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**DETERMINING THE FUNDAMENTALS OF THE REAL EXCHANGE RATE  
USING A SIMPLE GENERAL EQUILIBRIUM MODEL**

**A CASE STUDY OF INDIA**

by

**DEBANGSHU PARIA**

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of the Doctor of Philosophy. The City University of New York

1999

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**ABSTRACT****DETERMINING THE FUNDAMENTALS OF THE REAL EXCHANGE RATE****USING A SIMPLE GENERAL EQUILIBRIUM MODEL****A CASE STUDY OF INDIA**

by

Debangshu Paria

**Adviser: Professor Thom Thurston**

The purpose of this paper is to find the determinants of the RER for India where determinants is defined as forces affecting the demand and supply of foreign currency and RER is viewed as a relative price variable. The determinants selected for study were technological change, tariffs, foreign aid, foreign investment and government expenditure. These determinants were picked for testing only after a careful study of India's economic history. Only those policies that were consistently followed over fifty years and became dominant concerns of India's policy makers were used to select the determinants. To find the effects of these determinants on the long-run RER, the flow approach was followed by building a balance of payments model with traded and non-traded goods. The model was first developed by McDougall and is an extension of Mundell's model with only traded goods. Comparative statics using the determinants in the model only shows that it is not possible to know in advance whether the RER will appreciate or depreciate. Empirical testing using a regression equation with RER as the dependent variable and the determinants as the independent variables shows that only the government consumption determinant is significant for the 1960-1975 fixed exchange

rate period. The sign is positive indicating a depreciation (in real terms) of the Indian Rs. which is perhaps an explanation for the trend decline of the rupee for India since 1965. Furthermore an AR(1) correction for the same period shows government consumption and foreign aid to be significant in determining the next period's RER. For the 1976-1990 managed exchange rate period, tariff is found to be a significant determinant.

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To my wife, Madhulika, who has been my number one supporter. Without her love, this dissertation would have been a lot harder to finish.

To Professor Michael Grossman who has helped and guided me throughout the years of study in the program. Without his supervision, this program would have taken me a lot longer to complete.

## TABLE OF CONTENTS

### SECTION I: Introduction (Page 1)

*This section introduces the purpose of the paper which is to find the determinants of the RER for India. The RER is of immense importance to policy makers and it is surprising to find that little work has been done on finding the determinants of the RER of developing countries. The difficulty of identifying the determinants is mentioned and the section concludes with the layout of the paper.*

### Section II: Definition and Importance of RER (Page 7)

*The concept of RER is explained; its importance to policy makers is elaborated on and the RER is defined for empirical purposes. The end of the section has a graph to show visually the depreciation (in real terms) of the Indian rupee.*

### Section III: Background to India's Economic Approach with a View to Selecting Determinants (Page 12)

*Since economic objectives of policy makers are so important in determining fundamentals; this section provides a background on the goals of Indian planners to show how certain policies became dominant concerns. These policies motivated the selection of the fundamentals and thus addressed the neglect mentioned in the introduction.*

### Section IV.A.: Evolution of Exchange Rate Models (Page 19)

*The attempt here is to give a short history on the evolution of RER models to show that exchange rate models have shifted in emphasis from real factors to financial markets and back to real factors again.*

### Section IV.B.: Motivation for Selecting the Balance of Payments Model (Page 24)

*The flow approach and its variants are commented on. The extension of these variants is called the balance of payments theory. The motivation for*

*using this model is stated because the reduced form version of this model takes the determinants of trade and capital flows as explanatory variables for the RER. Furthermore, the concept of equilibrium long-run RER in this model is explained.*

Section V: The Balance of Payments General Equilibrium Model  
(Page 29)

*This section develops the model by first stating the assumptions and then working out the reduced form equations. The Hicksian imperfect stability condition is assumed for this model and is explained.*

Section VI: The Effect of Fundamentals on the RER: A Comparative Static Analysis (Page 38)

*The simple general equilibrium model is modified to take into account the various fundamentals affecting it. The fundamentals selected have been mentioned in Section III and are relevant to India's history. The procedure for comparative static analysis is mentioned and the analysis is done for each of the fundamentals to show the effect on the RER.*

Section VII: Econometric Methodology and Empirical Results  
(Page 60)

*The methodology is explained (unit root tests for stationarity/non-stationarity tests, OLS estimates and AR (1) model) and the results are computed.*

Section VIII: Conclusion (Page 70)

Section IX: Bibliography (Page 72)

## Introduction

It is no exaggeration when economists refer to the real exchange rate (RER) as the single most important price in an economy. Variation in the RER changes the price of national money in terms of foreign monies. It thereby produces instantaneous disequilibria in all markets for exportable and importable goods. A wide range of prices will respond to these disequilibria, and this will usually not remain without consequences for the general national price level. Variations in the general national price level, in turn, effect real incomes and real wealth of the community as a whole. The RER, viewed as a relative price variable, has thus gained immense importance in the strategic decision-making of policy makers of both developed and developing nations.

Policy makers are quite reluctant to leave the determination of this price entirely to market forces. Harberger (1986) and Williamson (1985) have argued that developed countries owe much of their success to having been able to maintain the RER at its 'appropriate' level. Needless to say, RER behavior occupies a central role in developing countries policy evaluation and design.

Ever since the demise of the Bretton Woods system of fixed exchange rates and the advent of the managed float in 1973 there has emerged a surge of theoretical models and empirical analyses of RER determination<sup>1</sup>. What is unusual is that very few attempts have been made to empirically analyze the fundamentals behind RER behavior in developing countries.

Edwards (1988) mentions that "the issue of RER<sup>2</sup> determination in the developing countries has remained in a murky state, with most of the discussion being carried out at an informal level". Perhaps this is because of the difficulties associated not only with the practical problems involved in discerning the source of the shocks and identifying the relevant structural characteristics but also with potential conflicts among various policy objectives. Identifying the nature of shocks responsible for macroeconomic instability is arduous. The economy is often affected simultaneously by various shocks from different sources, which cannot be accurately identified, let alone

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<sup>1</sup> A couple of useful references are Isard (1978) and Krueger (1982).

<sup>2</sup> The RER definition used by Edwards is the same as this author's as described in Section II.

quantified. For example, in the absence of a complete model of the economy, it is generally impossible to determine the extent to which a slowdown in economic activity can be attributed to sluggish domestic demand, tight monetary conditions, or weak external demand. Determining whether a particular shock, say a deterioration in terms of trade, is a transitory or permanent phenomenon further complicates the analysis. Thus, while in some particular cases - such as an oil price hike - the shock to the economy may be readily identified, in many cases it would not be possible to identify the source of the shock.

Delving into the literature provides some light to the 'murkiness' associated with structural determinants of the RER of a developing country. A few of the better researched papers on the subject are by Krum (1993), Odedokun (1997), Elbadawi (1989), Afridi (1995) and Faruqee (1995). The differences in these papers lies in the model chosen, different fundamentals and whether they are multi country or single country studies.

Further perusal of these papers (among others) highlights a few surprises. The fundamentals that affect the RER behavior in a developed country are often quite

different from the fundamentals of a developing country. A paper by Lim (1992) on the G-10 countries found productivity, terms of trade and foreign and domestic interest rates to be important factors. On the other hand, a pooled study of 38 African countries by Odedokun (1997) found that the primary factors are fiscal deficits, domestic credit growth, investment-GDP ratios and per-capita income. The few papers that concentrated on single countries often came up with important fundamentals that were not mentioned when the same country was included in multi country studies. Krum's paper (1993) on Tanzania found foreign aid flows to be important but when Tanzania was included in Odedokun's multi country study, foreign aid flows was not even mentioned.

The major criticism that I have of multi country studies is that in trying to generalize structural determinants across countries, it has neglected to take into account the unique economic characteristics and the policy objectives of each country. By studying one country, we're better able to isolate those structural determinants likely to affect the path of it's RER. The versatility of this approach is that the choice of specific variables or its

proxies would be more appropriate to the choice of the country. The signs of the coefficients could then be interpreted with the underlying economic conditions in the country.

As mentioned before, some studies on RER determinants for developing countries have been done. However, most of these studies have focused on countries where one particular determinant seems to predominate making it ideal for expository purposes<sup>3</sup>. India has been selected as a case study because finding the determinants of its RER will be considerably more complex. India has a large, self-contained economy. It holds no monopoly in the export or import of any goods or services. Strict control of exports and imports of goods, services and currency flows has largely insulated the country from outside 'shocks'. India has not suffered from hyperinflation or severe recession. There is no one predominant determinant that stands out in India's economic history that would explain the movements of India's RER.

Focusing on India, the aim of this paper is to find the determinants of the long run RER where determinant is

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<sup>3</sup> As an e.g., Harberger (1989) studies Ecuador and concludes that the oil price boom in the 70's influenced the real appreciation of the Ecuadorean currency.

defined as forces affecting the demand and supply of foreign currency and RER is viewed as a relative price variable.

The layout of the paper is as follows: Section II will explain the concept of the RER, its importance as a tool in decision making and define it for empirical purposes. Since economic objectives are so important in determining fundamentals, Section III will give a short background on the goals of Indian planners. Section IV.A will explain the evolution of RER models and show how the literature went from focusing on real factors to financial markets and back to real factors again. Section IV.B will explain the balance of payments theory to show the importance of the model to the paper. Section V and VI will develop a simple general equilibrium model with two countries and show how the fundamentals will affect the process of RER determination. Section VII will explain the econometric methodology and empirical results. Section VIII summarizes the objectives of the paper and its results and concludes.

## Section II: Definition and Importance of RER

This paper will view RER as the price of a real foreign currency unit measured in real domestic currency units. To avoid confusion, the following terminology is used; the domestic currency unit is the Indian rupee (Rs) and the foreign currency unit is the US dollar (\$).

The concept of RER is simple. It is nothing more than a deflated nominal exchange rate i.e., a nominal exchange rate which is deflated by a general price level. The ratio of the nominal exchange rate to the general price level  $(E/p_d)^4$  is an index that measures the real price of the dollar. If fewer rupees is paid for the dollar, we say that the RER is falling and the rupee is appreciating in value. If more rupees is paid for the dollar, then the RER is rising and the rupee is said to be depreciating in value.

The problem of this simple index is that it does not adjust for the fact that the dollar itself changes in value, or purchasing power, over time. To correct for changes in the value of the dollar, a more refined index would be  $(E p^*/p_d)$  where  $p^*$  is the general index of dollar prices in the world market. This index is then a measure of the real

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<sup>4</sup> where  $E$  = nominal exchange rate and  $p_d$  = general price level

price of the real dollar.

The definition of RER given above corresponds broadly to an index of domestic prices compared with world prices. In other words, the RER may be considered as a measure of the domestic price of tradables to the domestic price of nontradables (or home goods) -  $RER = P_t/P_{nt}$ . This RER measure is also known as the dependent economy concept of RER. It ascertains the competitiveness of producing and consuming tradables as opposed to nontradables in the domestic economy.

The aggregation of exportables and importables into a composite commodity such as tradables is dependent on the assumption that their relative prices do not change. This assumption is justified if the terms of trade (TOT) are given as is assumed in the small (or developing) country case.

The domestic price of tradables ( $P_t$ ) is related to the foreign price of tradables ( $P'_t$ ) via the nominal exchange rate ( $E$ ). So,

$$RER = E P'_t/P_{nt}$$

where,

$E$  = nominal exchange rate

$P'_t$  = foreign price of tradables

$P_{nt}$  = domestic price of nontradables

For empirical purposes, the above variables will be defined as

$E$   $\Rightarrow$  the International Financial Statistics (IFS) presents two series on exchange rates with the dollar. One is labeled 'ae' and is the local currency price of the dollar at the end of the period considered and the other is 'rf' which is the average price of the dollar, measured in local currency, over the reference period - month, quarter or year. This paper uses series 'rf' because I'm concerned with entire periods rather than terminal dates and also because the IFS price level data invariably refer to average prices over the period covered.

$P_{nt}$   $\Rightarrow$  the most widely used domestic price deflator is the Consumer Price Index (CPI) and it is the one this paper will use (from line 64 in the IFS). It is appropriate because it measures the overall loss/gain in purchasing power of the domestic currency.

$P'_t$   $\Rightarrow$  since we are interested in a measure of the price level of international goods, the US WPI which is heavily weighted with tradable goods is considered to be a good

proxy. Besides, the US has been India's largest trading partner since 1960. Line 63 from the IFS is used.

In the above definition, the RER depreciates (appreciates) when the index rises (falls).

The importance of the RER has been mentioned in the first paragraph of the Introduction. To elaborate further: the RER is the prime instrument used by policy makers for changing the expenditure patterns in a country and so directly influence growth in a particular sector. Where RER has to be adjusted, the required adjustment entails changes in the prices of tradable goods relative to those of nontradables. For e.g., if RER rises, imports will become more expensive and residents will switch to nontradables which are now relatively cheaper. This leads to growth in the nontraded sector.

The level of wages in the home country is very closely related to the general price index (used as the deflator). Thus major appreciations (in real terms) of a country's currency is likely to entail large gains in the real wages of workers while important depreciations involve substantial reductions of real wages.

Finally, the RER is important because there is a need

to work in real terms so you can put the analysis of trade on the same basis as real demand, real supply and real price of a single commodity. Using the definition on page 8, a graph is constructed showing the direction of India's RER. The graph is located on page 72. From 1965 onwards, the Indian currency has depreciated (in real terms). There is no dominant force affecting the demand and supply of foreign currency that can explain this depreciation so it would be interesting to see which determinants are causing this to happen. To identify the determinants, the paper looks at India's economic history to see which policies became dominant objectives of India's policy makers. Section III will identify the determinants selected for testing.

**Section III: Background to India's Economic Approach with a  
View to Selecting Determinants**

The introduction of this paper has already mentioned the difficulty associated with finding the correct determinants to test. The papers which deal with RER determinants for developing countries have generally followed two approaches; namely (1) testing as many determinants as possible without any proper justification for their inclusion or (2) selecting a short time period in a country's economic history to test one or two determinants. In the latter case, the time period selected was such that usually one determinant was predominant.

This paper approaches the problem of selecting the determinants to test from the viewpoint of pinpointing long-term policies followed by the Indian government. It looks at India's economic history to understand how certain objectives like import substitution, industrialization, development of key technologies etc., became dominant concerns of economic policy. It is useful to go back to the era before independence to see how India's economic goals were shaped.

Since 1857, when Great Britain had consolidated it's

rule over India, the British had instituted a policy of buying relatively inexpensive raw materials from the subcontinent; exporting and developing it in England and then shipping the finished products to India and other countries. This policy effectively choked off industrial growth and left India highly dependent on England's economy. When the freedom movement coalesced across the country in the last decade of the nineteenth century, a nationalist economic platform emerged which stressed industrial development with a buy-Indian-goods campaign. Economic growth through industrial development was seen as necessary to kickstart an agriculture based economy into the modern age. The buy-Indian-goods campaign was as much a weapon in the fight for national freedom as it was a struggle to break free from dependence on a foreign economy. There was widespread poverty in the country and caste and religion had created age old social inequalities in Indian society. To alleviate these concerns and to make economic growth consistent with social justice, government support and involvement on a large scale was seen as crucial. An active role for the government in formulating economic policy was held to be essential to increase national welfare. Thus, in

the pre-independence years, national welfare was synonymous with social justice, industrial development and import substitution.

India achieved independence in 1947 but along with it came the horrors of partition. Millions of Indian's died or were uprooted from their homes and forced to migrate across borders with few or no possessions. The trauma of partition tinged any national welfare plan with macroeconomic stability. Nationalist leaders viewed macroeconomic stability as vital to India's internal political stability and the nation's national integrity. The rush to independence and the transition to power left little leeway for preparatory thought and construction of a consistent plan based on a set of sound economic principles. However, in the late 1940's and early 1950's, Indian planners led by P.C. Mahalanobis, a scientist, physicist and systems analyst attempted to inform themselves of the 'state of the art' in development planning. They organized a vast intellectual debate with the best known economic experts of the country as well as from the West and East, whose views and beliefs ranged from the extreme liberal right to the equally extreme socialist left.

In the early 1950's, economic growth theories were in the experimental stage. The Harrod-Domar model of economic growth was being applied to developing countries. The model lay emphasis on increase in capital stock as a key to economic growth. Since India had a low level of per-capita income, government involvement to mobilize domestic savings was seen as a major requirement to finance investment and generate the desired rate of growth.

Industrial development in the Soviet Union made a big impression on India's politicians - especially, India's first prime minister, Jawarharlal Nehru who had visited the Soviet Union in 1927. Along with the bias of the left leaning Mahalanobis, Indian plans were gradually steered towards emphasis on developing core industries supported by ample power, transportation and communication services.

Also, influencing Indian planners were the theoretical analyses of economists like Raul Prebisch, Fritz Machlup and Ragnar Nurkse. They had doubts on the growth of Indian exports and advocated a policy of "export pessimism". Government intervention to promote "infant" industries and balance growth in all sectors of the economy gained popularity. Particular attention was paid to advancing

technical change in the capital-intensive industrial sector, agriculture and defense.

For Indian policy makers, the economic ideas which had been forged in the freedom struggle neatly coincided with 'state of the art' professional opinions of the early 1950's. To develop the "Big Push" in industrialization, it was imperative that the economy be shielded from diverse external shocks. The Reserve Bank of India was set up as the central monetary authority and its "management" of the nominal exchange rate was seen as a prime method for insulating the economy from random external shocks.

Exchange rates were to be managed to minimize the disruption of international trade and capital flows on account of exchange rate uncertainty. In the event that India's balance of payments reflected a "structural disequilibrium" due to the occurrence of some structural change, adjustment would be sought by the Reserve Bank of India by changing the exchange rate after appropriate consultation with the International Monetary Fund. A disequilibrium rate of exchange meant that a country would be experiencing a continuing net increase or decrease in its international reserves. There is much at stake here

since foreign exchange reserves may be depleted if what was thought to be cyclical movement in the balance of payments turned out to be a trend.

National welfare was to be attained through these key objectives of India's economic planning:

(1) macroeconomic stability to be achieved by internal and external balance in the economy (i.e., the clearing of the tradables and non-tradables sectors).

(2) implementing tariffs on importables to encourage "infant industries". The purpose was to indigenize domestic production of importables and free the country from dependence on foreign goods (which was thought of as another form of neo-colonialism). Foreign aid and direct investment was actively encouraged in the post-independence years to help build these "infant" industries.

(3) the government was to be an active player in developing the natural resources, power, transportation, financial and defense sectors.

(4) massive development of the industrial sector (like steel and chemicals) and encouragement of certain key technologies (for e.g., in agriculture, defense and nuclear power).

In the closed economy framework that the Indian

government created, a stable balance of payments target came to be seen as a macroeconomic stabilizer.

The general equilibrium model put forth in the following pages takes into account the above objectives (i.e., the fundamentals affecting the RER model will be foreign aid, direct investment, technological change, tariffs and government consumption). Section IV.A and IV.B. will explain the evolution of RER models and show the motivation behind selecting the balance of payments approach to testing the effect of selected determinants on the RER.

#### **Section IV.A.: Evolution of Exchange Rate Models**

The evolution of exchange rate models have shown a shift in emphasis from the effects of real factors to the influence of financial markets and, then, in the late eighties and nineties, the shift goes back to the effect of real factors again.

The traditional models of the fifties and sixties focused on the real sector. They addressed the effect of exchange rate variation on trade and the current account. The first of these models, called the "elasticities approach", showed the influence of exchange rates on the relative prices of domestic versus foreign goods. Prices, wages, non-traded sector and other areas were neglected giving the impression that tradables sector was the only one affected. The "absorption" models then came along to rectify the flaws in the elasticities approach. The models focused on the economy as a whole through the interaction between domestic production and absorption. However, they were similar to the elasticities approach in that they focused on exchange rates as largely determined in the real sector. They neglected or allowed very little play for the monetary sector and balance of payments; and hence became the focus

of controversy as financial markets were neglected.

The Mundell-Fleming (MF) model, in the late sixties, took the Keynesian IS-LM framework as its basis. The model shaped most balance of payments models in the sixties and seventies. Its distinguishing feature was the emphasis placed on the different conditions determining the current balance, on the one hand, and the net capital inflow, on the other. The outcome is an uneasy stock-flow equilibrium - not too implausible a description of the short-run response of a small open economy, but becoming less and less realistic the longer the time horizon involved.

The MF model was flawed because it retained the assumption of fixed money wages, which caused the explanatory power of the model to fall as inflation mounted. Expectations in the model were static and this limited its insights into the fundamentals of exchange rate variation. The static expectations assumption became a serious handicap as it became apparent that short run exchange rate movements depended primarily upon anticipated long run events.

The move to floating exchange rate regimes in the early-mid seventies shifted the focus to modeling the dynamics of exchange rates. This occurred because many

observers saw that exchange rates seem to vary much more than their long run determinants would seem to imply. This led to a framework that came to be known as the asset approach to exchange rate determination. It posited that exchange rates are determined by stock demands and supplies for financial and real assets and keep adjusting to make sure that asset markets are in equilibrium.

Despite the great potential of the asset approach, the early models (which came to be called monetary models) were narrow in focus and tended to neglect real factors affecting the RER in the long run. All subsequent monetary models rest on two foundations: monetary determination of national price levels and money neutrality in the long run (or equivalently, purchasing power parity). The monetary models were incapable of explaining the facts, not least because they relied on the assumption of purchasing power parity, but possibly also because it ignores the role played by expectations in determining international interest rate differentials.

The Dornbusch model is a hybrid between MF models and the monetary model. In its short run features, it fits into the restricted Keynesian tradition, with its emphasis on the

stickiness of prices in product and labor markets. On the other hand, it displays the long run characteristics of the monetary model. It refocused attention on the role of monetary forces in determining exchange rates. Monetary policy and expectations about its future course play a significant role in exchange rate stability. However, actual experience on exchange rate behavior in the seventies and eighties differed from predicted behavior.

As mentioned before, the source of dis-satisfaction with monetary models lay in their presumption that only money among the entire array of assets directly affects exchange rates. A new stream of thought in exchange rate determination was formulated around the foreign exchange "risk" premium. This development came to be known as the portfolio models. The greatest potential use of these asset models lay in their ability to depict the complex interactions among national financial policies.

Criticisms of the portfolio models were many. Empirical work found the foreign exchange risk premium to be small and it did not vary much in comparison with other exchange rate determinants. Also, portfolio models neglected real factors.

In the late eighties and nineties, papers on long run

RER determination refocused on the traditional models.  
Section IV.B. is a corollary to this section and will  
explain the motivation behind selecting the balance of  
payments approach to testing the determinants.

#### **Section IV.B. - The Balance of Payments Approach**

The traditional models can be fitted into two categories: the *flow* approach and the *capital asset* approach. This paper will follow the *flow* approach. This approach explains the long run RER by balancing the demand and supply of foreign currencies.

The first theory under this approach is the traditional purchasing power parity theory first developed by Ricardo (1809) and later popularized by Cassel (1932). In its weaker version, as relative purchasing power parity theory, it says that the ratio of the exchange rates of any two currencies with respect to any arbitrary base currency is proportional to the price levels of these countries. Thus the rates of growth of the exchange rates equals the difference in the inflation rates.

The second theory puts the export and import price elasticities in the center. They are functions of the exchange rate. Thus if there is equilibrium in the exchange market, the exchange rate is determined by these price elasticities.

The third theory is the absorption concept which was originally developed by Keynes and extended by Alexander

(1951). It explains an improvement of the current account balance by the surplus of production over the internal absorption of goods, given the exchange rate.

Extensions of these theories may be called balance of payments theories. The reduced form version of these theories takes the determinants of trade and capital flows as explanatory variables for the exchange rate. This paper uses this approach.

As mentioned before, the RER is the real price of the real dollar. In a supply-demand analysis, the quantity of real dollars demanded or supplied is expressed as a function of its real price i.e., RER is nothing more than a relative price variable. The supply and demand curves reflect alternative equilibrium situations in the foreign exchange market. The intersection of the supply-demand curves reflects a situation of no net movement of capital.

A country can have a balance of payments target (balance, surplus or deficit) and balance of payments equilibrium may be defined in terms of the consistency of an overall balance of payments target in a given country with that country's desired holdings of foreign exchange reserves. So, the long run equilibrium relative price (RER)

is the exchange rate that is consistent simultaneously with full employment of domestic resources and the overall balance of payments target.

Equivalently, in a number of countries (including India), the balance of payments equilibrium is defined in terms of a sustainable external current deficit given constraints on the availability and terms of inflows of foreign capital. Accordingly, the long-run RER is defined as that price that is consistent simultaneously with full employment of domestic resources and an external current account target that can be financed on a sustainable basis. If the long-run equilibrium RER is viewed as that price that equilibrates the external current account or trade balance, it will vary along with changes in real exogenous factors as well as policy actions.

The long run RER has been defined as  $(EP^*/P_{nt})$ . Specifically, at this equilibrium relative price, given world prices, the production possibility frontier (which circumscribes the maximum possible production of traded and nontraded goods), and domestic tastes, both the nontraded market clears and the external trade account is in equilibrium.

Thus once an equilibrium relative price is reached, three principal conditions are realized - (1) total expenditure coincides with full employment income (2) the demand for traded goods equals production (thus achieving external balance) and (3) the demand for nontraded goods equals production (thus achieving internal balance). Implied by these conditions, the marginal rate of consumers substitution equals that of production substitution, i.e., the selling price in each sector equals the respective marginal costs. The reason for the balance of payments general equilibrium model is to illustrate the effect on the long run RER of any kind of policy change or change in real exogenous factor. In the model, illustrated in the following section, both elasticities and absorption approach are fully integrated. It is a fundamental assumption of what follows that total demand is always equal to total supply both before and after any policy change.

Papers on balance of payments model using only traded goods is extensive but not much has been attempted with traded and nontraded goods in the model. An early paper by Meade, did use non-traded goods in his analysis of balance of payments but concluded that the model was too complex and

no further conclusion could be drawn until the model was simplified further. Pearce (1961) pointed out that Meade had not fully utilized the information in his model and that using basic results of microeconomic theory, the general model was not too complex. Komiya (1967) and McDougall (1965) expanded significantly the use of non-tradables in a general equilibrium framework.

This paper will use the model first developed by McDougall (1965). McDougall's model, is in turn, an extension of Mundell's model (1960) of general equilibrium in international trade. The extension lies in adding non-tradables. In this model the appropriateness of the exchange rate must be based on an analysis of the long run consistency of the RER with the simultaneous achievement of balance of payments and full employment equilibrium. Movement in RER will be determined by the movement in domestic prices of tradables and the domestic price of non-tradables. Section V will outline the model.

### Section V: A Model of Exchange Rate Determination

The model considers two countries labeled home and foreign. The home and foreign economies have similar production and consumption functions. Each economy produces tradable and non-tradable goods i.e., there are four commodities in all. The demand and supply of non-tradable goods in each country are equal. Demand is a function of all goods prices and total expenditure whereas supply is a function of goods prices only. Consumers and producers are assumed to have given respective utility and production functions with each consumer maximizing satisfaction given income and each producer maximizing profit. Supply of factors of production is fixed. By a suitable choice of quantity units it is assumed that all prices are initially equal to unity. There is perfect competition with full employment. Balance of payments equilibrium is assured by a flexible price mechanism.

The following notation is used (variables for the foreign economy are denoted by prime) :

$X_i, S_i$  = consumption and production of the  $i^{\text{th}}$  good in the home economy ( $X'_i, S'_i$  would be the consumption and production of the  $i^{\text{th}}$  good in the foreign economy).

$p_i$  = price of the  $i^{\text{th}}$  good in units of commodity  $j$  (the numeraire).

$M$  = real expenditure in the domestic country, i.e.,  $\sum p_i X_i$

$D_{i,j}, S_{i,j}$  = demand and supply elasticities of the  $i^{\text{th}}$  good with respect to the  $j^{\text{th}}$  price i.e.,  $(\partial X_i / \partial p_j) (p_j / X_i)$  and  $(\partial S_i / \partial p_j) (p_j / S_i)$ .

$C_i$  = marginal propensity to spend on the  $i^{\text{th}}$  good, i.e.,  $p_i (\partial X_i / \partial M)$

$\sigma_{i,j}$  = real income compensated elasticity of demand for the  $i^{\text{th}}$  good with respect to the  $j^{\text{th}}$  price i.e.,  $D_{i,j} + (p_j X_j / p_i X_i) C_i$ .

$x_1, x_2$  = domestic country's exports and imports respectively.

It follows that  $x_i = S_i - X_i = X'_i - S'_i$  etc.,.

$X_{i,j}, a_{i,j},$  and  $O_{i,j}$  = the price slope components of  $D_{i,j}, \sigma_{i,j}$  and  $S_{i,j}$  respectively.

$K_{i,j}$  = the aggregate demand supply substitution effect, i.e.,  $a_{i,j} - O_{i,j}$ . Hicks (1946) uses this term to specify market demand. He mentions that market demand has the same property as individual demand. This can be seen at once if we reflect that it is the actual change in the amount demanded (bought about by a small change in price) which we can divide into two parts, due

respectively to the income effect and the substitution effect. The change in the demand of a group is the sum of changes in individual demands; it is therefore also divisible into two parts, one corresponding to the sum of the individual income effects, the other to the sum of the individual substitution effects.

The following properties of individual demand and supply substitution effects (and of their elasticities) are assumed to hold in the aggregate (from Hicks) :

- (1)  $a_{ii} < 0$  ;  $\sigma_{ii} < 0$  ( $i=1,2,3$ )
- (2)  $a_{ij} = a_{ji}$  ;  $\sigma_{ij} = \sigma_{ji}$  ( $i$  and  $j = 1,2,3$ )
- (3)  $\sum p_j a_{ij} = 0$  ;  $\sum \sigma_{ij} = 0$  ( $i=1,2,3$ )
- (4)  $O_{ii} > 0$  ;  $S_{ii} > 0$  ( $i=1,2,3$ )
- (5)  $O_{ij} = O_{ji}$  ;  $S_{ij} = S_{ji} (p_j S_j / p_i S_i)$   $i$  and  $j = 1,2,3$
- (6)  $\sum p_j O_{ij} = 0$  ;  $\sum S_{ij} = 0$  ( $i=1,2,3$ )

It is assumed that the determinant  $K_{ii} \quad K_{ij} \quad (a)$   
 $K_{ji} \quad K_{jj}$

is positive where  $K_{ij} = a_{ij} - O_{ij}$ . The proof is outlined as follows:

$a_{ii} \quad a_{ij} \quad (b)$   
 $a_{ji} \quad a_{jj}$  is a determinant of income compensated partial derivatives of demand functions. Since indifference curves

are convex to the origin (from the theory of demand), this determinant is both symmetric and positive. It is, in fact, the determinant of a negative definite quadratic form.

Similarly, the production possibility curves (from supply theory) are concave to the origin; we know that the determinant is also the discriminant of a negative definite quadratic form

$$\begin{array}{cc} -O_{ii} & -O_{ij} \\ -O_{ji} & -O_{jj} \end{array} \quad (c)$$

All coefficients in the second matrix have been multiplied by -1, thereby turning a positive definite into a negative definite quadratic form.

As the sum of two negative definite quadratic forms must itself be negative definite, it follows that (a) is the discriminant of a negative definite quadratic form and is accordingly positive in sign.

Dividing (a) by  $K_{jj}$  which is necessarily negative, we obtain an expression

$$K_{ii} - (K_{ij}K_{ji})/K_{jj} = \Phi_{ij}$$

The above expression is assumed to be negative (so Hicksian imperfect stability can hold as explained later).

Rewriting the above in elasticity form we get,

$$X_{ii}\sigma_{ii} - S_i S_{ii} \quad X_i\sigma_{ij} - S_i S_{ij} \quad (d)$$

$$X_j \sigma_{ji} - S_j S_{ji} \quad X_j \sigma_{jj} - S_j S_{jj}$$

which is positive.

Dividing (d) by  $\kappa_i (X_j \sigma_{jj} - S_j S_{jj})$  which is necessarily negative, we get

$$\begin{aligned} & [(X_i \sigma_{ii}) / \kappa_i - (S_i S_{ii}) / \kappa_i] - [(X_i \sigma_{ij}) / \kappa_i - (S_i S_{ij}) / \kappa_i] [(\sigma_{ji} - S_{ji}) / (\sigma_{jj} - S_{jj})] \\ & = \Psi_{ij} < 0 \quad [\Phi_{ij} = \kappa_i \Psi_{ij}] \end{aligned}$$

The above expression is an aggregation of income compensated elasticities which indicates the degree of sensitivity of the goods concerned to a price change by considering not only the impact effect of the price change but also the indirect effects which are determined by the relative degree of competitiveness between nontraded and importable goods on one hand and nontraded and exportable goods on the other.

From Hicksian properties (1) and (4), a further assumption follows that as long as there is neither joint supply nor complementarity in demand (as long as neither  $\sigma_{ij}$  nor  $-S_{ij}$  is negative) that the bracketed portion of

$$\eta_{ij} = -C_i + C_j [(\sigma_{ij} - S_{ij}) / (\sigma_{jj} - S_{jj})]$$

must be negative and less than unity.  $\eta_{ij}$  measures the real income effects of the change in the  $i^{\text{th}}$  price and the induced substitution effects accompanying real income

changes. Hence, as  $C_i + C_j < 1$ , except where good  $i$  or  $j$  is an inferior commodity,  $\eta_{ij}$  is assumed negative and less than unity in magnitude.

The initial set of equilibrium conditions is given by:

$$D_1 = S_1 - X_1 = X'_1 - S'_1 \quad (1)$$

$$D_2 = X_2 - S_2 = S'_2 - X'_2 \quad (2)$$

$$D_3 = X_3 - S_3 \quad (3)$$

$$D'_3 = X'_3 - S'_3 \quad (4)$$

$$M = p_1 S_1 + p_2 S_2 + p_3 S_3 \quad (5)$$

$$M' = p_1 S'_1 + p_2 S'_2 + p_3 S'_3 \quad (6)$$

in which  $D_i$  is the excess demand for the  $i^{\text{th}}$  good. The first four equations state that in the world as a whole the supply of and demand for each commodity must be equal. Equations (5) and (6) are the expenditure in each country as equal to the value of production.

Stability in this model is defined as the Hicksian concept of imperfect stability. There are four commodities in this model. Assume, for the moment, that the market for the first commodity is stable if, starting from an equilibrium, an increase (decrease) in price induces an excess supply (demand). Since the excess supply (demand) of the first commodity is a function not only of its own price

but also of prices of the second and third commodities, however, whether the stability condition of the first market is satisfied depends on the situation in the second and third markets which are also thrown out of equilibrium when the price of the first commodity departs from equilibrium. The Hicksian imperfect stability condition of the first market is obtained under the assumption that the second and third markets are instantaneously cleared by the adjustment of the second and third prices. As the equilibrium conditions require every excess demand to be zero, it is clear that one equation can be omitted since it is implied by the three other equations.

Take  $p_1$  as the numeraire. Our demand and supply functions are :

$$X_i = X_i(p_2, p_3, M) \quad (7)$$

$$S_i = S_i(p_2, p_3) \quad (8)$$

$$X'_i = X'_i(p_2, p'_3, M') \quad (9)$$

$$S'_i = S'_i(p_2, p'_3) \quad (10)$$

Differentiating totally the equations (2) - (6) :

$$D_2 = (X_{22} - O_{22}) dp_2 + (X_{23} - O_{23}) dp_3 + M_2 dM \quad (11)$$

$$D_2 = -(X'_{22} - O'_{22}) dp_2 - (X'_{23} - O'_{23}) dp'_3 - M'_2 dM' \quad (12)$$

$$D_3 = (X_{32} - O_{32}) dp_2 + (X_{33} - O_{33}) dp_3 + M_3 dM \quad (13)$$

$$D'_3 = (X'_{32} - O'_{32}) dp_2 + (X'_{33} - O'_{33}) dp_3 + M'_3 dM' \quad (14)$$

$$dM = S_2 dp_2 + S_3 dp_3 \quad (15)$$

$$dM' = S'_2 dp_2 + S'_3 dp'_3 \quad (16)$$

In the last two equations,  $\sum p_i dS_i = 0$ . This means that in a world in which full employment without inflation is assumed, the ratio of changes in production must be equal to minus the ratio of marginal costs which, given perfect competition, is equal to minus the ratio of prices. All terms involving price times quantity change in the last two equations has been removed.

Substitute equations (15) and (16) into equations (11) through (14). In the resulting equations, substitute further  $(K_{i_j} - X_i M_j)$  for  $(X_{i_j} - O_{i_j})$ ;  $(K_{i_i} - X_i M_i)$  for  $(X_{i_i} - O_{i_i})$ ; and  $\kappa_i, \kappa_j$  or zero as indicated by the equilibrium conditions.

The resulting equations are:

$$D_2 = (K_{22} + K'_{22} - \kappa_2 M_2 + \kappa_2 M'_2) dp_2 + K_{23} dp_3 + K'_{23} dp'_3 \quad (17)$$

$$D_3 = (K_{32} - \kappa_2 M_3) dp_2 + K_{33} dp_3 \quad (18)$$

$$D'_3 = (K'_{32} + \kappa_2 M'_3) dp_2 + K'_{33} dp'_3 \quad (19)$$

If equilibrium is displaced in the market for the  $i^{\text{th}}$  commodity the system is imperfectly stable as defined above

$$\text{if } D_i / dp_i = |A| / A_{ii} < 0$$

where  $|A|$  is the Jacobian of the coefficients of (17), (18)

and (19)<sup>5</sup>.

Making use of the above and the previous relationships, we have

$$D_2/dp_2 \times 1/\kappa_2 = \Psi_{23} + \Psi'_{23} + \eta_{23} - \eta'_{23} = J < 0^6 \quad (20)$$

which is the condition for imperfect stability. For  $J > 0$ ,

$(\eta_{23} - \eta'_{23}) > (\Psi_{23} + \Psi'_{23})$ . We will assume that the

international market is stable, i.e.,  $J < 0$ .

Section VI will illustrate the effects of different fundamentals on the equilibrium RER.

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<sup>5</sup> This imperfectly stable general solution was first worked out by Mosak (1933).

<sup>6</sup> Using Cramers Rule and the Laplace Criterion, the solution given by (20) has been solved by MacDougall.

**Section VI: Effects of the Determinants of the RER on the Model**

The procedure for comparative static analysis will be as follows :

- (1) the impact effect of the exogenous shock on excess demands is examined holding the prices of non-traded goods and TOT constant.
- (2) the non-traded price is allowed to alter to bring the non-traded sector back to equilibrium.
- (3) having secured the non-traded market, we are left with a measure of excess demand in the international market.
- (4) we ask what changes need to be made to the TOT to restore the entire system to equilibrium.
- (5) Finally, we look at the effect of the exogenous shock on the nature of the shift in the non-traded price level.

The determinants considered are factors that are relevant to India's economic history. As mentioned in the Introduction, determinants is defined as forces that affect the demand-supply of foreign currency. The determinants are foreign aid, direct foreign investment, technological change, tariffs and government consumption.

(1) **Foreign Aid**

Foreign aid, strictly defined, relates to a transfer of real resources from the donor countries to the recipients. Furthermore, the giving of aid should not involve any expectations of commercial gain on the part of the donors. To the extent that aid flows confer commercial gains on donors, the real amount of resources transferred will be less than the nominal amount of aid flows. Thus, grants which are in the form of outright gifts constitute "full transfers", whereas loans which have to be repaid and bear an interest rate do not. Loans qualify as 'aid' only to the extent that they bear a concessionary rate of interest, and have longer maturity periods than commercial loans. In other words, their may be a 'grant' element in aid loans. The Development Assistance Committee (DAC) of the OECD stipulates that to qualify as aid, a loan must have at least a 25% grant element.

In absolute terms India has recieved more aid than any other developing country (however, in per capita terms, aid reciepts are very low - estimated at not more than \$2 per head). Foreign aid flows run into billions of rupees and peaked in the late sixties and early seventies. Commodity

aid and grants (from 1951 to 1981) ran anywhere from 8.5% to almost 50% of total aid. According to one study by DAC, the grant element in 'soft' loans to India was between 60%-75%.

Assume that the home country is the receiving country and the foreign country is the paying country. The equations for the model are stated again and modified to include transfers :

$$D_2 = X_2 - S_2 = S'_2 - X'_2 \quad (21)$$

$$D_3 = S_3 - X_3 \quad (22)$$

$$D'_3 = S'_3 - X'_3 \quad (23)$$

$$M = S_1 + S_2 p_2 + S_3 p_3 + T \quad (24)$$

$$M' = S'_1 + S'_2 p_2 + S'_3 p'_3 - T \quad (25)$$

As before, the equation for  $D_1$  has been omitted as it is implied by the rest. The numeraire is  $p_1$ . Equations (24) and (25) have been modified to show transfers which is denoted by  $T$ .

Differentiate totally and substitute  $dM$  and  $dM'$  in the remaining equations. Substitute further  $(K_{ij} - X_j M_i)$  for  $(X_{ij} - O_{ij})$ ;  $(K_{ii} - X_i M_i)$  for  $(X_{ii} - O_{ii})$ ; and  $\kappa_1, \kappa_2$  or zero as indicated by the equilibrium conditions. The resulting equations after re-arranging are :

$$D_2 = (K_{22} + K'_{22} - \kappa_2 M_2 + \kappa_2 M'_2) dp_2 + K_{23} dp_3 + K'_{23} dp'_3 + (M_2 - M'_2) dT \quad (26)$$

$$D_3 = (K_{32} - \alpha_2 M_3) dp_2 + K_{33} dp_3 + M_3 dT \quad (27)$$

$$D'_3 = (K'_{32} + \alpha_2 M'_3) dp_2 + K'_{33} dp'_3 - M'_3 dT \quad (28)$$

Equations (26) - (28) set out excess demand in each market following an exogenous transfer from the foreign country to the home country.

Following our procedure for comparative static analysis, we look at excess demand for importables in the home economy before any relative price changes =  $M_2 dT$  (at the time of transfer or impact). Adjustment has to be made in the non-traded market before excess demand for importables is computed in the home economy prior to an adjustment in the TOT. From (27),  $D_3 = M_3 dT$  and the rise in  $p_3$  required to remove excess demand in the market is (set  $D_3 = 0$  with  $dp_2$  constant)  $dp_3 = -M_3/K_{33} dT$ .

It follows from (26) that there must be a further induced change in demand for importables equal to  $K_{23} dp_3$  or  $-M_3 K_{23}/K_{33} dT$  and that prior to any alteration in the TOT the total excess demand for importables is

$$[M_2 - M_3 K_{23}/K_{33}] dT = -\eta_{23} dT$$

In the foreign country, excess demand for good 2 (that country's exportables) is  $[-M'_2 + M_3 K_{23}/K_{33}] dT = \eta'_{23} dT$

Total excess demand for importables is

$$D_2 = (\eta'_{23} - \eta_{23}) dT \quad (29)$$

Combining equation (20) which is  $D_2 = \kappa_2 J dp_2$  and (29), we get

$$dp_2/dT \times \kappa_2 = (\eta'_{23} - \eta_{23})/J \quad (30)$$

The international adjustment to equilibrium is also dependent on the change in the level of non-traded goods prices relative to those of the tradable goods. Substitute equation (30) into equation (27) and re-arrange :

$$dp_3/dT = [(K_{32} - \kappa_2 M_3) (dp_2/dT) + M_3] / -K_{33} \quad (31)$$

Re-writing in elasticity form

$$dp_3/dT = \{[\sigma_{32} - S_{32} - (p_2 \kappa_2 / p_3 X_3) C_3] (dp_2/dT) + M_3\} / -\sigma_{33} + S_{33} \quad (32)$$

In equation (30), the direction of TOT movement is determined according to whether  $\eta_{23}$  is greater than, less than or equal to  $\eta'_{23}$  in absolute magnitude. In equation (32), the denominator is positive. Only if the TOT does not change i.e.,  $\eta_{23} = \eta'_{23}$  will the non-traded price level rise relative to the traded price level. In effect, the RER will appreciate. If the TOT changes then the direction of RER change will be ambiguous. The home country's price level will rise relative to whichever traded commodity has fallen in price relative to the other traded commodity (in other words - the concept of a single price of a traded good is not clear since import and export prices will move in

opposite directions). Whether the rise in non-traded goods price level will exceed the price level of the traded good whose price has improved relative to the other traded good will depend on the magnitude of the TOT effect, by the importance of trade in the home country, by the marginal propensity to spend on non-traded goods and the degree of substitution between non-tradables and exportables and between non-tradables and importables.

For empirical purposes foreign aid will be defined as

$$AID = (NTO + NTP) / GDP$$

where,

NTO = net transfers official (line 77agd from IFS)

NTP = net transfers private (line 77afd from IFS)

GDP = gross domestic product (line 99b from IFS)

The Balance of Payments Yearbook defines transfers as transactions in which one transactor provides an economic value to another transactor but does not receive a quid pro quo on which an economic value is placed. Private transfers are migrant transfers and workers remittances and official transfers are government to government grants. The definition above will not include any "soft" loans since information regarding these loans is not available.

## (2) Direct Investment

Most developing countries still in the shadow of yesteryear's colonialism and jealous of their political independence are wary of foreign economic domination. But they also recognize that direct investment is a powerful conduit for the transference of the technology, managerial skills and capital they need for their development programmes. On one hand they have wooed foreign investors and on the other, they have instituted various forms of control on the operations of foreign firms. These attitudes are reflective of India's official policy towards foreign investment.

In relation to her size, the total amount of direct investment in India is not very high. Smaller countries like Mexico, Brazil, Australia have higher inflows of investment. A meaningful estimate of the direct investment in India would be its share in the total private capital formation in the country. Some studies have made rough estimates and these show foreign share in industries range from 10% in certain sectors to as much as 50% in others.

Since independence, significant changes have occurred in both the composition and the organizational pattern of

foreign enterprise participation in the Indian economy. Foreign capital and enterprise have been fanning out toward technologically-intensive fields of manufacturing industry, and away from the traditional strongholds of plantations and extractive industries. This was encouraged by Indian planners. They argued that the growth of the investment goods sector must anticipate and be independent of the growth in consumption. This anticipatory and independent expansion of the investment sector or capital goods industry would lay down the basis of rapid industrialization. This meant that during the period of basic industrialization the flow of goods would not be from the investment goods sector to the consumption goods sector but within the investment sector itself - i.e., "machines to produce more machines".

The equilibrium conditions are re-stated again with modifications for direct investment by the foreign country in the home country :

$$D_2 = X_2 - S_2 = S'_2 - X'_2 \quad (33)$$

$$D_3 = X_3 - S_3 \quad (34)$$

$$D'_3 = X'_3 - S'_3 \quad (35)$$

$$M = S_1 + S_2 p_2 + S_3 p_3 - w\lambda \quad (36)$$

$$M' = S'_1 + S'_2 p_2 + S'_3 p_3 + w\lambda \quad (37)$$

where  $\lambda$  is the vector of investments made in the home country by the foreign country and  $w$  is the income earned by these investments (or rate of return on investments) (Dixit & Norman 1980).

Differentiate totally and substitute  $dM$  and  $dM'$  in the remaining equations. Substitute further  $(K_{ij}-X_jM_i)$  for  $(X_{ij}-O_{ij})$ ;  $(K_{ii}-X_iM_i)$  for  $(X_{ii}-O_{ii})$ ; and  $\kappa_i, \kappa_2$  or zero as indicated by the equilibrium conditions. The resulting equations after re-arranging are :

$$D_2 = (K_{22} + K'_{22} - \kappa_2 M_2 + \kappa_2 M'_2) dp_2 + K_{23} dp_3 - K'_{23} dp'_3 - (M_2 - M'_2) \lambda dw - (M_2 - M'_2) w d\lambda \quad (38)$$

$$D_3 = (K_{32} - \kappa_2 M_3) dp_2 + K_{33} dp_3 - M_3 \lambda dw - M_3 w d\lambda \quad (39)$$

$$D'_3 = (K'_{32} + \kappa_2 M'_3) dp_2 + K'_{33} dp'_3 + M'_3 \lambda dw + M'_3 w d\lambda \quad (40)$$

Equations (38)-(40) set out excess demand in each market following an exogenous investment from the foreign country to the home country. Before any relative price changes, excess demand for importables in the domestic country =  $-M_2 w d\lambda$ .

Adjustment has to be made in the non-traded market before excess demand for importables is computed in the domestic economy prior to an adjustment in the TOT. From (39),  $D_3 = -M_3 w d\lambda$  and the rise in  $p_3$  required to remove

excess demand in this market is (set  $D_3=0$  with  $dp_2$  and  $dw$  constant)  $dp_3 = M_3w/K_{33} d\lambda$ . It follows from (38) that there must be a further induced change in demand for importables equal to  $K_{23}dp_3$  or  $(M_3w K_{23})/K_{33} d\lambda$  and that prior to any alteration in the TOT, the total excess demand for importables is  $[-M_2w + (M_3w K_{23})/K_{33}]d\lambda = \eta_{23}wd\lambda$ . In the foreign country, excess demand for good two (that country's exportables) is  $[M'_2w - (M'_3w K_{23})/K_{33}]d\lambda = -\eta'_{23}wd\lambda$ . Total excess demand for importables is  $D_2 = (\eta_{23} - \eta'_{23})wd\lambda$  (41)

Combining equation (20) and (41), we get

$$dp_2/d\lambda \times \kappa_2 = (\eta_{23} - \eta'_{23})w/J \quad (42)$$

The international adjustment to equilibrium is also dependent on the change in the level of non-traded goods prices relative to those of the tradable goods. Substitute equation (42) into equation (39) and re-arrange :

$$dp_3/d\lambda = [(K_{32} - \kappa_2 M_3) (dp_2/d\lambda) - M_3w] / -K_{33} \quad (43)$$

Re-writing in elasticity form :

$$dp_3/d\lambda = \{[\sigma_{32} - S_{32} - (p_2 \kappa_2 / p_3 X_3) C_3] (dp_2/d\lambda) - M_3w\} / -\sigma_{33} + S_{33} \quad (44)$$

Equations (42) and (44) are similar to equations (30) and (32) respectively. The explanation for the movement of RER is similar also. The direction of TOT movement in (42) is determined by whether  $\eta_{23}$  is greater than, less than or

equal to  $\eta'_{23}$  in absolute magnitude. Only if there is no change in TOT (i.e.,  $\eta_{23} = \eta'_{23}$ ) will the non-traded price level fall relative to the traded price level. The RER will depreciate. If TOT changes then direction of RER is ambiguous (the reasoning has been explained in the foreign aid section).

Direct foreign investment will be defined as

$$INV = (DFI + LTC) / GDP$$

where,

DFI = direct foreign investment (line 77bad from IFS)

LTC = long term capital (line 77bcd from IFS)

GDP = line 99b in the IFC

Direct foreign investment data was also obtained from the Statistical Outline of India (different year volumes had different line numbers). Balance of Payments Yearbook defines it as capital transactions between Indian enterprises and foreign citizens who hold at least 10% ownership interest in the Indian enterprises.

Long term capital is not defined in either the IFS or the Balance of Payments Yearbooks but references are made to long term loans by foreign residents to Indian enterprises.

### **(3) Technological Change**

As mentioned in Section II, industrialization and development of key technologies were some of the concerns of India's policymakers. Industrialization was viewed as an engine of growth for the rest of the economy and the supplier of jobs to reduce poverty. Progress in this area has been mixed. Although industry produced modern cars, airplanes, electronic equipment, space launchers, military weapons among other things - the bulk of the population had no electricity and used heat wasting traditional stoves.

Technology was imported but was "Indianized" as quickly as possible. One sector that did show tremendous improvement was agricultural. The use of new seeds and irrigation technologies in the fifties and sixties gave rise to the 'Green Revolution' and India became self-sufficient in food and even an exporter. Many studies have been conducted on India's productivity and, depressingly, show technical growth rate to be between -1% and 1.5%. By the late 1980s, government planners realized that the emphasis on large-scale, capital intensive industries created far fewer jobs than the annual entrants into the labor force leaving unemployment as an ever growing problem.

The equilibrium conditions have been written before and henceforth only the reduced form equations will be stated (modified for the exogenous shock). Assume that technological change occurs only in the domestic country and the increase in output due to technological change is denoted by  $d\alpha$ . Differentiating the equilibrium conditions and simplifying we have :

$$D_2 = (K_{22} - \kappa_2 M_2 + K'_{22} + \kappa_2 M'_2) dp_2 + K_{23} dp_3 + K'_{23} dp'_3 + (m_2 - n_2) d\alpha \quad (45)$$

$$D_3 = (K_{32} - \kappa_2 M_3) dp_2 + K_{33} dp_3 + (m_3 - n_3) d\alpha \quad (46)$$

$$D'_3 = (K'_{32} + \kappa_2 M'_3) dp_2 + K'_{33} dp_3 \quad (47)$$

where  $n_i = \partial S_i / \partial \alpha$  is the marginal propensity to produce the  $i^{\text{th}}$  good out of a given increase in output at constant relative prices, and where  $m_i = \partial X_i / \partial \alpha$  is the marginal propensity to consume the  $i^{\text{th}}$  good.

Equations (45)-(47) are excess demands in each market following the exogenous increase in output in the domestic country. Before any relative price changes, the excess demand for importables in the domestic country is  $(m_2 - n_2) d\alpha$ . Adjustment has to be made in the non-traded market before excess demand for importables is computed in the domestic economy prior to an adjustment in the TOT. The rise in  $p_3$  required to remove excess demand in this market is

$dp_3 = -(m_3 - n_3)/K_{33} d\alpha$ . It follows from equation (45) that there must be a further induced change in demand for importables equal to  $K_{23}dp_3$  or  $-(m_3 - n_3)(K_{23}/K_{33})d\alpha$ . Excess demand for importables prior to an adjustment in the TOT is

$$D_2 = [(m_2 - n_2) - (m_3 - n_3)(K_{23}/K_{33})]d\alpha \quad (48)$$

Re-writing in elasticity form

$$D_2 = -Y_{23}d\alpha \quad (49)$$

where  $Y_{23} = -(c_2 - s_2) + (c_3 - s_3)[(\sigma_{32} - S_{32})/(\sigma_{33} - S_{33})]$  and  $c_i = p_i m_i$  and  $s_i = p_i n_i$

Combining equation (20) and equation (49), we get

$$dp_2/d\alpha \times \kappa_2 = -Y_{23}/J \quad (50)$$

The international adjustment to equilibrium is also dependent on the change in the level of non-traded goods prices relative to those of the tradable goods.

Substitute equation (50) into equation (46),

$$dp_3/d\alpha = [(K_{32} - \kappa_2 M_3)(dp_2/d\alpha) + (m_3 - n_3)]/-K_{33} \quad (51)$$

Re-writing in elasticity form :

$$dp_3/d\alpha = \{[\sigma_{32} - S_{32} - (p_2 \kappa_2 / p_3 X_3) C_3](dp_2/d\alpha) + (m_3 - n_3)\} / -\sigma_{33} + S_{33} \quad (52)$$

Equation (50) is very difficult to interpret. The sign is dependent on whether  $Y_{23}$  is greater than or less than 0. The direction of the TOT movement will depend on the magnitude of the increase in output of the non-traded

sector; on the importance of the non-traded sector to the economy and on the degree of substitutability between non-traded and importable goods on one hand and non-traded and exportable goods on the other. Equation (52) is equally ambiguous. Nothing general can be said about the movement in non-traded prices. From the above it is clear that in the case of technological changes, it is not possible to know the direction of change in RER.

Many studies have been conducted on India's productivity and various measures of Total Factor Growth Productivity like Solow, Kendrick and Translog have been calculated. One of the most comprehensive studies was done by Goldar (1990) and the Solow residuals (denoted by TECH in the paper) calculated by him will be used to measure technical change in this paper.

#### **(4) Tariff**

The main feature of India's import-substituting industrialization strategy was the imposition of tariffs and quantitative restrictions on imports, coupled with a detailed system of foreign exchange allocation and a complicated system of industrial licensing. Many studies

done in India have shown that these policy instruments lacked any sort of economic rationale and were subject to ad hoc bureaucratic decision making. In sum, far from promoting the stated objective, it contributed to widespread economic inefficiencies.

Suppose that only the home country levies tariffs on importables, thus abstracting from the problems of retaliation. Assume that all tariff revenues are handed back to the public in a non-distortionary manner. The national budget constraint then is that expenditure should equal production plus net revenue from tariffs. The equations are:

$$M = S_1 p_1 + S_2 p_2 + S_3 p_3 + t \kappa_2 \quad (53)$$

$$M' = S'_1 p_1 + S'_2 + S'_3 p'_3 \quad (54)$$

where tariff is denoted by  $t = p_2 - p'_2$ ,  $p'_2$  is the free trade price and is taken as the numeraire. Assume that initially tariff is zero (so  $t=0$  and  $dp_2=dt$ ).

Our stability condition (eq. 20) can be re-written as  $D_2/dp_1 \times 1/\kappa_2 = - (\Psi_{23} + \Psi'_{23} + \eta_{23} - \eta'_{23}) = -J > 0^7$  (55)

Differentiating totally, we get

$$D_2 = (K_{21} - \kappa_1 M_2 + K'_{21} + \kappa_1 M'_2) dp_1 + K_{23} dp_3 + K'_{23} dp'_3 + (K_{22} - \kappa_2 M_2) dt \quad (56)$$

$$D_3 = (K_{31} - \kappa_1 M_3) dp_1 + (K_{32} - \kappa_2 M_3) dt + K_{33} dp_3 \quad (57)$$

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<sup>7</sup> Since  $dp_2 = -dp_1$

$$D'_3 = (K'_{31} - \alpha_1 M'_3) dp_1 + K'_{33} dp'_3 \quad (58)$$

Equations (56)-(58) are excess demands in each market following the increase in tariffs in the home country.

Before any relative price changes, the excess demand for importables in the domestic country is  $(K_{22} - \alpha_2 M_2) dt$ . Excess demand for non-traded goods is (from eq. 57)  $(K_{32} - \alpha_2 M_3) dt$ .

Holding TOT constant, the non-traded goods market will clear when  $dp_3 = -(K_{32} - \alpha_2 M_3) / K_{33} dt$ . It follows from (56) that there must be a further induced change in demand for importables equal to  $K_{23} dp_3$  or  $-(K_{32} - \alpha_2 M_3) K_{23} / K_{33} dt$ . Finally, add the induced and impact effects and we have excess demand for importables prior to an adjustment in TOT

$$D_2 = [(K_{22} - \alpha_2 M_2) - (K_{32} - \alpha_2 M_3) K_{23} / K_{33}] dt \quad (59)$$

Re-writing in elasticity form, we have

$$D_2 = \alpha_2 (\Psi_{23} + \eta_{23}) dt \quad (60)$$

Combining the stability condition (eq. 55) and eq. 60, we get

$$dp_1 / dt = (\Psi_{23} + \eta_{23}) / -J \quad (61)$$

The numerator is negative and so the TOT ( $dp_1$ ) is deteriorating.

The international adjustment to equilibrium is also dependent on the change in the level of non-traded

goods prices relative to those of the tradable goods.

Substitute eq.(61) into eq.(57)

$$dp_3/dt = [(K_{31} + \kappa_1 M_3)(dp_1/dt) + (K_{32} - \kappa_2 M_3)] / -K_{33} \quad (62)$$

A change in the price of the non-traded good relative to the importable good is  $d(p_3/p_2)$ . With  $p_2$  as numeraire, it can be written as  $d(p_3/p_2)/dt = dp_3/dt - 1$ .

Re-writing eq.(62) in elasticity form

$$d(p_3/p_2)/dt = [(\sigma_{31} - S_{31})(dp_1/dt - 1) - (p_2 \kappa_1 / p_3 X_3) C_3 (dp_1/dt)] / (-\sigma_{33} + S_{33}) \quad (63)$$

As mentioned above - equation (61) is negative in sign and so the TOT is unambiguously deteriorating. Then equation (63) shows that the sign of the non-traded price level is ambiguous relative to that of the traded goods sector. The RER could either increase or decrease i.e., appreciate or depreciate.

The above result seems to be in complete contradiction to the accepted wisdom. The imposition of a tariff (with no foreign country retaliation) is thought to improve the TOT. If non-traded goods and importables are competitive, then demand shifts to non-traded goods. If the magnitude of the shift is large then non-traded price level will rise relative to the traded goods sector. In effect, an

appreciation.

Tariffs is defined as

$$\text{TARIFF} = (\text{IMPTAX} + \text{CUST}) / \text{GDP}^8$$

where,

IMPTAX = import taxes (line 6.1 from Government Finance Yearbooks)

CUST = custom duties (line 6.1.1 from Government Finance Yearbooks)

GDP = line 99b in the IFC

Data has also been obtained from the Statistical Outline of India for import taxes and customs duties (different volumes have different line numbers). Neither the Government Finance Yearbooks nor the Statistical Outline of India have any definition of import taxes or customs duties.

#### **(5) Government Expenditure**

The first steps to form a public sector was taken soon after independence. A policy resolution in 1948 gave the government a monopoly in defence, atomic energy and railroads. Many private companies operating in telephone and

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<sup>8</sup> Data for IMPTAX and CUST were obtained from the Statistical Outline of India and the Government Finance Yearbooks.

telegraph and in natural resources were given notice of takeover. By 1956 (by the passage of another resolution), the private sector was relegated primarily to the production of consumer goods. By 1973, the insurance and the banking industries was nationalized too. Furthermore, the growth of this large public sector contributed to a substantial growth of the administrative structure of the government.

The above is only a very basic sketch when, in reality, the government's role in the economy was much more pervasive than outlined here.

Assume that the government finances its expenditure by using the proceeds from import tariffs. Its budget constraint is  $t\kappa_2 = g\sum p_i (i=1,2,3)$ . This means that the government uses tariff revenues to purchase tradable and non-tradable goods.

Using the same equilibrium conditions as in tariffs but substituting the government expenditure for tariffs and differentiating totally (and taking  $p'_2$  as numeraire), we get :

$$D_2 = (K_{21} - \kappa_1 M_2 + K'_{21} + \kappa_1 M'_2) dp_1 + (K_{22} + \kappa_2 M_2) dp_2 + K_{23} dp_3 + K'_{23} dp'_3 + M_2 (p_1 + p_2 + p_3) dg \quad (64)$$

$$D_3 = (K_{31} - \kappa_1 M_3) dp_1 + K_{32} dp_2 + K_{33} dp_3 + M_3 (p_1 + p_2 + p_3) dg \quad (65)$$

$$D'_3 = (K'_{31} + \kappa_1 M'_3) dp'_1 + K'_{33} dp'_3 \quad (66)$$

[In the above excess demand equations it has been assumed further that initial government expenditure is zero].

Before any relative price changes the excess demand for importables (from eq. 64) is  $M_2(p_1+p_2+p_3)dg$ . Excess demand for non-traded goods (from eq. 65) is  $M_3(p_1+p_2+p_3)dg$ . Holding TOT constant, the non-traded market will clear when

$dp_3 = -M_3(p_1+p_2+p_3)/K_{33} dg$ . It follows from (64) that there must be a further induced change in demand for importables equal to  $K_{23}dp_3$  or  $-M_3(p_1+p_2+p_3) K_{23}/K_{33} dg$  and that prior to any alteration in the TOT, excess demand for importables is

$$D_2 = [M_2 - M_3 K_{23}/K_{33}] (p_1+p_2+p_3) dg = -\eta_{23} (p_1+p_2+p_3) dg \quad (67)$$

Combining (67) and the stability condition which is equation (55), we have ;

$$dp_1/dg \times \kappa_2 = -\eta_{23} (p_1+p_2+p_3) / -J \quad (68)$$

The international adjustment to equilibrium is also dependent on the change in the level of non-traded goods prices relative to those of the tradable goods.

Substituting (68) into (65)

$$dp_3/dg = [(K_{31} + \kappa_1 M_3) (dp_1/dg) + K_{32} (dp_2/dg) + M_3 (p_1+p_2+p_3)] / -K_{33} \quad (69)$$

Re-writing in elasticity form

$$d(p_3/p_2)/dg = [(\sigma_{31} - S_{31}) (dp_1/dg - 1) + (p_2 \kappa_1 / p_3 X_3) C_3 (dp_1/dg)] / (-$$

$$\sigma_{33} + S_{33}) \quad (70)$$

The numerator and denominator in equation (68) is positive and so the TOT is unambiguously increasing. If  $dp_1/dg = 1$  or greater, then the non-traded price level (from eq. 70) will rise relative to the traded goods sector. The RER index is decreasing; in effect, a real appreciation. If  $dp_1/dg < 1$  then from equation (70), the sign is ambiguous and RER could be appreciating or depreciating. It depends on the magnitude of government spending on non-tradables compared to importables.

Government expenditure is defined as

$$\text{GOVEXP} = \text{GOVCONS}/\text{GDP}$$

where,

GOVEXP = government consumption (line 91 in the IFS)

GDP = line 99b in the IFS

No definition of government consumption is mentioned in the IMF books.

## **Section VII: Econometric Methodology and Empirical Results**

The econometric methodology followed is relatively simple. The dependent variable (RER) is regressed on the independent variables (aid, investments, technological change, government consumption and tariffs) by the method of ordinary least squares. A pre-test of cointegration is done to avoid a spurious regression situation. Furthermore the issue of stationarity of the time series data is addressed by the unit root test. The following pages will have more detail. Data for all the variables are annual and from 1960-1990. Since India followed a fixed exchange rate policy from 1945 to 1975, the above tests will be done for the period 1960-1975 (data for some of the variables is not available before 1960). After 1975, the Indian government took the decision to delink the rupee from the pound and peg it to a weighted basket of selected currencies. To test the effect on the RER, all the above tests will be redone for the period 1976 to 1990.

A basic model of RER is estimated to find out whether the fundamentals included in the study are statistically significant. Since India's RER has been steadily increasing since 1965, only those fundamentals which are statistically

significant and have a positive sign will be considered to be important. The basic model estimated is

$$\text{RER} = \beta_0 + \beta_1 \text{AID} + \beta_2 \text{INV} + \beta_3 \text{GOVEXP} + \beta_4 \text{TARIFF} + \beta_5 \text{TECH} + \mu$$

The variables have been explained earlier but for convenience, I list them again

RER = real exchange rate (defined as India's nominal exchange rate multiplied by US WPI and the whole divided by India's CPI).

AID = foreign aid (official and private transfers)

INV = direct foreign investment and long-term capital flows

GOVEXP = government consumption

TARIFF = import taxes and customs duties

TECH = technological change (using Solow residual). The TECH variable has been lagged one period for instrumentation.

$\beta_i$  = parameters to be estimated

$\mu$  = stationary disturbance term (RESID)

[All of the above variables are in logs]

The assumptions of the classical regression model necessitate that all the time series data be stationary and the errors have zero mean and finite variance. In the

presence of nonstationary variables, there might be what is called a spurious regression. A time series that has an unit root is known as a random walk and a random walk is an example of a nonstationary time series. If a time series is differenced once and the differenced series is stationary, we say that the original random walk series is integrated of order 1, denoted by  $I(1)$ . If the univariate time series in the basic model are integrated of the same order and a linear combination of the variables is stationary, i.e.,  $I(0)$ , then the nonstationary RER is co-integrated with the other non-stationary sequences. All the assumptions of the classical regression methodology apply.

The Augmented Dicky-Fuller (ADF) test statistics will be calculated to indicate the order of integration in each of the univariate time series. Since annual data is used, the lag length ( $k$ ) selected is 3 years of lags (i.e.,  $k=3$ ). If the F-statistic on lag 3 is insignificant at 5% critical value, then the ADF test is recalculated using lag  $k-1$ . The results of the unit root tests - based on a unit root null versus a trend stationary alternative - are reported in Table 1.

Table 1  
Tests of Order of Integration  
 ADF(k) test statistic (1960-1975)

<u>Variable</u>	<u>India</u>
RER	-0.06 (k=1)
$\Delta$ RER	-3.10*
AID	-0.93 (k=1)
$\Delta$ AID	-3.56*
INV	0.88
$\Delta$ INV	-4.42*
GOVEXP	-0.86 (k=1)
$\Delta$ GOVEXP	-4.19*
TARIFF	0.39 (k=1)
$\Delta$ TARIFF	-2.28**
TECH	0.74 (k=1)
$\Delta$ TECH	-3.67*

[\*= significant at the 1% level of significance]

[\*\* = significant at the 5% level of significance]

In every case, the ADF tests are consistent with each series being characterized as I(1) variables. Specifically, the ADF test fails to reject the presence of a unit root for each series in levels, but not in first differences. OLS estimates for the basic RER model is calculated in Table 2. In Table 2 the Newey-West correction for heteroscedasticity and serial correlation is used.

TABLE 2

Regression Results for the RER (1960-1975)

Intercept	AID	INV	GOVEXP	TARIFF	TECH
9.295	0.0435	-0.147	0.5427	0.1532	-2.135
(3.59)	(0.850)	(-3.524)	(2.6911)	(1.8558)	(-2.861)

Prob 0.0071 0.4200 0.0078 0.0274 0.1006 0.0211

$R^2 = 0.74$  ,  $DW = 2.2026$

PP = -7.198\* (intercept)

MacKinnon critical values for 1%, 5% and 10% are  
-4.1366, -3.1483 and -2.7180 respectively.

ADF = -6.19\* (intercept)

MacKinnon critical values for 1%, 5% and 10% are  
-4.227, -3.1801 and -2.7349 respectively.

[t-statistics are given in parenthesis]

[intercept was included and logs of all variables were  
taken]

[\* = significant at the 1% level of significance]

[The PP and ADF tests were conducted with 2 and 1 lag  
differences respectively]

The results show that government consumption, direct investments and technological change are significant at the 5% level. However, only the government expenditure variable has a positive sign indicating a rise in the RER index i.e., depreciation of the Indian Rs in real terms.

In order for the above results to be valid, a linear combination of the variables must be stationary i.e., the residuals of the regression must be  $I(0)$ . Both the Phillips-

Perron and ADF tests show the residuals to be stationary. Since all the series are integrated of order 1 and the error term is stationary, all the properties of classical regression model apply and the results are valid.

It is common for time series observations on economic variables to be correlated over time. A large value of a variable in one period often means that there is a high probability that that variable will be high again next year. The residual or error term in the basic model contains effects on the dependent variable that have not been explicitly modeled by the independent variables on the right hand side of the equation. If these effects come from variables that are correlated over time, then the error term will be correlated over time. The best way to model this autocorrelation is a first-order autoregressive process or AR(1).

When the AR(1) error specification is invoked in EViews, the interpretation of the coefficients, standard errors, and t-statistics is unchanged. This is because EViews gives you the results which have already been

corrected for serial correlation<sup>9</sup>. The results are in Table 3

TABLE 3

Regression Results for the AR(1) model 1960-1975

	Intercept	AID	INV	GOVEXP	TARIFF	TECH
	8.1575	0.1471	-0.192	1.2478	-0.0121	-2.793
	(6.624)	(4.323)	(-7.021)	(3.969)	(-0.192)	(-4.244)
Pr	0.0012	0.0075	0.0009	0.0106	0.8547	0.0081

AR(1) = -0.472 (-1.778) Pr = 0.135

$R^2 = 0.839$  , DW = 2.25

PP = -4.43\* (intercept)

MacKinnon critical values for 1%, 5% and 10% are -4.22, -3.18 and -2.73 respectively

ADF = -6.01\* (intercept)

MacKinnon critical values for 1%, 5% and 10% are -4.32, -3.21 and -2.75 respectively.

[t-statistics are given in parenthesis]

[\* = significant at the 1% level of significance]

With the AR(1) correction, all variables except tariff is significant but only foreign aid and government

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<sup>9</sup> The Help Index of EVIEWS details the manner in which the AR(1) specification corrects for serial correlation.

consumption have a positive sign.

Since India switched to a floating exchange rate after 1975, all the above tests were redone from 1976 to 1990. Table 4 will have the unit root tests for stationarity of each series. The explanation is the same as in Table 1.

Table 4

<u>Tests of Order of Integration</u>	
ADF(k) test statistic (1976-1990)	
<u>Variable</u>	<u>India</u>
RER	0.98 (k=1)
$\Delta$ RER	-2.96*
AID	0.59 (k=1)
$\Delta$ AID	-3.79*
INV	-1.55 (k=1)
$\Delta$ INV	-6.91*
GOVEXP	-0.90 (k=1)
$\Delta$ GOVEXP	-2.97*
TARIFF	-0.43 (k=1)
$\Delta$ TARIFF	-3.57*
TECH	-0.68 (k=1)
$\Delta$ TECH	-3.69*

[\*= significant at the 1% level of significance]

Following the same methodology as above, the OLS regression is done on the RER and the residuals of the regression are tested for stationarity. Table 5 has the OLS estimates

TABLE 5

Regression Results for the RER (1976-1990)

	Intercept	AID	INV	GOVEXP	TARIFF	TECH
	9.438	0.0020	0.106	-1.5399	0.3923	-0.218
	(3.80)	(0.177)	(1.582)	(-2.171)	(2.365)	(-2.40)
Prob	0.0052	0.8638	0.1522	0.0616	0.0456	0.0432

$R^2 = 0.66$  ,       $DW = 1.837$

PP = -5.18\* (intercept)

MacKinnon critical values for 1%, 5% and 10% are  
-4.068, -3.122 and -2.704 respectively.

ADF = -6.44\* (intercept)

MacKinnon critical values for 1%, 5% and 10% are  
-4.136, -3.148 and -2.718 respectively.

[t-statistics are given in parenthesis]

[intercept was included and logs of all variables were  
taken]

[\* = significant at the 1% level of significance]

[The PP and ADF tests were conducted with 2 and 1 lag  
differences respectively]

Table 5 shows that the OLS results are valid because  
the residuals are stationary. Only tariff and technological  
change are significant at the 5% level. However, tariff is

the only valid variable because it has a positive sign indicating a depreciation in the RER.

Table 6 invokes the AR(1) error specification. Again it follows the same procedure used in Table 3

TABLE 6

Regression Results for the AR(1) model 1976-1990

	Intercept	AID	INV	GOVEXP	TARIFF	TECH
	15.026	0.0849	0.090	-1.837	0.650	-0.1655
	(1.766)	(0.486)	(1.206)	(-1.375)	(1.422)	(0.5228)
Pr	0.1278	0.6442	0.2731	0.2180	0.2048	0.6198
	AR(1) = 0.157 (0.522) Pr = 0.6198					
	R <sup>2</sup> = 0.644 , DW = 1.62					
	PP = -5.61* (intercept)					
	MacKinnon critical values for 1%, 5% and 10% are -4.13, -3.14 and -2.71 respectively					
	ADF = -4.51* (intercept)					
	MacKinnon critical values for 1%, 5% and 10% are -4.22, -3.18 and -2.73 respectively.					

[t-statistics are given in parenthesis]

[\* = significant at the 1% level of significance]

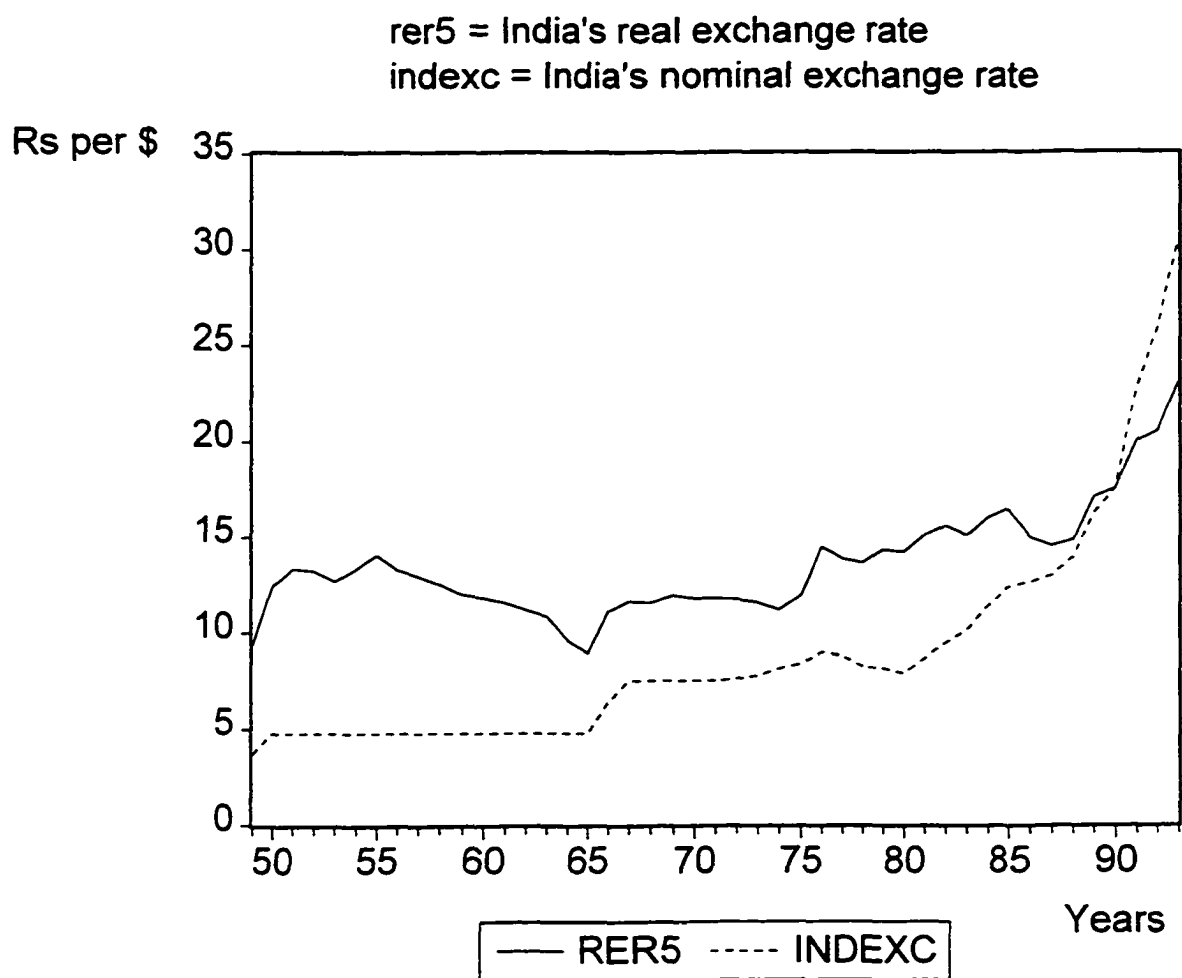
Table 6 shows that none of the variables are significant.

**SECTION VIII: CONCLUSION**

The purpose of this paper has been to find out which fundamentals affect India's RER. The first section mentions the importance of RER to developing countries and shows that the literature on determinants of RER for developing countries is not extensive; is biased towards developed/industrialized countries and is flawed to the extent that many authors neglect to take into account the unique economic characteristics of the countries they study. The second section explains the concept of RER, its importance to policymakers and defines it for empirical purposes. The third section gives a short lesson on India's economic history and shows how certain objectives became dominant concerns of India's policymakers. These objectives motivated the selection of the fundamentals and thus addressed the neglect mentioned above. The fourth section (A and B) shows the motivation for selecting a simple general equilibrium model of the balance of payments theory. The attempt, here, was to show that exchange rate models have shifted in emphasis from real factors to financial markets and then back to real factors again. The model selected uses only real factors and explicitly introduces non-traded

goods. The fifth and sixth sections develop the model and show how different fundamentals will affect the direction of RER. The seventh section describes the very simple econometric methodology and shows that only the government consumption variable is significant and of the right sign for the period 1960-1975. An AR(1) correction shows foreign aid and government consumption to be significant and of the right sign for the same period. For the period 1976-1990, the regression shows only tariff to be valid. The AR(1) correction finds none of the variables to be valid for the floating rate period.

The results obtained from the paper have shown that understanding the fundamentals of the RER for India is no easy task. Avenues for further research could be using different determinants like foreign exchange reserves and/or interest rates.



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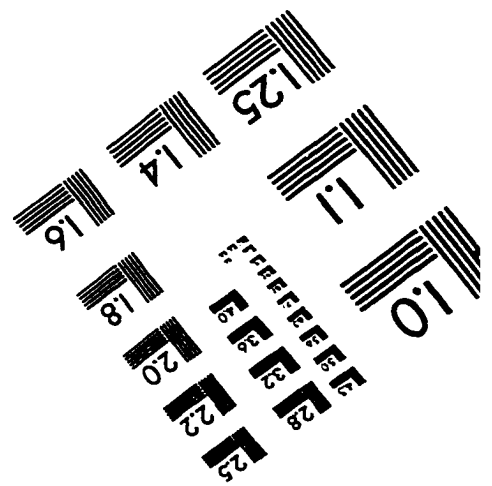
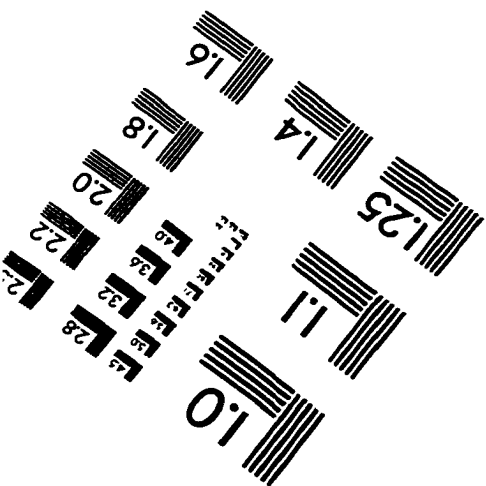
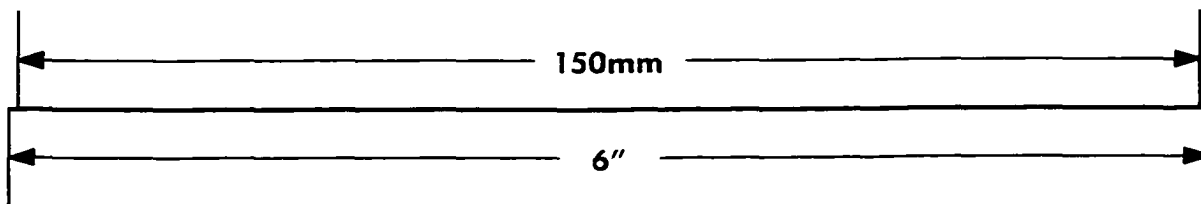
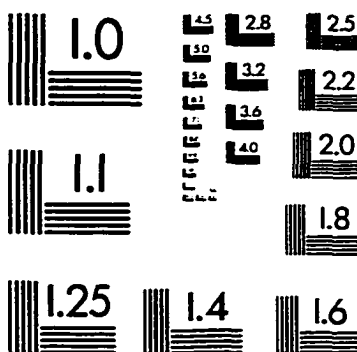
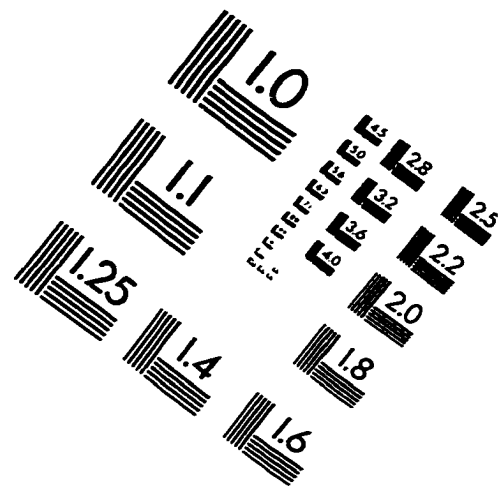
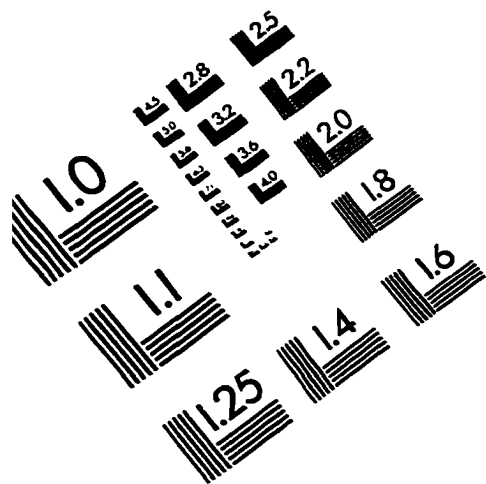
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