve S1S, the demand shock leads to lower output and lower prices. Supply shocks on the other hand, shift the short run supply curve of the economy. For example, an oil price hike causes an increase in the variable costs of firms for whom oil is an essential input into the production process. For this reason firms may seek to raise their prices to protect their profit margins. This shifts the short run supply curve from S1S to S2S. Given the demand curve D1D1, the supply shock leads to lower output and higher prices. Thus, according to the neoclassical literature, demand and supply shocks can adversely affect the output and hence the short run growth rate of the economy, although they have a contrasting effect on the price and inflation rates. However, the long run growth rates are determined by the long run supply curve (represented by the vertical curve SS in Figure 1) and the factors that determine the rate of growth of this curve. In the neoclassical growth models, this is given by the exogenous rate of technical progress which is assumed to be unaffected by these shocks.

The distinction between the impact of shocks on the short and long run growth rates is a characteristic of the neoclassical theories of growth. This distinction has been challenged by a number of alternative paradigms. One important school of thought that attempts this is the "Real Business Cycle (RBC)" approach that puts forward the view that growth and fluctuations are not distinct phenomena to be studied with separate data and analytical tools. This approach views economic fluctuations as being predominantly caused by persistent real (supply-side) shocks that are due to large random fluctuations in the rate of technological progress that result in fluctuations in relative prices to which rational economic agents optimally respond by altering their consumption pattern and supply of labour. According to the RBC theory, fluctuations in output and employment are Pareto efficient responses to real technology shocks to the aggregate production function of the economy. This implies that observed fluctuations in output are fluctuations in the natural rate of output rather than deviations of output from a smooth deterministic trend. Therefore, government intervention to smoothen fluctuations through a stabilization policy is not only undesirable because such attempts are unlikely to meet

its desired objective, but also because reducing instability results in welfare losses. Hence, in contrast to the Keynesian theory which views any departure from full employment as a distortion in terms of societal welfare calling for proactive government intervention, the 'bold conjecture' of RBC theory is that each phase of the business cycle, boom and slump, is a Pareto efficient equilibrium.

According to the neoclassical growth theory, investments have no impact on the long run growth rate and only "technical progress" can give rise to per capita growth. For a long time however, the idea of "technical progress" was a black box and there was no satisfactory theoretical analysis of the factors causing it. This situation changed significantly during the late eighties and the nineties, with the emergence of the theories of " Endogenous Growth". According to these theories, technical progress could depend on a whole range of factors like human capital formation, research & development (R&D) expenditures, government expenditure, especially on infrastructure, etc., and these could generate a steady state growth of per capita income. In recent years, these ideas have strongly influenced policymakers, and strategies of growth have focused more and more on these issues. Since these models envisage an important role for investment rates, one of the important implications of this approach is that permanent shocks to capital formation can also influence long run growth rates.

The theories of growth that have been described above use the concept of a steady state in order to explain the growth process. According to this concept, each economy has a long run (steady state) growth rate that is determined by exogenous factors like human capital, R&D expenditures, etc. As a corollary to this, it is envisaged that the short to medium run growth dynamics of any economy is a movement along a transitional trajectory that ultimately leads to the long run steady state growth path of the economy. This is, of course, a stylized abstraction of the growth process that is necessary in order to construct a benchmark model of growth. However, the high level of abstraction adopted in these models also diminishes their capacity to explain certain observed phenomena exhibited by economies in real life. For example, these models assume that any deviation from the growth path is temporary and reflects the business cycles originating from the short run behavior of the economy. This makes it impossible to incorporate the effect of domestic and external shocks that not only derail the economy from its short and medium

run growth paths, but also affect the long run growth paths. Clearly, any study that tries to analyse the effect of such shocks on the growth process needs an alternative framework that explicitly incorporates the sectors of the economy where these shocks originate and the intersectoral channels through which these shocks spread and affect the aggregate economy. This realization has given rise to a sizeable literature that analyses the impact of various kinds of shocks within the framework of a detailed model of the economy. The main approaches used for this purpose are structural macromodels, general equilibrium models and VAR models. Each of these approaches has its strengths and weaknesses and ongoing research continues to debate on which of these is the most useful approach.

3. INCIDENCE AND IMPACT OF DOMESTIC AND EXTERNAL SHOCKS ON THE INDIAN ECONOMY

It may be worthwhile to note at this juncture, that so far, the Indian economy has not experienced the extreme volatility in economic behavior witnessed in other emerging economies, especially in Latin America, Africa, and the formerly Soviet bloc of countries. During the last fifty years, negative GDP growth occurred in only three years with the most acute being in 1979 (about minus five percent). The inflation rate has also remained fairly stable, typically below double-digit figures and a negative rate of inflation was witnessed only twice during the fifties. A major reason for this kind of stable behavior could be attributed to the state control over production, consumption and prices till the early nineties. Another reason could be the low dependence on foreign trade and investment. Even after a decade of liberalization, India is one of the least globalized economies of the world. With the advent of freer markets and globalization, the economy has now become more sensitive to internal and external shocks.

In this section we shall try to identify the incidence and origin of the five types of shocks that we are analysing in this study. Moreover, we shall also try to identify the impact of these shocks on various intermediate and equilibrating variables in the economy. It may be noted however, that in a number of cases it is difficult to isolate the effect of the shocks, as other variables including corrective policy measures also changed

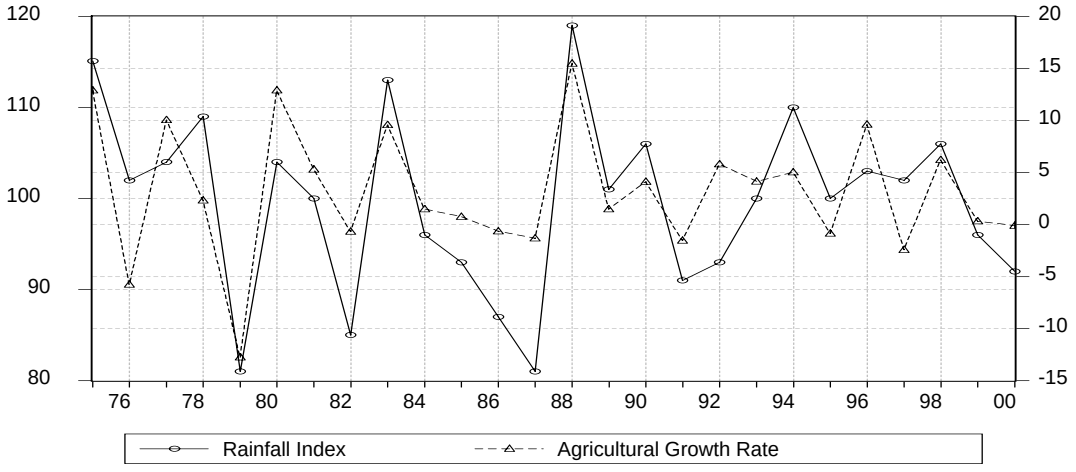
during this period. It may be noted that wherever we refer to a calendar year, it actually represents the corresponding fiscal year. For example, a reference to 1970 would indicate the fiscal year starting in April 1970 and ending in March 1971. We shall start our analysis with the two domestic shocks.

Rainfall Shock

Traditionally, the Indian economy has been significantly dependent on its agricultural sector. Agriculture has been an engine of growth not only due to the output from this sector but also due to the presence of demand and supply linkages to the non-agricultural sector. The most important input in agricultural production is water, for which the country is largely dependent on rainfall. As a result, rainfall deficits are the most frequent of shocks faced by the Indian economy. Let us first identify some of the periods that have experienced rainfall shocks in the past. Figure 2A plots the rainfall index (normal rainfall = 100) for the period 1975 to 2000 (units are shown on the left hand margin).

Figure 2A

The Association Between Rainfall and Growth of Agricultural GDP



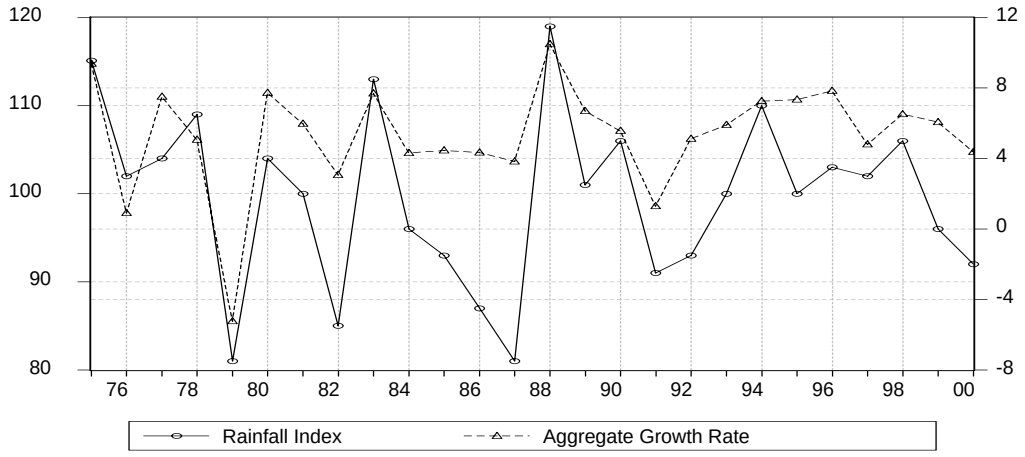
Note: Rainfall index normalizes the volume of rainfall by taking the long run average (normal) rainfall to be 100. Agricultural growth is the rate of growth (%) of real agricultural GDP.

From this figure we find that 1979 and 1982 were severe drought years when the rainfall was 20% and 15% below normal, respectively. Moreover, the period 1984 to 1987 saw

four consecutively bad rainfall years, leading to a medium term shock to Indian agriculture. Let us now look for the impact of these rainfall shocks on the economy. The direct impact is of course, on agriculture. From Figure 2A we find that agricultural growth (measured in percentage terms and units shown on the right hand margin) is heavily dependent on rainfall. Thus, the two drought years 1979 and 1982 show negative growth rates in Indian agriculture. The period 1984 to 1987 shows a striking contraction in agricultural output as well. Thus, the direct impact of a rainfall shock is very clear from this figure. However, as we have mentioned earlier, agricultural growth affects the growth of non-agricultural output through demand and supply linkages. Thus, a rainfall shock affects the growth of both the agricultural and non-agricultural sector. We look at the impact of a rainfall shock on the growth of total output in Figure 2B. We find that aggregate growth also became negative in 1979 and fell from its previous level in 1982. Similarly, in the period 1984 to 1987, the aggregate growth rate stagnated at around 4% and this is lower than the growth in the previous and the subsequent year.

Figure 2B

The Association Between Rainfall and Growth of Aggregate GDP



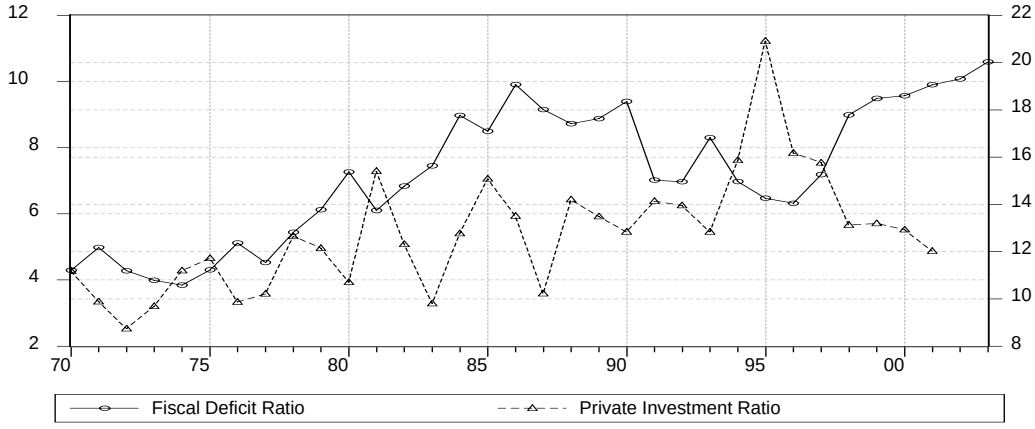
Note: Rainfall index as defined in earlier figure. Aggregate growth is the rate of growth (%) of real GDP.

Fiscal Profligacy

Fiscal profligacy is a widely used term in modern economics but it is hard to define. It can be literally interpreted to mean unproductive expenditure by the government. However, since most government expenditures have some social return from them, it is difficult to identify completely unproductive expenditure. Here we shall look at the fiscal deficit as a measure of profligacy, though it is by no means a perfect measure. Figure 3A plots the periods of high fiscal deficits (as a ratio to GDP) in the past.

Figure 3A

The Association Between Fiscal Deficit Ratio and Private Investment Ratio



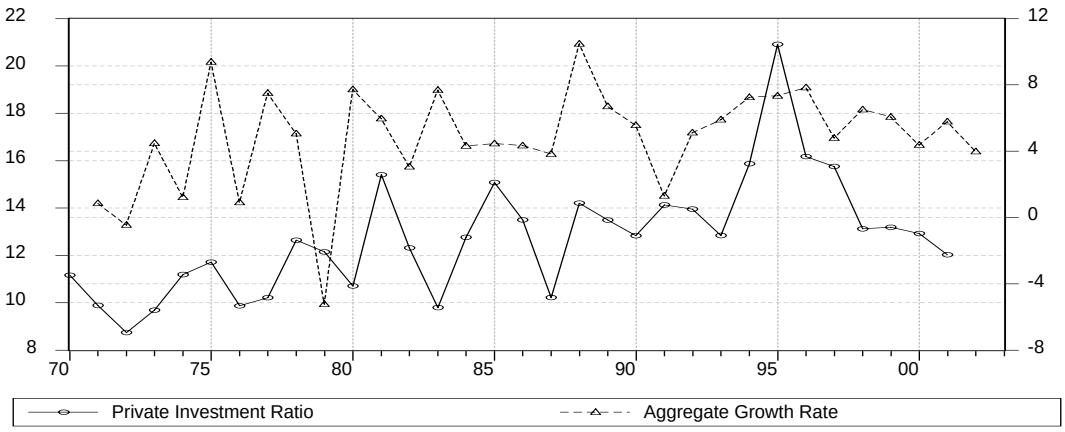
Note: Fiscal Deficit Ratio is the ratio (%) between nominal fiscal deficit and nominal GDP. Private Investment Ratio is the ratio (%) between nominal private investments and nominal GDP.

We find that the fiscal deficit ratio reached a high of about 10% (units are shown on the left hand margin of Figure 3A) in 1986 and hovered at around 9% for the net four years. It fell sharply during the first half of the nineties following the crises of 1991 but has again gone up to cross 10% in recent years. Let us next try to look for the impact of high deficits on other parts of the economy. According to the theoretical literature, fiscal deficits have a positive impact on growth by boosting demand and a negative impact by crowding out private investments. We try to look for the net effect in Figure 3A, which plots private investments as well (units are shown on the right hand margin). The graph seems to indicate a negative relationship between changes in the fiscal deficit ratio and changes in the private investment ratio. This negative relationship gets stronger in the

90s, when falling deficits coincide with rising private investments and rising deficits coincide with falling private investments. This point is further substantiated by the correlation coefficient between the first differences of the two variables, which is –0.39 for the entire period and –0.51 since the 90s. The next step is to understand the impact of fiscal deficits on aggregate growth. According to our analysis, this is possible through the impact of private investments on growth. We look at the relationship between private investments and the aggregate growth rate in Figure 3B. The data indicates that there is a positive relationship (as is expected) and this seems to have become stronger in the nineties.

Figure 3B

The Association Between Private Investment Ratio and Growth of Aggregate GDP



Note: Private Investment Ratio and Aggregate Growth as defined in earlier figures.

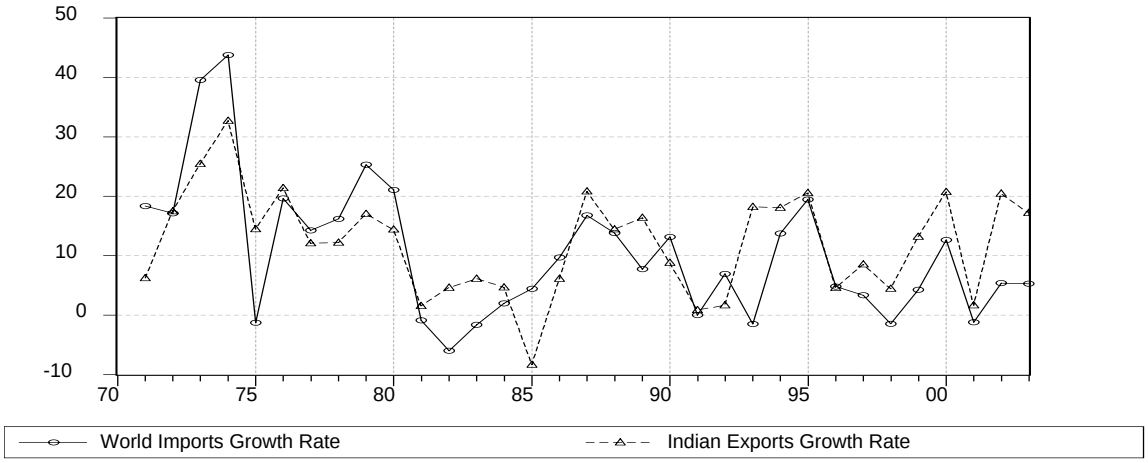
Next, we look at the three external shocks.

World Trade Shock

The shock of falling world trade affects almost all countries. Of course, the impact is stronger for countries that are more open and globalized. The Indian economy is no exception and since it has become more and more open in the last decade and a half, it is now more prone to such shocks. As a result, Indian exports are significantly dependent on the trends in world imports. We start by identifying the periods that experienced world trade shocks. Figure 4A plots the world imports growth.

Figure 4A

The Association Between Growth of World Trade and Growth of Indian Exports



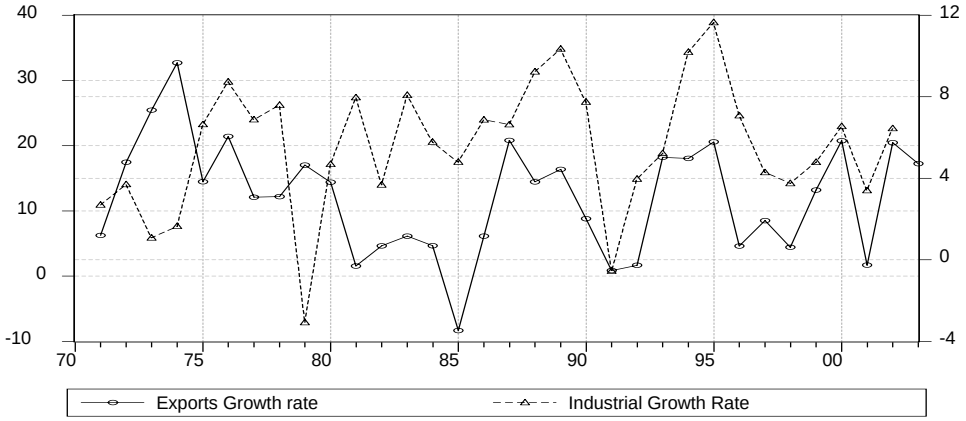
Note: World Imports Growth is rate of growth (%) of world imports in nominal dollars. Indian exports growth is rate of growth (%) of Indian exports of goods and services in nominal dollars.

Clearly, 1975 saw a significant slump in world trade and the periods 1981 to 1984 and 1996 to 1998 show persistent stagnation in the same. As expected, the impact of this shock is felt directly in the exports sector (see Figure 4A). Thus we find that in the periods mentioned above, export growth has fallen corresponding to the previous years. How does the world trade shock affect the rest of the economy? In order to understand this, we must take into account the differential impact of exports on the various sectors. The agricultural sector is still protected from the external sector and the service sector growth is largely dependent on domestic demand. Thus, it is the industrial sector that is most sensitive to movements in exports in the Indian economy. Figure 4B shows the relationship between exports growth and industrial growth.

The data indicates that there is no relationship between the two variables before the period 1985, but after this period, there is some co-movement between these variables. This clearly reflects the increasing role of exports in the economy in general, and in the industrial sector in particular.

Figure 4B

The Association Between Growth of Exports and Growth of Industrial GDP



Note: Exports growth as defined in earlier figure. Industrial growth is the rate of growth (%) of real industrial GDP.

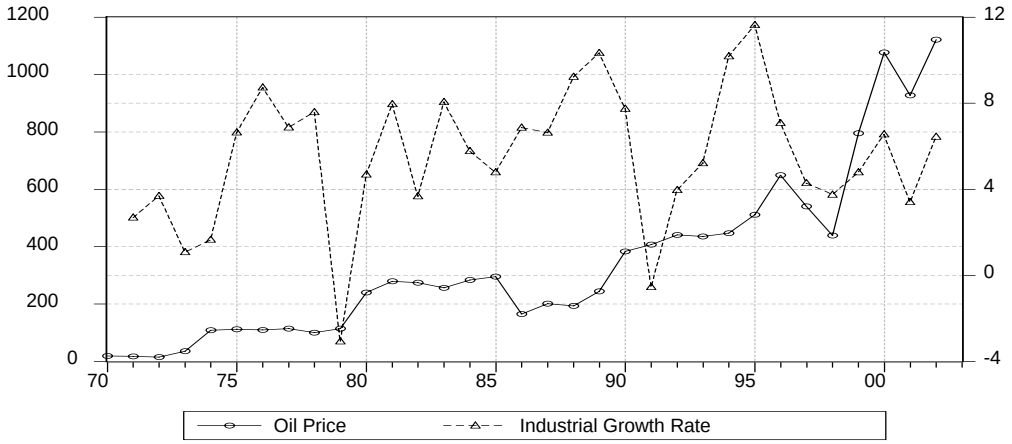
Oil Price Shock

The Indian economy imports about 70% of its oil requirements from international markets. This makes the economy vulnerable to any increases in oil prices in these markets. However, the oil prices do not affect the economy homogenously. The services sector is far less dependent on oil than the industrial sector. In fact, as most of the growth in the economy stems from the services sector, the economy and its performance is becoming less vulnerable to oil price fluctuations. Another reason due to which the oil-price shocks are not so effective in India is the governments administered pricing policies of oil, that diffuse the hikes by raising subsidy, etc. Figure 5A plots the trends in international oil prices in the past. The obvious shock periods are 1973 to 1974 and 1980, the two shocks that sent the world into a recession. However, 1990 (the first Iraq war) and the period around 1999 also show significant oil price hikes. The industrial growth rates are also plotted for the same year in Figure 5A (units on the right hand margin). We find that the industrial growth was low during the first hike during 1973 - 1974 but the second hike in 1980 does not seem to have any effect. The hike in 1990 coincides with a fall in industrial growth rates but the hikes during 1999 - 2000 again do

not seem to have any impact on industrial growth. From all of this, it seems that an oil price hike has a very limited impact on the industrial growth rates as well.

Figure 5A

The Association Between Price of Oil and Growth of Industrial GDP

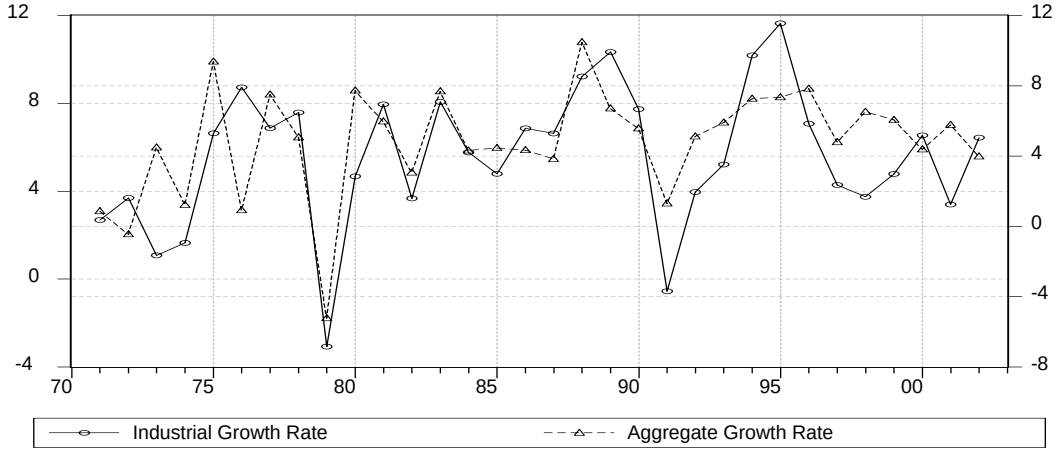


Note: Oil Price is the index of import price of petroleum products. Industrial growth as defined in the earlier figure.

Figure 5B shows the relationship between industrial and aggregate growth. It is clear that the relationship is significantly strong. Thus, any impact of the oil price hike on industrial growth rates is likely to be passed on to aggregate growth rates as well.

Figure 5B

The Association Between Growth of Industrial GDP and Growth of Aggregate GDP



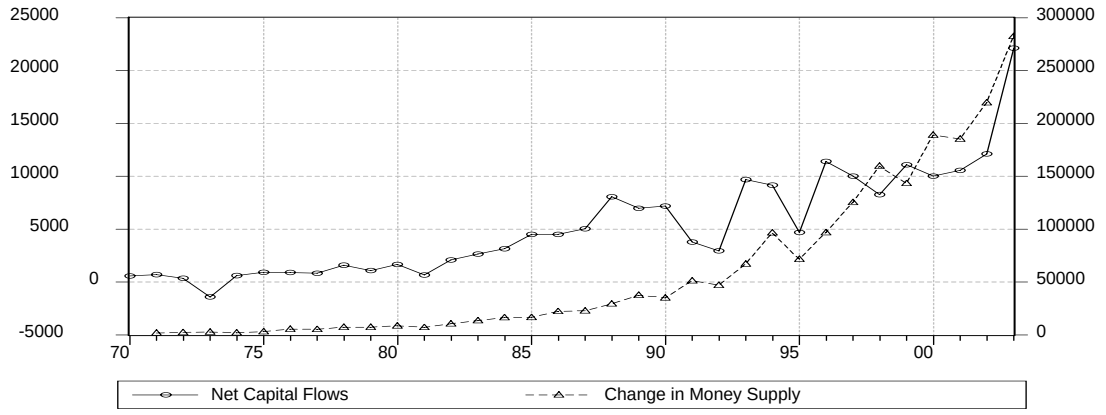
Note: Industrial growth and aggregate growth as defined in earlier figure.

Shock from Capital Flows

Large capital flows and the crises that are associated with them have become the bane of globalization in the twenty first century. Large capital flows have led to a currency crisis in a number of countries ranging from Mexico to Russia, while the most well-documented ones are those in the East Asian countries. Of course, capital flows need not always lead to a currency crisis and there are other effects of such flows on an economy as well. The Indian economy was largely insulated from such flows before 1990. Figure 6A plots trends in capital flows in the past. There is a continuously upward rising trend throughout, although the flows have been more erratic in the 90s and there is a steep hike in 2003.

Figure 6A

The Association Between Net Capital Flows and Changes in Money Supply



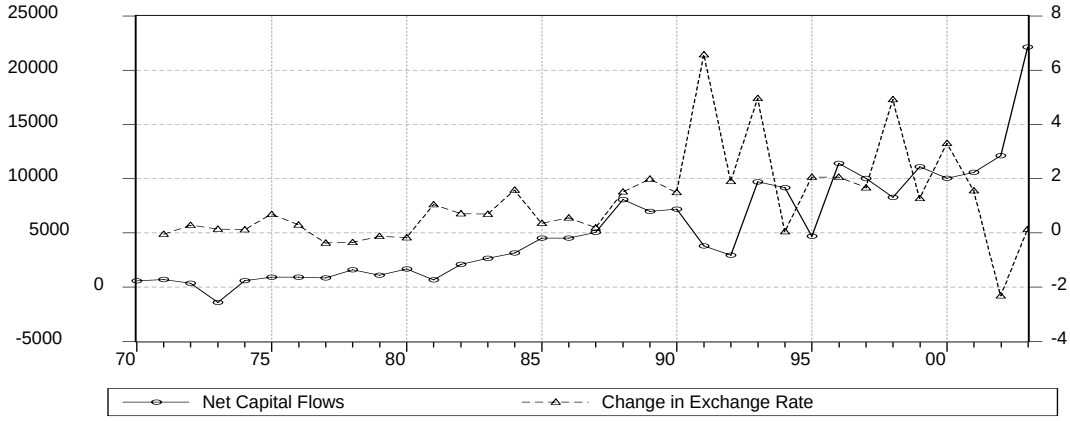
Note: Net capital flows is the capital account balance in nominal dollars. Money supply is nominal value of total money supply in rupees crores.

Capital flows affect the economy through foreign exchange reserves, which in turn, affect the monetary base and hence, the money supply in the economy. Figure 6A plots the trends in changes in money supply (units on the right hand margin) in the past. There is a very clear relationship between capital flows and the changes in money supply. Thus increased capital flows lead to a slack monetary situation in the economy. The other intermediate variable that is affected by capital flows is the exchange rate. Higher capital flows would increase the supply of foreign exchange leading to low or even negative changes in the exchange rate. Figure 6B plots the two variables over time. The expected

negative relationship between the two variables is not well manifested in the period before 1990, but in the post 1990 period, there are definite indications of this relationship.

Figure 6B

The Association Between Net Capital Flows and Changes in Exchange Rate



Note: Net capital flows as defined in earlier figure. Exchange rate is in rupees/$.

4. METHODOLOGY FOR EVALUATING IMPACT OF SHOCKS

Given the objectives of this study, the most appropriate tool that can be used for an analysis of these issues is a structural macro-modelling framework. Macro-modelling is based primarily on the 'structural modelling' methodology associated with the Cowles Commission. The methodology may be summed up in terms of the following steps:

1. Constructing a model of the macro economy on the basis of a theoretical framework and with a chosen degree of disaggregation. The framework will incorporate the sectors and variables that are affected by the shocks as well as policy variables that can be used to counter them.

2. Acquiring time series data for all the variables (endogenous as well as exogenous) for the period to be studied.

3. Estimating the behavioral equations on the basis of the *a priori* theories and the time series data. Suitable changes can be made to the behavioral equations during the course of this exercise.

4. The whole model including the technical equations, identities and the behavioral equations is solved (simulated) using the Gauss-Seidel method in order to generate the predicted values of the endogenous variables.

5. The model is then used to simulate base-run (normal) growth rates and counterfactual situations caused by a single or multiple shocks affecting the economy.

For our estimation exercise, we have used annual data collected from various sources to estimate a model for the Indian economy. A simultaneous estimation of all the equations will not be feasible as the number of observations is usually not sufficiently large and hence the equations have been estimated separately using the OLS method. In a number of cases where found suitable, the equations have been estimated using the logarithms of the variables. In order to keep the model tractable, we have chosen a few explanatory variables for each behavioral equation. This sometimes results in omitted variable bias leading to serial correlation and poor Durbin Watson statistics. In such cases we have estimated the functions with AR(1) errors. In order to incorporate both short run and long run effects of the shocks, we have incorporated a dynamic impact in a number of equations by using lagged dependent variables as regressors. In such cases, the Durbin Watson statistics become irrelevant and we have calculated the Durbin's h statistics.

The framework of the model is based on known stylized facts about the Indian macro-economy. Macroeconomic model builders are usually faced with a choice between the Neoclassical and the Keynesian paradigms depending on the role that is assigned to output and/or price adjustments in bringing about macroeconomic equilibrium. A third alternative that came up specifically in the context of developing economies is known in the literature as Structuralism. In practice however, most macroeconomic models of developing economies have put together different aspects of

all these paradigms. This is known in the literature as the eclectic approach. In this study, we shall adopt this approach. Keeping in view the liberalization process introduced in the economy in 1991, the model will be designed to represent a market-oriented economy. It will be broadly classified into the production, fiscal, monetary and external sectors.

Systems of equations like a macromodel have to deal with the identification problem. The identification problem may be dealt with by using exclusion restrictions in terms of the order and rank conditions. Structural equations in macro-models with a large number of exogenous variables are usually over-identified and this can be easily verified using the order condition. It is difficult to test for the rank condition for large models such as these. Following conventional macro-econometric modelling procedure a la Klein, we ensure the order condition only.

Using OLS for the estimation of the behavioral equations gives rise to simultaneous equation bias. The problem is that we have time series data for about 30 years and more than 40 exogenous and predetermined variables. This means that it is not possible to use TSLS methodology. In fact, due to this problem with degrees of freedom, all large macro econometric models eventually estimate parameters by OLS. Note that in this case, even though the estimation procedure does not take care of the simultaneity, the Gauss – Seidel technique that is used to generate the complete model solution, solves the endogenous variables simultaneously.

5. THE MODEL

Keeping in view the factors mentioned above we have built a macro model to measure the macro impact of domestic and external stocks (the whole model is given in the appendix). The Indian economy is heterogeneous in terms of production, investment and price behavior. Hence we have divided the economy into three parts, i.e., the agricultural sector, the industrial sector and the tertiary sector (which includes the rest of the economy and is the aggregate of the services sectors and public administration) and for each sector we have an output, private investment and price function (GDP Deflator). To incorporate

dynamic behavior and to distinguish between the short and long run effects, we have incorporated lagged dependent variables in the estimation of all these functions. In the case of output, this would represent the generalized distributed lag behavior between output and capital. In the case of investment this would represent the discrepancy between the desired and actual investment behavior. In the case of prices, the lagged dependent variable will incorporate the adaptive expectations in price formation. It may be noted that in our model presented below, figures in parenthesis are standard errors. Number of *s on the right side of regressors indicate the level of significance of the coefficients (i.e., * denotes 10%, ** denotes 5% and *** denotes 1% level of significance). Dh gives the Durbin's h statistic.

We postulate that agricultural output (XA) is constrained by supply side factors like capital stock in agriculture (KA) and rainfall (RF). The agricultural output function has an irregular dummy DUMXA (representing the extreme drought effect of 1979) and a structural dummy D80S (to take care of the secular fall in agricultural growth since the eighties).

$$XA = EXP(-8.16 + 1.43*LOG(KA)^{***} + 0.27*LOG(RF)^{***} - 0.12*D80S^{***} - 0.14*DUMXA^{***} + 0.10*LOG(XA(-1)))$$

(1.31) (0.24) (0.05) (0.03) (0.03) (0.14)

$R^2 = 0.99$ Dh = -1.06

The results indicate that capital stock in agriculture and rainfall affects agricultural output significantly. The relatively low value of the lagged dependent variable shows that capital formation in agriculture does not have a strong long run impact on output in this sector.

Industrial sector output (XI) and tertiary sector output (XT) are postulated to be functions of the productive capacity in these sectors and the capacity utilization rates. The productive capacity is determined by the capital stock (KI and KT) while large pools of unemployed labor ensure that there are no labor constraints in these sectors. Consistent with some recent studies on India, we postulate that output and capacity utilization in industry and the tertiary sector are sensitive to changes in demand. In the industrial output function, domestic and external demand are represented by autonomous

expenditure (RAE), which is the sum of government expenditure and exports of goods and services. Industry also depends on agricultural demand. Moreover, industrial output is negatively related to industrial price (PI), again reflecting the demand-constrained nature of this sector. The industrial output function has two structural dummies, DPLIB (representing the partial liberalization of the economy in the mid eighties) and D95 (representing the peak effect of liberalization in 1995 following the large deregulation of the economy in 1994). In the tertiary sector, the demand constraints are captured by the commodity output (XCOM), i.e., the sum of the output in the other two sectors. The tertiary output function has two dummies DPLIB (partial liberalization) and DUMPAY (representing the impact of large hikes in the salaries and wages of public administration that inflate the value added in the tertiary sector).

XI =EXP(-2.57 + 0.08*LOG(KI) + 0.34*LOG(XA)*** + 0.18*LOG(RAE)*** - 0.06*LOG(PI)
(0.83) (0.09) (0.07) (0.05) (0.04)

+ 0.02*DPLIB + 0.6*LOG(XI(-1))*** + 0.04*D95**)
(0.01) (0.06) (0.01)

R^2 = 0.99 Dh = -1.32

XT =EXP(-5.06 + 0.67*LOG(KT)*** + 0.13*LOG(XCOM)** + 0.01*DUMPAY* + 0.02*DPLIB**
(1.02) (0.17) (0.05) (0.006) (0.008)

+ 0.52*LOG(XT(-1))***)
(0.09)

R^2 = 0.99 Dh = -1.54

The results indicate that demand side factors like agricultural output and autonomous expenditure are the crucial determinants of industrial output. Capital stock has a small impact on current periods output but the lagged dependent variable indicates that capital has a strong long-term impact on industrial output. The output in the tertiary sector is largely determined by capital stock, which has an impact on current as well as future services output. The demand factor, i.e., the output from the commodity producing sectors also affects the output in this sector.

The capital stock in each of the three sectors is the sum of past capital stock in that sector (adjusted for depreciation) and private and public investments in that sector. The private investment functions are postulated to be a synthesis of a flexible accelerator theory and a

Keynesian investment function (represented by interest rate). It may be noted that due to institutional constraints, non-agriculturalists cannot invest in agriculture. Hence the agricultural investment function is based on agricultural output although the same in the industry and tertiary sectors are dependent on aggregate GDP. The nature of government expenditures also plays a crucial role in investments. We have postulated that public investment (IGA, IGI and IGT) plays a positive role by crowding in private investments, reflecting the fact that the Indian economy is still constrained by physical infrastructure, etc. On the other hand, other government expenditure (ORGE) - including government consumption and transfers - loosely representing the fiscal profligacy of the government, crowd out private investment by using up scarce resources. Agricultural investments (IPA) have a structural dummy D80S (representing a secular fall since the eighties). The industrial and tertiary sector investment functions (IPI and IPT) have an irregular dummy D95 (peak liberalization effect).

IPA = -4714.17 + 0.05*XA*** + 0.44*IGA** - 2700.76*D80S*** + 0.28*IPA(-1)**
(1704.33) (0.01) (0.2) (706.1) (0.13)

R^2 = 0.9 Dh = -1.81

IPI = -25029.76 + 0.20*XGDP*** + 0.71*IGI** - 0.56*ORGE*** - 649.003*RPLR - 939.56*IFR
(10074.05) (0.04) (0.3) (0.13) (696.28) (791.82)

+ 41506.12*D95*** + 0.22*IPI(-1)*
(7846.02) (0.11)

R^2 = 0.96 Dh = -0.91

IPT = -33116.9 + 0.08*XGDP** + 0.71*IGT - 663.11*RPLR - 2920.68*DFEMRPLR*
(12348.49) (0.04) (1.1) (590.26) (1628.1)

+ 0.45*IPT(-1)**
(0.19)

R^2 = 0.86 DW = 2.07 (Dh not computable)

The results indicate that the accelerator plays a strong role in determining private investment in all three sectors. Further, public investment crowds-in investment in the

agricultural and the industrial sector, but not in the tertiary sector. Similarly, other-government-expenditures crowd-out investment only in the industrial sector. The real interest rates (RPLR) have no impact on private investment in agriculture and a weak impact on industrial and tertiary sector investment. In the industrial sector, this is partly due to the fact that investors are worried of inflationary tendencies (IFR).

As far as public investment is concerned, it is assumed that the government exogenously determines their nominal values in all three sectors.

The demand side of the economy is largely determined by private consumption, while the other components are government consumption and investment, private investment and net exports. Private consumption (RCP) is postulated to be a function of private disposable income (RPDI). The private consumption function has a lagged dependent variable representing long run adjustments of consumption to income and a structural dummy DWTO (representing the effect of higher consumption of imported goods following the opening up of trade under the WTO agreement).

$$RCP = EXP(\underset{(0.33)}{2.89} + \underset{(0.06)}{0.65}*LOG(RPDI)*** + \underset{(0.01)}{0.03}*DWTO*** + \underset{(0.08)}{0.11}*LOG(RCP(-1)))$$

$R^2 = 0.99$ $\quad$ $Dh = 1.74$

The results show that, as in many other developing economies, private consumption is largely determined by private disposable income. The low significance of the lagged dependent variable indicates that income does not have a strong long-run effect on consumption.

Private disposable income is equal to nominal output at factor cost (YGDP) plus government transfers minus taxes. The nominal output at factor cost is estimated to have a unitary elasticity with nominal output at market prices (GDPMP).

$$YGDP = EXP(\underset{(0.03)}{-0.08} + \underset{(0.002)}{0.99}*LOG(GDPMP)***) + [AR(1)=\underset{(0.12)}{0.66}***]$$

$R^2 = 0.99$ $\quad$ $DW = 2.05$

The aggregate GDP deflator is assumed to be a weighted average of the sectoral deflators - the weights being the share of the sectors in real output in the base year

(1993). Agricultural prices (PA) are determined by both demand and supply factors. Agricultural output determines the supply in this sector while private disposable income (PDI) determines demand for agricultural output. The agricultural price function has an outlier dummy DUMPA (that takes care of the unusually high agricultural prices in 1973 and 1974 as a result of severe drought conditions in those years).

PA =EXP(4.002 - 0.71*LOG(XA)*** + 0.59*LOG(PDI)*** + 0.12*DUMPA*** + 0.31*LOG(PA(-1)**))
(1.71) (0.15) (0.08) (0.02) (0.14)

R^2 = 0.99 Dh = 1.29

The industrial sector is assumed to have mark up pricing and hence cost factors determine industrial prices (PI). The cost factors include agricultural prices, tariff rates (TRF) and import prices of oil (PMO) and non-oil commodities (PMN) separately.

PI = EXP(-0.20 + 0.37*LOG(PA)*** + 0.05*LOG(PMO)*** + 0.01*LOG(PMN) +
(0.06) (0.05) (0.009) (0.014)

0.53*LOG(PI(-1)***) + 0.06*LOG(TRF)***)
(0.05) (0.013)

R^2 = 0.99 Dh = 0.61

The tertiary sector prices (PT) are assumed to adjust to agricultural and industrial prices.

PT =EXP(0.11 + 0.16*LOG(PA)*** + 0.42*LOG(PI)*** + 0.39*LOG(PT(-1)***))
(0.01) (0.02) (0.04) (0.04)

R^2 = 0.99 Dh = 0.61

The results indicate that both the demand and the supply factors are equally important in the determination of agricultural prices. Industrial prices are found to be strongly affected by agricultural prices, tariff rates and import prices of oil but the import prices of non-oil commodities have no impact on them. The tertiary sector prices are strongly affected by prices in the other two sectors.

In the monetary sector, we assume that the demand and supply of money determine the interest rate, which in our model is the prime lending rate of commercial banks. The demand for money in real terms (RM3) is estimated to be a function of real

output and real interest rates. The function has an irregular dummy DUMM3 and a structural dummy DWTO (representing higher consumption demand for money corresponding the rise in consumption in that period).

RM3 =EXP(-9.801 + 1.68*LOG(XGDP)*** + 0.008*RPLR*** - 0.01*DFEMRPLR***
(0.5) (0.03) (0.002) (0.004)

+ 0.19*DUMM3*** - 0.07*DWTO*)
(0.03) (0.03)

R^2 = 0.99 DW = 1.52

From the results, we find that the coefficient of real interest rates has the wrong sign (positive) but shows the right sign (negative) with a slope dummy DFEMRPLR for financial and external sector liberalization. This is due to the fact that the monetary sector was stringently controlled before the liberalization of the economy and hence the positive relation between interest and money before liberalization actually represents the money supply function. In other words, the market determined interest rate is a post-liberalization phenomenon.

Given the demand for money, the interest rate is determined by the supply for money, which is assumed to be a function of the reserve money in the economy and the money multiplier. We postulate that the money multiplier is a function of interest rate and two monetary policy mechanisms, i.e., the bank rate (BR) and the cash reserve ratio (CRR). In the model, we invert the supply function of money by estimating interest rate (PLR) as a function of money supply (M3), reserve money (M0) and the monetary policy variables.

PLR = 0.49 + 1.65e-05*M3*** - 7.2e-05*M0*** + 0.43*CRR*** + 1.13*BR***
(1.42) (3.9e-06) (1.7e-05) (0.09) (0.21)

R^2 = 0.88 DW = 2.45

The results indicate that interest rates are strongly affected by money supply, reserve money and the monetary policy variables. It may be noted that the reserve money has two main components – monetized debt of the government net of non-monetary liabilities and foreign exchange reserves.

In the fiscal sector, government expenditure is equal to government consumption, investments and transfers, all of which are assumed to be exogenous variables. The revenue side consists of tax and non-tax revenue, of which the latter is assumed to be exogenous. Tax revenue (TAX) is estimated as a function of nominal output (GDPMP). The tax function has two dummies DLIB (representing the effects of lowering of domestic tax rates as a part of the liberalization process) and DWTO (representing effects of lowering customs duties following India's joining the WTO).

$$TAX = EXP(-2.95 + 1.08*LOG(GDPMP)^{***} - 0.104*DLIB^{***} - 0.11*DWTO)^{***}$$
$$\qquad\qquad (0.18) \qquad (0.01) \qquad\qquad (0.02) \qquad (0.02)$$

$$R^2 = 0.99 \qquad DW = 1.906$$

The difference between the revenue earned and the expenditure gives the gross fiscal deficit.

In the external sector, the current account balance is the sum of net exports and remittances, etc. Exports (EGS) are postulated to be a function of the volume of world trade (WT) - which is proxied in our model by world imports - and the depreciation in the real exchange rate. The export function has three structural change dummies - D80S (representing the beginning of export promotion policies since the eighties), DFEM (representing the effect of trade and exchange rate deregulation in 1993) and DWTO (representing the positive effect on exports of joining the WTO). It also has an irregular dummy DUMEGS.

$$EGS = EXP(-6.62 + 1.02*LOG(WT)^{***} + 0.34*LOG(REXR)^{**} + 0.09*D80S + 0.12*DFEM^{*}$$
$$\qquad\qquad (1.13) \qquad (0.05) \qquad (0.14) \qquad (0.05) \qquad (0.06)$$

$$+ 0.14*DWTO^{**} + 0.23*DUMEGS^{***})$$
$$\qquad (0.05) \qquad (0.05)$$

$$R^2 = 0.99 \qquad DW = 1.49$$

The results show that world trade is the most important determinant of exports although the depreciation in real exchange rate is also found to boost exports.

Imports are divided into two parts – oil imports and non-oil imports. It may be noted that oil imports were extremely volatile before 1985 due to the two oil shocks as well as the discovery and extraction of large volumes of oil since the beginning of the

eighties. Hence we have estimated the oil import function post 1985. We postulate that oil imports (MGSO) are strongly related to commodity production (the tertiary sector is much less oil intensive), import price of oil (PMO), domestic prices (PGDP) and exchange rate (EXR) (the last three determining the relative price of oil). It also has an irregular dummy DUMMGSO.

MGSO =EXP(-3.26 + 0.43*LOG(XCOM)* + 1.005*LOG(PMO)*** + 0.55*LOG(PGDP)**
(2.09) (0.21) (0.02) (0.2)

– 0.69*LOG(EXR)*** + 0.05*DUMMGSO)***
(0.1) (0.01)

R^2 = 0.99 DW = 1.85

The non-oil imports (MGSN) are postulated to be a function of output, price of non-oil imports(PMN), domestic prices, exchange rate and tariff rates. The non-oil import function also has two structural dummies D95 (peak liberalization effect) and DWTO (effect of joining WTO).

MGSN =EXP(-10.22 + 1.37*LOG(XGDP)*** + 0.09*LOG(PMN)** + 1.36*LOG(PGDP)***
(2.29) (0.2) (0.03) (0.1)

– 1.34*LOG(EXR)*** - 0.18*LOG(TRF)*** + 0.18*D95*** + 0.05*DWTO)
(0.06) (0.03) (0.05) (0.04)

R^2 = 0.99 DW = 1.66

The results show that oil imports are largely determined by factors that affect its relative price i.e., import price of oil, domestic prices and the exchange rate. Non-oil imports are also strongly affected by these three variables as well as the level of output and tariff rates.

The foreign exchange reserves are equal to the sum of past reserves, the current account balance and the capital account balance. The capital account balance is assumed to be an exogenous variable. The exchange rate (EXR) is hypothesized to be a function of the foreign exchange reserve (FER) as well as prices in the economy. We also postulate that the exchange rate adjusts to its past values. There is a dummy in the

exchange rate equation DEV91 (representing the large devaluation that was undertaken in 1991).

$$EXR = EXP(\underset{(0.1)}{0.39} - \underset{(0.01)}{0.07}*LOG(FER)^{***} + \underset{(0.04)}{0.27}*LOG(PGDP)^{***} + \underset{(0.04)}{0.19}*DEV91^{***} + \underset{(0.06)}{0.69}*LOG(EXR(-1))^{***})$$

$R^2 = 0.99$ Dh = -1.17

The results indicate that the exchange rate is strongly influenced by the size of the foreign exchange reserve (FER), as well as prices in the economy. The exchange rate is also found to adjust to past values.

6. IMPACT OF DOMESTIC AND EXTERNAL SHOCKS ON THE ECONOMY

Once the behavioral equations are estimated and the identities and technical equation are determined, the model is complete and ready for simulation. The simulation is done using the Gauss – Seidel methodology that solves for the endogenous variables corresponding to alternative assumptions about the exogenous variables. We have chosen the period 1997 to 2003 to evaluate the impact of external and domestic shocks on the economy. This period has been chosen for two reasons. Firstly, most of the policy changes that ushered in the liberalization of the economy had been adopted by this time and hence this period permits an analysis of the effects of liberalization. Secondly, it allows us to evaluate the impact of the shocks as close to the present as possible. In other words, this exercise may be interpreted to represent the present characteristics of the economy. The first step is to validate the model, which is done by comparing the base-run simulation values (where all the exogenous variables are assumed to have their historically given values) of important endogenous variables with their historical values, for the period 1997 to 2003.

Validation of the model

Table 1 presents the average annual values of historical data and base-run simulations of 18 key endogenous variables covering the period 1997 to 2003. From this

table it is clear that the model has simulated the Indian economy fairly accurately. It may be noted that while our regressions (and hence our model) are based on a far longer period (1970-2003), the validation is for a much smaller period that we have chosen for the counterfactual scenarios (1997-2003). This validation therefore shows that although the economy underwent significant structural changes during the period after 1994 due to liberalization of the economy, the model takes care of these changes and represents the economy quite accurately.

Table 1 : Actual and base-run simulation values (annual averages for 1997 – 2003)

Variables	**GDP Growth**	**Agricultural Growth**	**Industrial Growth**	**Tertiary Growth**	**Investment Rate**	**Inflation Rate**
Actual	5.6	2.4	4.7	7.9	23.8	4.8
Base-run	5.9	2.6	5.7	8.0	24.1	4.9
Variables	**Agricultural Inflation**	**Industrial Inflation**	**Money Growth**	**Interest Rate**	**Tax Ratio**	**Government Expenditure Ratio**
Actual	5.0	4.7	16.2	12.0	14.2	28.4
Base-run	4.8	4.7	16.4	11.4	14.3	29.0
Variables	**Gross Fiscal Deficit Ratio**	**Exports**	**Imports**	**Current Account Balance**	**Foreign Exchange Reserves**	**Exchange Rate**
Actual	10.5	62.8	67.4	-0.5	55.0	44.1
Base-run	11.0	63.3	68.1	-0.7	58.6	45.1

Note: All rates (except the exchange rate) and ratios are in percentage terms. The external sector variables are in billion U.S. dollars. The exchange rate is in rupees/dollar.

Apart from the table, graphical representations of base-run simulations and historical values of growth and inflation rates (for the simulation period) are presented in the appendix. These show that apart from approximating the historical long-run average values of the endogenous variables quite accurately, the simulations also predict the annual values of these variables reasonably well.

Now that the model has been validated we shall use it to evaluate the impact of shocks on the growth rates of the Indian economy. We shall do this by comparing the equilibrium values of growth rates and related variables under base-run (normal) and alternate scenarios (with shocks). It may be noted that one of the objectives of this study was to differentiate between the short run and the long run impact of the shocks. In the model, the long-run effects have been incorporated in terms of dynamic specifications of some behavioral equations using lagged dependent variables. In the shock simulations, we assume the shocks to impact the economy in the first two years of the chosen period, i.e., 1997 and 1998. Correspondingly, the average performance in these two years will represent the short run impact of the shocks. The average performance for the whole period, i.e., 1997 to 2003, will represent the long run impact of the shocks.

In the simulation exercises, we shall focus on five aspects of the impact of the shocks on growth. The first aspect is the actual impact of the shock on the aggregate growth rate, i.e., whether the shock leads to a mild or large fall in growth rate (as a percentage over base-run values). The second aspect is the sectoral distribution of the shock, i.e., how much each of the three sectors (agriculture, industry and tertiary) contributes to the negative impact of the shocks on growth rates. The third aspect is to find whether the shock leads to a stagflationary situation or not. This is particularly important from the policy point of view since non-stagflationary shocks can be mitigated by using demand management policies while stagflationary situations sometimes worsen with the use of such policies. The fourth aspect that we shall focus on is the effect of the shocks on the fiscal and external sectors. This is important because a large increase in the deficits in these sectors (in terms of rising fiscal deficit ratio and falling foreign exchange reserves) have the potential to destabilize future growth rates by affecting investor confidence in the economy. Thus, it is important to look at the impact on the actual growth rate and on these variables. The fifth and final aspect that we shall look into is the pervasiveness of the shock, i.e., how much of the short run impact of the shock spills over to the long run. This is again important from policy perspective, since a pervasive shock indicates that the economy is not very resilient to this shock, making counter shock policies that much more important.

EXTERNAL SHOCKS

Oil price shock

The first scenario represents an oil price shock. We assume that the price index of oil imports rises by 100% over actual values in 1997 and 1998. Thus, the price index goes up in 1997 from 540 to 1080 and in 1998 from 440 to 880, respectively. The average price during this period jumps by about 50% over 1996. This may be compared to the oil shock in 1979-80 when the corresponding jump was about 125%. Thus it is a plausible shock though not of the extreme nature as the first and second international oil price shocks. The results of the simulation together with the base-run are given in Table 2.

Table 2 : Effect of oil price shock

Variables		GDP Growth	Agricultural Growth	Industrial Growth	Tertiary Growth	Aggregate Inflation	Industrial Inflation	Gross Fiscal Deficit Ratio	Foreign Exchange Reserves
Short Run	Base-run	6.7	3.3	4.7	10.2	7.3	5.6	7.6	36.1
	Shock	6.5	3.2	4.3	9.9	8.4	8.4	8.0	26.9
	% Change	-3.0	-3.0	-8.5	-2.9	15.1	50.0	5.3	-25.5
Long Run	Base-run	5.9	2.6	5.7	8.0	4.9	4.7	11.0	58.6
	Shock	5.7	2.5	5.5	7.7	5.1	4.9	10.8	55.0
	% Change	-3.4	-3.8	-3.5	-3.8	4.1	4.3	-1.8	-6.1

***Note*:** In the shock scenario, oil price index is assumed to be 1080 in 1997 instead of 540 (base-run value), and in 1998 it is assumed to be 880 instead of 440 (base-run value).
The row showing '% Change' measures percentage increases in value of variables in shock scenario over base run values. Thus, for shock scenario values that are lower than base run values, '% Change' is negative.

The table indicates that in the short run there is a small decrease in the growth rate (3 %) as a result of this shock. This fall is largely due to a corresponding fall in the industrial growth rates, with the other sectors contributing much less to this fall. Inflation rises by 15 % as a result of a large rise in industrial inflation, leading to a slightly stagflationary

situation. There is no instability to the growth process from the fiscal sector but a significant fall in the foreign exchange reserves as a result of the shock, gives rise to some instability to growth from the external sector. In the long run, the growth falls by 3.4 %, which is slightly larger than the fall in the short run. This indicates that the impact of the shock is pervasive, i.e., the impact does not become weaker in the long run. The fall in the long run growth rate is the result of a similar fall in all the sectors. This indicates that the shock has a greater long run impact on the growth of the agricultural and tertiary sectors. The rise in inflation is more muted and there is no instability from the fiscal or external sectors.

World trade shock

The second scenario represents a world trade shock. In this scenario, we assume that the rate of growth of world imports is zero in 1997 instead of an actual growth of about 3.3 % and it is assumed to be –4 % in 1998 instead of an actual growth rate of–1.4 %. Thus the average growth in world imports in this period is assumed to be about –2 %, while the actual average growth was about 1 %, i.e., a fall of about 3 %. This is comparable to an average fall of about 3 % in 1981 and 1982, the sharpest fall in world imports in the recent past. It may be noted that although stagnation in world trade can also lead to changes in prices of imports, this scenario does not assume any such changes in import prices. The results of the simulation together with the base-run are given in Table 3.

The table shows that in the short run, there is a small fall in the growth rate as a result of this shock (3 %). The world trade shock leads to a fall in exports demand and this brings down the industrial and tertiary growth rates, while agricultural growth rates are untouched. The fall in aggregate demand (as a result of the fall of exports demand) dampens the inflation rate and hence, there is no stagflationary situation in this case. The fiscal balance and external reserves deteriorate, bringing some instability to the growth process. In the long run, there is no effect on the growth rate, indicating that this shock is completely temporary and not pervasive at all. This is due to the fact that while the shock

has no impact on agriculture and some negative impact on the tertiary sector, the industrial sector gets a positive boost from this shock in the long run due to a fall in inflation rates (since industrial output is inversely related to price) and this more than makes up for the fall in growth rates in the tertiary sector. There is no instability in the long run from the fiscal or external sectors.

Table 3 : Effect of world trade shock

Variables		GDP Growth	Agricultural Growth	Industrial Growth	Tertiary Growth	Exports	Aggregate Inflation	Gross Fiscal Deficit Ratio	Foreign Exchange Reserves
Short Run	Base-run	6.7	3.3	4.7	10.2	47.5	7.3	7.6	36.1
	Shock	6.5	3.3	4.4	9.8	42.8	6.4	8.3	31.3
	% Change	-3.0	-0.0	-6.4	-3.9	-9.9	-12.3	9.2	-13.3
Long Run	Base-run	5.9	2.6	5.7	8.0	63.3	4.9	11.0	58.6
	Shock	5.9	2.6	5.8	7.9	62.2	4.8	11.3	56.5
	% Change	0.0	0.0	1.8	-1.3	-1.7	-2.0	2.7	-3.6

***Note*:** In the shock scenario, rate of growth of world imports is assumed to be zero in 1997 instead of 3.3 % (base-run value), and in 1998 it is assumed to be –4 % instead of –1.4 % (base-run value).
The row showing '% Change' measures percentage increases in value of variables in shock scenario over base run values.

Capital flow shock

The third scenario represents a capital flow shock. It may be noted that the initial years of the simulation period saw the incidence of global financial market instability and the resultant East Asia crisis. Although India was left largely untouched by this shock, it would be worthwhile to see what would have happened if it did have an impact. In this scenario, we assume that the capital account balance is zero in both 1997 and 1998

instead of actual values of 10 billion dollars and 8.2 billion dollars, respectively. The results of the simulation together with the base-run are given in Table 4.

Table 4 : Effect of capital flow shock

Variables		GDP Growth	Agricultural Growth	Industrial Growth	Tertiary Growth	Aggregate Inflation	Gross Fiscal Deficit Ratio	Foreign Exchange Reserves
Short Run	Base-run	6.7	3.3	4.7	10.2	7.3	7.6	36.1
	Shock	6.6	3.3	4.9	9.7	7.2	7.6	25.5
	% Change	-1.5	0.0	4.3	-4.9	-1.4	0.0	-29.4
Long Run	Base-run	5.9	2.6	5.7	8.0	4.9	11.0	58.6
	Shock	5.8	2.6	5.7	7.7	5.0	10.8	54.3
	% Change	-1.7	0.0	0.0	-3.8	2.0	-1.8	-7.3

***Note*:** In the shock scenario, capital account balance is assumed to be zero in both 1997 and 1998 instead of 10 billion dollars and 8.2 billion dollars respectively (base-run values).
The row showing '% Change' measures percentage increases in value of variables in shock scenario over base run values.

The table shows that the shock has a very small impact on the growth rate in the short run. This is due to the fact that the shock leaves the agricultural sector completely untouched and gives a boost to industrial growth rates even in the short run, by bringing down inflation rates. Thus it is only the negative impact on the tertiary sector that results in a fall in GDP growth rates. The fall in inflation rates ensures that the situation is not stagflationary. There is no instability to the growth process from the fiscal sector but a sharp fall in the foreign exchange reserves as a result of the shock, gives rise to some instability to growth from the external sector. In the long run, the percentage fall is small (1.7 %) but it is larger than the short run impact, indicating the pervasive nature of this shock. The fall in growth is completely due to the tertiary sector, while the other two sectors have no long run impact. There is no instability in the long run from the fiscal or external sectors.

DOMESTIC SHOCKS

Rainfall shock

The fourth scenario represents a rainfall shock. Here, the rainfall index is assumed to be 80 in both 1997 and 1998, whereas the actual values were 102 and 106, respectively. It may be noted that the index is 100 in case of normal rainfall, and a value of 80 has given rise to drought conditions in 1979, 1987 and more recently in 2002. It may also be noted, that although such conditions are usually accompanied by government intervention, this scenario does not assume any reaction to the drought by the government. The results of the simulation and the base-run are given in Table 5.

Table 5 : Effect of rainfall shock

Variables		**GDP Growth**	**Agricultural Growth**	**Industrial Growth**	**Tertiary Growth**	**Aggregate Inflation**	**Agricultural Inflation**	**Gross Fiscal Deficit Ratio**	**Foreign Exchange Reserves**
Short Run	Base-run	6.7	3.3	4.7	10.2	7.3	9.0	7.6	36.1
	Shock	4.3	-1.7	0.7	10.1	11.7	16.2	6.5	35.3
	% Change	-35.8	-151.5	-85.1	-1.0	60.3	80.0	-14.5	-2.2
Long Run	Base-run	5.9	2.6	5.7	8.0	4.9	4.8	11.0	58.6
	Shock	5.3	2.0	4.5	7.6	5.9	6.1	10.0	59.7
	% Change	-10.2	-23.1	-21.1	-5.0	20.4	27.1	-9.1	1.9

***Note*:** In the shock scenario, rainfall index is assumed to be 80 in both 1997 and 1998 instead of 102 and 106 respectively (base-run values).
The row showing '% Change' measures percentage increases in the value of the variables in shock scenario over base run values.

The table indicates that there is a substantial fall in growth rates (almost 36 %) in the short run, as a result of this shock. This is due to a debilitating impact on the agricultural growth rates, which also has a significant spillover onto the industrial growth rates. The tertiary sector is almost unaffected by this shock in the short run. There is a

large increase in the inflation rates (about 60 %) – largely due to high agricultural inflation - leading to an acute stagflationary situation. There are no significant changes in the fiscal and external situation. The long run growth also falls significantly (by about 10 %) but it is a much smaller fall compared to the short run, indicating that the resilience of the economy to this shock makes it less pervasive. The fall in long run growth rates is again almost entirely due to the agricultural and industrial sector, while the tertiary sector is much less affected. The inflation rates also rise significantly leading to a long run stagflationary situation. There is no instability in the long run from the fiscal or external sectors.

Fiscal profligacy

The fifth scenario represents a case of fiscal profligacy. As we have discussed earlier, there is no objective definition of fiscal profligacy though it is loosely used to describe unproductive expenditure of the government. For our study, we have assumed fiscal profligacy to mean an increase in the state's revenue expenditure, which is financed (at least partly) by cutting back capital expenditure. In this scenario it is assumed that both government transfer and government consumption are 1 % (of nominal GDP) higher than in the base-run in both 1997 and 1998. Simultaneously, public investment is assumed to be 1 % (of nominal GDP) lower than the base-run in both the years. Since the cut in public investments does not fully cover the increase in revenue expenditure, this implies an increase in fiscal deficit. The results of the simulation together with the base-run are given in Table 6.

The table indicates a significant fall in growth rates (about 13 %) in the short run corresponding to the shock. This is largely due to a fall in agricultural and industrial growth rates which result from the cut in public investments in these sectors. There is not much impact on the inflation rate or the external sector, but the fiscal deficit goes up significantly, contributing some instability to the growth process. In the long run, the percentage fall in growth rate is very similar to that in the short run, indicating that this shock is pervasive. Moreover, the rise in inflation is proportionately more in the long run

leading to a stagflationary situation. There is no instability in the long run from the fiscal or external sectors.

Table 6 : Effect of fiscal profligacy

Variables		GDP Growth	Agricultural Growth	Industrial Growth	Tertiary Growth	Aggregate Inflation	Gross Fiscal Deficit Ratio	Foreign Exchange Reserves
Short Run	Base-run	6.7	3.3	4.7	10.2	7.3	7.6	36.1
	Shock	5.8	1.4	3.9	9.6	8.2	9.0	36.2
	% Change	-13.4	-57.6	-17.0	-5.9	12.3	18.4	0.3
Long Run	Base-run	5.9	2.6	5.7	8.0	4.9	11.0	58.6
	Shock	5.1	1.6	4.2	7.6	6.0	10.8	59.6
	% Change	-13.6	-38.5	-26.3	-5.0	22.4	-1.8	1.7

***Note*:** In the shock scenario, government transfer and government consumption are both assumed to be 1 % (of nominal GDP) higher than in the base-run in both 1997 and 1998. Simultaneously, public investment is assumed to be 1 % (of nominal GDP) lower than the base-run in both the years.
The row showing '% Change' measures percentage increases in value of variables in shock scenario over base run values.

It is interesting to note that, in the period that we have considered for the simulation exercise, the government was actually increasing its revenue expenditure at the cost of capital expenditure. Thus the base-run itself exhibited fiscal profligacy. It is of interest to examine the possible impact of a reversal of this policy (i.e., a positive shock) during this period. In order to do this we have run a simulation (simulation B) that assumes both government transfer and government consumption are 1 % (of nominal GDP) lower than in the base-run in both 1997 and 1998 and public investment is 1 % (of nominal GDP) higher than the base-run in both the years. The results of simulation B, together with the base-run are given in Table 7. We have also included the fiscal profligacy shock simulation from Table 6 (here we call it simulation A) for comparison.

Table 7 : Effect of alternative fiscal policies

Variables		GDP Growth	Agricultural Growth	Industrial Growth	Tertiary Growth	Aggregate Inflation	Gross Fiscal Deficit Ratio	Foreign Exchange Reserves
Short Run	Base-run	6.7	3.3	4.7	10.2	7.3	7.6	36.1
	Simulation A	5.8	1.4	3.9	9.6	8.2	9.0	36.2
	% Change (A)	-13.4	-57.6	-17.0	-5.9	12.3	18.4	0.3
	Simulation B	8.4	5.3	7.8	10.7	4.8	11.6	36.5
	% Change (B)	25.4	60.6	66.0	4.9	-34.2	52.6	1.1
Long Run	Base-run	5.9	2.6	5.7	8.0	4.9	11.0	58.6
	Simulation A	5.1	1.6	4.2	7.6	6.0	10.8	59.6
	% Change (A)	-13.6	-38.5	-26.3	-5.0	22.4	-1.8	1.7
	Simulation B	7.0	3.6	7.4	8.6	3.5	13.0	57.2
	% Change (B)	18.6	38.5	29.8	7.5	-28.6	18.2	-2.4

***Note*:** Simulation A has the same assumptions as in the case of Fiscal Profligacy. In Simulation B, government transfer and government consumption are both assumed to be 1 % (of nominal GDP) lower than in the base-run in both 1997 and 1998. Simultaneously, public investment is assumed to be 1 % (of nominal GDP) higher than the base-run in both the years.
The row showing '% Change (A)' measures percentage increases in value of variables in Simulation A over base run values. Similarly '% Change (B)'is for Simulation B.

The table indicates that in the short run, Simulation B would not only have given rise to higher growth than in the base-run but that this increase would have been proportionately more (about 25 %) than the loss in growth due to the Simulation A (about 13 %), where the policies are reversed. This underlines the non-linearity in the model. This asymmetry is present in the long run as well, although it is more muted. An important conclusion that can be drawn from this table is that the during the period under study, the economy was actually facing a fiscal profligacy shock that brought down the growth rate during this period to 5.9 % (compared to the 7 % growth rate in the period

1994 to 1996) and in the absence of this shock (i.e., a situation corresponding to Simulation B), growth rates could have been similar to that in the previous period.

It would be worthwhile to summarize the results of the individual shocks discussed above, before going on to a simulation of multiple shocks affecting the economy simultaneously,. This will enable a comparison of the individual shocks as well as provide an adequate background to understand the impact of the multiple shocks. Table 8 presents the percentage change in growth, inflation and foreign exchange reserves corresponding to the five shocks, both for the short and the long run. The last column gives the sum total of each of the percentage changes corresponding to the shocks. While these values do not correspond to a particular simulation, it is analytically useful to compare them with the corresponding values in the simulation of multiple shocks as this will indicate whether the impact of multiple shocks is more or less severe than the sum of the impact of the individual shocks.

Table 8 : Summary of the impact of individual shocks

Impact of the shocks		**Oil price shock**	**World trade shock**	**Capital flow shock**	**Rainfall shock**	**Fiscal profligacy**	**Total**
Short Run	% change in GDP growth	-3.0	-3.0	-1.5	-35.8	-13.4	-56.7
	% change in Inflation	15.1	-12.3	-1.4	60.3	12.3	74.0
	% change in Forex Reserves	-25.5	-13.3	-29.4	-2.2	0.3	-70.1
Long Run	% change in GDP growth	-3.4	0.0	-1.7	-10.2	-13.6	28.9
	% change in Inflation	4.1	-2.0	2.0	20.4	22.4	46.9
	% change in Forex Reserves	-6.1	-3.6	-7.3	1.9	1.7	-13.4

The table shows that rainfall and fiscal profligacy shocks have a stronger growth retarding effect compared to the oil price hike, capital flow shock and world trade shocks, both in the short as well as the long run. Furthermore, the rainfall shock and fiscal profligacy is stagflationary in the long run, while the other three shocks are not. We also

find that the oil price hike, the capital flow shock and fiscal profligacy show strong pervasiveness, while the economy is much more resilient to the rainfall shock and the world trade shock in the long run. Finally, the external shocks give rise to some instability in the external sector in the short run, but in the long run none of the shocks have any significant negative impact on this sector.

Multiple shocks

One of the objectives of this study was to examine the impact of multiple shocks. In the next simulation we do this by assuming that all the five shocks that we have discussed earlier impact the economy simultaneously. This will test the resilience of the economy to shocks and provide an idea about the worst possible performance by the economy under such conditions. The period under study is the same as in the earlier simulations, i.e., 1997 to 2003. The results of the simulation together with the base-run are given in Table 9.

Table 9 : Effect of multiple shocks

Variables		GDP Growth	Agricultural Growth	Industrial Growth	Tertiary Growth	Aggregate Inflation	Gross Fiscal Deficit Ratio	Foreign Exchange Reserves
Short Run	Base-run	6.7	3.3	4.7	10.2	7.3	7.6	36.1
	Shock	2.4	-3.5	-1.9	8.7	14.4	4.8	12.6
	% Change	-64.2	-206.1	-140.4	-14.7	97.3	-36.8	-65.1
Long Run	Base-run	5.9	2.6	5.7	8.0	4.9	11.0	58.6
	Shock	4.1	0.9	2.8	6.6	7.7	8.0	53.0
	% Change	-30.5	-65.4	-50.9	-17.5	57.1	-27.3	-9.6

***Note*:** In the shock scenario, all the assumptions of the five individual shock scenarios hold simultaneously. The row showing '% Change' measures percentage increases in value of variables in shock scenario over base run values.

The table shows that there is approximately 64 % fall in the growth rate in the short run. This is due to both the agricultural and industrial sectors showing retrogression (negative growth) during this period. Despite the multiple shocks, the services sector continues to grow at almost 9% and this keeps the aggregate economy from sinking into retrogression. The inflation rates almost double, making for a stagflationary situation. The external sector also deteriorates, leading to an unstable growth process. In the long run, the proportionate fall in growth is much smaller than in the short run (about 30 %), indicating that the economy is resilient to multiple shocks and its impact is not very pervasive. The rise in inflation is substantial even in the long run leading to a persistent stagflationary situation. There is no instability in the long run from the fiscal or external sectors. Next, comparing the values in Table 9 with the last column of Table 8, we find that both in the short and the long run, the impact of multiple shocks are more severe than the sum of the impact of the individual shocks, in terms of lower growth rates as well as higher inflation rates. Finally, the most important conclusion that can be drawn from this table is that even in the worst possible scenario, the economy will continue to show a long-run growth of more than 4 %, which is a reasonable performance even in ordinary circumstances.

So how does one interpret the overall impact of the multiple shocks? It may be noted that the Indian economy is a comparatively stable one among the developing countries in the world. During the last fifty-five years, the economy witnessed only three instances of negative annual GDP growth rates and every five-year average GDP growth rate has varied between 3.5% and 6.4%. Thus even a 2% point decline in the long run growth rate (as in the multiple shock case) may be considered to be severe by Indian standards. However, it would be very mild compared to the experience of some Latin American and African economies, which have witnessed sharp fluctuations in the past. In terms of international comparison therefore, the Indian economy is far more resilient to domestic and external shocks.

Effect Of Liberalization

The model that we have presented in an earlier section has incorporated various aspects of the liberalization process that were initiated since the mid eighties and particularly after 1991. These liberalization effects have been captured by a number of structural dummies that we have used in the estimation of the behavioral equations. As apparent from the last few tables, the model of the economy - that includes these structural changes due to liberalization – has shown resilience in the face of multiple shocks. It may be worthwhile to find out whether these structural changes due to liberalization play any role in making the economy more resilient. In order to do this, we have run two simulations with the assumption that the dummies for liberalization (DLIB), WTO effect (DWTO) and financial and external sector deregulation (DFEM) are dropped from the model (values set to zero). As far as the other exogenous variables are concerned, the first simulation retains the assumptions of the base-run scenario while the second simulation retains the assumptions of the multiple shocks. The period for the simulation was set from 1997 to 2003 to coincide with the Asian crisis. Comparing the two simulations will thus throw light on the resilience of the economy in the face of an Asian crisis induced external shock combined with a domestic shock, in the absence of the liberalization process. We find that in the base-run simulation (with no liberalization), the model gives a solution where the foreign exchange reserves fall drastically. This implies that the current buoyancy in the foreign exchange reserves is largely due to the liberalization process. Moreover, in the combined shock simulation (with no liberalization) we find that the model is incapable of providing a solution because the foreign exchange reserves fall to zero. This clearly implies that in the absence of all these structural changes due to liberalization, the economy would face a foreign exchange crisis in the eventuality of a combined domestic and external shock.

7. SUMMARY AND CONCLUSIONS

We have defined and studied the effect of five shocks that we believe might have affected the growth of the Indian economy. These include two domestic shocks (rainfall

shortfall and fiscal profligacy) and three external shocks (oil price hike, world trade shock and capital flow shock). Next, we have constructed realistic shock scenarios and estimated the effects of these shocks on the growth process. Shocks can have an impact on various aspects of the growth process. These aspects include (i) the magnitude of the impact on growth rates, (ii) the pervasiveness of the shocks in the long run, (iii) the capability of the shock to give rise to stagflationary situations, and (iv) the capability of the shock to give rise to instability in the fiscal or external sectors. It is important to classify the shocks according to what effect they have on these aspects of the growth process.

The primary focus in this study is the effect of shocks on the aggregate growth rates. In this context, it is fair to say that realistic rainfall and fiscal profligacy shocks have a stronger growth retarding effect compared to realistic scenarios of the other three shocks, both in the short as well as the long run. Thus, the two domestic shocks are the comparatively big shocks both in the short and long run.

The second issue of interest is the pervasiveness of the shocks, i.e., their long run persistence. Here we find that the oil price hike, the capital flow shock and fiscal profligacy show strong pervasiveness, while the economy is much more resilient to the rainfall shock and the world trade shock in the long run.

The third issue that is studied is whether the shock leads to a stagflationary situation or not. This is because demand management policies can be used in non-stagflationary situations while stagflationary situations sometimes worsen with the use of such policies. We find that the rainfall shock and fiscal profligacy is stagflationary in the long run, while the oil price hike, capital flow shock and world trade shocks are not stagflationary in the long run.

The fourth and final point of interest is to study whether the shock leads to some instability in the growth process by enlarging the disequilibrium in the fiscal or the external sectors. As we have mentioned, a large increase in the deficits in these sectors has the potential to destabilize future growth rates by affecting investor confidence in the economy. We find from our study that the oil shock, world trade shock and the capital flow shocks (i.e., the external shocks) give rise to some instability in the external sector in the short run. Similarly, the fiscal profligacy shock and the world trade shock give rise

to some short run instability in the fiscal sector. However, in the long run we find that none of the shocks have any significant negative impact on either the fiscal deficit or the external reserves.

There are a number of insights gained from this study that can aid in prescribing appropriate counter shock policies. These are:

1. Any shock that affects the supply side, such as the rainfall shock, will have a big impact on GDP growth. The impact is pervasive because rainfall deficiency not only reduces agricultural output but also non-agricultural output via sectoral interlinkages. The long run impact of this shock depends on the magnitude of the accelerator. However, since rainfall moves in cycles, it has a tendency to restore balance in the long run and hence the long run impact is more muted than the short run impact.
2. The shocks affecting the demand side lowers the output first in the industrial sector (which is demand constrained) and then in the tertiary sector through intersectoral linkages. The long run impact of demand-induced shocks again depends on the accelerator.
3. The fiscal profligacy shock affects both aggregate demand and supply. A rise in government expenditure may stimulate the industrial demand in the short run but has a marginal effect in the long run. However, a cut in public investment operates perversely through both aggregate demand and supply and thereby leads to a lasting long run impact.
4. In the case of the trade shock, the long run impact is neutralized by the exchange rate adjustment and hence this results in a marginal change in the long run growth rate corresponding to this shock. Clearly, the deregulation of exchange rate has introduced a built-in stability in the operation of this multiplier.

On balance, it appears that the Indian economy has become more resilient to shocks because of the reforms. This is clear from the section on the effect of liberalization, which shows that in the absence of such liberalization, the economy would end up with a balance of payments crisis as a result of a multiple shock. However, the lack of reform in the fiscal sector – a failure to protect public investment - has lowered

the long run growth prospects. This is supported by the results in the section on alternative fiscal policies. As far as counter shock policies are concerned, all major domestic and external shocks must be countered through contra-cyclical fiscal and monetary policies. In the short run, this may lead to higher inflation due to a tradeoff between growth and inflation in case of certain shocks that are stagflationary. The long run effect of the counter shock policies will depend on their impact on investments. In this context our estimation results indicate that in spite of interest rate deregulation, the overall impact of interest rate or private investment is small, and hence monetary policy is not very effective as a long run counter shock policy. The alternative is therefore to go in for a more bold fiscal policy involving higher public investment financed by the lowering of other government expenditure.

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APPENDIX 1

Variable List

BR Bank rate set by central bank ; **CAB** Capital account balance ; **CABR** Capital account balance ratio ; **CP** Nominal personal consumption expenditure ; **CRR** Cash Reserve Ratio set by central bank ; **D80S** Dummy for structural changes since the eighties ; **D95** Dummy for peak liberalization effect ; **DEV91** Dummy for large devaluation in 1991 ; **DFEM** Dummy for financial and external market liberalization in 1993 ; **DFEMRPLR** Slope dummy for effect of DFEM on RPLR ; **DKAR** Depreciation rate of agricultural capital stock ; **DKIR** Depreciation rate of industrial capital stock ; **DKTR** Depreciation rate of tertiary sector capital stock; **DLIB** Dummy for liberalization in 1991 ; **DPLIB** Dummy for partial liberalization in mid eighties ; **DUMEGS** Outlier dummy for exports ; **DUMM3** Outlier dummy for money demand ; **DUMMGSO** Outlier dummy for oil imports ; **DUMPA** Outlier dummy for agricultural prices ; **DUMPAY** Dummy for pay hike in public administration ; **DUMXA** Outlier dummy for agricultural output; **DWTO** Dummy for effect of joining WTO; **EGS** Export of goods and services in dollars ; **EGSR** Export of goods and services in rupees ; **EIGN** Errors and omissions in IGN; **EIPN** Errors and omissions in IPN ; **EOINV** Errors and omissions in INV ; **EXR** Exchange rate ; **FER** Foreign exchange reserves in dollars ; **FERR** Foreign exchange reserves in rupees ; **GC** Government consumption ; **GDPMP** Nominal GDP at market price ; **GE** Government expenditure ; **GFD** Nominal gross fiscal deficit ; **GFDR** Gross fiscal deficit ratio ; **GR** GDP growth ; **GSRBI** Central bank credit to government ; **GTR** Government transfer payments ; **IFR** Inflation rate based on GDP deflator; **IG** Real public investment ; **IGA** Real public investment in agriculture ; **IGAN** Nominal public investment in agriculture ; **IGI** Real public investment in industry ; **IGIN** Nominal public investment in industry ; **IGN** Nominal public investment ; **IGT** Real public investment in tertiary sector ; **IGTN** Nominal public investment in tertiary sector ; **INV** Total nominal investment ; **INVR** Total real investment ; **IP** Real private investment ; **IPA** Real private investment in agriculture ; **IPI** Real private investment in industry ; **IPN** Nominal private investment ; **IPT** Real private investment in tertiary sector ; **K** Capital stock ; **KA** Capital stock in agriculture ; **KAB** Capital account Balance ; **KI** Capital stock in industry ; **KT** Capital stock in tertiary sector ; **M0** Nominal reserve money ; **M3** Nominal money supply ; **M3G** Nominal money supply growth rate ; **MGFD** Monetised gross fiscal deficit ; **MGS** Nominal Imports of goods and services in dollars ; **MGSN** Nominal Imports of non-oil goods and services in dollars**; MGSO** Nominal Imports of oil in dollars ; **MGSR** Nominal Imports of goods and services in rupees ; **NNML** Net non-monetary liabilities ; **NTAX** Non tax revenues ; **ORGE** Other real government expenditure (other than public investments) ; **PA** Agricultural deflator ; **PDI** Nominal private disposable income; **PGDP** GDP deflator ; **PI** Industrial deflator ; **PLR** Interest rate (Prime lending rate) ; **PM** Import price ; **PMN** Import price of non-oil products ; **PMO** Import price of oil ; **PT** Tertiary sector deflator ; **RAE** Real autonomous expenditure ; **RCP** Real personal consumption expenditure ; **REM** Remittances etc. ; **RESFER** Errors and omissions in BOP account ; **RESGDP** Errors in 'GDP at market prices' identity ; **REXR** Real exchange rate ; **RF** Rainfall index ; **RGE** Real government expenditure ; **RM3** Real money supply ; **RMGS** Real imports of goods and services in dollars ; **RPDI** Real private disposable income ; **RPLR** Real interest rate ; **TAX** Tax revenues ; **TRF** Average tariff rate ; **XA** Real agricultural output ; **XAG** Growth in agricultural output ; **XCOM** Real commodity output ; **XGDP** Real GDP ; **XI** Real industrial output ; **XIG** Growth in industrial output **; XT** Real tertiary sector output ; **XTG** Growth in tertiary output **; YGDP** Nominal GDP at factor cost

APPENDIX 2

MODEL FOR THE INDIAN ECONOMY

GDP AT FACTOR COST

1. XGDP = XA + XI + XT

2. GR = 100* (XGDP - XGDP(-1))/ XGDP(-1)

3. XA = EXP(-8.16+ 1.43*LOG(KA) + 0.27*LOG(RF) - 0.12*D80S - 0.14*DUMXA
+ 0.10*LOG(XA(-1)))

4. XAG = 100*(XA-XA(-1))/XA(-1)

5. XI =EXP(-2.57 + 0.08*LOG(KI) + 0.34*LOG(XA) + 0.18*LOG(RAE) - 0.06*LOG(PI)
+ 0.02*DPLIB + 0.6*LOG(XI(-1)) + 0.04*D95)

6. XIG = 100*(XI-XI(-1))/XI(-1)

7. XT =EXP(-5.06 + 0.67*LOG(KT) + 0.13*LOG(XCOM) + 0.01*DUMPAY + 0.02*DPLIB
+ 0.52*LOG(XT(-1)))

8. XTG = 100*(XT-XT(-1))/XT(-1)

9. XCOM = XA + XI

10. RAE = 100*(GE + EGSR)/PGDP

CAPITAL STOCK

11. K = KA + KI + KT

12. KA = KA(-1) *(1-DKAR) + IGA + IPA

13. KI = KI(-1) * (1-DKIR) + IGI + IPI

14. KT = KT(-1) * (1-DKTR) + IGT + IPT

PRIVATE INVESTMENT

15. IP = IPA + IPI + IPT

16. IPN = (IP * PGDP*.01)+EIPN

17. IPA = -4714.17 + 0.05*XA + 0.44*IGA - 2700.76*D80S + 0.28*IPA(-1)

18. IPI = -25029.76 + 0.20*XGDP + 0.71*IGI - 0.56*ORGE - 649.003*RPLR - 939.56*IFR + 41506.12*D95 + 0.22*IPI(-1)

19. IPT = -33116.9 + 0.08*XGDP + 0.71*IGT - 663.11*RPLR - 2920.68*DFEMRPLR + 0.45*IPT(-1)

20. RPLR = PLR - IFR

PUBLIC INVESTMENT

21. IGA= 100*IGAN/PGDP

22. IGI = 100*IGIN/PGDP

23. IGT = 100*IGTN/PGDP

24. IG = IGA + IGI + IGT

25. IGN = IGAN + IGIN + IGTN + EIGN

TOTAL INVESTMENT

26. INV = IGN + IPN

27. INVR = 100*INV/GDPMP

AGGREGATE DEMAND

28. GDPMP = CP + GC + IGN + IPN + EGSR - MGSR + RESGDP

29. CP = RCP * PGDP*.01

30. RCP =EXP(2.89 + 0.65*LOG(RPDI) + 0.03*DWTO + 0.11*LOG(RCP(-1)))

31. PDI = YGDP -TAX + GTR + OPDI

32. RPDI = PDI*100/PGDP

33. YGDP = EXP(-0.08 + 0.99*LOG(GDPMP)) + [AR(1)=0.66]

PRICE

34. PGDP=0.309*PA+0.26*PI+0.42*PT

35. IFR = 100*(PGDP - PGDP(-1)) / PGDP(-1)

36. PA =EXP(4.002 - 0.71*LOG(XA) + 0.59*LOG(PDI) + 0.12*DUMPA + 0.31*LOG(PA(-1)))

37. PI = EXP(-0.20 + 0.37*LOG(PA) + 0.05*LOG(PMO) + 0.01*LOG(PMN)
+ 0.53*LOG(PI(-1)) + 0.06*LOG(TRF))

38. PT =EXP(0.11 + 0.16*LOG(PA) + 0.42*LOG(PI) + 0.39*LOG(PT(-1)))

MONEY AND INTEREST

39. M3 = RM3*PGDP/100

40. RM3 =EXP(-9.801 + 1.68*LOG(XGDP) + 0.008*RPLR - 0.01*DFEMRPLR
+ 0.19*DUMM3 - 0.07*DWTO)

41. PLR = 0.49 + 1.65e-05*M3 - 7.2e-05*M0 + 0.43*CRR + 1.13*BR

42. M3G = 100*(M3 - M3(-1))/ M3(-1)

43. M0 = FERR + GSRBI - NNML

44. FERR = FER * EXR/10

45. GSRBI = GSRBI(-1) + MGFD

FISCAL SECTOR

46. GE = GC + IGN + GTR

47. RGE = GE *100/PGDP

48. ORGE = RGE - IG

49. GFD = GE - TAX - NTAX

50. GFDR = 100*GFD/GDPMP

51. TAX = EXP(-2.95 + 1.08*LOG(GDPMP) - 0.104*DLIB - 0.11*DWTO)

EXTERNAL TRANSACTIONS

52. FER = FER (-1) + CAB + KAB + RESFER

53. CAB = EGS - MGS + REM

54. CABR = 100*(CAB*EXR*0.1)/GDPMP

55. EGS =EXP(-6.62 + 1.02*LOG(WT) + 0.34*LOG(REXR) + 0.09*D80S + 0.12*DFEM
+ 0.14*DWTO + 0.23*DUMEGS)

56. EGSR = EGS*EXR/10

57. MGS=MGSO+MGSN

58. MGSO =EXP(-3.26 + 0.43*LOG(XCOM) + 1.005*LOG(PMO) + 0.55*LOG(PGDP)
– 0.69*LOG(EXR) + 0.05*DUMMGSO)

59. MGSN =EXP(-10.22 + 1.37*LOG(XGDP) + 0.09*LOG(PMN) + 1.36*LOG(PGDP)
– 1.34*LOG(EXR) - 0.18*LOG(TRF) + 0.18*D95 + 0.05*DWTO)

60. MGSR = MGS*EXR/10

61. PM = 0.2788*PMO + 0.7212*PMN

62. EXR = EXP(0.39 - 0.07*LOG(FER) + 0.27*LOG(PGDP) + 0.19*DEV91 + 0.69*LOG(EXR(-1)))

63. REXR = 100*EXR/PGDP

APPENDIX 3