

EXCHANGE RATE DETERMINATION IN A MULTI-CURRENCY WORLD

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I, **Bidisha Bhattacharya**, hereby declare that this thesis on the topic entitled, "**EXCHANGE RATE DETERMINATION IN A MULTI-CURRENCY WORLD**" is submitted for the award of Degree of Doctor of Philosophy in Economics to the Gokhale Institute of Politics and Economics, Pune 411004. It is an original contribution and has been completed during my tenure as a research scholar at Gokhale Institute of Politics and Economics, Pune.

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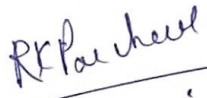
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~~Prof. Rajas Parchure~~

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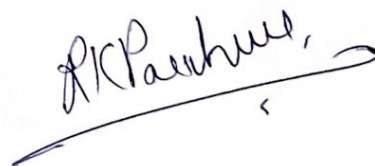
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Chapter 1

Introduction

The very selection of an optimal regime of exchange rates continues to remain one of the major unresolved questions in the field of international economics. The international monetary system that operated before the war in 1914 -18 was known as the gold standard. It was then that the countries used to accept the major assets, namely, gold and sterling when settling international debt. As trade expanded in the 1870s, there was a need to exchange currency rather than the gold that was being used because the latter was heavy and difficult to transport. This gives birth to the question of how could different countries equalise their currency in terms of another. The solution to this question was achieved by equalising all currencies in terms of the amount of gold they were representing (the gold-exchange standard). Under this system, that existed between 1879 to 1914, the major currencies' values was held fixed as per the mint-parity rate. Therefore a country was said to be on the gold standard when its central bank was obliged to hand over gold in exchange for its currency when the same is presented to it. The gold standard was considered as the foundation of the international system of trading. It was argued that the gold-standard system did provide significant amount of stability and a mechanism of automatic adjustment. Since the value of gold in comparison to other goods and services does not usually change to a great extent over long periods of time, therefore the monetary discipline that was imposed by the gold standard was expected to ensure price stability over the long run.

However, during World War-I this system broke down. At the very beginning, the international trading and payments system was being dominated by the flexible exchange rates. It was around this time, in 1918 that Gustav Cassel formulated the idea of the Purchasing Power Parity. Cassel was a Swedish economist who developed PPP in its current form in 1918. His work was based on the law of one price, which stated that

goods that are identical in different markets should sell for the same price when translated into a common currency. Cassel argued that if the price of a basket of goods in one country is higher than the price of the same basket of goods in another country, then the exchange rate between the two currencies should adjust so that the cost of the basket of goods is the same in both countries. If the exchange rate does not adjust, then there is an opportunity for arbitrage, where individuals can buy the cheaper goods in one country and sell them in another country where they are more expensive, making a profit.

The 1930s were characterised by competitive devaluations, import-substitution and export-promotion policies, typically resembling somewhat of the Keynesian tariff and rewarding policies, among less developed countries. Keynes, in 1931, had enunciated a remarkable theorem which stated that the depreciation of currency is equivalent to a uniform tariff on imports, the profits of which are used to finance a uniform subsidy on exports. This was introduced by Keynes not as an academic theorem but more as a policy proposal aimed to reduce unemployment and improve the balance of trade, which had the advantage over currency depreciation of not affecting contractual obligations denominated in gold.

The first strictly academic study of these questions appear to have been that of Robinson (1937), who developed a model originated by Bickerdike (1907) and used it to show that under conditions of underemployment equilibrium, the four measures (1) exchange depreciation, (2) wage reduction, (3) export subsidies, and (4) tariffs or quotas on imports, would equally well reduce unemployment and improve the balance of trade. While this type of argument did contain some serious pitfalls to the extent that it could be accepted, it also followed logically that if the exchange rate was flexible, and monetary policies were pursued to stabilise domestic prices, then either an export subsidy or an import tariff could lead to an appreciation of the country's currency. This, of course, was a much stronger statement than the one put forth by Keynes, from which one could easily infer that a combination of import tariff and export subsidy would strengthen the exchange rate of the country. From the latter it followed that one of these measures must exert a positive influence on the exchange rate, but this could only happen by it causing a more-than-proportionate increase in the exchange rate, while the other measure would cause a fall in the exchange rate. Finally in 1931, England departed from the gold standard in the face of massive gold and capital outflows. The gold exchange standard was typically finished and was replaced by the use of independent, uncoordinated trade policies of individual countries. These included managed exchange rates: currency devaluations and protectionism. The result was a 'beggar-thy-neighbour' trade war in

which nations devalued their currencies in order to increase their exports at other's expense and reduce imports.

At the beginning of Great Depression in the 1930s coupled with declining output and employment levels, countries had started engaging thoroughly in further trade wars. This eventually resulted in the collapse of the gold standard and led to countries abandoning the same by reducing the amount of gold backing their currency so that they could increase the money supply in order to stimulate their economies. However, as World War II was nearing its end, it became more and more obvious that international understanding on exchange rate and tariff management would be necessary. This led the leaders of the allied nations to decide the meeting at Bretton Woods, New Hampshire in 1944 in order to set up a better system of fixed exchange rates. The US dollar was fixed at 35 dollars per ounce of gold and all other currencies was expressed in terms of dollars. This official fixed exchange rate was better known as the par value of the currency. To activate this new Bretton Woods System (also known as the adjustable-peg system), the International Monetary Fund (IMF) was created where each country had to maintain an account with the IMF that was proportional to the country's population, the volume of trade, and national income.

However, the weakening of the Bretton Woods system started in the 1960s, when foreigners accumulated large amounts of US dollars from the post-World War-II aid and sales of their exports in the United States. There were concerns as to whether the US had enough gold to be able to redeem all the dollars. With the gold reserves falling steadily, the situation could not be sustained and this led to the US deciding to abandon this system. By 1973, this action led to the managed floating exchange rate system that exists till this day. These rates could be changed by countries at times, by having their central banks intervene directly in the foreign exchange market. They could do so usually by purchasing or selling the currency that the country wanted to influence so that the exchange rate would alter as a result of the new supply or demand. The two major benefits of the flexible exchange rate system were that it corrected trade imbalances automatically and allowed currencies to manage their own economies through monetary policy, by expanding the money supply to stimulate the economy or contracting it to curb inflation.

The Monetary Approach to exchange rate determination has been extensively tested in empirical studies since the 1970s and 1980s. The approach suggests that exchange rates are primarily determined by monetary variables such as money supply, interest rates, and inflation rates. Empirical studies have examined the ability of the monetary

approach to explaining exchange rate movements, typically by estimating regression models that relate exchange rate movements to monetary variables. These studies have found mixed evidence in support of the monetary approach, with some studies suggesting that monetary variables are important in determining exchange rates, while others find little support for the approach. In contrast, the Portfolio Balance Approach has not been extensively tested empirically. This approach suggests that exchange rates are determined by the demand and supply for assets denominated in different currencies and that the relative attractiveness of these assets to investors determines the exchange rate. Empirical studies of the Portfolio Balance Approach are limited, in part because elements of the approach were incorporated into the more eclectic/hybrid versions of the Monetary Approach for purposes of empirical testing. The incorporation of portfolio balance considerations into the Monetary Approach resulted in models that were easier to test empirically, and as a result, there has been less focus on testing the Portfolio Balance Approach specifically.

Overall, empirical studies of exchange rate determination have focused primarily on the Monetary Approach and its variants, while empirical studies of the Portfolio Balance Approach have been relatively limited. However, recent studies have suggested that incorporating portfolio balance considerations into macroeconomic models of exchange rates may be important, and this area of research is likely to receive more attention in the future.

Several studies have examined the linkages between exchange rates and macroeconomic fundamentals, overtime and their findings suggest that macro models, which attempt to explain exchange rate movements through economic fundamentals, are not effective predictors of exchange rates. In contrast, the micro model developed by Lyons (1995, 2001) and Evans and Lyons (2002, 2005) had proven to be more effective in predicting exchange rates. The micro model was based on the idea that exchange rate changes are driven by net buy and sell orders, and it focuses on the order flow in the market rather than economic fundamentals. However, both macro and micro exchange rate models are limited to the determination of only one exchange rate between two currencies of two countries at a time, and they do not consider the entire set of exchange rates between several currencies simultaneously. This limitation arises due to the partial equilibrium approach, which assumes that all other things remain constant while analyzing the exchange rate between two currencies. The limitation of the twoness feature of exchange rate models is significant because exchange rates between different currencies are interdependent.

The primary objective of this thesis is to address the limitations of the existing macroeconomic and microeconomic models for exchange rate determination by constructing a multicountry general equilibrium model that can provide a unique solution for the equilibrium exchange rates. The proposed model aims to ensure that the exchange rates do not allow currency arbitrage, meaning that there are no profitable opportunities for traders to exploit differences in exchange rates across multiple currency pairs. Furthermore, the model aims to equate the demands and supplies of all currencies involved in the exchange rate determination process. This is an important aspect as it considers the interdependence of order flows across multiple currency markets and exchange rate quotations. This means that the proposed model will be able to account for the effects of changes in economic fundamentals across multiple countries simultaneously and avoid the limitations of the twoness assumption.

The two hypotheses that will be tested are as follows,

- a) Currencies of deficit (surplus) countries will depreciate (appreciate) with its corollary being those countries whose deficit (surplus) declines (i.e., excess supply and excess demand respectively decline) will appreciate (depreciate) so that the exchange rate declines (rises) for deficit (surplus) countries. It follows that zero-balance countries will maintain fixed exchange rates.

- b) The rank correlation coefficient between the sizes of the percentage changes in exchange rates (appreciations and surpluses denoted by +, depreciations and deficits denoted by - and reductions in deficits by + and reductions in surpluses by - will be positively but imperfectly correlated with the proportion of surpluses/deficits to the total receipts of the countries.

In addition to constructing the model, the thesis aims to subject the same to empirical examination to assess its efficacy. This empirical testing of the model will involve using real-world data to simulate scenarios and compare the model's predictions with the actual outcomes. The objective is to determine whether the proposed model provides more accurate predictions of exchange rate movements than the existing macro- and micro-models. Overall, the thesis seeks to contribute to the development of a more comprehensive and accurate framework for exchange rate determination that takes into account the complexities and interdependencies of multiple currency markets. The data used for the aforementioned modeling and calculations have been derived from the IMF Database (data.imf.org).

Following is the chapter plan for the thesis:

Chapter 2 involves the Literature Survey starting from Mint Parity to the Managed Floating Exchange Rate regime, whilst covering the most prominent theories (namely, Monetary Approach, Portfolio Balance Approach, Fisher's Open Hypothesis and the Order Flows Model) in detail.

Chapter 3 involves an in-depth explanation of the Model. In this chapter we derive the Inter-country Payments Matrix.

Chapter 4 involves analysing different scenarios of changes in Total Payments of a country to the rest of the world and how the Exchange Rates would behave accordingly through Illustrations and Extensions. We also look into the instance of the fixed exchange rate regime which allows us to ensure that the Inter-country Payments Matrix significantly works in every scenario.

Chapter 5 covers the Obstacles to Empirical Testing. The more evidence a theoretical model can account for, the more credible it is. In the context of the general equilibrium model of exchange rate determination, the statement suggests that this model has a high degree of credibility because it provides a mathematically exact solution for exchange rates in terms of intercountry receipts and payments. This means that the model can explain exchange rate movements based on a set of fundamental economic factors, such as trade balances, capital flows, and interest rates. However, the credibility of the model could be weakened if it fails to explain certain exchange rate movements or if it contradicts empirical evidence.

Chapter 6 covers Results and Discussions-I where we showcase the Empirical Out-of-Sample Results Predictions.

Chapter 7 covers Results and Discussions-II which involves observing whether the resulting exchange rate changes are of commensurate with the presumed magnitudes of the payments or receipts, primarily studying episodes of the Latin-American Debt Crisis

and South-East Asian Crisis.

Chapter 8 concludes the thesis.

Chapter 2

Literature Survey

The choices of the exchange rate regimes have evolved considerably over the past hundred years. At the very beginning of the twentieth century, the choice was obvious: to join the gold standard, all the advanced countries had done it. The exchange rate of a gold standard country was determined on the basis of the theory of mint parity. This theory was used to explain how exchange rates are determined between two countries that are on the **gold standard**. Under this system, the value of a country's currency was determined by the amount of gold it contained. For instance, prior to World War I, both England and America were on the gold standard. The British pound contained approximately 113.002 grains of gold, while the American dollar contained 23.22 grains of gold. The exchange rate between the British pound and the American dollar was determined on the basis of the mint-parity system, which was equal to the ratio of the gold content of the two currencies. Therefore, 1 pound was equal to $113.002 / 23.22 = 4.867$ dollars.

The gold standard, while having its advantages, had several significant problems, as mentioned. One of the main drawbacks was that it did not allow for sufficient flexibility in times of economic distress. If a country was not competitive in the world marketplace and was importing more goods than it was exporting, it would lose gold reserves as payments for the imports. This reduction in gold reserves would force the country to contract its money supply, which would cause unemployment, reduced income, and output. This distribution of gold availability across countries was extremely uneven, so there were some countries with plenty of gold and others without it. During war time when money was required in huge amounts, then gold became a shackle. These limitations led to the eventual abandonment of the gold standard during the 1930s.

Although William Playfair (a Scottish economist) was the first to recognize the idea of the **Purchasing Power Parity** in 1786, the credit for the modern formulation of this theory goes to Gustav Cassel. Cassel was a Swedish economist who developed PPP in its current form in 1918. His work was based on the law of one price, which stated that identical goods in different markets should sell for the same price when translated into a common currency. Cassel argued that if the price of a basket of goods in one country is higher than the price of the same basket of goods in another country, then the exchange rate between the two currencies should adjust so that the cost of the basket of goods is the same in both countries. If the exchange rate fails to adjust, then there is an opportunity for arbitrage, where individuals can buy the cheaper goods in one country and sell them in another country where they are more expensive, making a profit.

PPP also has important implications for trade because it suggests that countries with lower prices should be able to export more goods and services because their currency will be cheaper in terms of other currencies. However, despite its popularity, the PPP theory has been criticised by numerous economists who argue that the theory has several significant defects. One major criticism of the theory is that it relies on price index numbers, which are not always reliable indicators of a country's relative purchasing power. Critics point out that the price index numbers used in the PPP theory have many defects, including the fact that the indices used in different countries include different sets of commodities and may also include commodities that are not traded internationally. The use of different weights assigned to different commodities and different base years for index numbers in different countries further complicates the reliability of price index numbers.

Another major criticism of the PPP theory is that it assumes a direct and exact relationship between the purchasing power of currencies and the exchange rate. However, this assumption is not accurate in reality, as there are many other factors that influence the exchange rate, such as tariff speculation, capital flows, etc. It is also difficult to find out the particular rate that actually prevailed between the currencies as the equilibrium rate. Critics of the PPP theory additionally argue that the exchange rate does not necessarily reflect the prices of all goods and services in an economy. Only some goods and services enter international trade, and all other goods traded internally have no direct bearing on the exchange rate. Additionally, the PPP theory assumes that changes in price levels cause changes in exchange rates, but empirical evidence shows that the opposite is true.

The Bretton Woods system of fixed exchange rates was established in 1944 in response to the economic turmoil that followed World War II. The system was designed to promote international trade by creating stable exchange rates among currencies, which would facilitate economic growth and reduce the risk of financial crises. The system was named after the location where the signing of the agreement had taken place: Bretton Woods in New Hampshire. Under the Bretton Woods system, the U.S. dollar was fixed at a rate of \$35 per ounce of gold, and all other currencies were expressed in dollars. This **fixed rate of exchange** was known as the par value of currency, or par exchange rate. However, to allow for adjustments in response to changing economic conditions, the system also included an adjustable peg. This allowed countries to alter their exchange rates within certain limits, with approval from the International Monetary Fund (IMF).

However, the Bretton Woods system also had several limitations and challenges. One of the most significant was the issue of balance of payments imbalances, where some countries were exporting more than they were importing, leading to a build-up of foreign reserves in their central banks. This could lead to pressure to revalue their currencies, or even to abandon the system entirely, which could create instability in the global economy. Another challenge was the dependence of the system on the U.S. dollar, which was the dominant currency in the world at the time. This gave the U.S. significant influence over the global financial system, and also made it vulnerable to external shocks, such as the rise of inflation in the 1960s and the increasing cost of the Vietnam War. This weakened the system in the 1960s, when foreign countries accumulated huge amounts of U.S. dollars from post-war aid and exports. The U.S. was no longer able to maintain its gold reserves, leading to the abandonment of the system in the year 1971. President Richard Nixon had announced that U.S. dollars would no longer be convertible into gold, allowing the exchange rate to float.

This led to the system of **managed floating exchange rates** that exists today, with the rates being determined by supply and demand in the foreign exchange market. Managed floating exchange rates refer to a system where exchange rates float, but countries occasionally intervene in the forex market to influence the exchange rate by buying or selling their own currency. This type of intervention is generally rare and is more common among smaller countries. For example, some countries may choose to peg their currency to the US dollar or a basket of currencies, such as Singapore. One of the primary advantages of a flexible floating exchange rate is that it can help to automatically correct trade imbalances. If a country imports more than it exports, then its currency will most likely decline in value relative to the currency of the exporting country. This can make imports more expensive and exports less expensive, which can ultimately help

to reverse or mitigate the trade imbalance. Additionally, floating exchange rates allow countries to manage their own economies through monetary policy. Countries can adjust their money supply to stimulate or slow down their economy, which can help to manage inflation and other economic indicators.

The most prominent theories of exchange rates, including the Monetary Approach, the Portfolio Balance Approach, and the Market Microstructure or Order-Flow Approach.

The **Monetary Approach**, which has been extensively tested in the 1970s and 1980s, looks at currencies as assets and uses asset pricing methods such as net present value in relation to a substitute currency to analyze exchange rates. Before we can review the performance of the models based on the monetary approach, it would be beneficial defining the same by contrasting it with alternatives that either have or have had a prominent place in the literature on exchange-rate determination. At a generic level, the monetary approach may be contrasted with the “flow” approach. The flow approach comprises of shocks such as shifts in monetary or fiscal policies that alter trade flows through terms of trade shifts or in the relationship between domestic absorption and the output. The foreign exchange demand is derived from the demand for imports, and the supply is derived from the exports. To give an example, an expansionary demand-management policy (for example, an increase in the government spending or in the money supply) will result in an increase in the demand for imports and for foreign exchange. As a result, the exchange rate will depreciate. These type of models ascertain that the strengthening of the current-account balance and appreciation of the exchange rate will go hand in hand, and conversely.

Maximum examples based the short-cut approach have derived exchange-rate equations by manipulating the money-market equilibrium conditions thereby acquiring the label of the **monetary approach** to exchange-rate determination. This approach has produced several interesting variations, as exemplified by Bilson (1976), Frenkel (1976), Gorton and Roper (1977) and Isard (1978). Other references can be found in Magee’s (1976) survey article. Frenkel had come up with a model of the mark-dollar exchange rate around the hyperinflation in Germany. This was tested using the monthly data for the period of February 1920 till November 1923. The demand for German money, measured in real units (Md/P) was represented as a function of the expected rate of German inflation (p^*), based on the assumption that the effects of these expectations overpowered the effects of changes in either real income or the real interest rate during 1920-23:

$$M^d = P_g(p^*) \text{ with } \frac{\partial g}{\partial p^*} < 0$$

The U.S. price level is assumed to be fixed and normalised in order to equal 1, and the purchasing-power parity assumption is cited to equate the exchange rate (S) with the German price level (P). Equating nominal demand for money to nominal money supply (M) yields the exchange-rate equation,

$$S = \frac{M}{g(p^*)}$$

By assumption, the expected inflation rate equals the expected rate of depreciation, which in turn is assumed to be reflected by the forward discount on Deutschmark ($\rho - 1$). A log-linear version of the exchange-rate equation is then estimated as,

$$\log S = -5.135 + 0.975 \log M + 0.591 \log \rho$$

$$(0.731) \quad (0.050) \quad (0.073)$$

$$R^2 = 0.994, D.W. = 1.91$$

with standard errors represented within brackets. The model is supported by the goodness of fit, the signs and significance of the coefficients, and the fact that the coefficient on log M does not differ significantly from 1. Frenkel's model is based on the assumption of purchasing-power parity, which has credibility during times of hyperinflation but has been discredited as a short-run hypothesis in more general circumstances. An interesting monetary approach which avoids the PPP assumption is that of Girton and Roper (1977), who generalize their model to explain "exchange-market pressures" under fixed, floating, or intermediate exchange-rate regimes. The reduced-form equation of this model has the form,

$$e_c + r_c = a_0 + a_1 d_c + a_2 h_u + a_3 y_c + a_4 y_u + v$$

where,

e_c = appreciation rate of the Canadian Dollar

r_c = increase in Canada's international reserves, valued in Canadian dollars, as a fraction of the Canadian base-money stock

d_c = Canadian domestic-credit expansion as a fraction of the Canadian base-money

stock

h_u = rate of growth of the US base-money stock

y_c, y_u = rates of growth of real income in Canada and the United States,

v = random error term

The dependent variable, here, is viewed as a measure of the pressure of the foreign exchange market. The data used in this model is on an annual basis and explains roughly 95 percent of the variation in $e_c + r_c$ during the period between 1952 and 1974. The estimated slope coefficients have the expected signs and are very much significant at the 95 percent level of confidence. In order to test the sensitivity of the results to the composition of exchange-market pressure, Dr. Girton and Dr. Roper reestimate the model with $Q = e_c / r_c$ which is included as an additional variable on the right-hand-side. The coefficients are left unchanged by the inclusion of Q . This result has been interpreted as empirical confirmation that the model is insensitive to the composition of exchange-market pressure. Dr. Bilson in 1976 had presented a third type of monetary approach, combining the assumption of PPP with the hypothesis that the money-market equilibrium condition may be written as,

$$\log M_j = a_j + \log P_j + c \log Y_j$$

where,

M_j = money supply of country j

P_j = price level in country j

i_j = nominal interest rate in country j

Y_j = real income in country j

and where the interest-rate and income parameters of the money-demand function (b and c) were assumed to be the same for all countries. The assumption of purchasing-power parity allowed Bilson to write,

$$\log e_j + \log M_0 - \log M_j = (a_j - a_0) - b(i_j - i_0) + c (\log Y_j - \log Y_0)$$

where the subscript 0 denotes the United States and e_j is the exchange rate for country j (in units of currency j per U.S. dollar). The model is estimated from annual data (1954-74) pooled over 33 countries, with exchange rates and money supplies combined

into a single endogenous variable. The estimates are then used to construct in-sample predictions of exchange rates. The mean absolute percentage error in the predicted logarithms of exchange rates is 16 % when country-specific information is taken into account.

Isard (1978) analysed an open-market purchase of domestic bonds by the domestic monetary authorities which established that the increase in money supply puts downward pressure on the domestic interest rate. At the initial exchange rates, the increase in the demand for money arising from a falling interest rate will be less than the reduction in the demand for domestic bonds, since asset holders will shift not only from domestic bonds to money but also from domestic bonds to foreign bonds. So, in fact, a currency depreciation is required to restore equilibrium by dampening the reduction in the demand for domestic bonds.

In contrast to exchange-rate models based on flows of goods and services, the monetary approach is one member of a class of stock or "asset" approaches, in which changes in relative prices of goods are assumed to play a fairly minor supporting role. The common feature of asset-market models is that the exchange rate is viewed as equilibrating the net stock demands for financial assets denominated in different currencies. These two general modelling strategies are not mutually exclusive, that is, one could treat the exchange rate as equilibrating the total demand for and supply of foreign exchange, with complete integration of the current and capital accounts of the balance of payments and with asset stocks fully consistent with the corresponding flows. A synthesis of this type was developed in a fixed-exchange rate framework for explaining the balance of payments by Frenkel (1980). As a practical matter, however, most research has tended to emphasise one dimension or the other; the predominant view throughout the floating rate period since 1973 has been that financial-asset markets play the central role in determining exchange rates.

For convenience, non-monetary asset models may collectively be referred to as portfolio-balance models. However, this term actually encompasses two rather different subclasses of models: models such as those of Hooper and Morton (1982) or Frankel (1983) that contain the monetary approach as a special case, and models such as those of Branson, Halttunen, and Masson (1977), Boughton (1984), and Dooley and Isard (1983) that do not. The latter derive more directly from the portfolio approach developed by Tobin (1969) in the context of domestic financial analysis. These two types of portfolio-balance models are discussed and compared in Boughton (1987).

The monetary approach and the specification of the more general portfolio-balance model may be illustrated by reference to the following two-country model, which is similar to the specification developed by Frankel (1983):

$$m - \bar{p} = \beta_1 y - \beta_2 i \quad (\text{a})$$

$$m^* - \bar{p}^* = \beta_1 y^* - \beta_2 i^* \quad (\text{b})$$

$$i - i^* = E(\Delta e) + \beta_3 k \quad (\text{c})$$

$$E(\Delta e) = E(\Delta p - \Delta p^*) - \beta_4 (e - \bar{e}) \quad (\text{d})$$

$$\bar{e} = \bar{p} - \bar{p}^* \quad (\text{e})$$

where m , p , and y refer to the logarithms of the money stock, the price level, and real output, respectively; i is the interest rate; k is the cumulative balance on the external private capital account; and e is the logarithm of the nominal exchange rate, expressed as local-currency units per unit of foreign currency (that is, an increase in e is a depreciation). The asterisks indicate the foreign country, bars over variables indicate long-run equilibrium values, and E indicates an expected value.

Equations (a) and (b) refer to money-demand functions that are identical for each country in which adjustment lags are eliminated by setting prices at long-run values. In this form, these equations may be interpreted as equilibrium price levels for each country. Equation (c) states that interest rates may differ in the two countries to the extent that the exchange rate is expected to change in response to the accumulation of international credit ($k < 0$) or indebtedness ($k > 0$). Equation (d) hypothesises that the expected rate of change in the exchange rate is equal to the expected inflation differential, adjusted for any difference between the current exchange rate and its equilibrium value. Finally, equation (e) asserts that the equilibrium exchange rate is the value that will equate prices in the two countries.

The empirical properties of the monetary approach to exchange-rate determination can be described by restrictions placed on the parameters of this general model. A general statement of the monetary approach comprises the following five hypotheses:

1. Purchasing power parity (PPP) holds over a relevant time horizon
2. Uncovered interest parity (UIP) holds all times
3. The demand for real money balances is a stable function of a small set of real variables
4. The supply of money is determined by a stable process
5. Expectations are rational

These hypotheses have not all been present in every model that has been called part of the monetary approach. However, they do describe an economic system in which money plays the dominant role.

Purchasing Power Parity

Before discussing the relationship between PPP and the monetary approach, it may be important to clarify three possible empirical definitions of PPP. First, as a relatively weak proposition, one can hypothesise that the nominal exchange rate between two currencies will move in line with the expected inflation differential between the two countries. In terms of equation (d), this simply means that the coefficient on the inflation differential is equal to 1. Some form of this first hypothesis is implicit in most asset-based exchange-rate models whether or not they would otherwise be classified as consistent with the monetary approach.

As a second, and stronger proposition, one can hypothesise that the real exchange rate will tend towards a time-invariant equilibrium level determined by the law of one price. Then, keeping rational expectations in mind, the expected rate of depreciation will be equal to the expected inflation differential plus a linear function of the gap between the current level of the nominal exchange rate and its equilibrium value. This proposition is the basis for the form of equation (d), which is similar to the Dornbusch-Frankel expectations function (refer to Dornbusch, 1976, and Frankel, 1979). Third, one can hypothesise that the real exchange rate will always be at its equilibrium value, i.e., that the gap is always zero, or equal to e in equation (d). The addition of this last requirement is what, in Frankel's (1983) taxonomy, constitutes a "monetarist" exchange-rate model rather than a "monetary" model.

There is a close and obvious relationship between PPP and the flexibility of goods' prices. If prices are not flexible, then changes in nominal exchange rates will not be fully reflected in the movements of aggregate price levels, and real exchange rates will very likely move in the same direction as nominal rates. Thus, the conditions for PPP are essentially the same as the conditions for the natural rate of unemployment to hold,

with an important addition that the prices must be flexible not only within a country but internationally as well. This gradual realisation during the past several years that PPP is an unrealistic hypothesis in the short or medium run has led to the dissatisfaction that has emerged with the natural unemployment rate as anything other than a long-run hypothesis. In the case of PPP, however, there may be considerably more reason to doubt its importance even in the long run (refer Appendix).

Uncovered-Interest Parity

The hypothesis of UIP states that expected returns on interest-bearing securities will be equal regardless of the currency of denomination, except possibly for an additive constant determined by differences in the characteristics of the securities. In terms of the simple model given above, UIP implies that $\beta_3 = 0$, so that,

$$i - i^* - E(\Delta e) = 0 \quad (f)$$

It may be noted that this hypothesis is the source of the proposition that the exchange rate is the relative price of national money except in the trivial sense in which the proposition holds by definition in terms of money as the unit of account. A more general statement of the proposition that would not require UIP would be that the exchange rate is the relative price of outside assets that are denominated in different currencies and are imperfect substitutes. Money, clearly satisfies at least the latter requirement, since national money stocks do not serve as wide a variety of functions outside the home country as they do within it.

UIP, which is also known as the "Fisher open hypothesis," after Fisher (1930), holds if and only if securities that are similar except for currency of denomination are perfect substitutes, in which case their expected rates of return should be equal. If government securities with different currency denomination are imperfect substitutes and are regarded as net wealth by the private sector, then an exogenous increase in the stock of dollar-denominated U.S. securities will reduce their price, raising U.S. interest rates without having a fully proportionate effect on the interest rates of other countries or on the expected rate of currency depreciation. In that case, UIP will not hold. This effect is usually described as a "risk premium" on the higher-yielding assets.

Stability of the Demand for Money

The stability of the money-demand function is a significant requirement for a monetary model of exchange rates and the requirement that the demand for real balances be homogeneous of degree zero is additionally important. Without the second condition, a change in the level of the money stock will not necessarily be neutral in its long-run economic effects. Stability in this context does not mean that occasional or even frequent shifts in estimated demand functions necessarily invalidate the monetary approach. To the extent that such shifts can be identified and quantified, they can be incorporated into an ex-post explanation of exchange-rate movements. Stability rather means that a shock to one of the arguments in the function will set a transmission process in motion that will cause one or more of the other arguments to respond in a predictable manner. An increase in the stock of money may generate a predictable increase in the price level whereas for a given stock of money, an increase in the level of real output may generate a rise in interest rates. The exact nature of these transmission processes is a more general macroeconomic question, but the hypothesis that they can be adequately described by a relatively simple money-demand function is a crucial element to the monetary approach.

In the sticky-price versions of monetary models, only the long-run demand for money appears directly in the solution for the exchange rate. Short-run changes are determined by real interest rate differentials. However, the latter are themselves determined by the excess demands for money balances. As Frankel (1983, p.91) puts it, "Intuitively, when a tight domestic monetary policy causes the nominal interest differential to rise above its equilibrium level, an incipient capital inflow causes the value of the currency to rise above its equilibrium level."

Stability of the Supply of Money

The role of the money-supply process in the monetary approach is perhaps less formulated in the theory compared to the role of the demand function. In a model of floating exchange rates without official intervention, the stock of money is frequently assumed to be an exogenous policy-controlled variable. It is equally valid, however, to postulate the existence of a reaction function in which the monetary authorities respond systematically or with discretion to changes in one or more indicator variables. Examples of monetary models incorporating reaction functions include Frenkel and Aizenman (1981) and Papell (1984). In Frenkel and Aizenman, the authorities are assumed to attempt to minimise losses arising from incomplete information and where stochastic real and

monetary shocks induce adjustments in monetary growth. This structure was used to derive optimum intervention in exchange markets under a variety of shocks.

In Papell's reaction function, monetary growth is hypothesized to be allowed to rise whenever the exchange rate appreciates or when domestic prices fall relative to foreign prices. In a model of managed floating exchange rates, a reaction function is always at least an implicit part of the model because the authorities can manage the exchange rate only by reacting to the observed changes in it. The important point for the monetary approach is that an unstable supply process will invalidate the ability of the money market to equilibrate the economy, in much the same way as will an unstable demand.

Rational Expectations

The final building block of the monetary approach is rational expectations, without which one cannot assure the efficiency of foreign-exchange markets. In this context, rational expectations may be defined as the full use of all available information which does not necessarily imply perfect foresight over a finite period of time. The failure of this weak-form rationality would imply that market participants could exploit the unused information in order to make economic profits. If financial-asset markets are inefficient processors of information, there is no reason to expect these markets to play the dominant role in the adjustment of exchange rates to an exogenous shock.

These aforementioned considerations suggest that an appropriate expectations function for a monetary model (in which PPP holds) must begin with the expectation that the exchange rate will respond one-for-one to changes in the rationally expected inflation differential. The exact specification of the latter term, as well as of other possible determinants of the expected change in the exchange rate, is open to interpretation.

An early attempt to estimate the monetary model was made by Bilson (1978), with the exchange rate between the deutsche mark and the pound sterling as the dependent variable. Bilson's unrestricted estimates revealed coefficients that were mostly insignificantly different from zero; however, by imposing a set of prior restrictions on the model, he was able to obtain estimates that were consistent with the monetary approach. Dornbusch

(1980) estimated the monetary model for the deutsche mark—U.S. dollar exchange rate and found that, even with the coefficient on relative money stocks constrained to unity, the estimates did not support the model. He concluded that current-account developments and portfolio shifts arising from limited substitutability among securities were important additional determinants of exchange rates.

Backus (1984) estimated a number of models for the exchange rate between the U.S. and Canadian dollars. He had found evidence that the monetary models were excessively restricted, that is the Durbin-Watson coefficients were extremely low, and tests against a more general compound model had rejected the restrictions. He had concluded that the exchange rate approximated a random walk. As for post-sample predictive tests, the in-sample problems simply cited that the monetary model will fail to generate useful forecasts. In a series of oft-cited papers, Meese and Rogoff (1983a, 1983b) demonstrated this fact quite clearly.

Meese and Rogoff presented estimates for the effective rate for the U.S. dollar and for bilateral rates against the U.S. dollar for the deutschemark, the Japanese yen, and the pound sterling. In almost no case was the monetary model able to predict out-of-sample exchange-rate movements better than a simple random walk. Their study compared the out-of-sample forecasting accuracy of various structural and time series exchange rate models which found that a random walk model performs as well as any estimated model at one-to-twelve-month horizons for the dollar/pound, dollar/mark, dollar/yen, and trade-weighted dollar exchange rates. The candidate structural models that were taken into account included the flexible-price (Frenkel-Bilson) and sticky price (Dornbusch-Frankel) monetary models and a sticky-price model which incorporated the current account (Hooper-Morton). The study estimated these models using ordinary least squares, generalised least squares and Fair's (1970) instrumental variables technique. In addition to this, a variety of univariate time series techniques were applied to the data as well. The structural models performed poorly despite the fact that they based on their forecasts on actual realised values of future explanatory variables. None of these techniques including estimation of a random walk with drift model, generally yields any forecasting improvement in root mean square error and mean absolute error over the random walk model. Nor does an unconstrained vector autoregression composed of the exchange rate and all the explanatory variables from the structural models. Similar results were reported in Boughton (1987) and Schinasi and Swami (1987). Schinasi and Swami found that monetary models could predict better than a random walk when the coefficients in the model were allowed to change over time and the lagged dependent variable was included as a regressor. However, their paper did not report the values of

the estimated coefficients, hence it is difficult to judge the extent to which their results support the monetary model.

There is evidence that some portfolio-balance models outperform monetary models. In particular, evidence has been presented by Boughton in his 1987 paper that the portfolio-balance models of Artus (1976, 1981, 1984) and Boughton (1984) perform better than the monetary models. Artus' models include very general expectations functions, while my model uses a stock-adjustment framework. Boughton (1987) compared the performance of different economic models. The study evaluated the effectiveness of portfolio-balance models developed by economists Artus and Boughton. These models were likely designed to capture the interaction between asset allocation decisions and economic variables. Artus (1976, 1981, 1984) developed a series of portfolio-balance models. These models included "very general expectations functions," which meant that they incorporated a wide range of factors that influence individuals' expectations about future economic conditions. This could include factors such as inflation, interest rates, government policies, and other relevant variables. Boughton (1984) had also introduced a portfolio-balance model that employed a "stock-adjustment framework." This framework focused on the adjustment of different asset holdings based on changes in economic conditions. For example, if interest rates or inflation change, individuals might adjust their asset allocations to maintain their desired level of wealth or risk exposure.

Rogoff (1984) additionally noted a number of studies that have provided evidence in favour of models that incorporate a portfolio-balance effect in the form of a risk premium. However, Rogoff questions the appropriateness of the measures of the portfolio effect in those studies, which typically involve some variant of the cumulated external balance. In Rogoff's view, the linkages between the cumulated external balance and the currency composition of the outstanding stock of securities are too weak to support the conclusions drawn in a favor of a portfolio effect on exchange rates.

Unfortunately, these and other studies have given relatively little firm indication of the direction in which research should turn in order to develop better models. Frankel (1983) concludes that his estimates for the monetary approach are enough better than the "disaster" that he found for the "synthetic" monetary-portfolio-balance model tentatively to justify a return of attention to the monetary approach. In contrast, Isard (1983) suggests revamping the portfolio-balance models by incorporating more microeconomic structural hypotheses. Ancotetal (1985) estimate a model that incorporates a rich dynamic structure, allows for imperfect asset substitutability, and reintroduces elements

of the flow approach by endogenising the determination of output and domestic prices.

Serious doubts about the macro-models began to be expressed within the first decade of their development when Meese and Rogoff (1983) conducted out-of-sample tests and found that the random walk model is as good a predictor of exchange rate movements as the structural macro models incorporating fundamentals like money supplies, real incomes, interest rates, inflation rates, etc. This finding was reinforced by subsequent examinations, such as Frankel and Rose (1995), Isard (1995), Taylor (1995), and Braille and Mac Mahon (2000). They all concluded that the linkages between exchange rates and macroeconomic fundamentals are extremely weak.

In contrast, the micro model of Lyons (1995, 2001) and Evans and Lyons (2002, 2005) has vastly outperformed macro models. This model is based on the idea that exchange rate changes are driven by net buy and sell orders, and it directly addresses the demand and supply forces represented by these orders. By doing so, the net buy and sell orders become a concrete measure of the excess demand and supply for the currency being bought and sold against the other, automatically leading to a prediction of an appreciation or depreciation of that currency against the other.

Instead of relying exclusively on macroeconomic determinants, Evans and Lyons drew on determinants from the field of microstructure. In particular, they focus on order flow, the variable within microstructure that is both theoretically and empirically—the driver of price. This was a radical departure from traditional approaches to exchange rate determination. Traditional approaches, with their common-knowledge environments, admit no role for information aggregation. The findings suggested instead that the problem this market solves is indeed one of information aggregation.

Their portfolio shifts model provided an explicit characterisation of this information aggregation problem. The model was also strikingly successful in accounting for realised rates. It accounted for more than 60 percent of daily changes in the DM/\$ rate, and more than 40 percent of daily changes in the Yen/\$ rate. Out of sample, the model produced better short-horizon forecasts than a random walk and the estimates of the sensitivity of the spot rate to order flow were sensible as well, and square with past estimates at the individual-dealer level. They found that for the DM/\$ market as a whole, \$1 billion of net dollar purchases increases the DM price of a dollar by about 0.5 percent. This relation should be of particular interest to people working on central bank intervention (though care should be exercised in mapping central bank orders to

subsequent interdealer trades).

For example, Lyons and Evans found that when order flow is added as an explanatory variable to the regression of changes in the exchange rates of the deutschemark against the dollar and yen against the dollar on changes in the daily interest rate differentials (a macroeconomic variable), the R^2 increases dramatically to 64% (DM/dollar) and 46% (Yen/dollar) and makes the coefficients of both explanatory variables including the interest differential, significant. This suggests that order flow is a better predictor of exchange rate movements than macroeconomic fundamentals. Subsequent studies for other currency pairs have produced similar findings. The superior performance of the micro-model lies in its direct focus on transactions, that is, buy and sell orders that are given effect in the bid and ask quotations of currencies against one another. In contrast, macro models look upon various currencies as assets and employ asset pricing methods such as the net present value of a currency in relation to a substitute currency. The macro-models seek to explain the underlying factors that affect the supply and demand for currencies in the foreign exchange market, such as money supplies, real incomes, interest rates, and inflation rates. They are more comprehensive in their approach than the micro-model, which only focuses on the observed order flows of currency trades.

The fact that the macro-models perform poorly in empirical testing raises questions about their validity. It suggests that the explanatory variables used in the models may be incomplete, insufficiently articulated, or based on invalid premises. This means that there may be other factors influencing exchange rate movements that the macro-models have not accounted for. Despite numerous empirical tests, the question of what exactly ails the macro-models remains unsettled in the literature. Further research is required to identify the limitations of these models and to improve their accuracy in predicting exchange rate movements.

However, a limitation common to both the macro-models and the micro-models in foreign exchange markets is that they only consider the determination of one exchange rate between two currencies at a time. This is referred to as the "twoness" limitation, and it arises from the partial equilibrium approach used in these models. This approach assumes that the forces operating in the markets for other currencies have no effect on the market for the currencies under study, and it relies on the *ceteris paribus* assumption (i.e., all other things being equal). However, this assumption is not applicable in the foreign exchange markets, as the exchange rates between several currencies are interdependent on one another. Suppose that on the euro-pound exchange counter, there is a

net sell position for euros against pounds, which means that euros will depreciate against the pound. At the same time, on the pound-yen counter, there is a net sell position for pounds, implying depreciation of the pound against the yen. According to triangular arbitrage, this means that the euro must depreciate against the yen. However, if on the euro-yen counter, there is a net buy position for the euro against the yen, the order-flow model would predict an appreciation of the pound against the yen. This results in two contradictory predictions, which cannot persist in reality as misalignments in spot exchange rates lead to profitable arbitrage opportunities, triggering off order flows across all counters until a set of consistent arbitrage-free exchange rates prevail.

However, it is important to note that both macro-models and micro-models share a fundamental limitation, both in theory and in practice. This limitation pertains to their exclusive focus on establishing a singular exchange rate between two currencies of distinct countries, rather than facilitating the determination of the complete spectrum of exchange rates spanning across multiple currencies simultaneously. Embedded within this characteristic of "twoness" is the adoption of a partial equilibrium approach, coupled with the underlying assumption of *ceteris paribus*. This combination effectively restricts the scope for any potential impact from market forces acting on other currencies upon the currency market under investigation. Let's begin by examining the micro-model. Imagine a scenario where there's a net selling position for euros against pounds at the euro-pound exchange counter, indicating an anticipated depreciation of euros against the pound. Concurrently, let's suppose there's also a net selling position for pounds against yen at the pound-yen counter, implying a projected depreciation of the pound against the yen. Following the principles of triangular arbitrage (euro-pound rate multiplied by pound-yen rate equals euro-yen rate), we would logically expect the euro to depreciate against the yen. However, consider another situation simultaneously occurring at the euro-yen counter, where a net buying position for euros against the yen is prevalent. According to the order-flow model, this would forecast an appreciation of the pound against the yen. This presents us with two conflicting predictions. Naturally, in reality, such contradictions cannot persist. Any disparities in spot exchange rates create profitable arbitrage opportunities, which in turn initiate order flows across all exchange counters until a coherent set of arbitrage-free exchange rates is established.

In essence, the *ceteris paribus* condition is not applicable within foreign exchange markets due to the intricate interdependence of order flows across multiple currency markets and their corresponding exchange rate quotations. The consequences of an increase in net buy orders for euros against the yen will extend beyond just an appreciation of euros against yen, contrary to the simplistic *ceteris paribus* assumption. Instead, this will

lead to an appreciation of euros against pounds as well, along with potential shifts in the yen-pound and pound-euro rates. The limitation of twoness also holds for the macro models, especially for their econometric equations, as the estimated coefficients may differ from their ideal theoretical sizes of +1, -1, or 0, resulting in predictions that are inconsistent across three or more currencies. In the event of misaligned exchange rate quotations, the macro-models will be unable to explain how the economic fundamentals would themselves change and ensure that consistent arbitrage-free rates prevail.

This thesis seeks to address the limitations of both macro and micro models for exchange rate determination that were discussed earlier. These models confine themselves to the determination of only one exchange rate between two currencies at a time, not the determination of the entire set of exchange rates between several currencies simultaneously. This means that they assume a *ceteris paribus* condition that effectively closes all possibilities that the forces operating in the markets for other currencies can have on the market for the currencies under study. To address these limitations, the thesis aims to construct a multi-country general equilibrium model. This model is intended to yield a unique positive solution for the equilibrium exchange rates that do not permit currency arbitrage and equate the demands and supplies of all currencies. In other words, this model will take into account the interdependence of all currency markets and the effects of order flows across several currency markets. By doing so, the model will be able to provide a more comprehensive understanding of exchange rate determination across multiple currencies.

Furthermore, this study also intends to subject this model to an empirical examination to evaluate its merits. This empirical examination will test the model's ability to predict exchange rate changes, its consistency with observed market data and provide a more comprehensive and accurate framework for understanding exchange rate determination in multi-currency markets.

Chapter 3

The Model

Imagine a scenario where the world consists of sovereign nations, each with freely convertible currencies for both regular transactions and capital movement. These currencies are exchanged in foreign exchange markets using a system of flexible exchange rates. Let's denote the total payments made by country "i" to country "j" in its own currency as " P_{ij} " (where i and j can take on values from A to N). It's evident that when i equals j ($i = j$), P_{ij} equals 0, as a country doesn't engage in international payments with itself. We assume that if there's a positive value for P_{ij} for a particular pair of countries (i and j), then there must be a positive value for P_{ki} for at least one other country k. In other words, no country conducts international payments without also receiving international receipts, and vice versa. Furthermore, we suppose that there exists at least one country that has economic relationships with all other countries, whether directly or indirectly. This implies that the global economy remains interconnected and doesn't fragment into separate economic units. Now, consider a specific time frame during which countries make intercountry payments to each other as detailed in Table 3.1.

Each row in Table 3.1 displays the payments originating from a given country "i" to other countries "j," indicating the amount of currency "i" supplied to country "j." The sum of

TABLE 3.1: The Intercountry Payments/Receipts.

Country	A	B	C	...	N	Total
A	0	P_{AB}	P_{AC}	...	P_{AN}	P_A
B	P_{BA}	0	P_{BC}	...	P_{BN}	P_B
C	P_{CA}	P_{CB}	0	...	P_{CN}	P_C
.
.
.
N	P_{NA}	P_{NB}	P_{NC}	...	0	P_N

these individual payments, denoted as P_i , represents the overall supply of currency "i" within the foreign exchange market. As currency "i" holds no value within country "j," it must be exchanged for currency "j" at the foreign exchange counter between i and j. Consequently, the values in P_{ij} reflect sales of currency "i," countered by residents of country "i" placing purchase orders for currency "j." When examining Table 1 column-wise, one can identify each country "j's" receipts from various countries. This reflects the demand for currency "j" against the supplies of different currencies "i." The total of these individual demands constitutes the comprehensive demand for currency "j." In this case, countries execute sell orders for currency "i" against buy orders for currency "j" on the foreign exchange counter corresponding to j-i (which is equivalent to the i-j counter). A direct correspondence exists between the matrix's elements, representing intercountry payments and receipts, and the flow of orders for currencies. However, the distinction arises in how exchange rates are determined. While the order-flow model implies that E_{ij} (the exchange rate between currencies i and j) can be determined solely by P_{ij} and P_{ji} , aggregated across all dealers (encompassing the twoness feature mentioned earlier), the general equilibrium model does not adhere to this approach. This is due to the resulting E_{ij} values (for $i \neq j$) not adhering to the conditions required for triangular arbitrage.

Instead, the general equilibrium model proposes that equilibrium exchange rates should align with the principle of balanced demands and supplies. This entails the total currency demands being equivalent to the total supplies, meaning that the overall buy orders for each currency (against the sell orders of all other currencies) balance out, resulting in net order flows summing to zero across all currencies. Letting E_{ij} denote the spot exchange rates, the balance of payments equations may be written as follows,

$$\begin{aligned}
 0 + (P_{BA}E_{AB}) + (P_{CA}E_{AC}) + \dots + (P_{NA}E_{AN}) &= P_A \\
 (P_{AB}E_{BA}) + 0 + (P_{CB}E_{BC}) + \dots + (P_{NB}E_{BN}) &= P_B \\
 (P_{AC}E_{CA}) + (P_{BC}E_{CB}) + 0 + \dots + (P_{NC}E_{CN}) &= P_C \\
 \text{-----} & \\
 (P_{AN}E_{NA}) + (P_{BN}E_{NB}) + (P_{CN}E_{NC}) + \dots + 0 &= P_N
 \end{aligned}
 \tag{1a}$$

Equation system 1a encompasses N equations involving $N(N - 1)$ exchange rates, corresponding to the exchange rate between each individual currency and every other currency in the set. The quantity of exchange rates significantly surpasses the number of equations, leading to a situation where multiple solutions for exchange rates can potentially

fulfill these equations. Nonetheless, the actions of foreign exchange dealers engaged in arbitrage activities, consistently seeking to achieve risk-free gains, play a role in ensuring that exchange rate quotations across various bilateral exchange platforms (across different dealers and geographical locations) strictly adhere to the principles of exchange neutrality.

$$E_{ij}E_{ji} = 1 \quad \forall i, j, i \neq j \quad (1b)$$

$$E_{ij}E_{jk}E_{ki} = 1 \quad \forall i, j, k, i \neq j \neq k \quad (1c)$$

Equations 1b and 1c emerge from exploiting arbitrage involving two and three currencies, respectively. These equations serve to eliminate a subset of the exchange rates outlined in 1a. Specifically, equations 1b collectively remove $N(N-1)/2$ exchange rates, while equations 1(c) eliminate $(N-1)(N-2)/2$ exchange rates from the original set described in 1a. Consequently, a total of $(N-1)2$ exchange rates are effectively eradicated. Remarkably, the necessity to determine the number of exchange rates is reduced to $N(N-1)-(N-1)2$, which simplifies to $N-1$ exchange rates, as demonstrated through equations 1b and 1c. Notably, more intricate arbitrage conditions involving four or more currencies become naturally redundant due to an insightful theorem established by Chacholiades (1971). This theorem asserts that if both two and three-currency arbitrage does not yield profits, the same holds true for m -currency arbitrage.

This redundancy of $(N - 1)^2$ exchange rates underscore those equations 1b and 1c can be harnessed to express all exchange rates from 1a relative to a chosen reference currency, such as currency A. This process entails retaining the original form of the first equation, and then multiplying subsequent equations by corresponding exchange rate factors (E_{BA} for the second equation, E_{CA} for the third, and so on), effectively streamlining the determination of exchange rates. Because $E_{BA} = 1/E_{AB}$, $E_{BC} = E_{BA}E_{AC} \dots E_{ZB} = E_{ZA}E_{AB}$, etc. the system of equations 2 is obtained,

$$\begin{aligned} 0 + (P_{BA}E_{AB}) + (P_{CA}E_{AC}) + \dots + (P_{NA}E_{AN}) &= P_A \\ P_{AB} + 0 + (P_{CB}E_{AC}) + \dots + (P_{NB}E_{AN}) &= (P_B E_{AB}) \\ P_{AC} + (P_{BC}E_{AB}) + 0 + \dots + (P_{NC}E_{AN}) &= (P_C E_{AC}) \\ \text{-----} & \\ P_{AZ} + (P_{BZ}E_{AB}) + (P_{CZ}E_{AC}) + \dots + 0 &= (P_N E_{AN}) \end{aligned} \quad (2)$$

By summing the equations outlined in 2 and taking into account the definition that P_i is equivalent to the sum of P_{iA} , P_{iB} , and so forth up to P_{iN} , we can nullify corresponding terms on both sides. This resultant simplification yields 0, which effectively demonstrates the validity of Walras's Law. This principle asserts that if the receipts of (N-1) countries match their corresponding payments, the same holds true for the remaining country. Thus one equation of system 2 say the first equation can be eliminated and we obtain the system (3) containing (N-1) independent balance of payments equations in (N-1) unknown exchange rates,

$$\begin{bmatrix} P_B & -P_{CB} & \dots & -P_{NB} \\ -P_{BC} & P_C & \dots & -P_{NC} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ -P_{BN} & -P_{CN} & \dots & P_N \end{bmatrix} \begin{bmatrix} E_{AB} \\ E_{AC} \\ \cdot \\ \cdot \\ \cdot \\ E_{AN} \end{bmatrix} = \begin{bmatrix} P_{AB} \\ P_{AC} \\ \cdot \\ \cdot \\ \cdot \\ P_{AN} \end{bmatrix} \quad (3)$$

In the context of system 3, the elements on the main diagonal correspond to the total payments, while the off-diagonal elements represent the payments made by countries B, C, and so forth, to countries other than country A. If country A is a participant in the international framework, it follows that there exists at least one $j (\neq A)$ for which $P_{Ai} > 0$, as well as at least one $i (\neq A)$ for which $P_{jA} > 0$.

As a consequence, the sums of the columns within the matrix are consistently non-negative, with at least one column-sum being positively non-zero. This matrix exhibits a dominant diagonal pattern. Drawing from the sufficient conditions articulated by Solow (1952), it can be deduced that the matrix possesses an invertible nature, with its inverse featuring elements that are strictly positive. Furthermore, due to the non-negative nature of the vector on the right-hand side, the solution for the (N-1) exchange rates is both uniquely determined and composed entirely of strictly positive values. Another way of looking at equation 3 is revealing; divide each equation of 3 by P_B , P_C , ... P_N respectively and arrange the equations as follows,

$$\begin{bmatrix} 1 & -p_{CB} & -p_{DB}\dots & -p_{NB} \\ -p_{BC} & 1 & -p_{DC}\dots & -p_{NC} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ -p_{BN} & -p_{CN} & -p_{DN} & \dots & 1 \end{bmatrix} \begin{bmatrix} E_{AB} \\ E_{AC} \\ \cdot \\ \cdot \\ \cdot \\ E_{AN} \end{bmatrix} = \begin{bmatrix} p_{AB} \\ p_{AC} \\ \cdot \\ \cdot \\ \cdot \\ p_{AN} \end{bmatrix} \quad (4)$$

In matrix notation, we may write equations (4) as,

$$\begin{aligned} [I - P][E_A] &= P_A \\ \text{or } E_A &= [I - P]^{-1}P_A \end{aligned} \tag{5}$$

Equation 5 encapsulates a crucial concept: the proportions of intercountry payments and receipts hold sway over the magnitude of exchange rates, rather than their absolute values. Hence, alterations in exchange rate levels must be attributed to shifts in the distribution of intercountry payments and receipts. This marks the conclusion of the process for establishing spot exchange rates.

The process of establishing the prices for derivative contracts, which rely on spot exchange rates, such as over-the-counter forwards or exchange-traded futures (including options), is relatively uncomplicated. For example, the t-period forward rates of exchange are obtained as,

$$F_{ij}^t = E_{ij}^t \times \frac{(1 + r_{it})^t}{(1 + r_{jt})^t}, \quad i \neq j \tag{6}$$

where t are the maturities of the forward contracts and r_{it} , r_{jt} are the spot interest rates for maturity t in countries i and j. The intricate process of aligning numerous forward rates with their underlying spot rates is surprisingly simplified, thanks to another theorem put forth by Chacholiades (1971). This theorem states that if both 3-point spot rate currency arbitrage and 2-point interest arbitrage fail to yield profits, the same holds true for 3-point forward arbitrage. Additionally, if 3-point forward arbitrage lacks profitability, this extends to m-point forward arbitrage (where m is greater than 3).

This concept arises from the fact that divergences between forward and spot rates can create opportunities for arbitrage, potentially resulting in disparities in pricing. These disparities, in turn, offer traders chances for profit and contribute to market inefficiencies. To counteract such inefficiencies, the market strives to bring about equilibrium, ensuring that forward rates achieve parity with the underlying spot rates. While this process might initially appear complex, it is less convoluted than it may seem.

Chapter 4

Illustrations and Extensions

Consider a world of 7 countries A to G and suppose that the intercountry payments matrix is as follows.

The market clearing exchange rates obtained by solving equation (2) are shown in row 1 of Table 4.2. The remaining cross rates derived from them using equations 1(b) and 1(c) are shown in rows 2 to 7.

TABLE 4.1: Intercountry Payments Matrix: 7-Country Example

Country	A	B	C	D	E	F	G	Total
A	0	120	85	32	401	555	20	1213
B	16	0	7	9	3	1	13	49
C	1131	2371	0	1555	5055	11216	12000	33328
D	221	308	151	0	15000	257	302	16239
E	266	250	562	1321	0	310	226	2935
F	7007	10000	3276	8008	22000	0	27000	77291
G	543	6012	231	300	15062	10000	0	32148

TABLE 4.2: Market Clearing Exchange Rates (in terms of currency A)

Country	A	B	C	D	E	F	G
A	1.000	27.898	0.041	0.173	1.668	0.029	0.065
B	0.036	1.000	0.001	0.006	0.060	0.001	0.002
C	24.390	680.439	1.000	4.220	40.683	0.707	1.585
D	5.780	161.260	0.237	1.000	9.642	0.168	0.376
E	0.600	16.725	0.025	0.104	1.000	0.017	0.039
F	34.483	962.000	1.414	5.966	57.517	1.000	2.241
G	15.385	429.200	0.631	2.662	25.662	0.446	1.000

While every country's overall receipts and payments will be equal at the market clearing exchange rates each country will have bilateral surpluses or deficits with the other countries ($\sum P_{ji}E_{Aj} - \sum P_{ij}E_{Ai}$) measured in currency A, e.g. country A has the following net positions with countries B, ... G; +326.37, -38.63, +6.23, +42.69, -351.8, +15.30, which sum upto zero. And so on for the other countries.

(I) If payments by any country i to the other countries rise uniformly by say 10%, that country's exchange rate with respect to other currencies depreciates by 10% but all other exchange rates vis-à-vis one another are not affected. This result has a familiar resonance with the relative version of the purchasing power parity theorem.

(II) If a country's receipts from other countries increase uniformly by 10% then that country's currency appreciates by 10% but other exchange rates vis-à-vis one another undergo a change. This can be readily seen by solving system (3) by Cramer's rule.

(III) If payments from country A to country B, P_{AB} , increases by 50 so that P_A also increases by 50 then, all else remaining the same, the equilibrium exchange rates stand at $E_{AB} = 29.672$, $E_{AC} = 0.0419$, $E_{AD} = 0.178$, $E_{AE} = 1.716$, $E_{AF} = 0.029$, and, $E_{AG} = 0.067$. Currency A has depreciated against all currencies by various extents but has depreciated the most against currency B. In addition, if, P_{CF} decreases by 7500 so that P_C also decreases by 7500, all else remaining the same, the equilibrium exchange rates in terms of currency A stand at $E_{AB} = 29.929$, $E_{AC} = 0.054$, $E_{AD} = 0.179$, $E_{AE} = 1.727$, $E_{AF} = 0.026$, and, $E_{AG} = 0.069$. Further if P_{GC} increases by 300, P_{GD} increases by 100 so that P_G also increases by 400, all else remaining the same, the equilibrium exchange rates in terms of currency A stand at $E_{AB} = 29.892$, $E_{AC} = 0.054$, $E_{AD} = 0.179$, $E_{AE} = 1.728$, $E_{AF} = 0.027$, and, $E_{AG} = 0.068$. In like manner, the consequences for the equilibrium exchange rates due to any changes in the configuration of intercountry payments can be worked out. Several countries of the world follow exchange rate regimes that are best described as semi-fixed semi-flexible i.e., they administer the external values of their currencies and attempt to maintain them at definite levels (pegs) or in definite bands and change the pegs/bands to different levels [see Reinhart (2000) and Reinhart and Rogoff (2004) and Ginzberg and Swoboda (2005) for the classification of exchange rate regimes] depending on the circumstances.

(IV) If countries adopt a fixed exchange rate system and fix the rates $E_{Ai} = (2.5, 2.5, 0.5, 3.5, 30, 1)$ say by declaring par values against currency A and standing ready to defend the equations of (2) solve for the balance of payments deficits/surpluses measured in currency

A viz. 213449 , 312966 , 17336, 240986, 685335.5, -2278919, 808846.5 which sum up to zero; countries that have fixed their parities at appreciated levels with respect to the market clearing rates show deficits and vice versa. The equations that solve the surpluses/deficits for the set of fixed exchange rates are, $-P_i + \sum P_{ji} E_{Ai}^* = S_i$, $i=1, \dots, N$, where $S_i > 0$ means surplus and $S_i < 0$ means deficit with $\sum S_i = 0$

The exchange rate systems (3) can be used in the reverse. If the countries B to G target the sizes of their deficits/surpluses (say as proportions of their GDP) at 100, 150, -200, -300, 250, and 120 in the own currencies of the countries then the corresponding exchange rate targets can be found from equation (7),

$$P_i + S_i - \sum P_{ji} E_{Ai}^* = P_{Ai}, i = B, \dots, N \quad (7)$$

where S_i^* is the target size of deficits that are duly added and surpluses subtracted from the total payments P_i . Then the corresponding exchange rate targets are 8.538, 0.036, 0.165, 1.699, 0.027, 0.054. At these exchange rates, country A has a deficit of 329.73 in A's currency which equals the sum of the surpluses and deficits of the remaining 6 countries also measured in A's currency.

(V) If country B pegs its exchange rate vis-à-vis A's currency at 17 (instead of the equilibrium rate of 27.898) then, even if all the remaining exchange rates are at their equilibrium levels, there is a worldwide disequilibrium; because B has devalued its currency its balance of payments it will be in surplus of 533.98 and all other countries' positions move into deficit with A, C, D, E, F and G's positions being -174.36, -76.28, -98.403, -32.7, -10.897 and -105.67 respectively and the sum of all is exactly zero. The implication is that the deficits experienced by countries other than B cannot be explained by variables pertaining to those countries but is entirely attributable to the unilateral action of B. The surplus of country B means an excess demand for currency B (at the devalued rate of 17) and deficits of other countries mean excess supplies of their currencies. Naturally, it should be expected that correction toward equilibrium must take place through a revaluation of B's currency and devaluations of other currencies and ensure an overall international equilibrium. But if some of the deficit countries, in their anxiety to correct their own balance of payments deficits, were to unilaterally act on their exchange rate levels towards devaluing them the result would be a movement from one disequilibrium to another.

(VI) If the exchange rates are pegged at levels that are very different from the equilibrium rates eg. $E_{A_i} = [20, 0.1, 0.5, 0.1, 1, 2]$ the following deficits/surpluses are observed $A, \dots, G = [+7450.2, +21580.1, +761.9, +988.1, +60297, -55434.9, -35642.4]$ which sum up to zero. The correlation coefficient between the percentage deviations of the pegged rates from the equilibrium rate (towards which the rates must adjust) and the ratios of deficits/surpluses to total receipts (with '+' representing surpluses and appreciation and '-' representing deficits and depreciations) is -0.95 and the rank correlation coefficient stands at 0.403. The same with pegged rates of $E_{A_i} = [60, 0.25, 0.1, 4, 1, 2]$ work out to -0.944 and 0.102 respectively.

(VII) In general, when many countries are simultaneously adjusting their pegs the change in the surpluses/deficits are given by,

$$\sum_{j=A}^Z P_{ji}(E_{A_j}^2 - E_{A_j}^1) - P_i(E_{A_i}^2 - E_{A_i}^1) = \Delta S_i, \forall i = A, \dots, Z \quad (8)$$

Where the initial set of exchange rates is $E_{A_j^1}$ which is changed to $E_{A_j^2}$. Clearly, whether ΔS_i declines or rises depends on how the first term on the left-hand side compares with the second term; if it exceeds the second the surplus declines (deficit rises) and if it falls short the surplus rises (deficit declines). And when the changes in pegs are accompanied by changes in the patterns of intercountry receipts and payments equation (8) will take the form,

$$[\sum_{j^i} P_{j^i}^2 E_{A_j^2} - P_{j^i}^1 E_{A_j^1}] - [P_j^2 E_{A_i}^2 - P_1^1 E_{A_i}^1] = \Delta S_i, \forall i = B, \dots, Z \quad (9)$$

If each country changes its pegs/bands/anchors depending on the circumstances obtained in that country it is very likely that the actual movements of exchange rates may exacerbate disequilibria instead of correcting them.

(VIII) If a country were to follow a dual exchange rate system with a predetermined exchange rate for some payments (e.g., payments for some key importable like oil and gas, etc.) that country's row of payments must be separated into two parts, one portion $P_{A_j^C}$ will be converted at the official rate $P_{A_j^C}$ and the other at the market rate $P_{A_j^f}$. Thus, if A follows a dual exchange rate policy, then the system to solve the market rates, (in the presence of the official intervention) is as follows,

$$\begin{bmatrix} P_B - P_{AB}^C E_{BA}^C & -P_{CB} & \dots & -P_{NB} \\ -P_{BC} & P_C - P_{AC}^C E_{CA}^C & \dots & -P_{NC} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ -P_{BN} & -P_{CN} & \dots & P_N - P_{AN}^C E_{NA}^C \end{bmatrix} \begin{bmatrix} E_{AB}^f \\ E_{AC}^f \\ \cdot \\ \cdot \\ \cdot \\ E_{AN}^f \end{bmatrix} = \begin{bmatrix} P_{AB}^f \\ P_{AC}^f \\ \cdot \\ \cdot \\ \cdot \\ P_{AN}^f \end{bmatrix} \quad (10)$$

Of course, if the country subsidizes some imports by fixing an appreciated official rate the “subsidy” that it thereby gives to its priority imports must be met from the “tax” that is imposed on other payments that take the form of depreciation of its free market rate. Vice versa for the “subsidy” it might give by means of a depreciated rate for its “priority receipts”. A similar procedure applies if the country is using an official exchange rate to convert a part of its receipts in which case it is the country’s receipts that must be separated into the official and market components. Multiple exchange rate regimes can be accommodated as well by making more elaborate extrapolations of (10) above.

Chapter 5

Obstacles to Empirical Testing

The accuracy of a theoretical framework is proportional to the empirical evidence and observations that lend support to it, while inversely tied to instances where empirical data falls short in explaining the phenomena it is meant to address. The model of general equilibrium in exchange rate determination has produced a rigorously mathematical solution for establishing exchange rate levels based on cross-border transactions and alterations stemming from various shifts in intercountry financial flows. The definitive assessment of its validity or invalidity necessitates a direct comparison of exchange rates derived from the model against observed real-world exchange rates. Furthermore, as intercountry financial transactions undergo transformations, it is important to compare the exchange rate fluctuations predicted by the model with those effectively observed.

Regrettably, the direct empirical validation approach is not feasible in the present context, primarily due to two constraining factors: a) the absence of data pertaining to intercountry payments denominated in respective national currencies, as exemplified in Table 3.1, and, b) the unavailability, within the public domain, of the specific exchange rates adopted by central banks or governments as fixed pegs or bands. Notably, the latter circumstance deviates from the model's underlying assumptions of (i) unrestricted convertibility of currencies, and (ii) complete flexibility of exchange rates. It is noteworthy, however, that these constraints do not inherently prevent the model from accommodating scenarios characterized by managed exchange rate frameworks, given the condition that such administered rates are sensible. Both of these constraints, with particular emphasis on the first, significantly reduce the scope of empirically verifiable deductions attainable from the exchange rate model. The absence of data describing intercountry payments transacted in their respective domestic currencies gives rise to an insurmountable challenge, as it prevents the computational derivation of exchange

rate levels as explained in equations (3) and (5) using authentic empirical data. Simultaneously, the magnitudes of exchange rate fluctuations stemming from modifications in intercountry payments remain beyond computational reach due to this fundamental data gap. In addition to the aforementioned limitations, there arise three additional conflicts between the available empirical data and the theoretical model. Firstly, the model suggests the universal inclusion of all nations within its purview, i.e., a premise that is not in practice, globally. The International Monetary Fund (IMF) has maintained a comprehensive dataset spanning the balance of payments for a subset of its member nations during the period from 1995 to 2022. This encompasses a global landscape of 195 sovereign states utilizing a total of 180 distinct currencies. The IMF, itself comprising 190 member countries, has undertaken the publication of quarterly balance of payments information for approximately 130 nations. Correspondingly, official exchange rates applicable for each quarter are also distributed, representing average values derived from market exchange rates within the respective periods. It is noteworthy that all balance of payments figures are represented in US dollars, serving as the underlying numeraire currency, through conversion procedures employed by the reporting countries. However, an element of heterogeneity prevails with regard to the starting dates from which consistent data reporting has been established across diverse nations. Consequently, this divergence imparts a deficiency in balance of payments and exchange rate data, rendering approximately 60 distinct currencies absent from the available dataset. The absence of both nations and corresponding data elements cause discrepancies within the intercountry payments matrix, thereby affecting the formulation of pertinent balance of payments equations and hindering the determination of exchange rates for these currencies.

The implications of these omissions and disparities are multifaceted. Notably, the extent of error introduced is dependent upon a country's degree of international economic engagement, encompassing the frequency and magnitude of transactions undertaken with other countries. A visible trend emerges, where nations representing relatively modest transaction volumes confined to a limited number of counterparts exhibit comparatively minor discrepancies. A further misalignment pertains to the model's foundational premise mandating the summation of surpluses and deficits across all participating countries to converge at an aggregate equilibrium of zero. This theoretical construct stands in variance with empirical realities, as evidenced by Graph 1, which portrays the proportional sum of deficits and surpluses among 124 member countries across successive quarters, invariably diverging from a zero equilibrium.

The final incongruence stems from the IMF's stipulation necessitating the translation of member countries' balance of payments data into the US dollar, the designated numeraire currency. In direct contrast, the model necessitates these values to be articulated in the domestic currencies of each respective nation. These dissimilarities in currency representation underline the complexities inherent in aligning empirical data with the theoretical framework. Consequently, the cumulative impact of the aforementioned mismatches on the precision of quantitative empirical assessments remains uncertain, thereby rendering deterministic prediction impossible.

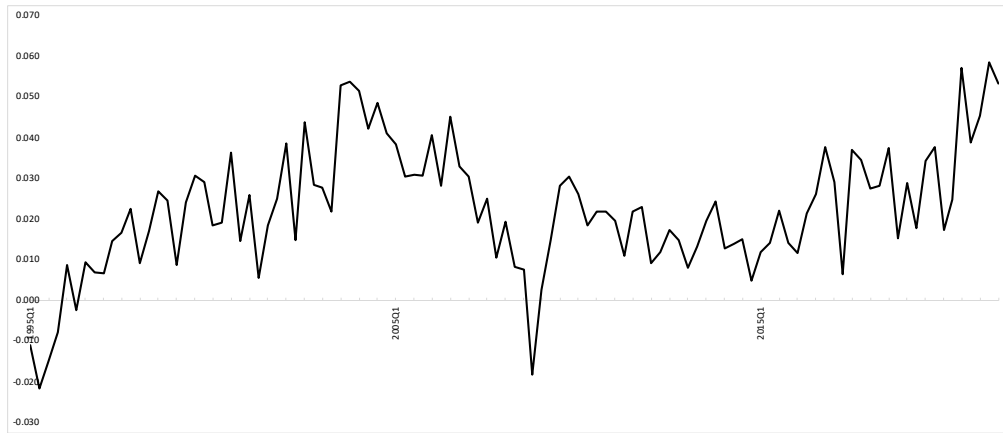


FIGURE 5.1: BOP Sum / Total Debit Sum

While the dataset provided by the International Monetary Fund (IMF) offers an intricate and comprehensive breakdown of components within the current and capital accounts of the Balance of Payments, alongside other pertinent financial disclosures, the empirical validation of our exchange rate model necessitates a focus on a select subset of items. Within this context, a trifurcation of relevant items emerges: (i) aggregate quarterly receipts and payments denominated in US dollars, (ii) the surplus or deficit in the quarterly balance of payments, also measured in US dollars, and (iii) the quarterly exchange rates. This depiction emphasizes the limitation imposed by the empirical scope, wherein only deductions and conclusions presented in terms of these three specified elements hold relevance and are consequently admissible for the purpose of conducting empirical assessments. The present analytical backdrop thus warrants a practical approach, necessitating the examination of the exchange rate model's applicability within the constraints of the available dataset. As such, we find ourselves compelled to extract valuable insights from the prevailing constraints, exemplifying a genuine endeavour to optimize the utility of available resources amidst inherent limitations.

Chapter 6

Results and Discussions I

Consider the Balance of Payments equation for country i , Consider the Balance of Payments equation for country i ,

$$\sum_{j=A}^Z P_{ji} E_{Aj} - P_i E_{Ai} = S_i, \quad i \neq j \quad (11)$$

where $S_i > 0$ indicates a surplus and $S_i < 0$ indicates a deficit with $S_i > 0$ indicating excess demands and $S_i < 0$ indicating excess supplies of currency i . The forthcoming analysis will centre on the empirical scrutiny of two core hypotheses, described as follows:

1. Currencies associated with nations experiencing deficits (surpluses) are anticipated to undergo depreciation (appreciation), accompanied by the analysis that countries marked by diminishing deficits (or declining surpluses)—indicative of reductions in excess supply or excess demand, respectively—will exhibit appreciation (or depreciation). This dynamic engenders the expectation of a decline (or escalation) in the exchange rate, denoted as E_{Ai} , for deficit (or surplus) nations. Furthermore, countries characterized by equilibrium in their balance of payments shall maintain exchange rates at fixed levels.
2. The rank correlation coefficient calculated between the magnitudes of percentage fluctuations in exchange rates—whereby appreciations and surpluses are denoted by ”+” and depreciations and deficits are denoted by ”-” while reductions in deficits are indicated by ”+” and reductions in surpluses are indicated by ”-” will demonstrate a positive yet imperfect correlation with the proportional extent of surpluses/deficits in relation to the overall receipts of the respective countries.

The selection of rank correlation, as opposed to the straightforward correlation coefficient, is a deliberate choice that stems from the intrinsic complexities caused by alterations in the magnitude of exchange rate fluctuations consequent upon shifts in excess demands or supplies of currencies. This phenomenon interacts intricately with modifications in the comprehensive array of payment and receipt patterns. The outcome of this interplay is the emergence of a scenario where a one-to-one correspondence between the dimensions of deficits or surpluses and the resulting magnitudes of exchange rate adjustments is unclear, necessitating a more nuanced analytical approach to reveal meaningful patterns of association.

The preliminary hypothesis which can be tested is hypothesis A. Consider the pooled regression across 10995 country-quarters shown in Table 6.1. It is,

$$\begin{aligned} \Delta E_{iA} = 0.754 - 0.000012S_i \quad R = 0.00081 \\ (1.32) \quad (-0.083) \quad p's > 0.5 \end{aligned} \quad (12)$$

where ΔE_{iA} shows the percentage change in the value of currency i . In the regression reported in equation (12) the correct sign for the slope parameter is obtained, however, the R 's and t -statistics are miserable. If instead ΔE_{iA} is regressed against the surplus/deficit as a proportion of total receipts of the countries in the corresponding quarters, we obtain,

$$\begin{aligned} \Delta E_{iA} = 0.754 - 0.002(S_i/TR_i) \quad R = 0.0004 \\ (1.32) \quad (-0.04) \quad p's > 0.5 \end{aligned} \quad (13)$$

Even for an individual country, say India, the fit that is obtained is,

$$\begin{aligned} \Delta E_{iA} = 0.203 + 0.0000082(S_i) \quad R = 0.0121 \\ (2.05) \quad (0.77) \quad p's > 0.5 \end{aligned} \quad (14)$$

where a wrong sign of the slope parameter is obtained apart from the fact that it is insignificant.

Furthermore, it becomes evident that varying signs and magnitudes of parameters result for the same nation across distinct sub-periods, yielding instances of unsuitability that go beyond mere isolated occurrences. Such numerous instances, underscoring the inherent weakness of parametric econometric methodologies in furnishing outcomes that are both robust and dependable within the context under investigation. It is plausible to deduce that these estimations, when extrapolated to out-of-sample scenarios, are poised to yield outcomes characterised by substantial volatility and unpredictability. Indeed, the inadequacies of econometric approaches are seemingly anticipated, given the underlying deterministic nature of the model presented within equations (3) or (5). The precision of the solution to the exchange rate uncertainty is tied to the commitment of the inter-country payments data, rendering irrelevant influences of minimal consequence. In the face of these quantitative test failures, a pragmatic recourse is expected, i.e., a recalibration towards qualitative or non-parametric assessments that pivot upon the anticipated directions of exchange rate shifts, rather than fixating solely upon their magnitudes.

We direct our attention to Table 6.1, which provides a comprehensive depiction of exchange rate movements dependent upon quarterly balance of payments data emerging from a cohort of 130 nations across the years spanning 1995-Q1 to 2021-Q3—encompassing a total of 107 quarters. The aggregate number of quarterly observations during this interval, wherein both Balance of Payments and Exchange Rate data remain accessible, corresponds to 10995 instances. It is worth noting that within this dataset, there exists a subset of six nations that have a fixed exchange rate regime throughout the period under consideration. Specifically, these nations comprise Ecuador, St. Vincent and Grenadines, Marshall Islands, St. Kitts and Nevis, St. Lucia, and the territories of West Bank and Gaza. Cumulatively, these entities contribute 642 observations, equating to 6 multiplied by 107—the duration of the analysed quarters. An exhaustive review of the quarterly balance of payments pertaining to these countries for the entirety of the observed periods distinctly reveal a recurrent approximation to a balance of nearly zero. This collection of observations is designated as "item (i)" within Table 6.1.

In contrast, the remaining 124 countries, characterized by exchange rate variability, have been subject to scrutiny. Specifically, each country-quarter configuration was examined to work out the polarity of its balance of payments, i.e., whether indicative of a deficit

TABLE 6.1: Agreement between the Model and the Observed Balance of Payments Data

Total Number of Observations	10995(100%)
(i) Zero Balance and Fixed Rate	642(5.84%)
(ii) Deficits and Depreciation	5658(51.46%)
(iii) Surpluses and Appreciation	3136(28.52%)
(iv) Deficit Decline and Appreciation	548(4.98%)
(v) Surplus Decline and Depreciation	1011(9.2%)
Total (i) to (v)	10995(100%)

or surplus.

Correspondingly, the subsequent change in the official exchange rate—a computed average throughout the quarter—was catalogued, describing instances of depreciation or appreciation. This detailed analysis leads to the documentation of the outcomes in "item (ii)" and "item (iii)" within Table 6.1. It is crucial to emphasize that balance of payments deficits (that indicates an excess supply situation), and surpluses (indicating an excess demand situation), inherently entail corresponding depreciation and appreciation of respective currencies vis-à-vis the designated numeraire currency, which is the US Dollar. Additionally, we observe the manifestation of what could be termed as "second-order effects." As evidenced by the 548 instances captured within "item (iv)" and the 1011 instances within "item (v)," reductions in deficits and surpluses, respectively, are recorded within the two preceding quarters. These reductions signify a reduction of excess supply and demand dynamics, and consequently, they signal appreciations and depreciations of the respective currencies. Notably, a salient finding emerges as the interactions between these second-order effects and their primary counterparts, embodied in "item (ii)" and "item (iii)" unfold. The second-order effects markedly supersede the primary influences, invariably spreading across the dimensions of deficit and surplus situations observed in the immediate preceding quarter. This dominance of second-order effects over first-order influences underscore the composite entries featured in Table 3, which collectively sum up an exhaustive array of scenarios, encompassing both mutually exclusive and collectively exhaustive permutations.

The findings mentioned in Table 6.1 substantiate a precise alignment with the postulates summarised within Hypothesis A, as posited by the exchange rate model, when evaluated against the backdrop of the examined dataset encompassing 10995 distinct observations. Significantly, this notable congruence between the theoretical framework and empirical observations is confirmed despite the pronounced disparities that are apparent between the available dataset and the foundational presumptions underpinning the model, as

TABLE 6.2: Agreement between Model and the Observed Current Account Balance Data

Total Number of Observations	10995(100%)
(i) Zero Balance and Fixed Rate	642(5.84%)
(ii) Deficits and Depreciation	5798(52.73%)
(iii) Surpluses and Appreciation	2975(27.1%)
(iv) Deficit Decline and Appreciation	709(6.45%)
(v) Surplus Decline and Depreciation	871(7.92%)
Total (i) to (v)	10995(100%)

explained in the preceding section. It becomes evident that in spite of these visible disparities, the convergence between the model and actual data is upheld in a manner that is remarkably robust. Curiously, the semblance between the theoretical construct and empirical reality persists, underscoring the capacity of the model to accommodate variations between the available data and the model's foundation. This persistence is further emphasized by the presumption that other methodical deviations between the dataset and the model's requisites might chiefly impact the calculated exchange rates in relation to their observed counterparts, as well as the magnitudes of exchange rate fluctuations, rather than engendering inaccuracies in their directional movements.

In the pursuit of comprehending the pragmatic dynamics characterising the operational mechanics of the prevailing exchange rate regime, an avenue of inquiry pertains to the exploration of outcomes resulting from an analytical focus upon exchange rate alterations in conjunction with current account deficits and surpluses, as well as alterations therein. In this context, Table 6.2 serves as the complementary counterpart to Table 6.1, despite being centered upon current account balances, with the objective of fostering an enhanced understanding of the interplay between these pivotal variables and exchange rate fluctuations within the analytical framework.

Evidently, a marked consistency exists between the numerical data present in the two tables. This compatibility implies that the operational exchange-rate regime places paramount importance on the management of the current account, whether on a domestic or multilateral scale. Notably, accommodations of the current account position via capital account inflows are infrequent occurrences and, when they do happen, are of a partial nature. In specific instances, the volume of observations wherein currency depreciation results from current account deficits (5798 observations, Table 6.2) slightly surpasses the corresponding instances of currency depreciation stemming from overall deficits (5658 observations, Table 6.2), a discrepancy amounting to a mere 140 country-quarters. This discrepancy implies a modest accommodation of current account deficits

through capital inflows, constituting an approximate 2.41% of instances. Similarly, the occurrences of currency appreciation stemming from overall surpluses (3136 observations, Table 6.1) exceed those emerging from current account surpluses (2975 observations, Table 6.2) by 161, thereby accounting for 5.13% of cases wherein the current account is not in surplus, yet currency appreciation takes place owing to a surplus in the capital account. Notably, these proportions constitute relatively modest fractions of the aggregate observations, with percentages of 1.27 and 1.46, respectively.

Conversely, adjustments effected through alterations in exchange rates display with notable frequency and amplitude. This confirms to the practical adoption of exchange rate regimes typified by flexible anchors, pegs, or bands within the majority of nations. Over successive periods, outcomes within the balance of payments framework encompass deficits, surpluses, declines in deficits, and declines in surpluses. Notably, the dichotomous entries within Tables 6.1 and 6.2 are exhaustive and mutually exclusive, thereby interpreting the precise concordance of the disparities of 140 and 161 with the discrepancies between deficit declines (1011-871) and surplus declines (709-548), instances partially offset by net capital inflows and outflows, respectively.

Consequently, the following conclusion is that within practical contexts, the exchange rate regime renders the sustenance of prolonged exchange rate pegs impracticable. Moreover, the automatic convergence of current account deficits (surpluses) and capital account surpluses (deficits) remains difficult to track down. In consequence, a reliance on currency depreciation (appreciation) becomes important to effectuate a substantial portion of adjustments aimed at equilibrium attainment.

Furthermore, the relative insignificance of capital account movements and adjustments becomes evident upon comparing the relative magnitudes of the capital account and the current account. To illustrate, in the year 2019, comparing the total current account receipts of 130 reporting countries with the total capital account debits (amounting to \$0.169 trillion) and comparing the total current account debits (valued at 17.2 trillion) highlights a marginality of merely 0.98%. In spite of episodes wherein autonomous capital flows have assumed pivotal roles, occasionally precipitating dire crises (exemplified by the Latin American debt crisis of the 1980s and the East and South-East Asian Currency Crisis in the late 1990s), the relatively inconsequential influence of capital flows on the global stage is irrefutable.

Given the striking consistency evident in the results explained within Table 6.1, which impeccably align with the fundamental principles of general equilibrium theory, a further step is required. Specifically, the explanatory power of the variables, namely (1) deficit/surplus and (2) decline in deficit/surplus, warrant evaluation with regard to their impact on the directional shifts in exchange rates. Capitalizing on the categorical nature of the data contained within Table 6.1, the assignment of dummy variables in accordance with prescribed sign conventions is to the point. By assigning +1 and -1 to denote currency appreciation and depreciation, respectively, while designating surplus and deficit as +1 and -1 correspondingly, and signifying declines in deficit and surplus as +1 and -1 (where the effects thereof are appreciation and depreciation), the data can be subjected to standardization into normal variates. This standardization, applied to the 10353 observations (inclusive of the 10995-642 fixed-exchange rate observations), serves to ensure the continuity of the variables, facilitating rigorous analysis of their explanatory potential. The pooled standardized linear regression model for the sample data in Table 6.1 is,

$$\begin{array}{rcccccc}
 Z_E = 0 & +0.75Z_B & +0.236Z_{DB} & R^2 = 0.518 & R = 0.72 & \\
 (0) & (105.54) & (33.29) & p's \approx 0.5 & N = 10353 & (15)
 \end{array}$$

It can be readily observed that the sum of the slope coefficients (being unit-free numbers) is $0.9866 \approx 1$. What this means is that the explanatory variables Z_B and Z_{DB} are practically the only important variables that account for changes in the directions of exchange rates and that the possibilities of having excluded additional important explanatory variables are negligible.

Next consider hypothesis (B), viz. the greater the excess demand/supply for a currency the greater will the appreciation/depreciation be. This has been illustrated with hypothetical examples of the structure of actual exchange rates deviating from that of the equilibrium exchange rates in chapter 4 (VI) earlier. The same computation has been performed on the balance of payments data and consequent exchange rate changes for 107 quarters for the 124 countries whose exchange rates have been variable (i.e., barring the 6 countries with fixed exchange rates).

Graph 6.1 shows the rank correlation coefficient between the size of the exchange rate changes and the surplus/deficit to total receipts ratio across countries in each quarter.

For all quarters it is found to be positive.

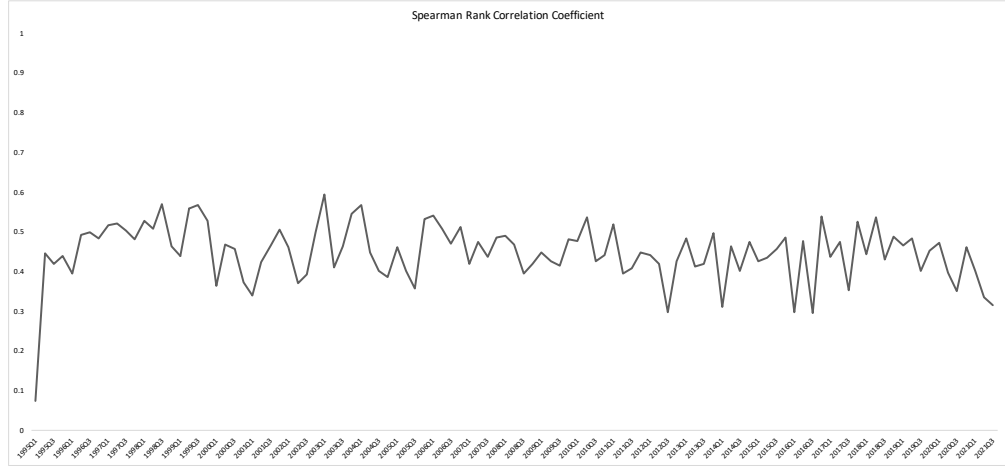


FIGURE 6.1: Spearman's Rank Correlation Coefficient

6.1 Out-of-Sample Forecasting

6.1.1 Results

The out-of-sample performance of the model can be tested by using equation (15) and estimating its parameters for a sample of the available data, estimating the parameters, and then using the realized values of the independent variables from the remaining data and using the fitted equation to generate values of the dependent variable viz. the exchange rate movement and finally to compare these with the actual out-of-sample to assess their accuracy. The danger in doing so with equation (15) is that two independent variables Z_B and Z_{DB} have opposite effects on the exchange rate movement with Z_{DB} completely dominating Z_B . But since Z_B and Z_{DB} are separate into mutually exclusive subgroups in Table 4, the out-of-sample performance can be improved by estimating separate regressions for the two subgroups having 1559 observations in which deficits or surpluses undergo declines and 8794 observations in which countries experience deficits or surpluses but without any declines in their sizes over the preceding quarter. Next, consider the sample period to be the quarters from 1995 to 2007 and fit separate regressions for the two subgroups. These are,

$$\begin{aligned}
 Z_E &= -3.39E - 31 + Z_{DB} & R^2 &= 1 \\
 &(-1.50E - 13) \quad (4.432E + 15) & p &\approx 0 \quad F = 0 \quad N = 1020
 \end{aligned} \tag{16}$$

$$\begin{aligned}
 Z_E &= 1.11E - 29 + Z_B & R^2 &= 1 \\
 (9.11E - 13) & (8.25E + 16) & p \approx 0 & F = 0 \quad N = 6080
 \end{aligned}
 \tag{17}$$

with intercepts= 0 and slopes= +1 showing that (16) and (17) amount to the deterministic statements that $Z_E = Z_B$ and $Z_E = Z_{DB}$ being our assignments of +1 and -1 for the dummy variables standing for the directions of exchange rate movement. Naturally, when (16) and (17) are applied to the out-of-sample period 2008 to 2019 i.e., to 1559-1020 = 559 and 8794-6080 = 2714 observations in number a perfect matching obtained between the inferred and actual movement of exchange rates, a 100% accuracy with no errors [the same exercise if done with equation (15) gives 86% accuracy]. In effect the model is able, using the available data, to make very accurate out-of-sample forecasts of the directions of exchange rate movements.

6.1.2 Predictions

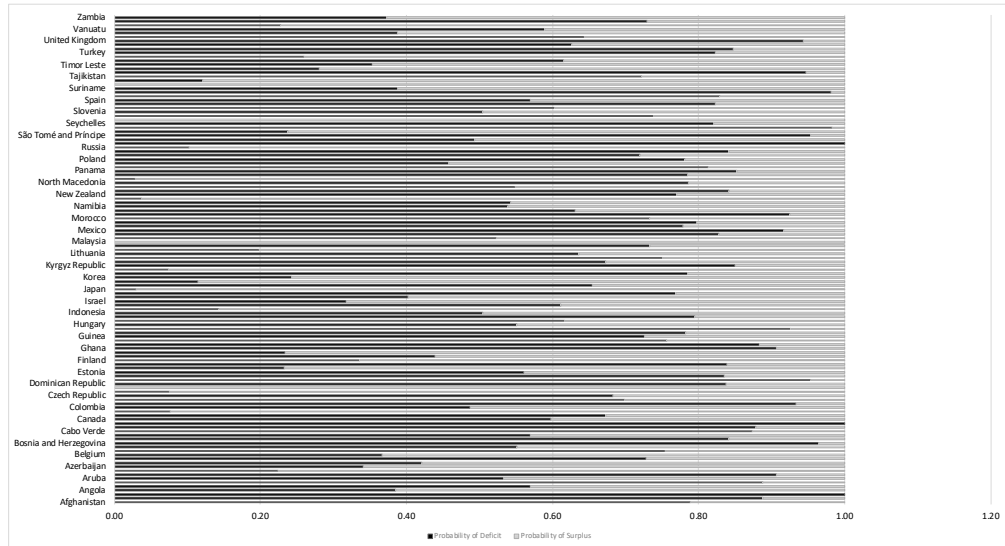


FIGURE 6.2: Probabilistic Distribution of the Balance of Payments Deficits/Surplus

Figure 6.2 shows for each country the frequency of occurrence of deficits and surpluses. Countries shown on the horizontal axis are in the same alphabetical order as they appear in the IMF data. Likewise, probabilities of deficit/surplus declines can be estimated.

These, along with the probabilities of deficits/surpluses, can also form the basis for a probabilistic prediction. Each bar represents a country and the countries are in the same order as they appear in the IMF database, for eg., the first bar is for Afghanistan and the last for Zambia.

Clearly, the out-of-sample results reported above can hardly qualify to be considered to be “predictions about the future directions of exchange rates”, they are only in the nature of a confirmation of the accuracy of the directions in which the exchange rates can be expected to change attendant upon deficits/surpluses or declines in deficits/surpluses. To obtain genuine predictions or forecasts, i.e., estimates of what will happen in future periods based on information available only until the present time t , it must in the first place be possible to predict the future values of the explanatory variables themselves, viz., whether a deficit/surplus or deficit/surplus decline will occur in future.

This will involve judgements based on past trends and also on the particularities of the economic contingencies that each country is encountering. No simple general rules suggest themselves which can be applied across countries and over time. Under these circumstances, the best that can be done is to make probabilistic judgements based on past data suitably modified to incorporate emergent situations.

Chapter 7

Results and Discussions II

So far, we have been able to associate that the balance of payments deficit is followed by an exchange rate depreciation, the balance of payments surplus is followed by an exchange rate appreciation, a deficit decline is followed by an appreciation and a surplus decline is followed by depreciation of the currency. We have also been able to establish the directions and that the general equilibrium predictions apply exactly to the foreign exchange market. What remains now is the possibility to additionally predict the magnitudes by which the exchange rates should change in response to the changes in the inter-country payments matrix.

Unfortunately, due to the absence of the data on the same, we have looked into the next best option that involves studying episodes in which a substantial change can be observed either in a row or a column pertaining to the payments or receipts of one of the countries within the inter-country payments matrix. This would enable us to observe whether the resulting exchange rate changes are of commensurate with the presumed magnitudes of the payments or receipts. This is the purpose of Chapter 7.

Under the Exchange Rate regime (1995-2021), we have been able to establish that every change in currency values is a reflection of the corresponding change in the balance of payments (refer to Table 6.1 in Chapter 6 of the Thesis). If this is the case then rapid fluctuations in currency values, which are experienced during crisis periods should be traceable, in the first place, to corresponding changes in the balance of payments. In order to verify if this is really so, we have explored two periods of currency crises, namely, the Latin American Debt Crisis and the South-East Asian Crisis.

TABLE 7.1: Balance on Current Account (\$ million)

Country Name	1979	1980	1981	1982	1983	1984
Argentina	-513.0	-4774.0	-4712.0	-2353.0	-2436.0	-2495.0
Brazil	-10516.0	-12831.0	-11764.0	-16317.0	-6834.0	-33.0
Chile	-1189.0	-1971.0	-4733.0	-2304.0	-1117.0	-2111.0
Mexico	-5409.0	-10422.0	-16240.0	-5889.0	5866.0	4183.0
Peru	729.5	-101.1	-1727.8	-1608.8	-872.0	-232.5
Venezuela	350.0	4728.0	4000.0	-4246.0	4427.0	4651.0

7.1 Latin American Debt Crisis

Whenever a country experiences a huge influx in capital account, the current account balance starts moving into a deficit. However, as the capital account surplus keeps increasing, the current account deficit keeps worsening which eventually results in reduced confidence amongst foreign investors. As a consequence, they start withdrawing the money from banks. Now, since the banks had already lent the money in the form of not only short term but long-term loans as well, they turn to other banks for support who are in a similar problematic situation which results in the domestic currency to start depreciating, thereby leading to banking crisis. Many countries that have experienced the most severe banking crisis during the late 2000s also ran sustained current account deficits in the run-up to the crisis.

To understand how the Balance of Payments and Exchange rates of countries behave during the period of a financial crisis, let us analyze the countries that were affected during the Latin American Debt Crisis. The countries that were most affected during the crisis were Mexico, Brazil, Argentina, Venezuela, Chile and Peru. Table 7.1 above reports the Current Account Balance of some LAD countries for a few years prior to and during the period of the crisis.

It is very apparent from the above data that the Current Account Balance of all countries shows a marked deficit during the peak years of the Crisis (1981-1982). We now delve deeper into how the exchange rates of certain countries react to the decline in deficit during the aforementioned period.

7.1.1 Argentina

As we can notice from the following figure, the current account balance and exchange rate of Argentina have been moving in complete agreement with one another, i.e., a current account deficit is followed by depreciation of the Argentine Peso and the current

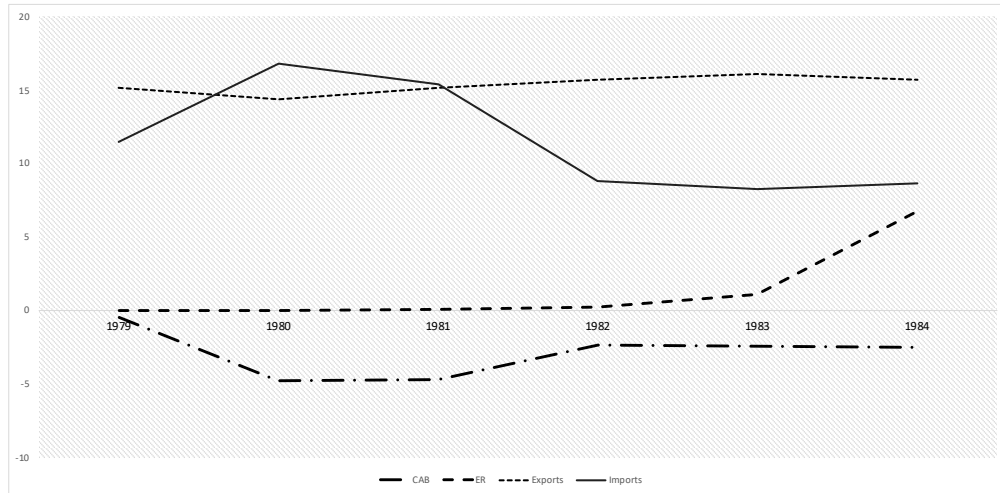


FIGURE 7.1: Comparison of Current Account Balance, Exchange Rate and Export Data of Argentina

account surplus is followed by exchange rate appreciation, except for the peak-crisis period (1980-81). This period showcases an abnormality where despite a decline in current account deficit, the exchange rate shows depreciation. Argentina was one of the countries that abandoned their import substitution industrialisation (ISI) models of economy and adopted an export-oriented industrialisation strategy, usually the neoliberal strategy encouraged by the IMF. In order to verify if this is reflecting in the data, we studied the exports and imports on goods and services during the same period. It is clearly evident from Figure 7.1, that the exports between 1980 and 1981, increased by 0.75 billion USD whereas the imports, over the same period, fell by 1.4 billion USD which portrays the clear-cut move from the import substitution industrialisation model to an export-oriented industrialisation strategy encouraged by the IMF.

7.1.2 Brazil

As we can notice from the following figure, the current account balance and exchange rate of Brazil have been moving in complete agreement with one another, i.e., a current account deficit is followed by depreciation of the Brazilian real and the current account surplus is followed by exchange rate appreciation, except for the peak-crisis period (1980-81). This period showcases an abnormality where despite a decline in current account deficit, the exchange rate shows depreciation. Very similar to Argentina, Brazil had also abandoned their import substitution industrialisation (ISI) models of economy and

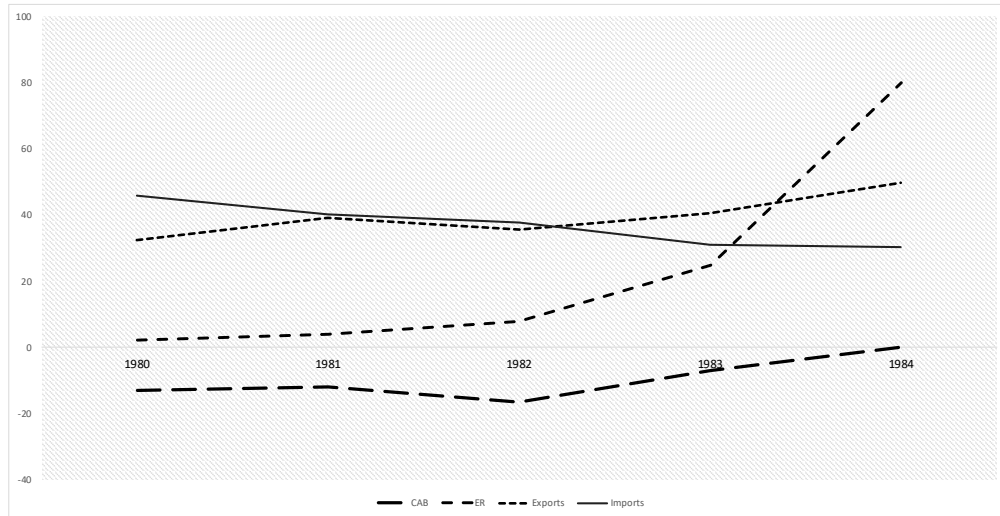


FIGURE 7.2: Comparison of Current Account Balance, Exchange Rate and Export Data of Brazil

adopted an export-oriented industrialisation strategy, usually the neoliberal strategy encouraged by the IMF. In order to verify if this is reflecting in the data, we studied the exports and imports on goods and services during the same period. It is clearly evident from Figure 7.2, that the exports between 1980 and 1981, increased by 6.9 billion USD whereas the imports, over the same period, fell by 5.7 billion USD which clearly showcases the move from import substitution industrialisation model to an export-oriented industrialisation strategy encouraged by the IMF.

7.1.3 Peru

As we can notice from the following figure, the current account balance and exchange rate of Peru have been moving in complete agreement with one another, i.e., a current account deficit is followed by depreciation of the sol and the current account surplus is followed by exchange rate appreciation including the peak-crisis period (1980-81). This period also showcases that the exports between 1980 and 1981, decreased by 0.3 billion USD whereas the imports, over the same period, increased by 1.7 billion USD which signals that this country might not have adopted an export-oriented industrialisation strategy and stuck to the usual import substitution industrialisation model during the crisis period.

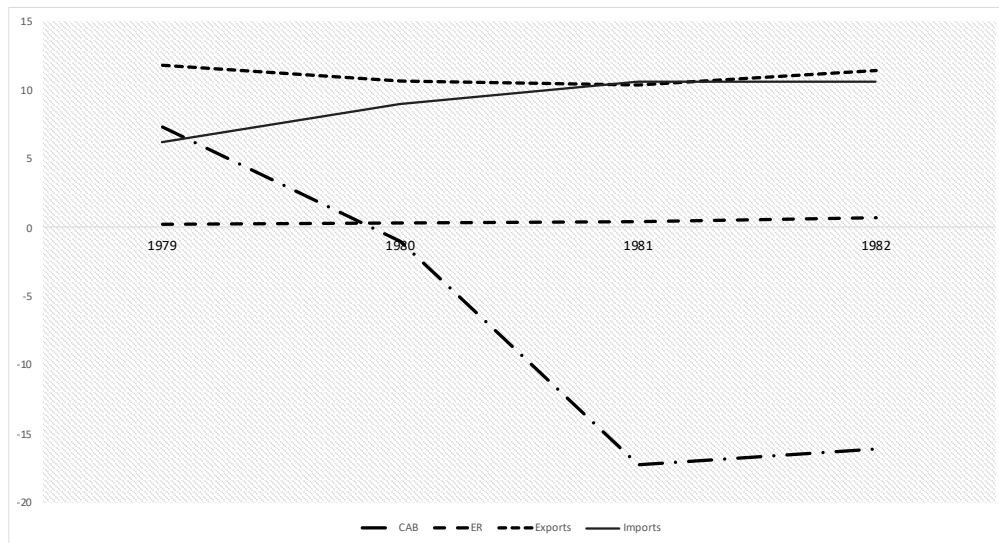


FIGURE 7.3: Comparison of Current Account Balance, Exchange Rate and Export Data of Peru

7.2 South-East Asian Crisis

A rapidly decreasing capital account in a country can contribute to a currency crisis through various channels. When the capital account experiences a sharp decline, it indicates a reduction in foreign investment and a potential flight of capital from the country. The Asian Financial Crisis provides a notable historical example of how a rapidly decreasing capital account can lead to a currency crisis. In the late 1990s, several Asian economies, including Thailand, Indonesia, South Korea, and Malaysia, experienced a sharp decline in their capital accounts. Foreign investors, who had previously invested heavily in these economies, rapidly withdrew their capital due to concerns about over-valued currencies and economic imbalances. The withdrawal of foreign capital led to a sharp depreciation of the local currencies. For example, the Thai Baht and the Indonesian Rupiah experienced significant declines. The currency crisis had severe economic consequences, including banking system failures, corporate bankruptcies, and economic downturns in the affected countries. Let's take a look at the South-East Asian Crisis. Table 7.2 below reports the Current Account Balance of some SEA countries for a few years prior to and during the period of the crisis.

It is very apparent from the above data that the Current Account Balance of all countries shows a marked deficit during the peak years of the Crisis (1996-1997). We now delve deeper into how the exchange rates of certain countries react to the decline in

TABLE 7.2: Balance on Current Account (\$ million)

Country Name	1994	1995	1996	1997	1998	1999
Indonesia	-2790.0	-6430.0	-7660.0	-4890.0	-4100.0	-5780.0
South Korea	-4790.0	-10230.0	-24460.0	-10810.0	40110.0	21780.0
Malaysia	-4520.0	-8640.0	-4460.0	-5940.0	9530.0	12600.0
Mexico	-5409.0	-10422.0	-16240.0	-5889.0	5866.0	4183.0
Philippines	-2950.0	-1980.0	-3950.0	-4350.0	1550.0	-2880.0
Thailand	-8060.0	-13580.0	-14690.0	-3020.0	14240.0	12430.0

deficit during the aforementioned period.

7.2.1 Indonesia

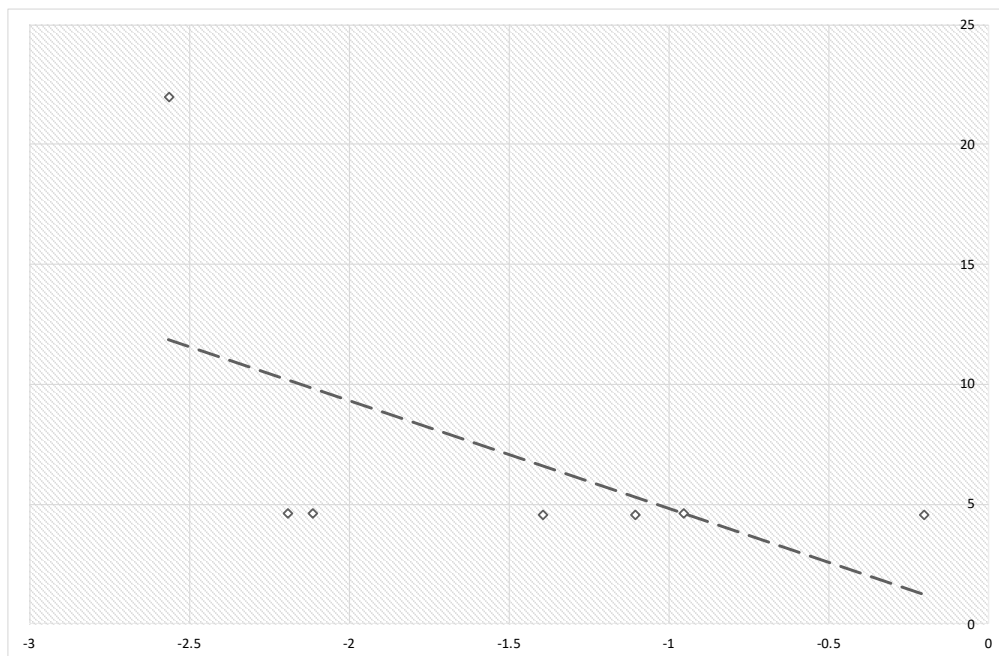


FIGURE 7.4: Trendline between Current Account Balance and Exchange Rate Data of Indonesia

From the above quarterly data of Indonesia's current account balance and percentage change in the exchange rate, it is very clear from the trend lines that, despite going through a peak crisis phase, a current account deficit has been accompanied by an exchange rate depreciation and a deficit decline is being accompanied by an exchange rate appreciation.

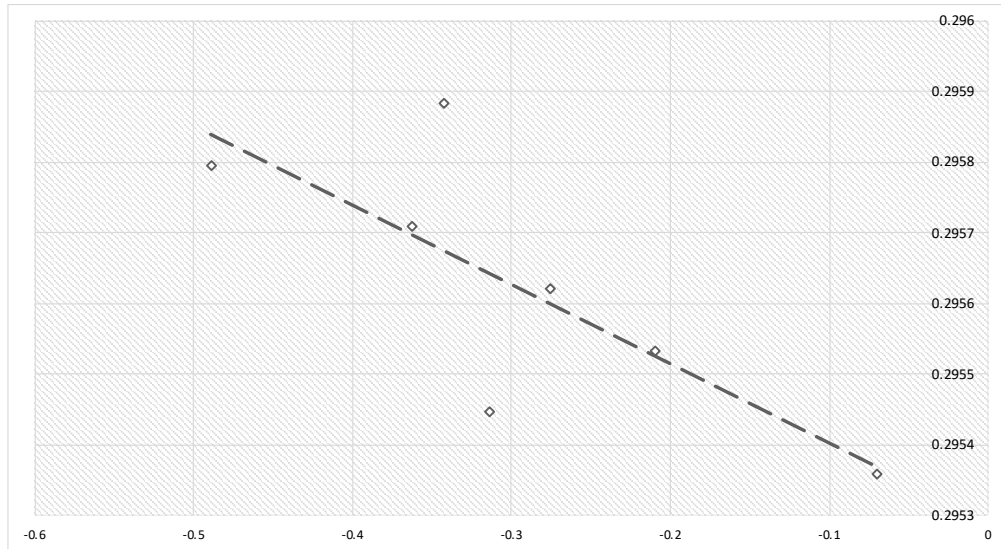


FIGURE 7.5: Trendline between Current Account Balance and Exchange Rate Data of Thailand

7.2.2 Thailand

From the above quarterly data of Thailand's current account balance and percentage change in the exchange rate, it is very clear from the trend lines that, despite going through a peak crisis phase (1996-97), a current account deficit has been accompanied by an exchange rate depreciation and a deficit decline is being accompanied by an exchange rate appreciation.

7.2.3 South Korea

From the following quarterly data of South Korea's current account balance and percentage change in the exchange rate, it is very clear from the trend lines that, despite going through a peak crisis phase (1996-97), a current account deficit has been accompanied by an exchange rate depreciation and a deficit decline is being accompanied by an exchange rate appreciation.

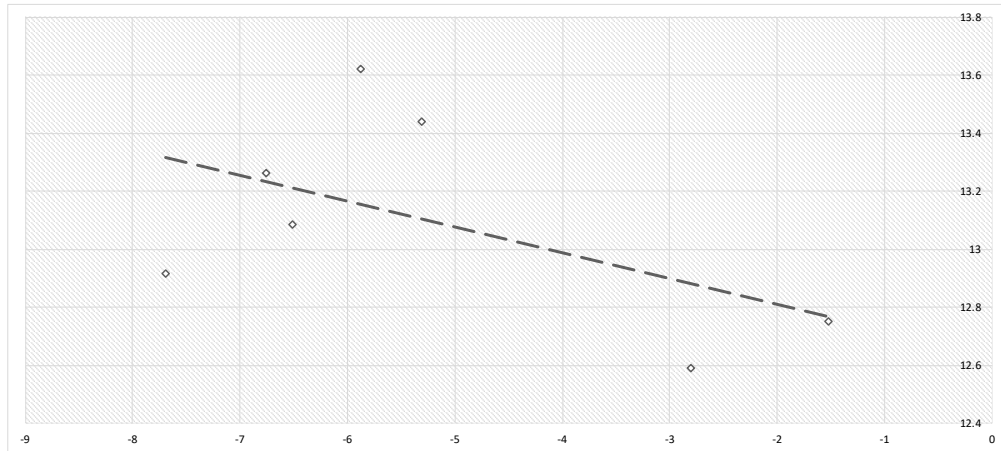


FIGURE 7.6: Trendline between Current Account Balance and Exchange Rate Data of South Korea

TABLE 7.3: Growth in Exchange Rates of Latin-American Countries (%)

Period	Argentina	Brazil	Chile	Mexico	Peru	Venezuela
1970-75	864.62	76.92	43441.70	0.00	4.32	-2.27
1975-79	3500.73	231.57	658.51	82.44	456.64	0.00
1979-84	51267.37	6758.44	164.40	635.91	1442.75	63.18
1984-90	7207519.37	3695753.52	209.62	1575.89	5419383.20	568.29
1990-95	105.04	3104607.34	30.13	128.24	1099.31	277.13
1995-2000	-0.03	99.36	35.99	47.30	54.88	284.51
2000-05	190.51	33.07	3.74	15.25	-5.56	207.33

7.2.4 Examination of the Speed of Exchange Rate Movements before, during and post Crisis periods

We will now look into the growth rate of exchange rates for the years when there wasn't a debt crisis and compare the same with the growth rate for the debt-crisis periods. Beginning with the Latin American Debt Crisis, we have calculated the percentage changes in Exchange Rate for the following periods before, during and after the crisis.

As is very clear from the above data that the peak years of the Latin American Debt Crisis (1979-89), the growth in Exchange rates for every country has been abnormally high. We can verify the same from the following figure,

Next, we look into the years before, during and after the South-East Asian Crisis where we have calculated the growth rates of Exchange rate for the aforementioned periods in Table 7.4.

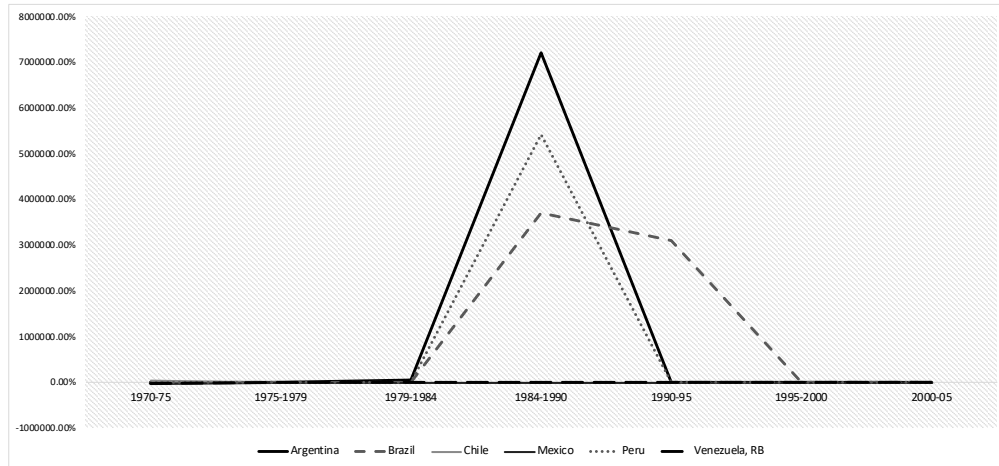


FIGURE 7.7: Growth in Exchange Rates of Latin-American Countries

TABLE 7.4: Growth in Exchange Rates of South-East Asian Countries (%)

Period	Indonesia	South Korea	Malaysia	Philippines	Thailand
1970-75	14.38	55.85	-21.80	22.76	-2.02
1975-80	51.08	25.56	-9.06	3.64	0.48
1980-85	77.13	43.16	14.06	147.72	32.64
1985-90	65.93	-18.65	8.93	30.65	-5.79
1990-95	22.02	8.97	-7.41	5.78	-2.62
1995-98	345.33	81.94	56.70	59.03	66.00
1998-2005	-3.08	-27.00	-3.50	34.71	-2.75

As is very clear from the above data that the peak years of the South-East Asian Crisis (1995-98), the growth in Exchange rates for every country has been abnormally high. We can verify the same from the Figure 7.8.

Maintaining the exchange rate in the face of a Balance of Payments deficit can only be possible via two methods: (a) by completely using up the existing foreign reserves, and, (b) borrowing even more from abroad. The graph below correctly depicts the growth of External Debt outstanding for the three countries highly affected during the SEA crises. It is clear from Figure 7.9 that all the external debt outstanding are entirely due to the fresh debts raised by these countries during those years.

It is a no-brainer that current account deficit is definitely responsible for the rise in indebtedness but we could delve deeper into understanding the same from the perspective of capital inflows. The rise in Capital Inflows has a direct relation to the increase in Current Account Deficit. This depends highly on the sequence of events. The former can impact the latter only if capital inflows precede those deficits. The reason why this happens is Capital Inflows are primarily of three kinds: foreign direct investment,

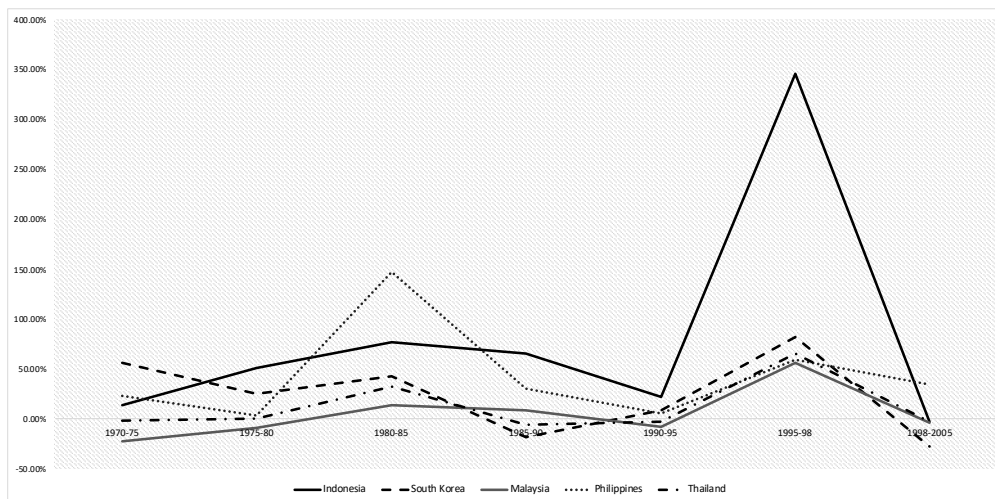


FIGURE 7.8: Growth in Exchange Rates of South-East Asian Countries

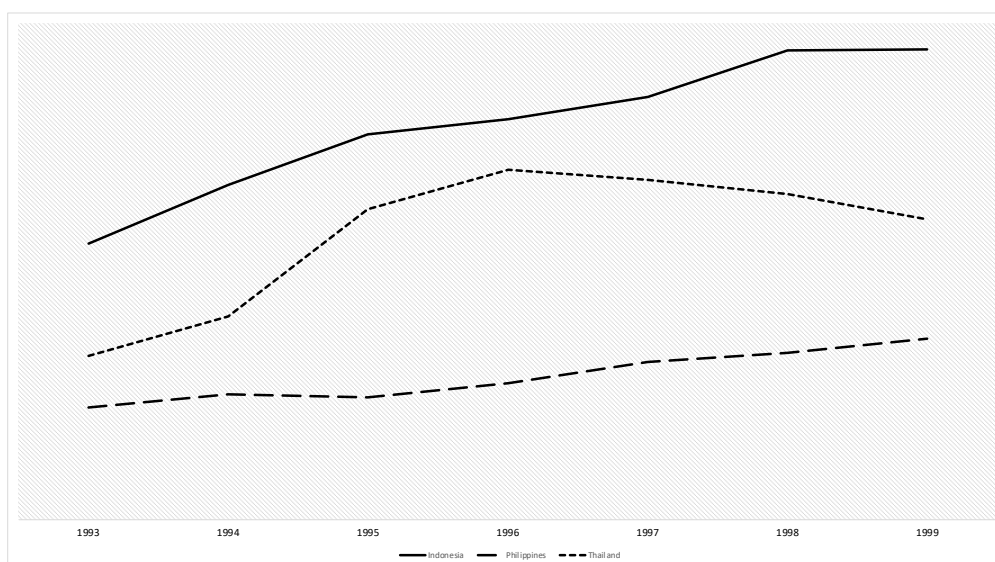


FIGURE 7.9: External Debt Data of Indonesia, Philippines and Thailand

TABLE 7.5: Foreign Direct Investment (\$ million)

Year	1985	1995
Indonesia	310.00	4346.00
South Korea	355.30	2487.10
Malaysia	694.71	4178.24
Philippines	12.00	1478.00
Thailand	163.20	2067.94

TABLE 7.6: Funds raised on International Capital Markets (\$ million)

Year	1994	1995	1996
Indonesia	6199	7588	10772
Malaysia	3526	3205	3347
Philippines	1164	1272	3799
Thailand	7910	6634	7417

foreign portfolio investment and debts raised by the government and commercial sector.
investment and debts raised by the government and commercial sector.

Foreign Direct Investment (FDI) which is usually spent on imports of machinery, and imports of components, spares, and raw materials and Foreign Portfolio Investments (FPI) which focus on project finance induce increase in imports. Both FDI and FPI increase domestic investment so much so that it can rise above domestic saving that increases domestic production and income thereby inducing additional imports. Similarly, the government's foreign debt via expenditure on national income may directly result in increase in public sector imports. Capital inflows to the countries in the form of FDI and Funds raised on International Capital Markets are shown in Tables 7.10 and 7.11.

The above exploration of the crisis has revealed two things: first, Table 7.4 does not exhaust all possibilities but that happens during crisis periods where exchange rates and BOP is under administrative negotiation which is a non-market phenomenon. Second, if we intend to put the piece on the crisis together, we notice that the aforementioned South-east Asian countries experienced phenomenal growth during the 80s and 90s. As a result of the growth in these economies, they initiated liberalisation of international commodity trade and their financial systems. As a result, the foreign investors felt their investments in SEA countries were safe and solid. Hence these countries became beneficiaries of capital inflows from abroad. Now as we have seen, capital inflows (surpluses) have a natural counterpart in current account outflows (deficits). As the capital inflows increased so did the current account deficits. However, in the ultimate analysis all the accumulated capital inflows have to be serviced but the only way in which a country

can service them is by having a current account surplus.

There is always a way of borrowing more but that leads to a classic instance of an external debt trap. This is the irony of capital inflows and foreign debt. Capital inflows directly cause current account deficits and yet current account deficits are a sure sign of the inability of the country to meet its capital account liabilities. Thus, even as the inflows to SEA countries was increasing rapidly their capacity to service these inflows were decreasing. Therefore, during the year 1995-96 the current account deficits increased enormously and when the international commercial banks and financial institutions realised this they began to withdraw. As the withdrawing begun, capital account surplus began to fall but the current account deficit remained as it was leading to an increase in the overall balance of payments deficit. Therefore, now the fear was that then who and what will bear the burden of adjustment. Either the government must shop around for aid to pump in the foreign exchange or the exchange rate must depreciate. The SEA countries did both. While the former requires some time, exchange rate depreciation is automatic. This can also be clearly seen in the aforementioned graphs of the SEA countries where a sharp depreciation of every country's currency against the US dollar is quite evident.

Chapter 8

Concluding Remarks

This thesis has proposed a general equilibrium framework of exchange rates that ensures simultaneous clearing of the multi-currency foreign exchange markets. Although the model possesses a natural affinity to the market microstructure-based order-flow models it goes a step further to yield a unique mathematical solution of the equilibrium exchange rates in terms of the inter-country payments/receipts in the own currencies of the countries. Unfortunately, due to the absence of data on the same, the mathematical formula for the exchange rate solution cannot itself be empirically confirmed or rejected. Additionally, it places severe restrictions on the number and type of testable inferences that can be drawn for empirical testing.

Two hypotheses have been put to test,

A) Currencies of countries experiencing balance of payments deficits (surpluses) will depreciate (appreciate) and those of countries experiencing declining deficits (surpluses) will appreciate (depreciate), and,

B) Currencies of countries experiencing greater severities of deficits (surpluses) will depreciate (appreciate) to greater extents.

In addition to the above two hypotheses, we have studied two particular episodes in history, namely the Latin-American Debt Crisis and the South-East Asian Crisis in which we observed a substantial change in the row and column pertaining to the payments or receipts of one of the countries within the Inter-country Payments Matrix (refer to Chapter 7). This enabled us to observe that the resulting exchange rate changes are of commensurate with the presumed magnitudes of the inter-country payments (and

receipts).

Although in comparison with the potentially rich testability of the model from an empirical point of view, the hypotheses that have actually been tested are somewhat simplistic and obvious. However, for both these hypotheses a close agreement is found between the sample data and the model. Additionally, the model gives very reliable and robust out-of-sample results.

If so much is agreed, it can be the basis for an earnest appeal to the International Monetary Fund (IMF) to compile the complete inter-country payments matrix (refer, Table 3.1) on a pilot basis, to begin with. If the formulaic solutions of the exchange rates of equation (3) or equation (5) are found to be in agreement with the observed exchange rates, then the matrix can be compiled and published regularly. This is not at all a difficult task as the inter-country payments data in the own currencies of the countries already exist with the commerce ministries, commercial banks, central bank, and capital market regulators of the member countries, i.e., all of the agencies from which the IMF customarily collects various types of financial data. All that is needed to be done is for IMF to obtain a country-wise break-up of the payments of each country in their own currencies. Also, each country compiles data on its receipts from other countries which can also be reported to the IMF that in turn can use the same to tally and verify the figures on payments from other countries to this country. The inter-country payments matrix can prove to be an important tool for the multi-country coordination of the balance of payments and exchange rates.

In practical terms, the task principally necessitates the addition of a breakdown of payment transactions for each individual country, formulated in its own currency. Additionally, each nation's data on receipts arising from foreign interactions can be submitted to the IMF for consolidation and validation purposes. This endeavour ensures the IMF's ability to confirm payment figures originating from other nations in relation to a given country. It stands to reason that the intercountry payments matrix can potentially assume a salient and pivotal role, serving as an instrumental mechanism supporting the multifaceted coordination of balance of payments dynamics and the fluctuations in exchange rates across the data of participating nations.

The model of determination of exchange rates proposed in our thesis shows that to every configuration of inter-country payments and receipts, there does belong a unique set of equilibrium exchange rates which change with every change in the configuration of the

inter-country payments matrix. If the various countries anchor their exchange rates at levels other than the equilibrium rates, they will experience deficits as well as surpluses. The currencies of deficit (surplus) countries are in excess supply (excess demand), i.e., have net sell (net buy) order positions and will accordingly depreciate (appreciate). Opposite effects are expected and observed if the deficits (surpluses) decline. This sums up the model and the results that emerge from its empirical examination based on the available balance of payments data.

Clearly the general equilibrium model worked in the thesis (like the order-flow model) is nowhere close to being a “theory” of exchange rates. A theory of exchange rates is expected to identify the dominant economic forces and circumstances that explain the observed changes and configurations of inter-country payments and receipts and the patterns of demands and supplies of currencies that emerge from those configurations and changes in them, i.e., the order flows themselves. It is most unlikely, going by the disappointing empirical performance of the macroeconomic models of exchange rates, that these economic forces will be adequately represented by the usual economic aggregates.

What is far more likely, instead, is that the theory that will comprise of a series of models: a model of inter-country trade in goods and services based on inter-country comparative advantages for various goods and services, a political-economy model for trade policy and forex market interventions and domestic monetary and fiscal policies as they impact international economic transactions, a financial model to identify the relative strengths and weaknesses of the financial sectors, and so on. The model of exchange rate determination proposed in this thesis will be an integral part of such a theory.

Appendix A

Relative Version of Purchasing Power Parity Theorem

It has been evident in Chapter 4 Table (3.1) that if a country experiences very rapid inflation of money supplies, wages, prices and incomes that causes its domestic and international payment volumes to increase proportionately with no appreciable change in the receipts of the same from other countries, then the deficit of that country must increase proportionately and cause a proportionate depreciation in its currency. This result is not only well-known since the last 100 years, but it is encouraging how it also is perfectly consistent with the proposed model of exchange rates (refer Chapter 4 Table (3.1)) and does not necessarily imply the absolute version of the purchasing power parity theorem which has often been claimed to be the ultimate theory of exchange rate determination.

An empirical study of this phenomenon (as mentioned in Chapter 4) is possible only if a natural market experiment has taken place in which one or more countries have undergone episodes of very high inflation in comparison to others. As far as the data of 1995-2021 is concerned, a set of countries, namely, Zimbabwe, Argentina, Sri Lanka, Sudan, Turkey, and Venezuela are shown in the following table.

The Balance of Payments and Exchange Rate data are unfortunately not available yearly for all the countries mentioned in the database of IMF. The only country whose data is available for all the years and quarters is Argentina.

TABLE A.1: High Inflation Countries

Country	Inflationary Episode	Cumulative Inflation
Zimbabwe	2002-2007, 2019-2021	578438.503 , 45.362
Argentina	2014-2021	14.675
Sri Lanka	2005-2008	0.7444
Sudan	2017-2021	45.4612
Turkey	1995-2002, 2017-2021	65.86 , 1.00044
Venezuela	2013-2020	260331558

Source: International Monetary Fund, World Bank and OECD Inflation CPI Indicator

TABLE A.2: Cumulative Values of Argentina

Country	Inflationary Episode	Cumulative Inflation	Cumulative Episode	Cumulative Depreciation
Argentina	2014-2021	14.675	7.26	10.36

High inflation period of Argentina begins from 2014 and continues till 2021. The cumulative inflation rate calculated during this period has been 14.68 which implies that wages, income and prices have increased by similar magnitudes which leads to the implication that the payments by Argentina to the rest of the world along with its Balance of Payments have increased substantially resulting in a depreciation of its currency, peso by a similar amount.

The following Graph (A.1) shows the movement of the exchange rates of peso against countries that have relatively lower inflation, namely, Bolivia, China, Europe and the United States having average annual inflation rates of 2.76, 1.92, 1.18 and 2.17 percent. Over the period 2014-2021, the average exchange rate movement annually between Boliviano, Yuan, and Euro against the USD have undergone a relative small depreciation of 2.20 and appreciations of 0.57 and 1.94 percent, respectively. The following graph reveals how the exchange rates of the aforementioned countries, including, the United States, China, Bolivia, and Germany, in terms of Argentina's peso follow the same trend when plotted together,

As Figure A.1 shows that during the period 2014-2021, the high inflation episode in Argentina has presented us with a natural market experiment in which the relative version of the purchasing power parity theorem is seen to have manifested itself, in broad terms. Better availability of data would have enabled further validation for even more countries.

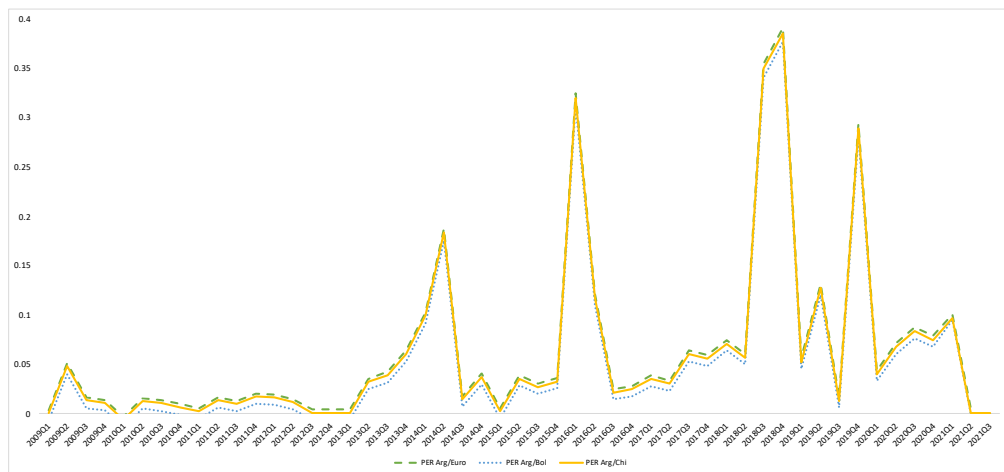


FIGURE A.1: Comparison of Exchange Rates between Argentina and other Countries' Currencies

Appendix B

Keynes' Critique of Absolute Purchasing Power Parity Theorem

The theoretical and empirical validity of the relative purchasing power parity theory in some special circumstances of the kind just illustrated cannot be attributed to the validity of absolute purchasing power parity theory even though the relative purchasing power parity theory can be directly derived from the latter. And that is because, as Keynes (1930, pp. 72-74) pointed out long ago, the absolute purchasing power parity theory is a tautology if the price indexes are confined to post-trade prices of traded commodities but is simply wrong if prices of non-tradeable goods are included. To see why, suppose that there are N commodities of which commodities $1, \dots, k$ are traded and the remaining $k + 1, \dots, N$ are non-tradeable. Further, suppose without loss of generality that of the k traded commodities, $1, \dots, g$ are exported by A to B and $g + 1, \dots, k$ are imported by A from B. Then, if q_j ($j = 1, \dots, N$) is the representative basket of commodities, the absolute purchasing power parity exchange rate should be,

$$E_{AB} = \frac{\sum_{j=1}^g p_{jA} q_j + \sum_{j=g+1}^k p_{jB} E_{AB} q_j + \sum_{j=k+1}^N p_{jA} q_j}{\sum_{j=1}^g p_{jA} E_{BA} q_j + \sum_{j=g+1}^k p_{jB} q_j + \sum_{j=k+1}^N p_{jB} q_j} = \frac{P_A}{P_B}$$

where $E_{AB} p_{jB}$ and $E_{BA} p_{jA}$ are the post-trade prices of the traded commodities in countries A and B, respectively. It can be readily seen from the equation above that if the price indexes are confined to traded goods, then the equation holds good by definition because $E_{AB} E_{BA} = 1$. But if non-tradeables are included then it is generally false unless by some fluke $p_{jA}/p_{jB} = E_{AB}$ for all $j = k+1, \dots, N$.

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