ESSAYS ON THE EXCHANGE RATE AND MONETARY POLICY IN NEPAL

By

Anjan Panday

Submitted to the

Faculty of the College of Arts and Sciences

of American University

in Partial Fulfillment of

the Requirements for the Degree

of Doctor of Philosophy

In

Economics

Chair: Robert A. Blecker
Dr. Robert A. Blecker

Ellen E. Meade
Dr. Ellen E. Meade

Xuguang Sheng
Dr. Xuguang Sheng

Dean of the College

July 20, 2012
Date

2012
American University
Washington, D.C. 20016

ESSAYS ON THE EXCHANGE RATE AND MONETARY POLICY IN NEPAL

by
Anjan Panday

ABSTRACT

Nepal has a large and growing trade deficit with India and an overall negative trade balance. Its economy is growing slowly relative to India's, while the exchange rate is pegged with India at a parity that is believed to be overvalued. India is Nepal's largest trading partner, with which it also shares an open order. The peg is considered central to macroeconomic stability and is treated as the monetary policy anchor. Nepal also represents a typical case of a country in which remittances are vital for short-run macroeconomic stability, while they may have adverse consequences for the long-run health of the economy. The three essays in this dissertation are relevant to a broader discussion on the macroeconomic impact of remittances in the context of a low-income country.

In the first chapter, I consider possible misalignment of Nepal's real effective exchange rate by estimating a behavioral equilibrium exchange rate using a set of fundamentals for the period 1975–2008. The estimates from the Johansen (1998) cointegrated-VAR model as well as a single equation bounds-testing approach to cointegration suggest that Nepal's trade-weighted real exchange rate was overvalued in the last decade and a half.

The question of the efficacy of monetary policy in influencing the exchange rate is analyzed in the second chapter, using a monetary model of exchange market pressure. Applying a recently developed estimation technique, impulse indicator saturation, along with general-to-specific modeling, I find that a contractionary

monetary policy results in easing pressure on the exchange rate. The robustness of the results is confirmed using various tests.

The final essay entails a comprehensive analysis of economic symmetry between Nepal and India, which is one of the pre-conditions for monetary integration. A two-pronged empirical investigation reveals inconclusive evidence to justify such integration on economic grounds. First, using a three-variable SVAR showed a low and negative correlation in the supply shocks. Decomposing the structural shocks into regional and idiosyncratic components showed a favorable co-movement with the regional element only in Nepal's monetary shock. Second, the business-cycle analysis using state-space models of GDP and its components showed some evidence of co-movement with the regional element in some variables while others showed divergence.

ESSAYS ON THE EXCHANGE RATE AND MONETARY POLICY IN NEPAL

by
Anjan Panday

ABSTRACT

Nepal has a large and growing trade deficit with India and an overall negative trade balance. Its economy is growing slowly relative to India's, while the exchange rate is pegged with India at a parity that is believed to be overvalued. India is Nepal's largest trading partner, with which it also shares an open order. The peg is considered central to macroeconomic stability and is treated as the monetary policy anchor. Nepal also represents a typical case of a country in which remittances are vital for short-run macroeconomic stability, while they may have adverse consequences for the long-run health of the economy. The three essays in this dissertation are relevant to a broader discussion on the macroeconomic impact of remittances in the context of a low-income country.

In the first chapter, I consider possible misalignment of Nepal's real effective exchange rate by estimating a behavioral equilibrium exchange rate using a set of fundamentals for the period 1975–2008. The estimates from the Johansen (1998) cointegrated-VAR model as well as a single equation bounds-testing approach to cointegration suggest that Nepal's trade-weighted real exchange rate was overvalued in the last decade and a half.

The question of the efficacy of monetary policy in influencing the exchange rate is analyzed in the second chapter, using a monetary model of exchange market pressure. Applying a recently developed estimation technique, impulse indicator saturation, along with general-to-specific modeling, I find that a contractionary monetary policy results in easing pressure on the exchange rate. The robustness of the results is confirmed using various tests.

The final essay entails a comprehensive analysis of economic symmetry between Nepal and India, which is one of the pre-conditions for monetary integration. A two-pronged empirical investigation reveals inconclusive evidence to justify such integration on economic grounds. First, using a three-variable SVAR showed a low and negative correlation in the supply shocks. Decomposing the structural shocks into regional and idiosyncratic components showed a favorable co-movement with the regional element only in Nepal's monetary shock. Second, the business-cycle analysis using state-space models of GDP and its components showed some evidence of co-movement with the regional element in some variables while others showed divergence.

ACKNOWLEDGEMENTS

I take this opportunity to express my gratitude to several people whose guidance and support have been immeasurable. From the time when I first met to discuss the possible topics for dissertation to his current role as the committee chair, Prof. Blecker has always posed questions that are intellectually stimulating, challenging, and of relevance to research (current and future). He has consistently mentored my work throughout this period, guided me through the job-market process, and offered numerous practical suggestions. For all his efforts, I remain deeply indebted to him.

Dr. Meade, who was the committee chair before she joined the Fed, has been instrumental in shaping my raw ideas into a coherent set of essays. Earlier, I had taken second-year macroeconomics with her, and had developed some hope of working with her for the dissertation. I still remember the day when I first met her to discuss possible dissertation ideas. She not only agreed to oversee my work, but also helped in setting up the committee. Having come through the process, I can only admire her for the efforts she put into getting the process sailing as smoothly as possible. We met several times to discuss results, analyses, problems, solutions and so forth. On every occasion, I have come out learning more and advancing my knowledge further. I sincerely appreciate her efforts throughout this process.

Prof. Sheng's guidance in completing the econometric work is as valuable as were his suggestions in developing the job-market paper more fully. I will always remember his practical suggestions on writing journal articles, and the need to offer detailed exposition of technical aspects. I especially acknowledge his remarks that the understanding of a subject matter calls for explaining each step meticulously, which speaks volume about the quality of work. He has all my generous appreciation.

I would also like to thank Prof. Neil E. Ericsson of George Washington University for offering me guidance through emails and meetings. I benefitted from his seminar and conversations, which were very useful in completing the econometric work in the second essay. Special thanks also go to Prof. Martha Starr for writing letters on my behalf, and to the AU College of Arts and Sciences for a dissertation fellowship.

At this point, I would like to acknowledge the role of two women in my life—my mother (Bimala) and my wife (Sarita). Quite simply, they are my rock. I would also note constant inspiration from my father, brother, sister-in-law, and two beautiful nieces. Finally, this acknowledgement would be incomplete without thanking all those hard working Nepalese workers, especially in the Gulf States, whose contributions have sustained the economy in perhaps the most perilous time in the nation's history.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

EXCHANGE RATE MISALIGNMENT IN NEPAL

1.1 Introduction

Exchange-rate management in Nepal started only in the 1960s following the establishment of the central bank in the late 1950s. The immediate concern for the central bank was to mandate the use of the domestic currency throughout the country, which until then was dominated by the use of the Indian rupee for all practical purposes. It is quite striking that, by 1957, the shares of deposit and credit denominated in the Indian rupee in the total portfolio of the only commercial bank at the time had reached 72.9 percent and 81.1 percent, respectively.

Soon after its inception, Nepal's central bank announced a series of reform measures targeted at carrying out an orderly currency substitution. As a policy decision, the central bank announced a fixed parity of 1.6 Nepalese rupees (NPR) per Indian rupee (INR), and allowed unlimited convertibility of the Indian rupee at this rate. It also started quoting exchange rates for some major convertible currencies. Since then, the exchange-rate regime has evolved from a managed peg to a peg based on a basket of currencies and then, after a brief period, to the current peg with the Indian rupee.[1] The current nominal exchange rate peg stands at 1.6

[1] The International Monetary Fund (IMF) has placed Nepal's exchange-rate regime into the "other conventional fixed peg arrangement." *Source*: http://www.imf.org/external/np/mfd/er/2008/eng/0408.htm

NPR/INR.

The centrality of the exchange rate with India is rooted deeply in Nepal's historical ties with its southern neighbor. Nepal shares an open border with India that extends more than 1400 kms (almost 900 miles) along its eastern, southern, and western sides. The treaty to keep the border open allows for the easy flow of labor and capital. India is Nepal's dominant trading partner, accounting for more than 50 percent of its total trade for a long time. Exports and imports from India averaged about 59 and 52 percent of the respective totals from 2000 to 2008. Despite easy access to the huge market to its south, Nepal hasn't been able to improve its export performance with India so far. It suffers from a perennial trade deficit with India and has a progressively worsening overall trade balance in goods and services (see figures 1.1 and 1.2). Nepal's trade deficit (goods and services) deteriorated from 9 percent to 21 percent of GDP between 2000 and 2009. Meanwhile, remittances grew from 2 to 23 percent of GDP in the same period. As a reliable source of funds, Nepal's external balance and macroeconomic stability depend vitally on foreign-currency reserves built from remittances. The upward trend in the current account since the mid-1990s seen in figure 1.2 reflects the growing contribution of remittances in maintaining a favorable current account position.

Maskay (2000) outlines four distinct periods in the exchange-rate history of Nepal, pertaining to different exchange-rate regimes and the corresponding domestic economic environment.[2] The common feature during different policy regimes has been the authorities' attempts to intervene in the market to adjust parity with the Indian rupee when faced with persistent misalignment. In figure 1.3, the plot of the NPR/INR exchange rate for nearly five decades shows mainly stable periods with occasional changes in parity. Since 1960, the nominal exchange rate has ranged between near 1.0 and 1.7.

---

[2] These periods can be characterized as a) a relatively stable pegged exchange-rate regime (1960–73); b) anomaly in pegged regime (1973–83); c) managing a basket of currencies (1983–92); and d) a brief period of dual exchange rate and the current pegged regime (1992/93–present).

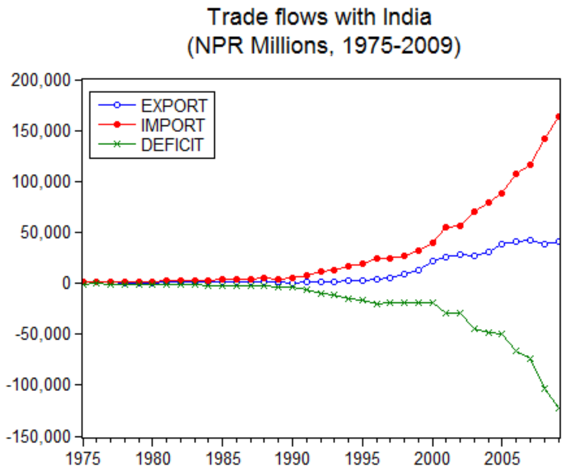

Figure 1.1: Trade with India
(*Source*: Nepal Rastra Bank)

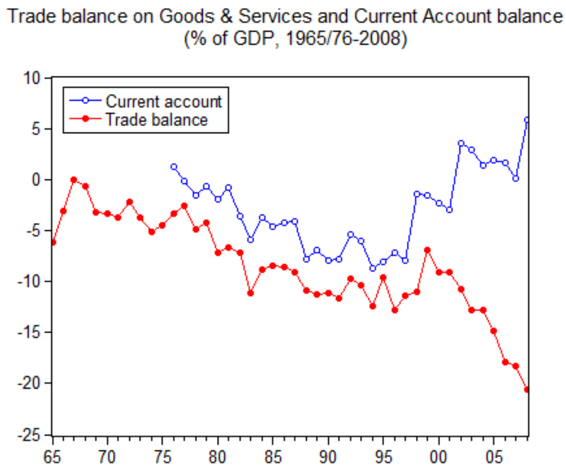

Figure 1.2: Overall Trade and Current Account Balance
(*Source*: World Development Indicators)

In regard to its goal of exchange-rate stability, Nepal's central bank has performed reasonably well. It has relied on its reserve of convertible currencies to meet the demand for Indian rupees. This has helped to mitigate pressures on the exchange rate. Furthermore, by pegging the domestic currency, the central bank has managed to keep Nepal's inflation close to that in India. For a long time, this pol-

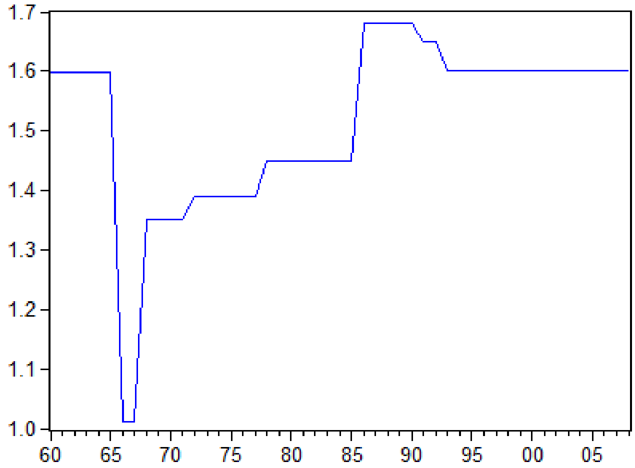

Figure 1.3: Annual NPR/INR Exchange Rate, 1960–2009
(*Source*: Nepal Rastra Bank)

icy has been viewed a success since inflation is relatively better managed in a big economy. As shown in figure 1.4, the two CPIs track very well, and the inflation differential is not very large and is stationary.

Nevertheless, as noted earlier, Nepal has a large deficit in its external sector, mainly in trade in goods and services. The overall trade balance is on a long-term decline. A large and persistent imbalance in the trade account can be seen as indicative of possible misalignment in the real exchange rate. In this chapter, I estimate

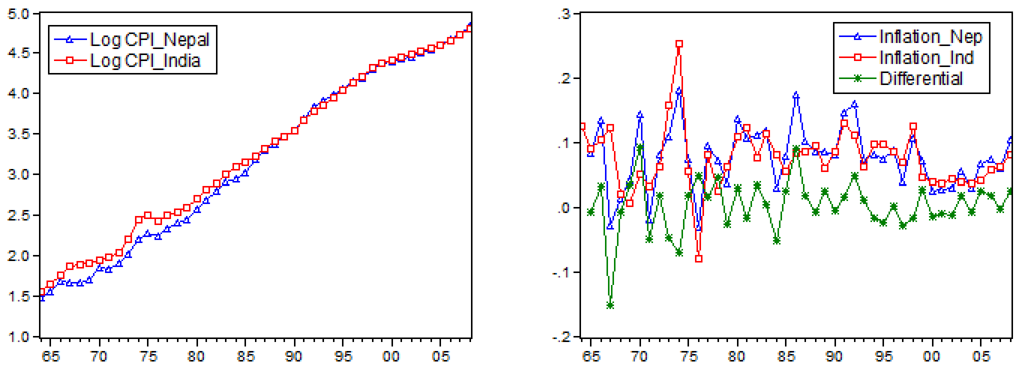

Figure 1.4: Annual Log CPIs, Inflation, and the Inflation Differential, 1965–2008
(*Source*: International Financial Statistics)

Nepal's behavioral equilibrium exchange rate (BEER) with the aim of further investigating the possibility of exchange-rate misalignment. Clark and MacDonald (1998) first proposed the BEER model, which is an extension of earlier studies that seek to explain changes in the real exchange rate using some fundamental variables. The idea is to empirically establish a long-run relationship between the real exchange rate and the fundamentals, which would then provide a baseline estimate of the equilibrium exchange rate that can be used to measure the degree of misalignment in the actual real exchange rate.

The remainder of the chapter is organized as follows. Section 1.2 begins with a definition of exchange-rate misalignment, followed by an explanation of the BEER approach. I also present a discussion of the fundamentals driving the real exchange rate and a brief literature review in that context. In section 1.3, the properties of the data set and and the estimation techniques to be used are discussed. Section 1.5 presents the results from an error correction model, bounds tests, and VAR estimates; concluding remarks are given in section 1.6.

1.2 Exchange Rate Misalignment

This section begins with a general discussion of exchange-rate misalignment and a review of the proposed method for estimating the equilibrium exchange rate. The case for possible misalignment in Nepal is also briefly discussed.

1.2.1 Definition

Quite simply, exchange-rate misalignment means that a nation's currency is either under or overvalued. It is under (over) valued when it is more depreciated (appreciated) than its "ideal" value. The ideal is some measure of equilibrium, which is perhaps a steady-state level towards which the exchange rate tends to converge. The equilibrium, in turn, is the level of the real exchange rate that is consistent with the goals of internal and external balance. Internal balance is achieved with equilibrium in the goods and labor markets, i.e., full capacity (potential) output and full employment at a given level of the capital stock. External balance requires a nation to have a sustainable current account given its desired capital position, as a net lender or borrower. Thus, the definition makes it clear that any misalignment of the real exchange rate can induce structural imbalances in the economy. Conversely, structural imbalances can also result in misalignment of the real exchange rate.

As a policy tool, the exchange rate can address the two policy goals only under certain conditions. In small developing countries, policymakers may wish to keep the exchange rate mildly undervalued in order to help the export sector, which in turn can benefit the nation by expanding output while also helping to maintain a sound current-account balance. Yet it must also be noted that achieving two goals simultaneously with a single policy instrument is often quite challenging, if not impossible. First, it is difficult, in practice, to identify a desired level of equilibrium exchange rate given changing conditions. Second, it requires an active role on part of the central bank to monitor and intervene in the market as and when required. Any impact of such intervention—sterilized or unsterilized—must be analyzed in terms of consequences for the broader economy.

In an open economy, national income is given by the sum of total consumption, investment, and net exports:

$$Y \equiv C + G + I + (X - M), \tag{1.1}$$

which implies

$$S - I \equiv X - M. \tag{1.2}$$

A nation in balanced trade has total national savings (S) equal to domestic investment (I).[3] A deficit (surplus) country has less (more) savings than investment,

[3] Total national savings (S) equals private savings plus the government surplus, which is tax receipts (T) net of government expenditure (G): $S = S_{private} + T - G$.

necessitating a capital inflow (outflow) from (to) its trading partners. Changes in the exchange rate is often viewed as necessary for correcting these imbalances.

Nepal has a perennial trade deficit with India and in general since the 1960s (see figure 1.2). Average GDP per capita growth during 2000 to 2008 was 1.83 percent, while the per capita growth rate has never exceeded 6.9 percent (see figure 1.5). In India, the average GDP per capita growth during the same period was 5.47 percent. Based on the fact that the economy is growing slowly, as well as the large trade deficit, the case for overvaluation of the real exchange rate is a logical possibility.

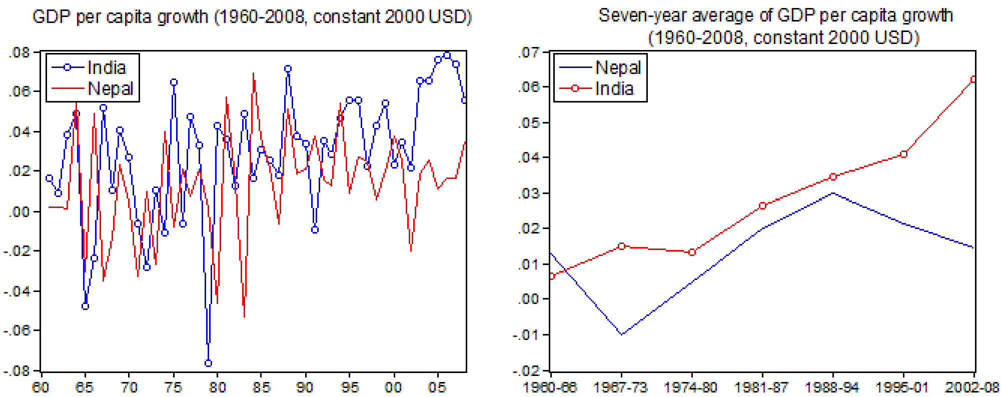

Figure 1.5: Annual and Seven-year Average of Real GDP per Capita Growth
(*Source*: World Development Indicators)

1.2.2 Measurement: Bilateral Real Exchange Rate and Multilateral Real Effective Exchange Rate

The bilateral real exchange rate (RER) is defined simply as the price of a consumption/production basket in the home country (d) relative to the foreign country (f), measured in the same currency. An expenditure-based bilateral real exchange rate can be defined as:

$$q = E\frac{CPI^d}{CPI^f}, \tag{1.3}$$

where E is the nominal exchange rate (say, USD/NPR, i.e., in foreign currency units) multiplied by the ratio of domestic to foreign consumer price indexes (CPI).[4] A multilateral RER is an index which takes into account the exchange rates of a

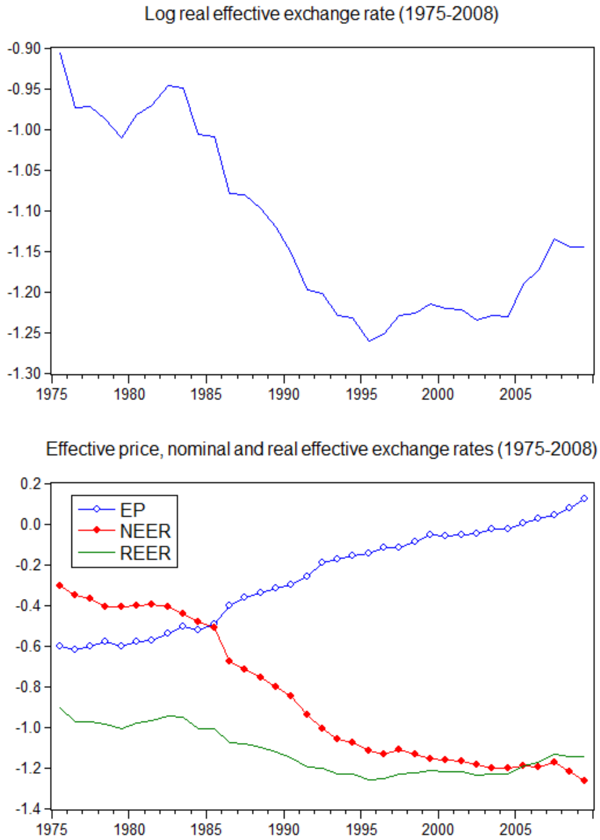

Figure 1.6: Nepal's Real Effective Exchange Rate and its Components
(*Source*: IFS and Nepal Rastra Bank)

nation with its various trading partners. Formally, it is a geometrically-weighted

[4] A rise here is an appreciation of the domestic currency.

average of the bilateral real exchange rates using trade shares as weights:[5]

$$q_t^{REER} \equiv \sum_{j=1}^{n} w_j q_t^j, \tag{1.4}$$

where q_t^j is the (log) real exchange rate relative to country j at time t and w_j is the trade share with country j in total trade. The RER or REER is calculated using a measure of prices such as the CPI or PPI/WPI. The top panel in figure 1.6 shows Nepal's real effective exchange rate, based on trade-weighted bilateral exchange rates with its top 8 trading partners. Table 1.1 shows Nepal's trade shares used in this study. Nepal's real effective exchange rate depreciated markedly until the mid-1990s. The next ten years show relative stability, followed by a sharp rise beginning around 2004–5. The bottom panel in figure 1.6 shows the components of the real effective exchange rate—the nominal effective exchange rate (NEER) and the effective price (EP).[6] It is clear that the decline in the real effective exchange rate is largely due to the decline in the nominal effective exchange rate. Nepal's price performance, on the other hand, has clearly worsened over time as evidenced by the rising effective price.

1.2.3 Equilibrium Exchange Rate: The BEER Approach

There are several approaches to estimating the equilibrium exchange rate. The first one and perhaps the most commonly used is based on purchasing power parity (PPP). Assuming the law of one price, no significant arbitrage opportunity, and the absence of impediments to international trade, a strict version of PPP requires

---

[5]See Chinn (2006). Different measures of trade share are discussed in the literature. Leahy (1998) presents a nice illustration on constructing an index for overall trade competitiveness in the US. The author demonstrates a weighting scheme based on the competition between U.S. goods and foreign goods in the domestic market, foreign market, and the third-country market where both home and foreign goods compete. Similarly, Zanello and Desruelle (1997) account for sectoral competition in addition to the competition in domestic and foreign markets. Their competitiveness index is a weighted average of trade in manufacturing, non-oil primary commodities, and tourism services.

[6]NEER is simply the trade weighted log nominal exchange rates, while the effective price is trade weighted logarithm of the ratio of domestic to foreign prices.

Table 1.1: Nepal's Average Trade Share (1981–2009)

Country	Trade share(%)	Country	Trade share(%)
India	33	Germany	8.5
US	8	Japan	8
Singapore	6	Thailand	3
UK	3	France	2

the real exchange rate to be unity. Since these assumptions generally do not hold, a mean reverting real exchange rate is generally accepted as a sign that a relative version of PPP holds. However, many empirical investigation have found persistence in deviations of the real exchange rate, and a non-stationary real exchange rate is the basis for further investigation of the equilibrium exchange rate.[7] Some researchers have also used monetary models to investigate the determinants of prices. These are generally considered an extension of the PPP approach.

A slightly different way is to decompose the real exchange rate into permanent and transitory components, where the former represents the equilibrium exchange rate. The Beveridge-Nelson decomposition of the real exchange rate is one such example. Similarly, structural vector autoregression (SVAR) technique can also be used to extract shocks that can explain movements in the real exchange rate.

McDonald (2000) argues that the internal-external balance approach may be the best way to estimate the equilibrium exchange rate, especially when PPP deviations are recognized. In this case, the equilibrium exchange rate is assumed to satisfy both internal and external balance. Internal balance is represented by the non-accelerating inflation rate of unemployment (NAIRU), while the external balance is achieved when the net savings generated at this output level is equal to the

[7]In this study, the real effective exchange rate was found to be non-stationary, and therefore the PPP approach was deemed not suitable for analyzing the equilibrium exchange rate. More details are offered in section 1.4.

current-account balance. Cline (2008) uses a similar approach to define the fundamental equilibrium exchange rate (FEER). A fair amount of normative assessment is applied to determine the equilibrium. This study applies one of the commonly used methods of estimating the equilibrium exchange rate, which is discussed in detail.

The BEER method is essentially an extension of a single-equation, fundamentals-based approach (Edwards, 1988). The main assumption in all fundamentals-based approaches is that the real exchange rate is an endogenous macroeconomic variable, and that its non-stationary behavior is attributed to non-stationary fundamentals. In the BEER approach, the real exchange rate is influenced by long-run variables, medium-term determinants, and short-run shocks. Clark and MacDonald (1998) first proposed the model, which is presented here in its entirety with some additions from MacDonald and Dias (2007). A reduced form expression of the determinants of the REER can be written as:

$$q_t = \beta_1' Z_{1t} + \beta_2' Z_{2t} + \tau' T_t + \varepsilon_t, \tag{1.5}$$

where Z_{1t} represents a set of economic fundamentals that are expected to have long-run persistent effects on the equilibrium real exchange rate, Z_{2t} is a set of fundamentals that affect the real exchange rate over the medium term (i.e., over the business cycle), T_t is a set of variables with transitory, or short-run, effects, β_1', β_2', and τ' are vectors of reduced-form coefficients, and ε_t is the random error term.[8]

The current misalignment, cm_t, is defined as the sum of transitory variables and the random error term. In other words, the current misalignment represents the

[8] In the short run, expansionary fiscal and monetary policies lead to an appreciation of the equilibrium RER, especially if they have inflationary impact such as when the economy is operating near its potential. In the long run, a deterioration in the terms of trade (TOT) and a fall in capital inflows leads to a depreciation of the equilibrium RER, while higher import tariffs and trade restrictions can lead to appreciation. Empirically, different authors have identified the dynamics of the RER in terms of monetary and real variables, where short-run changes respond to both nominal and real disturbances, while long-run changes are induced only by real variables.

difference between the actual real exchange rate and the real exchange rate given by the current value of all fundamentals. First, define the real exchange rate given by the current value, q'_t, of the fundamentals

$$q'_t = \beta'_1 Z_{1t} + \beta'_2 Z_{2t}, \tag{1.6}$$

$$cm_t = q_t - q'_t = \tau' T_t + \varepsilon_t. \tag{1.7}$$

Clark and MacDonald argue that the current value of these fundamentals may deviate from their long-run levels. The idea is to emphasize calibration of fundamentals at the level consistent with the goals of internal and external balance, comparable to the definition under the FEER.[9] With fundamentals at their long-run levels, we can now define total misalignment, tm_t, as the difference between the actual real exchange rate and the real exchange rate based on the long-run levels of these fundamentals

$$tm_t = q_t - \bar{q}_t = q_t - \beta'_1 \bar{Z}_{1t} - \beta'_2 \bar{Z}_{2t}. \tag{1.8}$$

Adding and subtracting q'_t on the right hand side and replacing for the value of fundamentals, we get

$$\begin{aligned} tm_t &= (q_t - q'_t) - \beta'_1 \bar{Z}_{1t} - \beta'_2 \bar{Z}_{2t} + \beta'_1 Z_{1t} + \beta'_2 Z_{2t} \\ &= \tau' T_t + \varepsilon_t + [\beta'_1 (Z_{1t} - \bar{Z}_{1t}) + \beta'_2 (Z_{2t} - \bar{Z}_{2t})]. \end{aligned} \tag{1.9}$$

Therefore, the total misalignment at any point in time can be factored into effects due to transitory components, the random error, and the degree to which the fundamentals deviate from their long-run levels.

MacDonald and Dias (2007) suggest that the BEER is a very general approach

[9] Empirically, MacDonald and Dias (2007) suggest using the Hodrick-Prescott filtered trend series as the proxy for long-run value of these fundamentals. They also point that selecting long-run values involves some subjective evaluation. Others have used a five-year moving average of the fundamentals as the proxy for long-run value.

to estimating the equilibrium exchange rate, one that is not based on any specific model of exchange-rate determination. Nonetheless, there are some key ideas used to explain the BEER approach. The following presentation draws heavily from their paper. They begin with a risk-adjusted real interest parity relationship as shown in equation 1.10[10]

$$\Delta q^e_{t+k} = -(r^e_{t,t+k} - r^{*e}_{t,t+k}) + \lambda_t, \tag{1.10}$$

where Δq^e_{t+k} is the difference between the real exchange rate expected at time t for the period $t+k$ ($q^e_{t,t+k}$) and the observed real exchange rate at time t (q_t).[11] Similarly, $r^e_{t,t+k}$ is the expected real interest rate at home between t and $t+k$ and an asterisk denotes the same for the foreign country. Furthermore, λ_t is the measure of the time-varying risk-premium, which is assumed to be a function of the relative supplies of domestic- and foreign-government debt

$$\lambda_t = g(gdebt/gdebt^*). \tag{1.11}$$

An increase in the relative supply of outstanding domestic to foreign debt increases the risk premium, thereby necessitating a fall in the current equilibrium exchange

[10] The variables in the following expressions are the nominal exchange rate (E), home and foreign nominal interest rates (i_t, i^*_t), expected inflation at home and abroad ($\Delta P^e_{t+k}, \Delta P^{*e}_{t+k}$), and the risk premium (π_t), which has a time-varying component (λ_t) and a fixed component (κ). Δ is the first difference operator and the superscript 'e' is the conditional expectations operator of the variables

$$\begin{aligned} \Delta E^e_{t+k} &= -(i_t - i^*_t) + \pi_t; \pi_t = \lambda_t + \kappa, \\ \Delta E^e_{t+k} - \Delta P^e_{t+k} + \Delta P^{*e}_{t+k} &= -(i_t - i^*_t - \Delta P^e_{t+k} + \Delta P^{*e}_{t+k}) + \lambda_t, \\ \Delta q^e_{t+k} &= -[(i_t - \Delta P^e_{t+k}) - (i^*_t - \Delta P^{*e}_{t+k})] + \lambda_t, \\ &= -(r^e_{t,t+K} - r^{*e}_{t,t+k}) + \lambda_t. \end{aligned}$$

[11] Again, since the nominal exchange rate is defined as units of foreign currency per unit of home currency, a rise is an appreciation of the home currency.

rate. Now, equation 1.10 can also be written as follows

$$q_t = q^e_{t,t+k} + (r^e_{t,t+k} - r^{*e}_{t,t+k}) - \lambda_t. \quad (1.12)$$

If $q^e_{t,t+k}$ is interpreted as the long-run component of the real exchange rate, it can be assumed to take the fundamentals-driven value of the real exchange rate, so that

$$q_t = \bar{q}_t + (r^e_{t,t+k} - r^{*e}_{t,t+k}) - \lambda_t. \quad (1.13)$$

In order to determine $\bar{q}_t$, the following long-run equilibrium exchange-rate condition, which suggests a balanced current account, is used[12]

$$ca_t = tb_t + r^*_t nfa_t = 0, \quad (1.14)$$

$$tb_t = -r^*_t nfa_t. \quad (1.15)$$

In simpler terms, the current account (ca_t) is the sum of the trade balance (tb_t) and interest (r^*_t) earned on outstanding net foreign assets (nfa_t). As such, any deficit or surplus on the trade account is matched by net borrowing or lending from abroad. The trade balance and exchange rate are inversely related, which suggests that, in a steady state, a larger trade deficit implies greater depreciation. This is seen in equation 1.16. Also, in equation 1.16, x_t represents other factors determining the real exchange rate. The trade balance is replaced by $r^*_t nfa_t$ in equation 1.17. As

[12]Note that the zero balance in the current account is a restrictive condition. An alternative to this equilibrium is the idea of a sustainable current account. The literature on current-account sustainability points to a stable external debt to GDP ratio as one such indicator of current-account balance. Milesi-Ferretti et al. (1996) further clarifies by arguing that debt exposure should be considered in conjunction with exchange-rate policy, structural factors such as the degree of openness, the levels of saving and investment, and the health of the financial system. They also point out that the external debt plus interest expressed as a ratio of exports is a better indicator than debt as a ratio of GDP.

seen, the real exchange rate is increasing in nfa_t[13]

$$q_t = -\alpha tb_t + \beta x_t, \tag{1.16}$$

$$q_t = \alpha' r_t^* nfa_t + \beta x_t. \tag{1.17}$$

The empirical estimation of the BEER in MacDonald and Dias (2007) is based on the following equation[14]

$$q_t = f(\overset{-}{tb_t}, \overset{+}{tot_t}, \overset{+/-}{prod_t}, \overset{+}{r'_t}), \tag{1.18}$$

where tb_t is the trade balance (net exports) as a proportion of GDP, tot_t is the terms of trade differential, $prod_t$ is the difference in per capita real GDP, and r'_t is the real interest differential.[15] Before deciding on the fundamental variables for this study, table 1.2 presents a summary of variables used in some previous studies.

As shown in table 1.2, the key variables represent a combination of economic fundamentals and policy variables. It is also recognized that the appropriate variables must reflect the specific context of each nation. Moreover, there are limitations on the availability of quality data or proxies for the desired variables, especially in developing nations like Nepal. With this in mind, I turn to a brief discussion of the potential variables for this study. I propose the following tentative model for analyzing Nepal's REER:

$$q = f(prod, tb, gdebt, m1, rem), \tag{1.19}$$

where *prod* is the per capita real GDP differential between Nepal and its trad-

---

[13] As the income identity ($S - I \equiv X - M$) suggests, nfa_t is driven by domestic savings and investment, which are further determined by demographics and the structural fiscal balance.

[14] Clark and MacDonald and others use equation 1.17 to estimate the equilibrium exchange rate.

[15] Expected partial effects are shown as +/- in the equation.

Table 1.2: Some BEER Studies and the Fundamental Variables

Authors	**Estimated Equation/Currency**	**Variables**
Clark and MacDonald (1999)	$q = f$(RID, gdebt/gdebt*, tot, tnt, nfa); Currencies studied: Japanese Yen, German Mark and the US Dollar	Real interest differential (RID), relative stock of government debt, terms of trade as effective ratio, relative price of nontraded to traded (tnt) goods (ratio of domestic CPI to WPI/PPI relative to equivalent foreign ratio), net foreign assets (nfa) as a ratio of GNP
Komárek and Melecký (2007)	Czech Koruna	Productivity differential (GDP to employment), RID, tot, net FDI, nfa, government consumption, and trade openness
Iimi (2006)	Botswana (Pula)	RID, terms of trade, relative price of nontraded to trade goods, nfa, government debt ratio
Loukoianova and Iossifov (2007)	Ghana (Cedi)	Real GDP per capita (PPP) relative to trading partners, terms of trade, fiscal stance, trade openness, nfa of the banking system

ing partners, *tb* represents Nepal's overall trade balance (goods and services) as a proportion of GDP, *gdebt* is the relative government debt supplies at home and in foreign countries, $m1$ is the relative money supplies at home and in foreign countries, and *rem* is remittances.

The size of remittances has grown significantly in recent years. Remittances accounted for about 1 to 2 percent of GDP in the 1990s. By 2008, they reached 21.7 percent. Thus, it is timely to incorporate the possible effects of remittances on the real exchange rate.[16] Equation 1.19 does not include the terms of trade or the relative price of nontraded-to-traded (*tnt*) goods due to unavailability of the

[16]Moreover, the IMF country report on Nepal published in June 2010 also notes remittances as a significant variable in explaining changes in the real exchange rate.

necessary data.[17] Similarly, relevant real interest rate data are also not available. Since Nepal has maintained capital account restrictions, the role of interest rates may be less important in terms of capital flows. However, the open border creates a possibility of capital flows, especially when significant arbitrage opportunity exists. For the purpose of this study, it seems appropriate to include the differential of real money supplies in order to capture a possible demand-induced (monetary policy) effect on the real exchange rate.

At this point, it is appropriate to explain the hypothesized impact of some of the variables included in equation 1.19. They are intended to capture the demand and supply effects on the exchange rate. One long-run, supply-side variable is the productivity measure. In the literature, the supply side effect—according to the Balassa-Samuelson (BS) hypothesis (Balassa 1964; Samuelson 1964)—is considered important in explaining the changes in the real exchange rate. The BS hypothesis suggests that richer countries tend to have higher price levels and therefore appreciated currencies. The traded and non-traded goods sectors differ in terms of productivity. The traded goods sector has higher productivity and higher wages, while labor mobility across sectors induces higher wages in the non-traded sector, thereby raising the overall price level. It is, therefore, predicted that a country with rapid productivity growth will experience rapid inflation and a secularly appreciating long-run real exchange rate. Empirical testing of the BS effect is limited due to data unavailability, especially in developing countries. A crude proxy of the productivity measure commonly used is the growth rate of real per capita GDP, which is also used in this study.

The trade balance (tb) is the another fundamental variable in equation 1.19. Several researchers (see table 1.2) have used net foreign assets to represent a long-term balance on the current account. It seems that the use of net foreign assets is driven by the need to have a sustainable external balance, which in turn is required

[17] The WPI series needed to construct tnt is available only from 2000.

for macroeconomic stability. This is perhaps of a greater concern in economies with open capital account, which allows for unrestricted capital flows. In countries with capital-account restrictions like Nepal, the long-term sustainability of its external sector is contingent upon the performance of its exports sector. Using the trade balance offers a possibility for observing the connection between the export sector, domestic production, and employment with the policy variable. In this context, it is natural to expect that the exchange rate serves goals toward both the external and internal balances, first by making exports competitive, which in turn aids domestic production/employment.

Next, remittances can have several competing effects in the economy. First, if the remittance flow is treated as an exogenous increase in household income, it can raise aggregate spending.[18] If this spending falls more on the non-tradable sector of the economy, that can lead to inflation in that sector followed by overall inflation and, therefore, appreciation of the real exchange rate. However, if the spending increases imports, it can lead to exchange-rate depreciation. Alternatively, if increases in income translate into increases in savings, then an exchange-rate appreciation can result. Remittances also increase the money/credit base of the economy. In a growing economy, this will likely have effects similar to foreign direct investment (FDI), i.e., to increase the productive capacity of the economy by bridging the investment need. Improvement in the savings-investment gap implies improving trade balance and, hence, an appreciating exchange rate. Yet if the absorptive capacity is low in the economy then the rapid inflow of capital leads to overvaluation, through appreciation or rapid growth in consumption. Prasad et al. (2007) note that some non-industrial countries suffer from exchange-rate appreciation following huge capital inflows, either through direct appreciation of the nominal exchange rate, or through inflation if the reserve inflows are not sterilized. A comparable

---

[18] This is likely to be the case since migrant workers are typically poor and therefore likely to have a high marginal propensity to consume.

effect could also result from large remittances.

1.3 Preliminary Data Analysis

1.3.1 Data Description

The variables used in this study include Nepal's real effective exchange rate and the set of fundamentals identified in equation 1.19. Only annual data for the period 1975–2008 are used due to limited data availability. In the VAR analysis of import- and export-demand equations, I use quarterly and monthly data starting in 1981, which is the earliest period for which higher frequency trade-flows data are available. Table 1.3 presents brief definitions of the variables and explains their construction.[19] Most of the variables are constructed to show Nepal's position vis-à-vis its trading partners. In addition, there is a detailed discussion of the variables included in the estimation of the import- and export-demand equations in the appendix to this chapter.

1.3.2 Unit-root Tests

One test for the presence of a unit root in a time series y_t is based on the augmented Dickey-Fuller (ADF) regression:

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \tag{1.20}$$

where the null hypothesis is $\gamma = 0$ and failing to reject the null implies the existence of a unit root in the series. The ADF test assuming no trend in the series, i.e., $a_2 = 0$, is presented with the notation 'c' under test type, while the test results that include both a constant and a trend are presented with the notation '$c + t$.' The generic form of equation 1.20 is also the basis for other specific tests. First, in the Dickey-Fuller with GLS trending (DFGLS) test, the original series is transformed via a generalized least squares (GLS) regression before running the test. Studies have

[19] See the appendix for sources and other details on the data.

Table 1.3: Variable Construction

Variables	Names	Description
LREER	Real effective exchange rate	$\prod_{i\neq j}\left(\frac{P_iS_i}{P_jS_j}\right)^{\omega_{ij}}$ where P_i, S_i are the home price (CPI) level and the nominal exchange rate in USD terms. Similarly, P_j, S_j are trading partner's price and the exchange rate in USD terms. ω_{ij} is the trade share of country i with j in its total trade. In this construction, any upward movement is an appreciation. The geometric average is transformed to a logarithmic average weighted by respective trade shares. All price levels are based on 2005 = 100.
LPROD	Relative productivity	$\log\left(\frac{GDPPC_i}{\sum_{i\neq j}^{n}\omega_{ij}GDPPC_j}\right)$ where GDPPC is GDP per capita at home (i) and trading partners (j).
RDEBT	Relative govt. debt	$\frac{Debt_i/GDP_i}{\sum_{i\neq j}^{n}\omega_{ij}Debt_j/GDP_j}$ where Debt is the net claim on the central government normalized by nominal GDP.
TBG	Trade balance	$\frac{TB_i}{GDP_i}$ where TB_i is Nepal's overall trade balance measured relative to its GDP.
M1DA	Money-supply differential	$\log\left(\frac{M1_i/GDP_i}{\sum_{i\neq j}^{n}\omega_{ij}M1_j/GDP_j}\right)$ where M1 is the money supply (narrow money in most cases) relative to GDP.
LREM	Remittances	log(Rem) where Rem is the remittances flow denominated in convertible currencies (mainly in the dollar and the euro).

shown that this test has more power to reject the null of a unit root in the series when in fact there is no unit root than the ADF test. Second, the Philip-Perron test is a non-parametric test for a unit root, in which the test statistic is modified so that serial correlation does not affect its asymptotic distribution. In both the DFGLS and Philip-Perron tests, the null hypothesis is the presence of a unit root in the series. Finally, the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) test is different from the previous ones and is considered a complementary test. KPSS assumes that the series is stationary around a deterministic trend. The null for the test is that the series is stationary.

Results from different unit-root tests are presented in table 1.4. These results suggest that the null of a unit root cannot be rejected for most of the variables. A few of them indicate so at a higher significance level (1 percent). In general, it is safe to conclude that all of the variables are integrated of order one, I(1), at 1

Table 1.4: Various Unit-root Test Results (1975-2008)

Variable	Test type	ADF Null:Uroot	DFGLS Null:Uroot	PP Null:Uroot	KPSS Null:Stationary
LREER	c	-1.41	-0.91	-1.95	0.54**
	c + t	-0.23	-1.58	-0.52	0.17**
LPROD	c	-3.42**	-1.29	-4.12***	0.52**
	c + t	-2.85	-2.1	-2.88	0.17**
RDEBT	c	-3.11**	-1.55	-3.1**	0.18
	c + t	-2.85	-1.97	-2.95	0.18**
TBG	c	-0.39	0.45	-0.006	0.64**
	c + t	-1.9	-2.15	-2.01	0.09
M1DA	c	-3.2**	-1.19	-3.33**	0.29
	c + t	-2.64	-2.06	-2.57	0.19**
LREM	c	1.01	0.81	-3.32**	0.64**
	c + t	-1.97	-1.97	-1.97	0.18**

[a] Lag selection for DFGLS is based on the Schwartz information criterion (SC).
[b] The DFGLS test statistics is valid in the case of a minimum sample size of 50. It may, therefore, not be useful other than complementary to remaining tests. Here, the DFGLS test does not contradict results from other tests.
[c] Significance levels: ***1 percent, ** 5 percent, and * 10 percent

percent significance level.[20]

In the appendix to this chapter, figure A.1 shows plots of Nepal's REER and the fundamentals. Some variables show a pattern of a trend while others do not. The trade balance and remittances show long-term trending behavior. Importantly, the dependent variable, the real effective exchange rate, shows a downward trend. Closer scrutiny, however, suggests otherwise. First, it appears that the variable is stationary during 1975-85 and from 1995 onwards except for the uptick after 2005. There is evidence of a downward trend from the mid-1980s to the mid-1990s. In the ADF test, the coefficient γ in equation 1.20 is statistically insignificant in both the trend only and the trend plus a constant cases. This suggests that the variable is not a deterministic series but rather a random walk.[21] It is then reasonable to assume

[20] This conclusion can be drawn based on the observation that the null of a unit root can not be rejected for the level of the variables, but it can be rejected in their first difference.

[21] And the null is rejected in the first difference of the series.

no trending behavior in the series. The remaining variables—relative productivity, relative debt supplies, and relative money supplies—do not show evidence of a trend for most periods, although some wild fluctuations are apparent.

1.4 Estimation Methods

There are two techniques used to estimate the equilibrium exchange rate. First, since the variables are found to be non-stationary, there is the possibility of long-run relationships among them. Moreover, macro variables often evolve simultaneously with the possibility of contemporaneous and/or lagged feedbacks. Under these circumstances, the choice for estimation is between a system-based approach of cointegrated-VAR models and single-equation estimation. Here, I first consider the Johansen (1988) cointegration test to identify the number of equilibrium (cointegrating) relationships. This is then followed by estimating the vector error correction model (VECM) to capture the short- and long-run dynamics. While the Johansen method is suitable to capture the endogenous effects and is considered superior to the Engle-Granger two-step method, it is nonetheless found to underperform in small samples and also suffers from pre-testing requirements. Therefore, as an alternative approach, I also consider the Pesaran, Shin, and Smith (2001) single-equation based bounds-testing approach to cointegration. A brief discussion of the two techniques is presented below. The methodological approach used in estimating the import- and export-demand equations is also discussed.

1.4.1 Cointegrated-VAR Models

The basic motivation behind adopting a cointegrating relationship is that there are some inter-related dynamics in the data generating process such that non-stationary variables have a stable relationship in the long run. In other words, some linear combination of I(1) variables may produce a stable relationship that is deemed stationary, I(0). The Johansen procedure can be summarized beginning with a reduced form VAR of order p

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + B x_t + u_t, \tag{1.21}$$

where y_t is a k-vector of I(1) variables, x_t is an n-vector deterministic trend, and u_t is a vector of i.i.d. shocks. The above VAR can also be written in a VECM form

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + B x_t + u_t, \tag{1.22}$$

where $\Pi = \sum_{i=1}^{p} (A_i - I)$ and $\Gamma_i = -\sum_{j=t+1}^{p} A_j$. The rank of the Π matrix indicates the presence of one or more cointegrating relationships.[22] If Π has reduced rank $r < k$, then there exist $k \times r$ matrices α and β such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is stationary. The rank (r) of the Π matrix is the cointegration rank, which suggests r linear combinations of y_t that are stationary and each column of β represents the cointegrating vector (the equilibrium relationship). Each cointegrating vector enters the k equations of the VAR. The α matrix represents the adjustment parameter, i.e., the direction and speed with which the endogenous variables respond to a disequilibrium in the cointegrating relationship. The Γ_i matrix captures the short-run dynamic adjustments. Equation 1.22 is estimated using maximum likelihood.

1.4.2 Bounds-testing Approach

Macroeconomic data are sometimes available only for relatively short time spans. In this study, there are only 34 annual observations. It then becomes necessary to avoid overparameterization and allow enough degrees of freedom to obtain efficient estimation. The bounds-testing approach by Pesaran et al. (2001) offers this possibility and suggests a parsimonious model based on a single equation. Moreover, their method is free of the pre-testing requirements of the Johansen method.

[22] The number of cointegrating relationships is identified by two tests, namely, the trace test and the maximum eigenvalue test (Johansen 1988, 1992).

Here, the variables can be either I(0), I(1), or fractionally integrated. Nevertheless, a major limitation of this method is that it cannot account for endogenous effects as in a system of equations. The authors propose the following model within the traditional autoregressive distributed lag (ARDL) framework

$$\Delta y_t = \beta_0 + \beta_1 t + \pi_{yy} y_{t-1} + \boldsymbol{\pi}_{yx,x} \mathbf{x}_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta y_{t-1} + \sum_{j=0}^{q} \phi_j' \Delta \mathbf{x}_{t-j} + \theta w_t + u_t, \quad (1.23)$$

where Δy_t is the dependent variable, t represents the time trend, $\mathbf{x}_t$ is a vector of regressors, and w_t represents exogenous components such as dummy variables.

The authors propose a bounds test based on standard F- and t- statistics to test the existence of a lagged-level relationship in equation 1.23. They argue that the asymptotic distributions of these tests are nonstandard under the hypothesis of no level relationship. Therefore, they offer two sets of asymptotic critical values, which they call the upper, I(1), and lower, I(0), bounds. If the calculated F-statistic exceeds the upper-bound F-critical value, then the null (H_0: $\pi_{yy} = \pi_{yx,x} = 0'$) of no level relationship can be rejected, which suggests that the variables are jointly integrated of order one, and is therefore evidence of the existence of a level (cointegrating) relationship. The null cannot be rejected if the calculated F-statistic is less than the lower-bound critical value. If the calculated value lies in-between, then the order of integration needs to be determined. The critical value differs based on different assumptions regarding the trend, constant, and the number of regressors in the equation. It is also important to include adequate numbers of lags in estimating the equation. However, as suggested by the authors, once the existence of a level relationship is confirmed, a more parsimonious model can be adopted. Equation 1.23 is estimated using OLS.

1.4.3 Import- and Export-demand Equations

A key fundamental variable used in explaining the equilibrium exchange rate is the trade balance. The conventional approach to establish a relationship between the trade balance and the exchange rate is to directly estimate the effects of the exchange rate on the trade balance (or trade flows). Therefore, in order to complement the investigation of the equilibrium exchange rate, I will also estimate the import- and export-demand equations to see if Nepal's trade flows (imports and exports) respond to changes in the real effective exchange rate, using higher frequency data—mainly quarterly and monthly series. In doing so, it is also possible to study the impact of exchange-rate volatility on trade flows. This is particularly relevant since 1993, when India liberalized its exchange-rate regime and opened up to volatility in the international currency market. By maintaining a pegged regime with India, Nepal has implicitly opened itself up to this exchange-rate volatility. Simple import- and export-demand equations, augmented with a volatility term, are useful for analyzing the impact

$$M = f(Y, PX, V), \tag{1.24}$$

$$X = f(Y^*, PX, V), \tag{1.25}$$

where M and X represent import and export volumes in real terms, Y and Y^* are home and foreign real income, PX is the real effective exchange rate, and V is the measure of exchange-rate volatility.[23] In studying German-US trade flows, McKenzie and Brooks (1997) use domestic and foreign income as well as prices in both equations. The variables in equations 1.24 and 1.25 are transformed to make them stationary, and the equations are estimated in a simple VAR framework.[24]

The use of the volatility term (V) in equations 1.24 and 1.25 has been widely discussed in the literature. In Mckenzie and Brooks, real and nominal exchange rates are used to calculate different measures of volatility. In a major study on

---

[23]In the empirical estimation, models with and without the volatility term are considered. Note also that the real effective exchange rate is defined, only in this case, in terms of domestic units.

[24]VAR is used mainly because the variables did not evidence cointegrating relationships, and an OLS regression would not have captured the dynamic effects as would a VAR model.

the topic by the international monetary fund (IMF), Clark et al. (2004) use the standard deviation of the first difference of logarithms of the exchange rate as a measure of volatility. The moving standard deviation is calculated over one- and five-year periods to capture the short- and long-run volatility. Additionally, a time-varying measure of volatility based on an ARCH/GARCH model is also considered in light of its frequent use in the literature. In this case, volatility is measured by the conditional standard deviation obtained from a GARCH(p,q) model based on the ARMA specification of the first difference of the real effective exchange rate. A GARCH(1,1) model with AR(2) specification is given as follows

$$z_t = \beta_0 + \beta_1 z_{t-1} + \beta_2 z_{t-2} + u_t, \quad u_t | I_{t-1} \sim N(0, v_t^2) \tag{1.26}$$

$$v_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \alpha_2 v_{t-1}^2, \tag{1.27}$$

where z_t is the first difference of the log real/nominal effective exchange rate, and the conditional variance (v_t^2) has a GARCH (1,1) representation.

A survey of the literature by Bahmani-Oskooee and Hegerty (2007) on the impact of volatility shows varying results. Asset prices, like the exchange rate, are prone to speculative market behavior, and the volatility in the exchange rate is often documented to have a negative impact on trade flows. The argument offered is that volatility in the exchange rate adversely influences business decisions and therefore has negative consequences on trade flows. Some other studies have found that volatility has a positive impact on trade, since there are good chances of prices turning favorable. Yet some other studies have found no significant impact of volatility on trade flows.

1.5 Econometric Results

In this section, I first present the results for the BEER model based on the Johansen cointegrated-VAR model, beginning with the maximum-eigenvalue and trace tests, followed by the VECM results—including long and short-run dynamics—and model fitness. Then, I present the BEER results from bounds testing of the long-term relationship based on single equation estimates. The final set of results is from the VAR estimates of import- and export-demand equations. I conclude the section with a discussion of the findings and analysis of the degree of misalignment using the different definitions outlined in section 1.2.

1.5.1 Cointegrated VAR

In table 1.5, a summary of different trace and maximum-eigenvalue tests is presented. These results correspond to different assumptions regarding the data behavior, with respect to using a constant and a linear trend in the equilibrium relationship. Under different formulations, only one significant cointegrating vector is found and the two tests (trace and maximum eigenvalue) do not contradict. Moreover, the results are presented at a high significance level (1 percent) to account for any bias due to small sample size. Prior to estimating the error-correction model, it is necessary to determine the appropriate number of lags to be included. Inadequate lags can mean serially correlated residuals, while unnecessary lags mean overparametrization and the possibility of non-random errors. Therefore, in the first step, an unrestricted VAR was estimated and the lag-length tests were conducted. The results are shown in table 1.6. Based on the Schwarz information criterion, only one lag is selected. Although three other tests suggest higher lag, only one is selected considering the use of annual data and the small sample size.[25]

In the next step, a VECM is estimated with a single cointegrating vector. At this point, it is important to recognize the possibility of varying results based on different assumptions regarding the trend term and a constant in the equilibrium

---

[25]Since the error-correction model is estimated in first differences, that implies a reduction of lags in the level data by one. Thus, one lag selected here is a compromise between different test results. Moreover, including higher lags in cointegration tests showed evidence of more than one (between 2 to 3) cointegrating relationships. It is well known that accounting for more than one equilibrium relationship introduces many challenges.

Table 1.5: Summary of Johansen Cointegration (RR) Test with One Lag

Data Trend:	None	None	Linear	Linear	Quadratic
Test type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	1	1	1
Max-Eig	1	1	1	1	1

[a] Five different specifications of cointegration test are based on different assumptions regarding intercept and a linear trend term, in VAR and in cointegrating equation.
[b] Test result shows number of cointegrating vector at 1 percent significance level.

Table 1.6: Lag Length Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	166.05	NA	1.32E-12	-10.33	-10.05	-10.24
1	308.79	221.01	1.41E-15	-17.21	-15.27*	-16.58
2	350.75	48.73	1.28E-15	-17.6	-13.99	-16.42
3	411.76	47.23	6.12E-16*	-19.21*	-13.94	-17.49*

relationship. It is equally important to decide on a particular choice of the two to best represent the data behavior. In the literature, there are two commonly used assumptions regarding the data behavior. These pertain to whether a trend is included or not in the cointegrating relationship (noted as "linear" under data trend in table 1.5). Yet as noted in the discussion of unit-root tests in section 1.3.2, the dependent variable (LREER) displays features of a non-stationary (random walk) series. It is then reasonable to take the no-trend case to best represent the data. In the following discussion, I will analyze the result from the VECM estimation that does not include the trend term in the cointegrating relationship. Table A.4 (in the appendix to this chapter) presents the full dynamic long- and short-run relationship. Some parts of the results are rewritten in equations 1.28 and 1.29. In addition, for reference purposes, I also briefly discuss the trend case (i.e., including both a constant and the trend term in the cointegrating relationship) to compare

Table 1.7: Different Tests on VECM Residuals

Autocorrelation (LM-test)			Normality (Joint)		Heteroskedasticity (Joint)	
Lags	LM-stat	P-val	Jarqe-Bera	P-val	Chi-sq.	P-val
2	38.12	0.37	16.71	0.16	290.11	0.55
4	27.58	0.84				
8	22.60	0.96				

and contrast the results in section 1.5.3.

Finally, a set of tests were conducted to confirm the white-noise property of the VECM residuals. A properly specified model should not contradict the assumption of white-noise behavior. Table 1.7 presents the results of different tests on the VECM residuals.[26] Based on different test results for the VECM residuals, it is safe to conclude that the model is properly specified. First, the LM statistics show the test results for the null of no autocorrelation in the residuals. At different lag levels, the test statistics suggest failure to reject the null as indicated by high p-values. Second, the Jarque-Bera statistic shows the test result for the joint normality of the residuals. At a conventional significance level, the residuals are jointly normal. Third, the result for the null of no heteroskedasticity in the residuals is shown in the chi-squared test. The high p-value suggests that heteroskedasticity is not an issue here. Finally, there is no evidence of trend movement in the cointegrating relationship in figures 1.7 and 1.8. The fluctuations in the equilibrium relationship are less prominent in figure 1.8, where the short-run effects have been removed, suggesting that the relationship is stable in the long run.

A. Long-run relationship

In equation 1.28, the cointegrating relationship between the real effective exchange

[26] Although not shown here, all AR roots lie within the unit circle, suggesting a stable system.

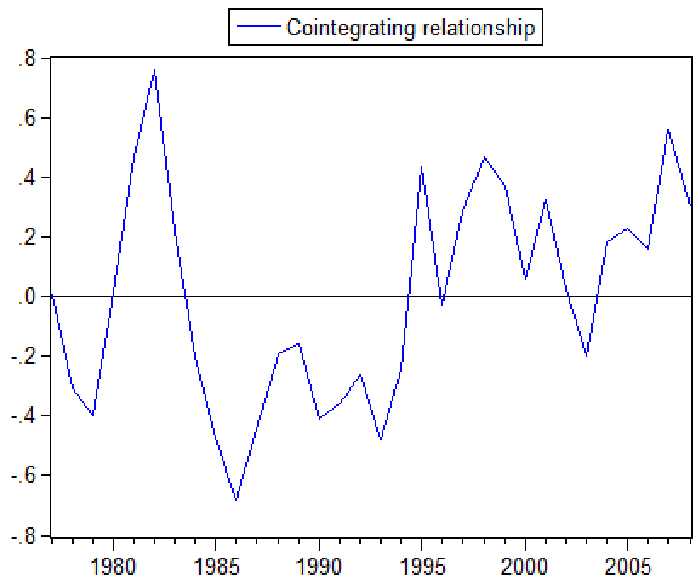

Figure 1.7: Cointegrating Relationship Based on the Johansen Estimates

Figure 1.8: Cointegrating Relationship Adjusted for the Short-run Effects

rate and the fundamentals is shown, with the standard error in parentheses

$$LREER_t = -9.7^{***} \underset{(1.55)}{-1.98LPROD_t} \underset{(0.26)}{+2.5RDEBT_t^{***}} \underset{(1.76)}{+9.38TBG_t^{***}} \underset{(0.27)}{-1.8M1DA_t^{***}} \underset{(0.02)}{+0.03LREM_t} \quad . \tag{1.28}$$

All of the variables in equation 1.28 are statistically significant except LPROD and LREM. However, government debt (RDEBT) and the trade balance (TBG) are positively signed in equation 1.28, contrary to their theoretical negative impact. In terms of the magnitude of the effects, an increase in government debt (RDEBT) of one percent of GDP relative to its trading partners results in about 2.5 percent appreciation of the REER. Clark and MacDonald (1999) also report appreciation in response to an increase in home debt supplies in Japan (about 0.13 percent) and Germany (.005 percent). In Botswana, Iimi (2006) found depreciation in response to an increase in the government's fiscal deficit, although by a very small amount (0.0013 percent). Similarly, MacDonald and Ricci (2004) found that an improvement in the fiscal balance of 1 percentage point of GDP resulted in a 2 percent depreciation of the REER in South Africa. An increase in one percent of Nepal's money supply as a percent of GDP relative to its trading partners results in about 1.8 percent depreciation of the REER in equation 1.28. The effect of remittances, although in the expected direction (i.e., appreciation), is statistically insignificant.[27] See section 1.5.3 below for further discussion of these results.

B. Weak exogeneity and short-run dynamics

In equation 1.29, the error-correction and dynamic adjustment parameters from the VECM estimation are shown

$$\begin{aligned}\Delta(LREER_t) = \quad & \underset{(0.01)}{0.06ec_{t-1}^{***}} \quad \underset{(0.17)}{-0.26\Delta(LREER_{t-1})} \quad \underset{(0.2)}{-0.16\Delta(LPROD_{t-1})} \\ & \underset{(0.04)}{-0.04\Delta(RDEBT_{t-1})} \quad \underset{(0.24)}{+0.18\Delta(TBG_{t-1})} \quad \underset{(0.04)}{-0.01\Delta(M1DA_{t-1})} \\ & \underset{(0.008)}{+0.006\Delta(LREM_{t-1})} \quad \underset{(0.004)}{-0.008.}\end{aligned} \tag{1.29}$$

The alpha parameter (coefficient on the error correction term, ec_{t-1}) is significant, but it is wrongly signed, i.e., in a disequilibrating direction. However, the size of this

[27] In a separate regression, where the remittances were expressed as a proportion of GDP, the variable turned significant with a positive sign.

Table 1.8: Bounds-test Results

Test type	F-stat	F-critical		F-critical*			Level relationship
		I(0)	I(1)	n	I(0)	I(1)	
int & no trend	9.57	2.62	3.79	30	3.1	4.61	Yes
(At 5% significance)				35	3.04	4.44	
int & no trend	9.57	3.41	4.68	30	4.54	6.37	Yes
(At 1% significance)				35	4.26	6.04	

[a] Asterisk in the fourth column indicates that the critical values control for the small sample size.

coefficient is small. And, as noted earlier, the characteristic roots of the system all lie within the unit circle suggesting that the system is stable. Next, none of the lagged difference variables is significant. This shows that the exchange rate doesn't respond to short-term changes in any fundamental variables, which is perhaps expected given Nepal's nominally pegged exchange-rate regime with India.

1.5.2 Bounds Test and Single-equation Estimates

To conduct a bounds test, equation 1.23 was estimated using an ARDL(p,q) model. In order to correctly specify the order of the model, I closely followed the standard approach and also considered additional checks. Pesaran et al. (2001) suggest that the number of lags of dependent (p) and regressors (q) can be determined by first estimating an unrestricted VAR and then selecting the appropriate lag length. Additionally, I also consider whether the selected order satisfies the white-noise behavior of the error term. Then, a parsimonious model is selected by sequentially eliminating any insignificant parameters without compromising on model specification.

As in the Johansen estimation, two different tests were conducted: a) with a constant and the regressors in the equation, and b) including a constant and the trend term along with the regressors. In equation 1.30, the chosen ARDL (1,0,0,0,0,0) model is shown for the no-trend case. The trend case result is shown in equation A.1 in the appendix to this chapter. The F-statistic for testing the hypothesis of no level relationship among the variables in equation 1.23 is compared with the critical values offered by the authors. As shown in table 1.8, the joint hypothesis that all of the level variables (lags of the dependent variable and the regressors), including the constant, in equation 1.23, are zero (i.e., no level relationship) can be rejected. Even allowing for the small sample size, the calculated F-statistic at the 1 percent significance level is greater than the upper bound critical value, allowing rejection of the null and supporting a level relationship.[28]

$$\begin{aligned}
\Delta(LREER_t) = \; & \underset{(0.06)}{0.05LREER^{***}_{t-1}} \; \underset{(0.2)}{-0.08LPROD_{t-1}} \; \underset{(0.03)}{-0.2RDEBT^{***}_{t-1}} \\
& \underset{(0.04)}{+0.08M1DA^{*}_{t-1}} \; \underset{(0.23)}{-0.57TBG^{**}_{t-1}} \; \underset{(0.004)}{-0.001LREM_{t-1}} \; \underset{(0.15)}{-0.45\Delta(LREER_{t-1})} \\
& \underset{(0.16)}{-0.35\Delta(LPROD_t)} \; \underset{(0.04)}{-0.06\Delta(RDEBT_t)} \; \underset{(0.04)}{-0.008\Delta(M1DA_t)} \\
& \underset{(0.2)}{-0.22\Delta(TBG_t)} \; \underset{(0.006)}{-0.01\Delta(LREM_t)} \; \underset{(0.74)}{-0.16}
\end{aligned} \tag{1.30}$$

$\bar{R}^2 = 0.65, n = 32$

Having shown that the level relationship exists, a parsimonious model can be selected from equation 1.30 by avoiding overparametrization. In this case, different model specification tests suggest that the equation is adequately specified. In table 1.9, test results on randomness of the bounds test residuals are shown. All of the tests suggest that the model is properly specified, and there is no information left in the residuals. With this, the final cointegrating relationship can be derived by setting the difference terms in equation 1.30 to zero and solving for the coefficients of the regressors. The resulting long-run relationship is presented in equation 1.31, and the error-correction form of the model is given in equation 1.32.[29]

---

[28] Since the exact critical value for the sample size of 34 is not available, the two sets of available critical values are shown, for n = 30 and 35.

[29] The ec_{t-1} in equation 1.32 is derived from equation 1.31. OLS was used to estimate the equation.

Table 1.9: Different Tests on Bounds Test Residuals

Autocorrelation (LM-test)			Normality (Joint)		Heteroskedasticity (Joint)	
Lags	LM-stat Breusch-Godfrey	P-val	Jarqe-Bera	P-val	F-stat. Bresuch-Pagan-Godfrey	P-val
2	1.46	0.26	2.16	0.34	0.87	0.59
4	1.09	0.4				
8	0.87	0.57				

$$LREER_t = 3.2 + 1.6LPROD_t + 4.14RDEBT_t + 11.4TBG_t - 1.6M1DA_t + 0.02LREM_t \tag{1.31}$$

$$\Delta(LREER_t) = \underset{(0.006)}{0.05ec^{***}_{t-1}} \underset{(0.12)}{-0.45\Delta(LREER^{***}_{t-1})} \underset{(0.12)}{-0.35\Delta(LPROD^{***}_t)} \underset{(0.03)}{-0.06\Delta(RDEBT^{*}_t)} \underset{(0.02)}{-0.01\Delta(M1DA_t)} \underset{(0.15)}{-0.21\Delta(TBG_t)} \underset{(0.005)}{-0.01\Delta(LREM^{**}_t)} \underset{(0.003)}{-0.002} \tag{1.32}$$

$\bar{R}^2 = 0.72, n = 32$

C. Long-run relationship and short-run dynamics

In equation 1.31, RDEBT, TBG, and M1DA are significant at the 1, 5, and 10 percent levels, respectively. The other two variables are insignificant. Further, RDEBT and TBG have different signs than predicted by theory. Generally, the magnitudes of the coefficients are higher in this case compared to the Johansen estimates, and several variables have similar signs in either estimation. More discussion on this is presented in section 1.5.3. As seen in equation 1.32, the error-correction coefficient (ec_{t-1}) has a similar magnitude and same sign as in the Johansen estimate. The coefficient is positive and significant. Moreover, some short-run variables are significant in this case.

Table 1.10: Summary of Long-run Estimates

Regressors	**Johansen results**	**Bound-test results**
LPROD	-1.98	1.6
RDEBT	2.5***	4.14***
TBG	9.38***	11.4**
M1DA	-1.8***	-1.6*
LREM	0.03	0.02***
Constant	-9.69	3.2

[a] Dependent variable: LREER
[b] *** 1%, ** 5%, * 10% significance levels

1.5.3 Discussion

To compare and contrast the Johansen and bound-test estimates, a synopsis of the results is presented in table 1.10. Since we are concerned about the equilibrium relationship, only long-run effects are compared and analyzed in light of economic reasoning. It is clear that there are some similarities in the direction of effects in the two estimates. In both estimates, the productivity variable is insignificant (although it has different signs), while government debt (RDEBT) and the trade balance both have positive coefficients and are significant. Similarly, the money supply is found to cause depreciation of the real effective exchange rate in both, while remittances cause appreciation, although the latter result is significant only in the bounds-test results. Below, I discuss some possible explanations for these effects in the context of the Nepalese economy.

The use of per capita GDP to represent productivity turned out not to yield significant estimates of the BS effect. This is not surprising since several previous studies have also reported similar findings in different countries. The use of per capita GDP was motivated by the lack of better proxy for productivity, such as a ratio of output to workers employed or the ratio of output to primary-age workers. In any case, the evidence in this study makes it difficult to determine the precise nature of the impact of a productivity variable.

Next, the standard mechanism through which an increase in government debt supplies affects the real exchange rate is by indicating a weakening fiscal situation. In theory, this raises the risk premium and necessitates a depreciation. In practice, this mechanism may not necessarily hold in the case of Nepal given its insignificant standing in the global economy, capital-account restrictions, primitive financial market, and almost no direct financing from the international financial market. Most of the foreign investment in the country is in large development projects and takes the form of equity participation. There is almost no bond- or short-term financing from the international capital markets.

In the absence of active private-market participation, the impact of increasing debt supplies can be looked upon in terms of its influence on the domestic economy. Nepal started deficit financing as early as the late 1950s. However, the pace of government involvement in the economy has increased rapidly since the 1970s. Expansionary fiscal policy can impact prices by raising domestic demand as well as imports. From a two-sector (tradeable and non-tradable goods) view of the economy, an increase in the demand for non-tradable goods will raise their prices and subsequently overall prices, which is a similar mechanism to the Balassa-Samuelson hypothesis. Expansionary fiscal policy can also increase the cost of capital (interest rate) by altering the composition of private and public investments in output. Therefore, under a nominally pegged exchange-rate regime, the impact of expansionary fiscal policy can be mainly in terms of higher inflation, which then causes appreciation of the real exchange rate.

On the other hand, expansionary monetary policy influences businesses' and households' decisions by making credit cheaper. Increasing the money supply reduces the nominal interest rate, and with inflationary expectations properly anchored, this reduces the real interest rate, resulting in a capital outflow and a real exchange rate depreciation. Although Nepal has capital-account restrictions, there still is the possibility of capital outflow, especially to India, because of the open border. Nevertheless, the standard mechanism through which the money supply affects the exchange rate in the presence of capital controls is by altering credit-availability conditions. In this case, increases in the money supply weaken the currency through expansionary effects on the economy. The negative coefficient on M1DA suggests a depreciating effect, which also reflects the conventional direction of monetary policy effects.

Yet events in Nepal, especially in the last decade, indicate some other possibilities. Monetary expansion is expected to spur public and private investments as well as boost consumption. This will likely result in inflationary pressure when the economy is running near capacity. In Nepal, with underutilization of capacity, positive benefits from expansionary monetary policy are limited by various supply-side constraints such as inadequate infrastructure, low monetization, poor investment climate, rigid labor laws, etc. Some of these problems have become more acute in the last decade. With an underperforming domestic economy, a rise in demand is satisfied through a rise in imports. The trade deficit in Nepal has remained above 10 percent of GDP since 2002, and in 2008 it reached 20 percent. With large imports from India, where prices have a systemic pressure to rise with rising productivity, Nepal can experience a real exchange-rate appreciation as a result of monetary expansion.

Next, the trade balance (TBG) is found to have a positive coefficient in both estimates. This suggests that a reduction of the trade surplus results in a depreciation of the REER. As per theory, a decline in the trade deficit requires a real depreciation of the currency in order to restore competitiveness. The long-run estimates suggest otherwise. Yet whether the depreciation will be successful in improving the trade balance will be discussed in section 1.5.4, where I present the results of estimating the export and import demand functions. Here, I present some observations based on the results so far.

As Nepal's real sector is underperforming, the excess of aggregate demand over domestic production is met through imports. As noted earlier, Nepal imports a lot from India where the economy has been growing at a faster pace for nearly two decades now. With average GDP growth in real terms in India at around 7 percent in the last decade alone, prices there have generally risen faster than in Nepal. Under a pegged exchange-rate regime, Nepal has effectively borrowed the impact of rising prices in India on its domestic prices through imports. This may be one reason as to why falling domestic production combined with increasing imports have resulted in appreciation of Nepal's REER.

In figure A.1 in the appendix to this chapter, Nepal's real effective exchange rate and the trade balance both can be seen to have overall downward trends. The two series move roughly in same direction up until mid-2000s, after which they diverge, i.e., the trade balance continues on a downward path while the exchange rate surges. Nepal has seen a worsening of its trade deficit despite a declining real effective exchange rate for most of its history. In general, there is some evidence to suggest that the exchange rate and the trade balance lack a conventional relationship, and structural impediments as well as the pegged exchange-rate policy to some degree are the likely causes.

The impact of remittances makes an interesting case since it contributes directly and indirectly to the appreciation of the REER. It affects prices in the domestic economy directly by raising consumption and also impacts on prices in the non-tradeable sector. Again, since consumption is also supported through imports, it indirectly contributes to rising prices through tradeable goods, mainly imports from India. Although correctly signed in both estimates, remittances have a significant effect only in the bounds test (ARDL) estimates.

The preceding discussion is also relevant for explaining the positive albeit small coefficient on the error-correction term in the Johansen and bounds test estimates (equations 1.29 and 1.32). A positive sign on the adjustment parameter indicates that the change in the real effective exchange rate is in a disequilibrating direction.[30]

[30] Note that this is not troublesome since the characteristic roots of the system imply conver-

For example, in equation 1.29, when the exchange rate is above equilibrium in the previous period, the adjustment in the current period takes it further away at the rate of six percent per annum. The absolute magnitude of the coefficient is very small, especially given annual data, which is an indication of the lack of adjustment in the exchange rate. Once again, this result seems to suggest the absence of any meaningful policy response or correction in the face of currency misalignment.

Before ending the section, it is worth noting the results from the trend case (i.e., the trend and a constant in the cointegrating relationship). These results are presented in table A.5 (Johansen estimate) and equation A.1 (bounds test estimates) in the appendix to this chapter. There is a great deal of contrast in this case compared to the no-trend results. Relative debt supplies, the trade balance, and the money-supply differential show completely opposite effects than in the no-trend case in both Johansen and bounds test estimates. Relative debt supplies and the trade balance now show depreciating effects, whereas they had an appreciating effect in the no-trend estimates. Similarly, the money-supply differential has a positive relationship compared to the negative effect in the no-trend case. Since the unit root tests show that the dependent variable is difference stationary and not trend stationary, however, the estimates that include a trend may be deemed less reliable. These results are therefore provided only for reference.

1.5.4 Import- and Export-demand Estimates

Only selected results from the estimation of import/export demand equations are presented. This is mainly because most of the results showed statistically insignificant effects. The estimation was attempted for two sample periods (1975–2008 and 1993–2008) using quarterly and monthly data, with different definitions of volatility, and using the volatility augmented and non-augmented equations. Prior to estimating the equations, unit root tests and a cointegration test were considered.

---

gence to the long-run equilibrium.

Although the unit root test revealed that the series were non stationary, the cointegration test (Johansen (1988)) didn't offer a clear evidence of a long-run relationship between the variables. For instance, in the case of the import-demand equation (without a volatility term) for the quarterly period (1993–2008), the import-demand equation under the assumption of no trend in the cointegrating relationship found no cointegrating vector, while with the trend assumption, the trace test suggested one cointegrating vector and the maximum eigenvalue test revealed no cointegrating vector. In several cases, a similar conflict in results was observed. Moreover, some alternative models failed to satisfy different specification tests. While keeping all these issues in mind, I present some of the best results below in equations 1.33 and 1.34.[31] In the equations, the VAR estimates of import- and export-demand equations (not including volatility) are shown for the quarterly period 1993–2008. Similarly, in figure 1.9 a set of impulse response graphs from different VAR estimations for the quarterly period 1993–2008 is shown.

$$\begin{aligned}
\Delta(M_t) = \; & \underset{(0.12)}{-0.51\Delta(M_{t-1})^{***}} \quad \underset{(0.13)}{-0.32\Delta(M_{t-2})^{**}} \quad \underset{(0.13)}{+0.08\Delta(M_{t-3})} \quad \underset{(0.13)}{+0.18\Delta(M_{t-4})} \\
& \underset{(1.15)}{+2.89\Delta(PX_{t-1})^{***}} \quad \underset{(1.05)}{+0.37\Delta(PX_{t-2})} \quad \underset{(1.07)}{-0.63\Delta(PX_{t-3})} \quad \underset{(1.07)}{+2.27\Delta(PX_{t-4})^{**}} \\
& \underset{(1.09)}{+0.83\Delta(Y_{t-1})} \quad \underset{(1.00)}{+1.91\Delta(Y_{t-2})^{*}} \quad \underset{(0.94)}{+2.04\Delta(Y_{t-3})^{**}} \quad \underset{(0.93)}{+2.75\Delta(Y_{t-4})^{***}} \\
& \underset{(0.04)}{-0.1^{***}} \\
\bar{R}^2 = 0.4, n = 64 &
\end{aligned} \tag{1.33}$$

[31] The VAR was estimated in first difference and four lags were included in the estimation. The lag selection was primarily based on lag-length criteria, but I also considered retaining lags of higher order based on statistical significance. For example, in equation 1.33, FPE (Final prediction error), AIC (Akaike information criterion), and HQ (Hannan-Quinn information criterion) suggested four lags, while SIC (Schwarz information criterion) suggested one lag. The models satisfy all residual-based tests.

$$\Delta(X_t) = \underset{(0.14)}{-0.45\Delta(X_{t-1})^{***}} \quad \underset{(0.15)}{-0.22\Delta(X_{t-2})} \quad \underset{(0.15)}{-0.1\Delta(X_{t-3})} \quad \underset{(0.14)}{+0.24\Delta(X_{t-4})^{*}}$$
$$\underset{(1.15)}{-0.47\Delta(PX_{t-1})} \quad \underset{(1.11)}{+0.07\Delta(PX_{t-2})} \quad \underset{(1.1)}{-0.52\Delta(PX_{t-3})} \quad \underset{(1.09)}{+1.72\Delta(PX_{t-4})}$$
$$\underset{(1.56)}{+0.49\Delta(Y^*_{t-1})} \quad \underset{(1.65)}{+1.33\Delta(Y^*_{t-2})} \quad \underset{(1.57)}{+0.05\Delta(Y^*_{t-3})} \quad \underset{(1.46)}{+1.35\Delta(Y^*_{t-4})}$$
$$\underset{(0.03)}{-0.03}$$
$$\bar{R}^2 = 0.26, n = 64 \tag{1.34}$$

As shown, the import equation (1.33) and the export equation (1.34) have some significant variables on the right hand side. However, these estimates are all for the post-1993 period. As such, it is clear that the exchange rate did not have any meaningful effect on trade flows for most of Nepal's history. In equation 1.33, the first and fourth lags of the REER (PX) have a positive effect on imports, while a similar impact is observed for the second and fourth lags of income (Y).[32] In the export equation 1.34, neither the REER nor the foreign income (Y^*) has any significant effect.

A comparable set of qualitative results can be seen in the impulse response graphs in figure 1.9. There are three significant responses in imports following depreciation. All three responses are in the same direction and have almost similar magnitude. Imports rise in response to depreciation and reaches their peak towards the end of the second quarter. Following a depreciation, imports rise mainly because it costs more to pay for the same amount of imports and firms are bound by their contractual obligation to carry out trade. This rise in imports is evidence toward a deteriorating trade balance. Over time, however, firms and individuals can respond to increases in costs by cutting their demand for imports. Meanwhile, it takes time to realize any gains in exports from increased competitiveness. The initial

[32]Note again that the REER used in equations 1.33, 1.34, and figure 1.9 are constructed differently from the rest of the chapter, i.e., it is expressed in domestic units which implies that an innovation in the exchange rate is a depreciation. The data on imports and exports are the nominal figures deflated by the GDP deflator.

worsening followed by the improving trade balance is termed the "J-curve" effect. In the graphs, it is clear that imports fall after an initial rise, in the next three quarters, after which the effect is insignificant. Moreover, there is no evidence of a significant impact of the REER on exports over time. This implies that the trade balance does not recover following a depreciation, and, in essence, moves in the same direction as the exchange rate. This co-movement in the same direction also corroborates the earlier finding that the real effective exchange rate is found to be positively associated with the trade balance.

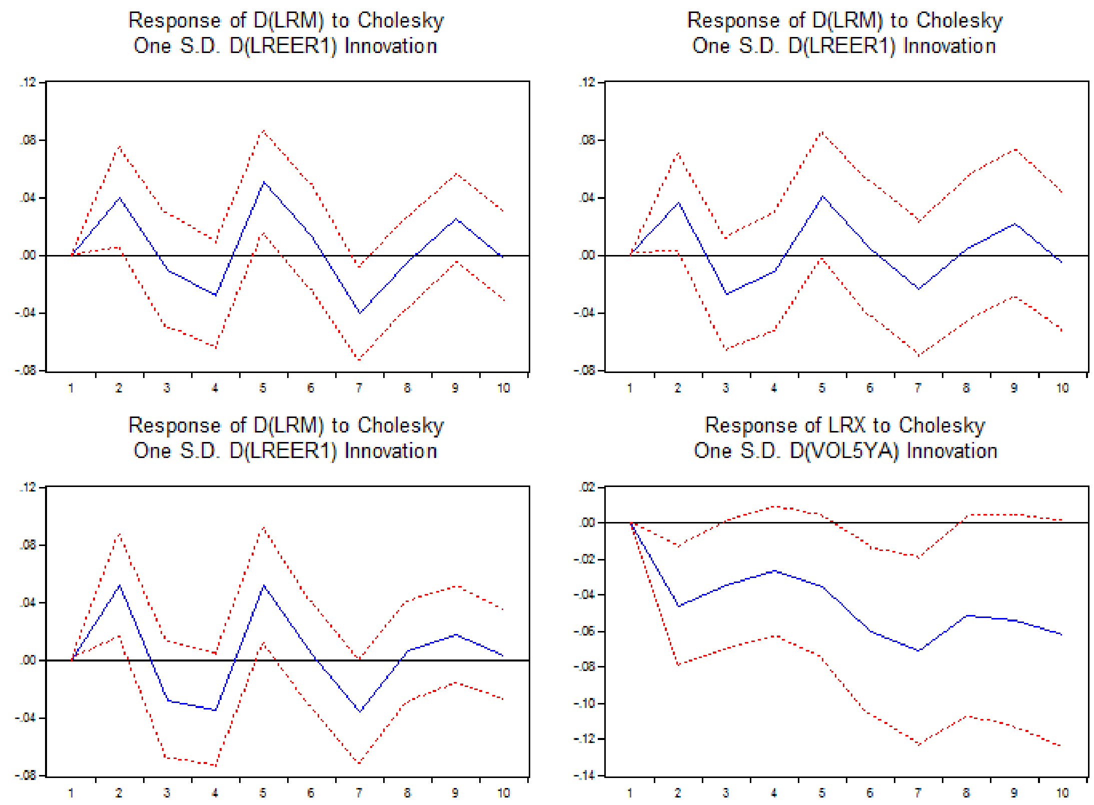

Figure 1.9: Impulse Responses from Imports and Exports Equations Using Quarterly Data for 1993-2008

a) Top left panel shows response of imports to a depreciation of the REER in a non-augmented (without volatility) import demand equation; b) Top right panel shows response of imports to a depreciation of the REER in the equation with the volatility derived from a GARCH model; c) Bottom left panel shows response of imports to a depreciation of the REER using the long-term volatility (Five-year moving standard deviation); d) Bottom right panel shows response of exports to increase in the long-term volatility.)

In order to further investigate these impacts on imports/exports, let us first consider movements in the REER. In the post-1993 period, Nepal experienced a decline in its trade-weighted nominal exchange rate, NEER, while at the same time its trade-weighted logarithm of domestic to foreign prices (effective price, EP) continued to rise. As a result, the REER was on a long-term rise. The decline in the NEER is to a large extent a reflection of movements in the Indian rupee vis-à-vis the US dollar and other major currencies. In terms of the rising effective price, there can be two possible explanations. First, price developments in Nepal are influenced by prices in India, mainly because domestic prices in the former include a large share of import prices. In the post-1993 period, India has grown faster leading to systemic upward pressure on prices. Second, as already discussed, Nepal suffers from severe supply-side constraints mainly because of political instability and a worsening business environment. This combination of events suggests that Nepal lost any advantage it could have had in terms of price competitiveness following a depreciation. Nepal's overall exports rose after the mid-1990s until the turn of the millennium. This rise is mainly attributed to increases in third country exports (other than India), while the trade deficit with India continued to slide further (see figure 1.1). In such a scenario, any gains in exports as a result of increased competitiveness via real depreciation would be transitory at best, and perhaps ineffective/inadequate to cover the widening trade deficit, especially with India.

Also, as shown in figure 1.9, exports are seen falling in response to a shock to long-term volatility, which reaches its peak towards the end of the second quarter. Volatility in this case is measured by the five-year moving standard deviation of the first difference of the real effective exchange rate. In the subsequent period, there is a recovery but the impact is declining and turns insignificant in the third quarter.

These results and the preceding discussion have important implications for policymakers. It begs to ask whether Nepal can benefit by devaluing its currency with the aim of reducing its trade gap. The evidence so far is not supportive of such a policy change. Unless Nepal can create a platform for growth oriented policies, a devaluation could have adversary effects, especially higher inflation and a worsening trade gap. Nevertheless, there is a question of how long the current situation can last before a forced exit from the current peg takes place. The fallout from the global financial crisis of 2008 showed that Nepal remains vulnerable to external shocks, especially those that lead to a drop in remittances. Lately, however, remittances have been increasing again and given that the situation in the real sector has not changed much, inflationary concerns may lead to a rethinking towards an alternative exchange-rate system.

1.5.5 Misalignment

In order to analyze the extent of misalignment, various definitions introduced in section 1.2.3 are used. First, the current misalignment (cm_t) is the difference between the observed real effective exchange rate and the estimated behaviorial equilibrium exchange rate (BEER).

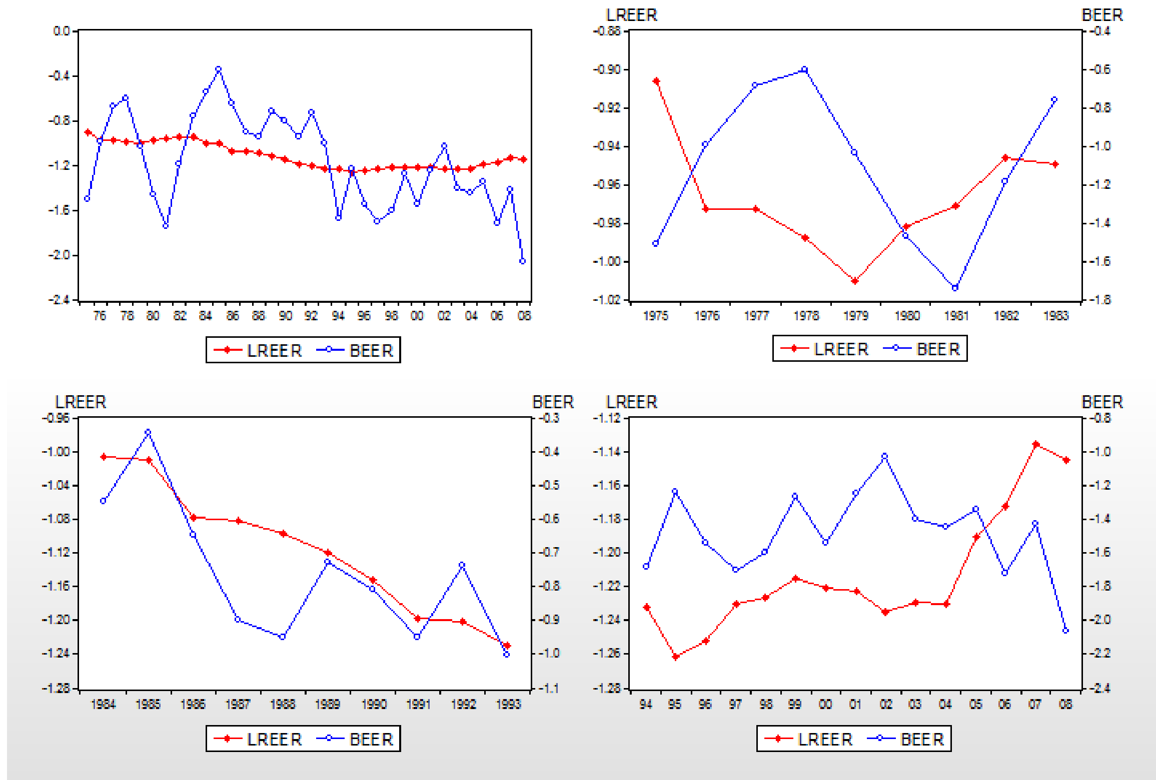

Figure 1.10: Various Graphs Depicting the Observed REER and the Estimated BEER (Without Trend) Based on the Johansen Estimates (First panel on top-left shows the two series for the full sample period, panel on top-right is for the period 1975-83, panel on bottom-left is for the period 1984-93, and the bottom-right panel covers 1994-2008. LREER is the actual series and BEER is the estimated series.)

Figure 1.10 shows plots of the REER and BEER. In the first graph (top left), the actual and estimated series are plotted on the same axis. Therefore, the difference in the two series is the current misalignment. Specifically, when the estimated series is over the actual series that implies an undervalued (or more depreciated) REER. Similarly, when the estimated series is below the actual series that implies an overvalued (or more appreciated) REER. On the remaining graphs, the two series are plotted for different time periods and are shown on different axes, so that the direction of misalignment is not clear, but a pattern of co-movement in the two series can be seen.[33] The plot of actual and estimated series in the first graph in

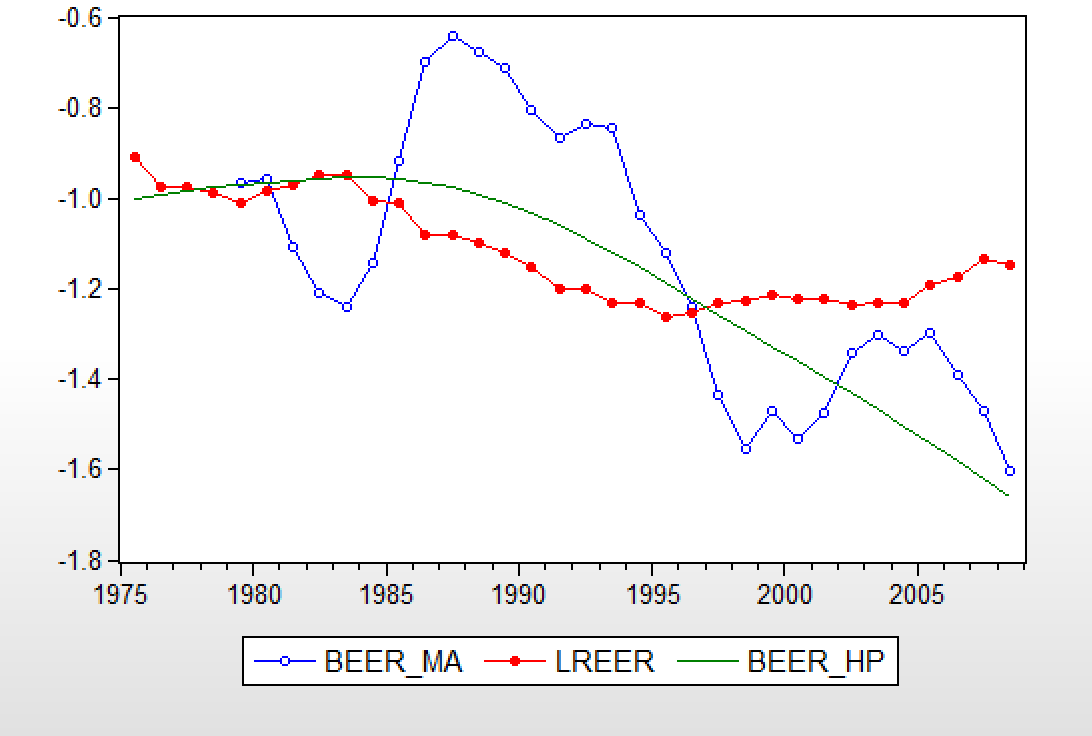

Figure 1.11: Observed REER and the Estimated BEER Series Using the Long-run (HP Filtered Series (BEER-HP) and a Five-year Moving Average (BEER-MA)) Level of the Fundamentals

Figure 1.10 reveals that the estimates of the equilibrium exchange rate fluctuate much more than the actual. This probably indicates that the current value of

[33]The plots look very similar when using estimates from the bounds test.

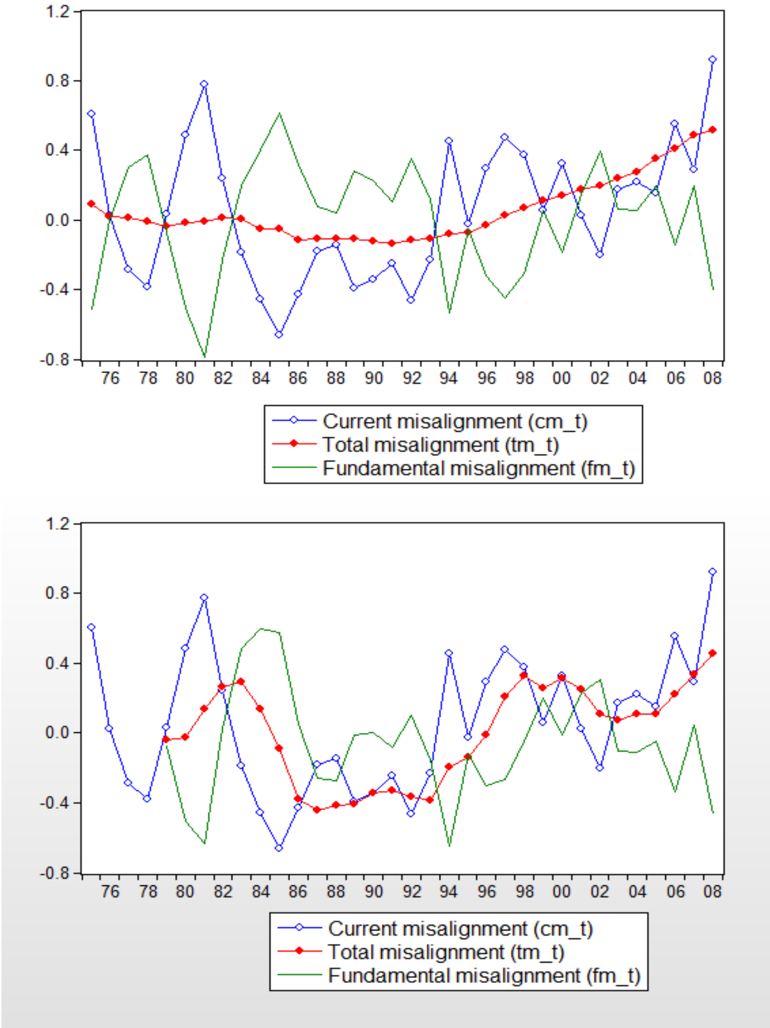

Figure 1.12: Various Components of Misalignment (Using the HP Filtered Series and the Five-year Moving Average of the Fundamentals)

the fundamentals fluctuates more than the dependent variable. As it turns out, remittances in particular have a high volatility compared to any other variables. Their standard deviation is several times that of the dependent variable, LREER, or any other fundamental variables, and this is likely inducing higher volatility in the estimated BEER series. Next, the total misalignment (tm_t) is defined as the difference between the observed real effective exchange rate and the estimated series generated using the long-run level of the fundamentals. In figure 1.11, the observed and estimated series—using the HP-filtered data on fundamentals and a five-year moving average of the fundamentals—are shown. Using the HP-filtered data produces a smooth equilibrium exchange-rate series, while using the five-year moving average yields a series with pronounced fluctuations.

Finally, in figure 1.12, misalignment in the real effective exchange rate is decomposed into effects due to transitory factors, i.e., current misalignment (cm_t), and deviations of the fundamentals from their long-run levels, i.e., fundamental misalignment (fm_t). The first panel shows this decomposition where the long-run level is identified using the HP filtered series, and the second panel shows the long run as defined by the five-year moving average of the fundamentals. In both graphs, the total and fundamental misalignments appear to mirror each other, which is because of the way the fundamental misalignment is derived (see equation 1.9). The important point is that the total misalignment has a larger contribution from the current misalignment for most of the period, although the magnitude is lesser in the first one. Moreover, in both graphs, the current misalignment appears to be the main source of overvaluation since late 1990s.[34] To analyze different patterns in misalignment, it is useful to breakdown the whole sample into different sub-periods. This is done as shown below:

- Sub-period I (1975–1983);
- Sub-period II (1984–1993); and
- Sub-period III (1994–2008).

Sub-period I (1975–1983)

This period corresponds to the top-right graph in figure 1.10. The actual real effective exchange rate fell from 1975 to 1979, after which it appreciated almost to the end. On the other hand, the estimated equilibrium exchange rate rose in the

[34] As already discussed, the current misalignment includes the impact of policy changes, among others, especially those that may have short-run effects. This finding suggests that policy changes can be useful in tackling overvaluation.

first four years then fell in the next three years, and rose again towards the end. Clearly, the magnitude of fluctuations is higher in the estimated series. The current misalignment in this period is marked by episodes of both over and undervaluation. In terms of the fundamentals, Nepal's productivity relative to its trading partners fell significantly during this period; government debt in general rose significantly, so did the relative money supplies; the trade balance in general remained increasingly in deficit; and the remittances were very low, perhaps with a negligible impact.

Sub-period II (1984–1993)

Although the estimated series rose and fell during this period, the observed series fell proportionately more. As indicated by the estimated equilibrium exchange rate, this was a period of undervaluation. The actual real exchange rate depreciated more than implied by the fundamentals. In terms of changes in the fundamentals, this sub-period differs from the earlier one in that the fluctuations were generally modest. First, productivity fell slightly compared to the earlier period, about 6 percentage points from the peak; relative government debt actually decreased in this period. While Nepal's government debt as a percentage of GDP stood at a factor of about 1.02 relative to its trading partners, in the beginning, it fell to about 0.9 by the end; the money supply rose by about 8 percentage points during its peak, which is very small compared to the 60 percentage point rise in the earlier period; the trade balance (deficit) fluctuated between 9 and 12 percent of GDP during the whole period; and remittances were increasing, albeit at a modest growth rate. In general, the combination of all these factors suggests an equilibrium exchange rate that was higher than the observed real exchange rate.

Sub-period III (1994–2008)

On the bottom-right graph in figure 10, the estimated series looks stable overall during 1994-2008, although some large swings are also seen. The actual series is less volatile but with a slight upward trend. The two series diverge after 2004–05, when the estimated series fell sharply while the actual series continued to rise. In the same figure, the top-left graph suggests that the estimated equilibrium exchange rate for most of this period lies below the actual real exchange rate. In general, this sub-period shows long episodes of an overvalued real exchange rate.

There are some contrasting observations in the fundamentals during this period and the earlier ones. Nepal's productivity didn't change in any meaningful way. The total change was about 5 percentage points, with a general decline over the period. Government debt was largely stable, with a maximum change in the ratio (Nepal's vis-à-vis its trading partners) of about 0.19. Relative money supplies rose significantly before falling even more. Nepal's money supply (as a fraction of its GDP relative to a similar fraction in its trading partners) was higher until 2001, after which it fell. The maximum change was about 24 percentage points (when its money supply was higher until 2001). After 2002, the change was about negative 13 percentage points with fall in the money supply vis-à-vis trading partners.

The trade deficit had improved to about 7 percent of GDP by 1999, but by the end of this period, the trade deficit worsened and reached a record 20 percent of GDP. In the meantime, remittances grew very significantly. Between 1995 and 2008, they grew by a factor of about 48. It is possible that the trade balance and remittances had a larger impact on the equilibrium exchange rate in this period, although the coefficient on remittances was found insignificant in the whole sample (see equation 1.28). To conclude, periods of overvaluation coincide with a worsening trade deficit, rising remittances, a combination of rise and fall in money supply, unchanging productivity, and a stable government-debt ratio.

1.6 Conclusion

This chapter investigated possible exchange-rate misalignment in Nepal by estimating the equilibrium exchange rate using the BEER approach, due to Clark and MacDonald. Nepal's current peg with India, which has not changed since 1993, and which is considered a nominal policy anchor for price stability, is believed to be the source of overvaluation of the real exchange rate. Nepal has a sustained trade deficit with India and an overall negative trade balance. However, it has not faced any major balance of payments problem mainly due to the stable foreign currency reserves built from remittances. In the aftermath of the 2008 global financial crisis, there was a slowdown in remittances, and this combined with a surge in imports led to a negative balance of payments. A credit facility of USD 40 million was approved by the IMF in July 2010, upon the government's request. While Nepal continues to maintain a peg with India at a parity equivalent to that announced in 1960, many observers believe that rapid growth in India, slow growth in Nepal, and a widening trade deficit offer a classic case of exchange rate overvaluation in Nepal. Using the real effective exchange rate and a set of fundamentals, this study offers evidence to support that conclusion, at least for the most recent period.

There are two sets of regression estimates of the equilibrium exchange rate and VAR estimates of import- and export-demand equations in this study. In the first regression, I used Nepal's real effective exchange rate and a set of fundamentals to estimate the equilibrium exchange rate using the Johansen cointegrated-VAR model. The second set of regression estimates comes from a single-equation based bounds-test approach to cointegration. VAR estimates of import and export equations were presented as complementary to the findings for the determinants of the real effective exchange rate.

In both regressions for equilibrium exchange rates, I use productivity differentials, relative debt supplies, the trade balance, the money supply differential, and remittances as the fundamental variables. The two estimates provide similar results, and the estimated equilibrium exchange rate suggests that the real effective exchange rate was overvalued in the period 1994–2008. By implication, this finding points towards the likely overvaluation of the current peg with India. The fact that the two estimations, namely the system approach (cointegrated-VAR models) and the single-equation estimations, yield qualitatively similar conclusions offers evidence that the results are robust.

The results also suggest that the period of undervaluation was accompanied by falling government debt supplies, relatively modest increase in the money supply, and a decline in the trade balance. During the period of overvaluation, debt supplies remained largely stable, the money supply rose and fell, the trade deficit worsened, and remittances increased substantially. The estimates from import- and export-demand equations suggest that imports rise following a depreciation, but there is no impact on exports. This showed that currency depreciation, when it has occurred, has not been effective for improving the trade balance. In light of these findings, it is fair to say that Nepal should consider reviewing its current peg policy, which is however less likely to bear any positive impact on the trade balance in the absence of efforts toward mitigating supply-side constraints in the economy.

CHAPTER 2

THE IMPACT OF MONETARY POLICY ON EXCHANGE MARKET PRESSURE: THE CASE OF NEPAL

2.1 Introduction

Many developing countries face a difficult task of managing the exchange-rate regime in the 21st century, especially in light of globalization, rapid technological change, and constantly evolving global economic relationships. For many countries that means not only having a market-friendly system, but also avoiding instability arising from market vulnerabilities. For instance, several emerging market economies have voiced their concern about the rush of capital inflows, which can fuel consumption, cause a real exchange-rate appreciation, and erode competitiveness. In a similar vein, many other less developed economies receive substantial inflows from remittances, which are different from capital inflows but can have similar implications. Furthermore, in countries that allow capital flows, the short-run impact on the exchange rate is strongly influenced by returns to capital, i.e., the difference between interest rates at home and abroad. In the long run, the prospect for any country to have a desired exchange-rate regime depends on the fundamentals of the economy, including trade flows, economic growth, etc.

In these countries, policymakers are confronted not only with situations evolving domestically, but they must remain vigilant with respect to external events and their ramifications. A pertinent issue in this regard is the ability of the monetary authority to maintain a desired exchange-rate system, which promotes economic stability and fosters growth. The role of monetary policy as a tool to stabilize the economy from regular boom-and-bust cycles has been widely discussed in the literature. One key issue in this regard is policy effectiveness in averting a currency collapse, or preventing the buildup of unsustainable pressure on the currency.

Girton and Roper (1977) introduced a framework that links policy variables to a measure of pressure on the currency. Their model provides a simple yet useful framework for understanding the impact and interaction of monetary policy on the exchange rate. The authors introduced the term "exchange market pressure" (EMP), which defines pressure on a domestic currency as the sum of the percentage change in the exchange rate and the percentage change in international reserves. With this definition, EMP encompasses pressure on the currency under both flexible and fixed exchange-rate regimes. EMP is also a useful indicator of a potential currency crisis. In a typical sense, a currency crisis means severe pressure to depreciate and/or a substantial loss of foreign-currency reserves, often measured by some threshold level of EMP. The focus of this chapter is on investigating whether monetary policy can mitigate or affect the pressure on Nepal's exchange rate with India.

In this context, it is necessary to note the distinction between periods when EMP reaches a tipping point, after which the currency is in a crisis stage, and periods when there is sustained pressure but the currency does not collapse. This differentiation is necessary because the policy response in these two situations can vary. In a crisis situation the conventional policy response may be inadequate. This distinction also makes it possible to study the response of policy changes in countries which are not in crisis, but face sustained pressure on their currency. According to the monetary model of EMP, this pressure results from disequilibrium in the money market. Particularly, an expansionary monetary policy increases pressure on the currency, while the tightening of money supply reduces this pressure. As such, monetary policy can have a direct impact in moderating pressure on the currency. Later studies have shown that this interaction is, however, contingent on a confluence of events and is rarely straightforward. Nevertheless, the monetary model's predictions are simple, and there is some empirical evidence in favor of the model in different countries.

In 2008, the IMF classified 68 countries, mostly developing, in the category of a conventional pegged exchange-rate system. There are several other countries which have some form of managed exchange-rate regime. Most of these countries place paramount interest in their goals toward external balance. Many countries even choose the exchange rate as the target for their monetary policy. Nepal is a case in point with its pegged exchange-rate regime (with India) as the monetary policy anchor. It has so far avoided any serious currency crisis, but continues to face unrelenting pressure on the exchange rate (NPR/INR).[1] This is primarily due to weak growth and a huge trade deficit for goods and services.

India is Nepal's dominant trading partner, accounting for more than 50 percent of its trade for a long time. Nepal's exports to and imports from India averaged about 59 and 52 percent of the respective totals from 2000 to 2008. Nepal's average GDP growth during 2000 to 2009 was 3.9 percent, while its growth rate has never exceeded 6.9 percent. In the same period, India's economy has grown by an average of 6.8 percent per year in real terms. Nepal's trade deficit (goods and services) in the same period deteriorated from 9 percent of GDP to 21 percent. Meanwhile, remittances grew from 2 to 23 percent of Nepal's GDP between 2000 and 2009. Thus, Nepal's external balance and macroeconomic stability now depend vitally on foreign currency reserves built from remittances. At the same time, remittances

[1] In chapter 1, I found evidence of overvaluation of the real exchange rate in Nepal in the period 1994–2008. NPR = Nepalese Rupee; INR = Indian Rupee

exert pressure on the domestic currency by expanding monetary conditions. By adding to the monetary base, remittances may lead to disequilibrium in the money market and thereby impact on the exchange rate.

This chapter investigates the pressure on Nepal's exchange-rate regime in a historical context, using a variant of the Girton and Roper monetary model of exchange market pressure. The goal here is to use the EMP framework to analyze whether monetary policy has any meaningful impact on Nepal's EMP. In other words, this chapter investigates if domestic credit, which the authorities can target to respond to the changing domestic economic environment as well as exogenous changes, has significant effects on the exchange rate. Using a monetary model also allows us to capture the effects of output growth.

One important feature of this study is the application of a recently developed technique in empirical estimation called impulse indicator saturation (IIS). In modeling US expenditure on food, Hendry and Mizon (2011) note that the empirical testing of a theory that is essentially "correct" may exhibit mis-specification if the data generating process is not properly modeled. Many macroeconomic data often incorporate shocks to the system arising from structural changes in the economy following events such as recessions, wars, and changes in policy regime. The authors argue that a theory can perform well in a general framework, which incorporates dynamics as well as possible outliers, breaks, and shifts in the data. The IIS technique by Hendry, Johansen, and Santos (2008) allows for these possibilities in the special case of a regression equation in which a dummy variable is added for each observation. The application of the IIS technique is useful not only in detecting structural changes in the data, but also is flexible enough to capture analytical insights when the model is complete and correct, reject the model if it is incorrect, and improve it when additional information is provided.[2] In addition to the IIS

---

[2] See also Johansen and Nielsen (2009), Santos and Oliveira (2010), and Castle, Doornik, and Hendry (2008).

technique, I also rely on generalized impulse responses using different vector autoregression (VAR) models as a sensitivity test. This alternative estimation is expected to capture possible endogenous evolution of relationships between the variables.

Using the IIS technique, I find a theory-consistent effect of monetary policy on EMP. In particular, by treating domestic credit as a monetary policy variable, I find evidence of easing pressure on the home currency following a contractionary policy. Yet the magnitude of the effect falls well short of the one-to-one effect of monetary policy on EMP as predicted by the model.

The remainder of this chapter is organized as follows. Section 2.2 begins with various definitions of EMP, followed by the derivation of the monetary model and a brief survey of the EMP literature. In section 2.3, preliminary data analysis is presented. This is followed by a brief discussion of the IIS technique, general-to-specific (GETS) modeling, and the algorithm in Autometrics in section 2.4. The identification of VAR models is also discussed. In section 2.5, the results are presented, including a comparison of OLS and IIS estimates, results from multiple structural breaks test, a forecast evaluation, and an economic interpretation of the findings. Finally, some concluding remarks are given in section 2.6.

2.2 Review of the EMP Literature

2.2.1 Various EMP Definitions

The first generation of EMP models, starting with Girton and Roper's monetary model, used the combination of the percentage change in the exchange rate and the change in international reserves scaled by base money as the indicator of pressure on the currency. By using the monetary model in a two-country setting, the authors derived an EMP indicator, which is especially applicable in countries with some kind of managed exchange-rate regime.[3] Intuitively, the model suggests that disequilibrium in the domestic money market can be restored through some combination of

[3] The original Girton-Roper model is derived in the appendix to this chapter.

currency appreciation/depreciation and international reserves inflow/outflow.

The next generation of the EMP model was based on the parameters derived from a structural model of the economy proposed first by Weymark (1995, 1998). The author presented an index to measure EMP that includes a combination of the exchange-rate changes, ΔE_t, and the change in international reserves (scaled by base money), ΔR_t. In addition, it also includes an elasticity component as shown below

$$EMP_t = \Delta E_t + \eta \Delta R_t, \tag{2.1}$$

where $\eta = -\dfrac{\partial \Delta E_t}{\partial \Delta R_t}$ is derived from a structural model that allows for deviation of the exchange rate from purchasing power parity (PPP), and incorporates uncovered interest-rate parity, money market equilibrium, and the foreign-reserve response function. As both of these definitions depend on the derivation of parameters, they are generally termed model dependent in the literature.

Critiquing the linear weighting scheme in the monetary model, Eichengreen, Rose, and Wyplosz (1994) proposed a model-free estimate of EMP. Unlike the equal weights assigned to the exchange-rate changes and the changes in international reserves in the Girton-Roper model, a weighting scheme is developed that equalizes the variance of the components of EMP. As such, the weights are independent of any structural relationship. In this case, EMP also includes the change in the interest-rate differential (home and foreign)

$$EMP_t = \Delta E_t + \eta_1 \Delta R_t + \eta_2 \Delta I_t, \tag{2.2}$$

$$\eta_1 = \sqrt{\frac{var\Delta E_t}{var\Delta R_t}} \quad \text{and} \quad \eta_2 = \sqrt{\frac{var\Delta E_t}{var\Delta I_t}}$$

where ΔR_t and ΔI_t represent the differential in reserves and interest rates. The idea behind equalizing the variance is to smooth out the different degrees of volatility in each component so that neither dominates the EMP index.[4]

EMP thus calculated has been used to analyze policy changes leading up to and after crises, especially to study speculative attacks on a currency. The use of the interest-rate differential in the above formulation is relevant in open economies, where the authorities try to defend mounting pressure on the currency, inter alia, by adjusting the interest rate.[5] In Nepal, the monetary authorities have tried to keep interest rates above India's with the aim of preventing capital flight. Even with capital controls, the open border presents a challenge to the authorities, especially when the arbitrage opportunity is significant. Thus, the interest-rate changes are designed to complement the explicit policy of targeting the exchange rate. It is therefore reasonable to include the interest-rate differential to capture the effects on the domestic currency of the possible divergence in returns on capital in Nepal and India. In the appendix, a list of different versions of EMP, which are used mainly in the context of currency crisis, is presented.

2.2.2 A Variant of the Girton and Roper Model

Girton and Roper used conventional money demand and supply functions as well as purchasing power parity (PPP) to derive a monetary model of EMP. A variant of the original model is adopted here following Connolly and Da Silveria (1979), Kim (1985), Bahmani-Oskooee and Shiva (1998), Stavárek and Dohnal (2009), and many others.

The first component of the model is money demand, which is a stable function

[4]The authors note that, in their sample, the conditional volatility of the percentage change in reserves is several times that of the percentage change in the exchange rate, which in turn is several times the percentage change in the interest-rate differential. In later studies, several authors reported similar observations and have since adopted the volatility-equalizing approach.

[5]One of the basic tenets of modern finance is the interest-rate parity relationship, which predicts the direction of movement in the exchange rate based on the interest-rate differential, at home and abroad.

of real income (Y_t) and the price level (P_t)

$$M_t^d = kP_tY_t, \tag{2.3}$$

where k is a constant and represents the fraction of income that firms and households desire to hold as money balance. The money supply, M_t^s, is the product of the money multiplier (m_t) and the monetary base ($B_t = R_t + D_t$)

$$\begin{aligned} M_t^s &= m_tB_t \\ &= m_t(R_t + D_t). \end{aligned} \tag{2.4}$$

The monetary base is backed by the aggregate stock of foreign assets, R_t, and domestic credit, D_t.[6]

Two assumptions are needed at this point. First, the money market is assumed to be in continuous equilibrium. Second, PPP holds[7]

$$M_t^d = M_t^s, \tag{2.5}$$

$$P_t = E_tP_t^f. \tag{2.6}$$

Combining equations 2.3-2.6 gives the following expression

$$kE_tP_t^fY_t = m_t(R_t + D_t). \tag{2.7}$$

[6] The link between the monetary base and the stock of foreign assets plus domestic credit can be illustrated using the basic definition of central bank's balance sheet. Liabilities of the central bank are the outstanding currency in the economy and the deposits of the commercial banks. Proceeds from these are invested in various financial assets, foreign-exchange reserves, and gold. In the above definition of the monetary base, the liability side of the central bank is replaced by its asset holding.

Assets	Liabilities
Financial assets	Currency
Foreign-exchange reserves	Deposits of the commercial banks
Gold	

[7] The nominal exchange rate (E_t) is expressed as units of home currency per unit of foreign currency.

Taking the logarithm of both sides and then the time derivative yields

$$\frac{\dot{E}_t}{E_t} + \frac{\dot{P}_t^f}{P_t^f} + \frac{\dot{Y}_t}{Y_t} = \frac{\dot{m}_t}{m_t} + \frac{\dot{R}_t}{R_t + D_t} + \frac{\dot{D}_t}{R_t + D_t}.$$

Re-define the variables as follows:

- $e_t = \frac{\dot{E}_t}{E_t}$ is the percentage change in the exchange rate;
- $rsv_t = \frac{\dot{R}_t}{R_t + D_t}$ is the change in foreign reserves as a proportion of the monetary base;
- $dc_t = \frac{\dot{D}_t}{R_t + D_t}$ is the change in domestic credit as a proportion of the monetary base;
- $mm_t = \frac{\dot{m}_t}{m_t}$ is the rate of the change of the money multiplier;
- $p_t^f = \frac{\dot{P}_t^f}{P_t^f}$ is the percentage change in the foreign price level; and
- $y_t = \frac{\dot{Y}_t}{Y_t}$ is the percentage change in real income.

Rewriting the equilibrium in growth rate form yields the following expressions

$$\begin{aligned} e_t + p_t^f + y_t &= mm_t + rsv_t + dc_t, \\ rsv_t - e_t &= -dc_t - mm_t + p_t^f + y_t. \end{aligned} \tag{2.8}$$

To consistently apply the notation of EMP, equation 2.8 is rewritten as[8]

$$e_t - rsv_t = dc_t + mm_t - p_t^f - y_t. \tag{2.9}$$

Here, rsv_t represents the percentage change in foreign-currency reserves and e_t is the percentage change in the NPR/INR exchange rate. The foreign price is that of India. As derived, a rise in the left-hand side of equation (2.9) suggests rising

[8]Some authors have also added the term $q = \frac{e}{rsv}$ to the right hand side of equation (2.8) to see if pressure is absorbed through the exchange rate and/or reserves. Connolly and Da Silveira (1979) include $q = \frac{e-1}{rsv-1}$ on the right hand side.

pressure to depreciate the home currency.

The model suggests that an increase in domestic credit (dc_t), ceteris paribus, will result in a loss of foreign-currency reserves when the exchange rate is fixed (i.e., $e_t = 0$), and in exchange-rate depreciation under a fully flexible system (i.e., $rsv_t = 0$). Clearly, the case of Nepal for the period of this study, is that of a managed-peg regime, and therefore, an expansionary policy will result in either reserve losses, depreciation, or a combination of both. The monetary model predicts that domestic credit and the money multiplier will have a coefficient of one. Similarly, increases in domestic income or higher inflation in the foreign country will result in either appreciation of the home currency and/or increases in foreign reserves.

However, Garcia and Malet (2005) point out that the relationship between domestic credit and EMP may not be straightforward. They argue that while restrictive credit policy will reduce pressure against the domestic currency, it can at the same time be adverse to economic growth. A decline in growth can in turn bring pressure against the domestic currency. Furthermore, the policy response in large part depends upon the growth prospects of the economy. In a growing economy, a policy change is closely linked with the state of the economy, which makes a case for possible interaction of variables.

2.2.3 A Brief Review of the Girton-Roper Type EMP Model

As noted above, EMP has been used as an indicator of pressure on the currency by many researchers for different purposes. After the Girton-Roper paper, several authors tried to use their model, or variants thereof, to analyze the interaction of monetary policy and EMP. The model has been widely used in countries with pegged or managed-peg type exchange-rate regimes. Even with some strong assumptions (such as PPP and the quantity theory of money), there is general empirical support for the predictions of the Girton-Roper type monetary model. The two key issues consistently discussed in the literature are: a) the use of domestic credit as a policy variable; and b) the appropriate estimation technique.

First, the domestic credit component of the monetary base is an important channel through which monetary policy operates.[9] In the literature, there are two channels through which monetary policy affects economic activities. The standard approach, also known as the "money view," entails changing the short-term interest rate or money supply, to alter the credit availability conditions. Similarly, in times of financial stress, the central bank can directly inject liquidity into the banking system with the intention of increasing the credit supply. There is another channel through which monetary policy can have broader effects on the economy. This is the so-called "credit view."[10] The credit view is premised on the possible existence of a gap between the external and internal sources of financing for borrowers. A change in monetary policy can affect this gap.

There are two ways through which the credit channel operates. First, a policy change, for example a contractionary one, can increase the external finance premium for some borrowers, especially those with low net worth. This can lead to decreases in business investment and household consumption. Second, a similar policy change reduces retail deposits as well as drains reserves from the financial institutions (banks). This in turn can induce banks to respond by lowering lending (i.e., reduce credit supply) to businesses and households. In Nepal, remittances add an interesting dimension to policy change and its intended effects since it has direct effects on credit/money base of the economy. A policy change, therefore, has to not only anticipate the possible trajectory of remittances but also incorporate its effects

[9]There are variations in the use of domestic credit to represent the monetary-policy stance. In Connolly and Da Silveria (1979), the authors derive domestic credit by subtracting the rate of change in foreign reserves from the rate of growth of the money supply. Some other studies (e.g., Kaminsky and Reinhart (1999)) use a broader measure such as the monetary aggregates, while others use narrow money or even the monetary base (e.g., Tanner (2000, 2002)). In this study, considering the importance of remittances to the whole economy, outstanding net domestic claims on all depository institutions is considered in deriving a measure of domestic credit. This measure of domestic credit is expected to incorporate primarily policy changes, but it will also account for the effects of remittances (received through banking channels) on credit flows.

[10]See Hubbard (1995).

on the channels (money and credit) through which monetary policy operates in the economy.

By using domestic credit to represent monetary stance, it is possible to accommodate some of the effects of policy changes as just discussed. Moreover, using domestic credit allows one to capture the possible endogenous relationship with EMP during a financial crisis. In fact, some studies have shown that the authorities were successful in relaxing monetary conditions by increasing domestic credit in response to higher EMP. Tanner (2000, 2002) argues that although the interest rate reflects the ex ante policy stance, domestic credit indicates if monetary policy has been tight or loose ex post. The author also proposes using the interest-rate differential, in addition to domestic credit, to more fully incorporate policy changes and their impact. A lower marginal rate can induce capital flight from a country and result in reserve losses. In several papers that use EMP to study currency crisis, researchers have augmented EMP with an interest-rate differential term.[11]

The original Girton-Roper model and the modified version presented earlier have been widely tested to establish the static relationship between the variables. Many of the papers did not consider dynamic effects and also used the OLS technique, in spite of possible endogeneity especially between foreign reserves and domestic credit. Some papers have used two-stage least squares (2SLS), while others have used maximum likelihood, to address endogeneity. Several other papers have used VAR models to account for dynamic effects and the endogenous relationships between the variables. Although the VAR identification is a matter of concern, this has been dealt with either by altering the ordering of the variables or by using the generalized impulse response, which permits order-invariant identification. Tanner (2000, 2002), in this regard, points out that the VAR formulation allows one to detect if monetary policy affects EMP in the direction prescribed by theory, while allowing for endogenous relationships, without being too concerned about the parameter

[11] See table B.1 in the appendix to this chapter.

estimates. In the structural model of Weymark (1995, 1998), similar estimation techniques were used including 2SLS and 3SLS. In tables 2.1 and 2.2, a survey of empirical studies of the monetary model of EMP, especially the Girton-Roper type and its variants, is presented.

To the best of my knowledge, there are no previous applications of the EMP model to Nepal in the literature. However, there are two studies on Nepal on related topics that have some relevance for this study. Ginting (2007) found that price developments in Nepal were affected by Indian prices. Nepal's core inflation converges with India's core inflation, and the duration of pass-through is about 7-8 months. In an earlier study on the correct currency anchor for Nepal, Yelten (2004) found that import prices in Nepal were solely determined by the Indian currency area, and that fluctuations in third currencies (dollar/rupee, euro/rupee) did not lead to inflationary or deflationary pressures in Nepalese import prices. Although it is questionable whether import prices are completely determined in India, since the study considers only a small sample of monthly observations (2001:01–2003:05) and uses the import goods component of the wholesale price index, it nevertheless gives credence to the argument that traded goods prices may have a big role in overall price determination in Nepal.

2.3 Preliminary Data Analysis

2.3.1 Data Description

I rely primarily on quarterly data (1975Q1–2009Q4) for the empirical analysis. Except for the data on output, all other series are available on a quarterly basis. Real GDP is available only in annual series. Further, there is no industrial production data to proxy output. Therefore, I apply linear interpolation in levels of real GDP to generate the quarterly output series from annual data.[12]

[12] There are minor differences in the data due to modified interpretation by the IMF over time. Similarly, small difference exists due to data source (i.e., between Nepal's central bank and the IMF).

Table 2.1: Survey of Studies Based on the Monetary Model of EMP

Authors	EMP model	Estimation	Result
Girton and Roper (1977)	Monetary approach to EMP (Canada)	OLS	Domestic credit is significant and has correct sign. Other variables are also significant and have predicted effects.
Connolly and Silveira (1979)	Variant of the G-R model (Brazil)	OLS	Variables are significant and have correct signs.
Hodgson and Schneck (1981)	Monetary approach (European countries)	2SLS	Domestic credit has correct sign in all countries, but other variables have low significance and different signs than predicted.
Kim (1985)	Variant of the G-R model (Korea)	OLS	Domestic credit and real wage income have correct signs, but foreign inflation is insignificant.
Wohar and Lee (1992)	G-R model (Japan)	OLS	Generally supportive of the predictive effects. A restricted version has lower significance for different variables.
Shiva and Bahmani-Oskooee (1998)	Modified G-R model (Iran)	OLS	Domestic credit and the money multiplier have correct signs and are significant. Foreign inflation and domestic real income are not significant.
Mathur (1999)	Different version of the G-R model (India)	OLS	Domestic credit and income have correct signs and are significant.
Martinez (1999)	Modified G-R model (Mexico)	Cointegrated-VAR model	Long-run relationship between the growth rate of domestic credit, exchange-rate changes, and international reserves is found.
Pollard (1999)	Modified G-R model (Caribbean countries)	OLS	Domestic credit and the money multiplier have predicted effects in all countries. Domestic real GDP is also significant, but foreign GDP and foreign inflation have selective impact.

Table 2.2: Survey of Studies Based on the Monetary Model of EMP (contd. from Table 2.1)

Authors	**EMP model**	**Estimation**	**Result**
Pentecost, Hooydonk, and Poeck (2001)	Wealth augmented monetary model (several EU countries)	Principal-component analysis and OLS	Current account and budget deficits have an inverse relationship with EMP in some countries. Similarly, the competitiveness (change in the real exchange rate) measure has a direct effect on EMP.
Tanner (2000, 2002)	Modified G-R without real income	VAR	Tighter money reduces EMP (in line with theory) in many emerging-market countries.
Modeste (2005)	Modified G-R model (Guyana)	Cointegrated-VAR model	Tighter money reduces EMP. Also, increases in foreign debt increases EMP.
Garcia and Malet (2005)	Modified G-R model (Argentina)	VAR	Increasing domestic credit resulted in higher EMP. Domestic real income has ambiguous effect.
Gochoco-Bautista and Bautista (2005)	Interaction of domestic credit, EMP, and the interest-rate differential in the Philippines	VAR	Generally, reducing domestic credit and increasing the interest-rate differential resulted in reducing EMP.
Kumah (2007)	Interaction among money growth, inflation, and exchange-rate changes in Kyrgyz Republic	Markov regime-switching model	Contractionary monetary policy has the dampening effect on pressures to depreciate.
Stavarek and Dohnal (2009)	Variant of the G-R model	OLS	Variables have predicted effect in four central European countries.
Hegerty (2009)	Interaction of EMP, domestic credit growth, and capital inflows in Bulgaria	VAR generalized impulses	FDI and non-FDI investment reduce pressure on the exchange rate.

In table 2.4, various descriptive statistics are presented. There are two measures of EMP used in this study. The first one uses the Girton-Roper definition ($emp1$), while the second one ($emp2$) is constructed by adding an interest-rate differential term to it.[13] Most of the variables in quarterly frequency show high kurtosis, and therefore the normality assumption is rejected. The plots of EMP and domestic credit (dc) are shown in figures 2.1 and 2.2. Similarly, table 2.5 presents correlation coefficients between the variables. In the annual data in the top panel of figure 2.1,

[13] $emp1 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}}$; $emp2 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}} + \Delta(i_t - i_t^f)$.

$emp1$ and the domestic-credit growth show a broad pattern of comovement, with a correlation coefficient of 0.16. When the interest-rate augmented $emp2$ is used (figure 2.2), there is low comovement and the correlation coefficient is only -0.1. Using the quarterly data, the correlation coefficient is 0.05 with $emp1$ and 0.18 with $emp2$. There is thus some variation in the comovement using annual and quarterly data.[14] Further, in table 2.5, the growth rate of the money multiplier is positively correlated with $emp1$ and negatively with $emp2$, while income growth is negatively associated with both of them in quarterly data. Correlation coefficients between foreign inflation and the two EMP measures show opposite signs.

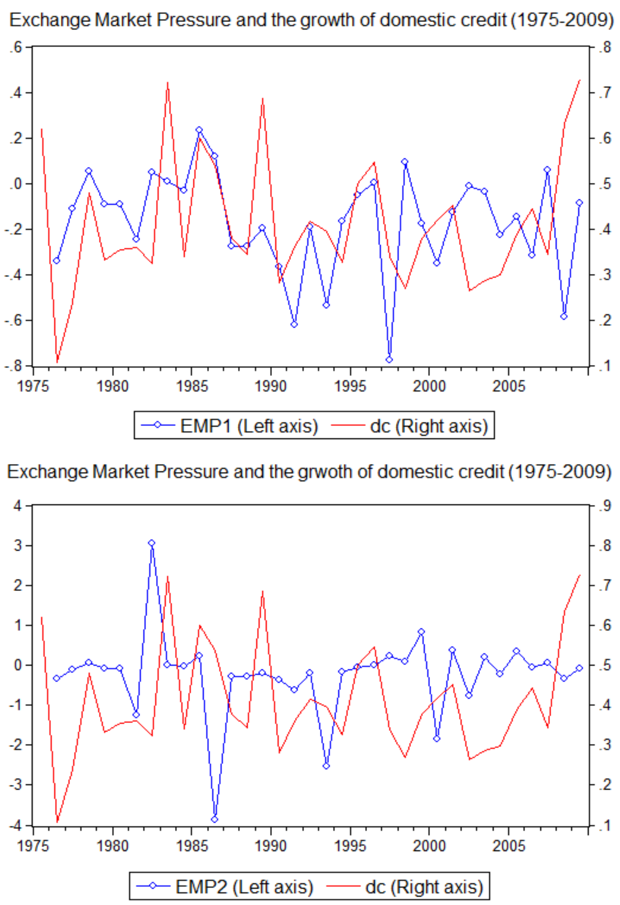

Figure 2.1: EMP and Domestic Credit (Annually, 1975–2009)

[14] One of the variance-equalizing definitions of EMP is also used in the estimation as complementary to overall discussion.

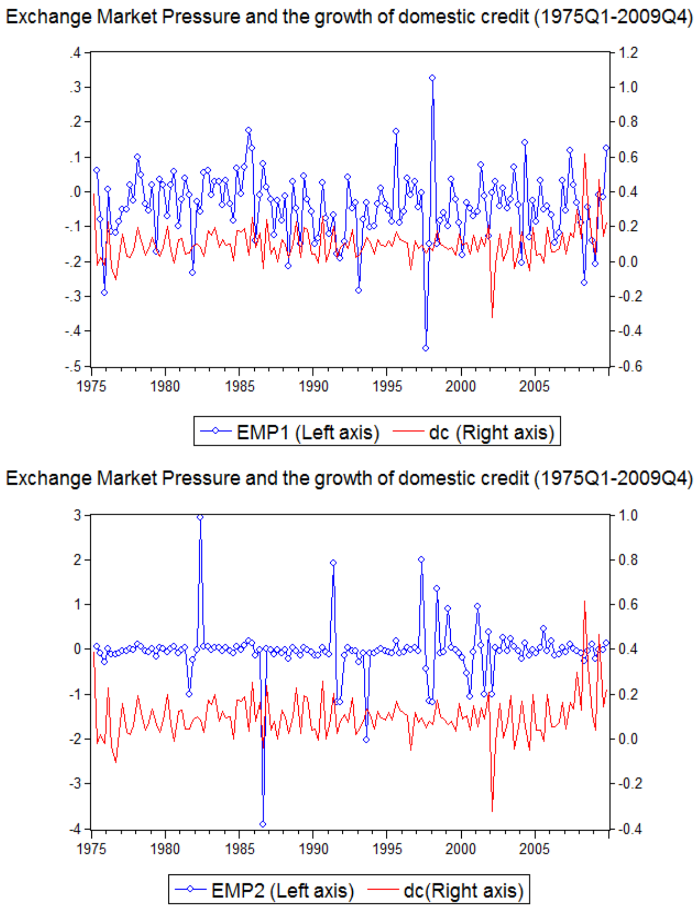

Figure 2.2: EMP and Domestic Credit (Quarterly, 1975Q1–2009Q4)

2.3.2 Unit-root Tests

Various unit-root test results are presented in table 2.6. One test for the presence of a unit root in a time series is based on the augmented Dickey-Fuller (ADF) regression

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t, \tag{2.10}$$

where the null hypothesis is $\gamma = 0$ and failing to reject the null would imply existence of a unit root in the series. The ADF test assuming no trend in the series, i.e., $a_2 = 0$, is presented with the notation 'c' under test type. The generic form of

Table 2.3: Data Details

Variables	Annual 1975–2009	Quarterly 1975Q1–2009Q4
NPR/INR exchange rate	Nepal Rastra Bank(NRB)	NRB Series computed by noting periods of change in annual data.
Net foreign asset	IMF(1975–08: 55831N..ZF...) IMF(2009: 55831N..ZK...)	IMF (1975Q1–2009Q1: 55831N..ZF...) IMF (2009Q2–Q4: 55831N..ZF...)
Home (Nepal) interest rate	IMF, Central Bank Discount Rate (1976 data applied for missing year 1975)	IMF, Central Bank Discount Rate (1976Q1 data applied for four quarters of 1975)
Foreign (India) interest rate	IMF, Bank rate (End of Period)	IMF, Bank rate (End of Period)
Monetary base	IMF; Reserve Money (1960–2008) & Monetary base (2009)	IMF; Reserve Money (1975Q1–2009Q1)& Monetary base (2009Q2–2009Q4)
Domestic credit	NRB	IMF; Domestic credit (1975Q1–2000Q1)& Domestic claims (2001Q1–2009Q4)
Money multiplier(Money/MB)	IMF	IMF
Foreign (India) CPI	IMF	IMF
Real GDP	WDI (constant local currency unit)	Interpolated from annual series

[a] Variables in equation 2.9 are constructed using above data.

equation 2.10 is also the basis for other specific tests. In the Dickey-Fuller with GLS trending (DFGLS) test, the original series is transformed via a generalized least squares (GLS) regression before running the test. Studies have shown that this test has more power to reject the null of a unit root in the series when in fact there is no unit root than the ADF test. Next, the Phillips-Perron (PP) test is a non-parametric test for a unit root, in which the test statistic is modified so that serial correlation does not affect its asymptotic distribution. In both the DFGLS and PP tests, the null hypothesis is the presence of a unit root in the series. Finally, the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) test is different than the previous ones and is considered a complementary test. KPSS assumes that the

Table 2.4: Descriptive Statistics

Variables	$emp1$	$emp2$	dc	mm	y	p^f
Mean	-0.17	-0.25	0.41	-0.003	0.04	0.07
Median	-0.14	-0.09	0.38	-0.02	0.04	0.08
Maximum	0.23	3.05	0.73	0.14	0.1	0.14
Minimum	-0.78	-3.88	0.11	-0.1	-0.03	-0.08
Std.Dev	0.22	1.05	0.14	-0.06	0.03	0.04
Skewness	-0.79	-0.73	0.6	0.76	-0.7	-1.27
Kurtosis	3.42	8.4	2.9	3.25	4.61	6.57
Jarque-Bera	3.76	44.39	2.08	3.45	6.39	27.25
Probability	0.15	0.00	0.35	0.18	0.04	0.00
Sum	-5.85	-8.35	14.48	-0.09	1.44	2.52
sum Sq. Dev.	1.67	36.5	0.71	0.11	0.02	0.05
Observations	34	34	34	34	34	34
Mean	-0.04	-0.06	0.1	0.02	0.01	0.00
Median	-0.04	-0.03	0.09	0.02	0.01	-0.01
Maximum	0.33	2.94	0.61	0.07	0.03	0.19
Minimum	-0.45	-3.92	-0.32	-0.07	-0.01	-0.14
Std.Dev	0.1	0.61	0.1	0.02	0.01	0.06
Skewness	-0.33	-0.84	0.95	-0.63	-0.59	0.58
Kurtosis	5.77	19.97	9.4	5.21	4.81	3.21
Jarque-Bera	46.88	1683.55	259.63	37.51	26.56	8.07
Probability	0.00	0.00	0.00	0.00	0.00	0.02
Sum	-5.87	-8.37	13.92	2.51	1.41	0.11
sum Sq. Dev.	1.32	50.62	1.45	0.05	0.01	0.51
Observations	139	139	140	139	136	140

[a] $emp1 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}}$

[b] $emp2 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}} + \Delta(i_t - i_t^f)$

[c] The upper panel shows descriptive statistics for annual data, and the lower panel shows the same for quarterly data.

series is stationary around a deterministic trend. The null for the test is a stationary series. As seen in table 2.6, all test results confirm that none of the series contain unit roots in either annual or quarterly data.[15]

2.4 Estimation Methods

In this study, I primarily apply the impulse indicator saturation (IIS) technique for estimation following the approach taken in Hendry and Mizon (2011). The authors apply the technique in modeling U.S. expenditure on food. They also

[15]These results are shown only in the case where the test equation includes a constant. They are not presented in the case where the test equation includes both a constant and the trend term. This is mainly because the plot of the variables show no trending behavior. Figures B.1 and B.2, in the appendix to this chapter, show plots of all variables. Clearly, there is no indication of any trend movement.

Table 2.5: Matrix of Correlation Coefficients

Variables	$emp1$	$emp2$	dc	mm	y	p^f
$emp1$	1					
$emp2$	0.18	1				
dc	0.16	-0.1	1			
mm	0.37	0.07	-0.16	1		
y	-0.22	-0.1	-0.09	-0.28	1	
p^f	0.02	-0.05	0.3	0.01	-0.007	1
$emp1$	1					
$emp2$	0.03	1				
dc	0.05	0.18	1			
mm	0.22	-0.19	-0.23	1		
y	-0.14	-0.03	0.04	-0.08	1	
p^f	0.13	-0.18	0.00	0.35	-0.07	1

[a] $emp1 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}}$

[b] $emp2 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}} + \Delta(i_t - i_t^f)$

[c] The upper panel shows correlation coefficient using annual data and the lower panel shows the same using quarterly data.

use Autometrics to select a parsimonious model based on the general-to-specific (GETS) modeling approach. The dynamic models are simple autoregressive distributed lag (ARDL) single-equation estimates. Alternatively, I also consider the VAR estimation and impulse response analysis. The motivation for using the alternative technique is discussed later on. I begin with a brief discussion of the IIS technique and the VAR model.

2.4.1 Impulse Indicator Saturation

Hendry, Johansen, and Santos (2008) propose selecting a regression model using the GETS approach for the case in which there are more variables than observations. It is a special case in which the regression equation is saturated by indicator variables, that is, the regression equation is augmented by impulse dummies $d_{j,t} = 1_{(j=t)}$, one for every j. Under such a scenario, if one wishes to estimate the mean μ and standard deviation σ_ϵ^2 by regressing y_t on $\{\mu, d_{j,t}, j = 1, ..., T-1\}$, a perfect fit is achieved and nothing is learned. Therefore, in the first step, only half of the indicators are included in the general unrestricted model (GUM). As shown in equation 2.11, an i.i.d. random variable is regressed on a constant, augmented

Table 2.6: Various Unit-root Test Results

Variable	Test type	DFGLS Null: Uroot	PP Null:Uroot	KPSS Null:Stationary
$emp1$	c	-5.57***	-5.85***	0.18
$emp2$	c	-6.81***	-6.7***	0.08
dc	c	-3.97***	-5.55***	0.09
mm	c	-5.32***	-5.65***	0.09
p^f	c	-2.31**	-5.77***	0.14
y	c	-7.35***	-7.5***	0.15
$emp1$	c	-3.56***	-11.44***	0.17
$emp2$	c	-11.83***	-12.31***	0.07
dc	c	-1.14	-12.47***	0.22
mm	c	-0.55	-21.77***	0.08
p^f	c	-3.57***	-8.55***	0.16
y	c	-1.75*	-3.9***	0.09

[a] Lag selection for the DFGLS test is based on the Schwartz Information Criterion (SC).
[b] emp1 $= \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}}$
[c] emp2 $= \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}} + \Delta(i_t - i_t^f)$
[d] Significance levels: ***1 percent, ** 5 percent, and * 10 percent
[e] Upper panel presents test result using annual data, while the bottom panel shows the same using quarterly data.

by a block of impulse indicators:

$$y_t = \mu + \sum_{j=1}^{T/2} \delta_j d_{j,t} + \epsilon_t. \tag{2.11}$$

Thus, the equation contains $T/2$ parameters for $T/2$ impulse indicators for the first $T/2$ observations. A parsimonious model is then selected and stored from equation 2.11 subject to all mis-specification tests being insignificant and all retained variables being significant at the desired significance level. Any indicator with an estimated t-value less than the critical value $|t_{1,\widehat{\delta_t}} < c_\alpha|$ (where α is the desired significance level such as 0.01 or 0.025 depending on T) is deleted. In the second step, the regression is estimated for the remaining half of the impulse indicators, and y_t is regressed upon $\{\mu, d_{j,t}, j = T/2+1, ..., T\}$. All the redundant indicators are eliminated subject to

$|t_{2,\widehat{\delta_t}} < c_\alpha|$ and the resulting parsimonious model is stored. The selected indicators from the terminal models are combined and reestimated to give us a final model wherein all indicators that did not truly belong to the model are "dummied out." When testing the null of no significant indicators in the regression, the authors find that the average retention rate of impulse indicators is αT, where α is the significance level (target size) of the test. This is true even when the sample is split into smaller sizes.

Hendry et al. (2008) note that the estimated mean and the variance for any alternative divisions are unbiased. In this case, the authors report finding the following:

$$\widehat{\mu_1} = \frac{1}{T/2} \sum_{t=T/2+1}^{T} y_t, \tag{2.12}$$

$$s_1^2 = \frac{1}{T/2-1} \sum_{t=T/2+1}^{T} (y_t - \widehat{\mu_1})^2, \tag{2.13}$$

$$\widehat{\delta_t} = y_t - \widehat{\mu_1}, \qquad t = 1, ..., T/2, \tag{2.14}$$

and the errors are

$$\widehat{\epsilon_t} = 0, \qquad t = 1, ..., T/2 \tag{2.15}$$

$$\widehat{\epsilon_t} = y_t - \widehat{\mu_1}, \qquad t = T/2+1, ..., T.$$

Hendry et al. further report that the following mean and variance obtained using the GUM estimators are unbiased:

$$\mathrm{E}[\widehat{\mu_1}] = \mu \text{ and } \mathrm{V}[\widehat{\mu_1}] = (T/2)^{-1}\sigma_\epsilon^2,$$

$$\mathrm{E}[s_1^2] = \sigma_\epsilon^2.$$

The final estimators of the mean and the variance are the following:

$$\widetilde{\mu} = \frac{\sum_{t=1}^{T_1} y_t 1_{\{|t_1, \widehat{\delta}_t| < c_\alpha\}} + \sum_{t=T_1+1}^{T} y_t 1_{\{|t_2, \widehat{\delta}_t| < c_\alpha\}}}{\sum_{t=1}^{T_1} 1_{\{|t_1, \widehat{\delta}_t| < c_\alpha\}} + \sum_{t=T_1+1}^{T} 1_{\{|t_2, \widehat{\delta}_t| < c_\alpha\}}}, \tag{2.16}$$

$$\widetilde{\sigma_\epsilon^2} = \frac{\sum_{t=1}^{T_1} (y_t - \widehat{\mu_1})^2 1_{\{|t_1, \widehat{\delta}_t| < c_\alpha\}} + \sum_{t=T_1+1}^{T} (y_t - \widehat{\mu_2})^2 1_{\{|t_2, \widehat{\delta}_t| < c_\alpha\}}}{\sum_{t=1}^{T_1} 1_{\{|t_1, \widehat{\delta}_t| < c_\alpha\}} + \sum_{t=T_1+1}^{T} 1_{\{|t_2, \widehat{\delta}_t| < c_\alpha\}} - 1}. \tag{2.17}$$

Hendry et al. further note that including additional regressors in the equation will add to computational efforts, but do not affect the analysis. Johansen and Nielsen (2008) show that this approach can be generalized to a class of models including dynamic ones. And, for small α, the cost of retaining impulse indicators corresponds to omitting αT observations.[16] A more useful representation of equation 2.11 is

$$y_t = \beta' X_t + \sum_{i=1}^{T} \gamma_i 1_{(i=t)} + \epsilon_t, \qquad t = 1, ..., T \tag{2.18}$$

where X_t is an m-dimensional vector of regressors and γ_i represents the coefficient of a significant impulse indicator where $1_{(t)} = 1$ for observation at time "t," and 0 otherwise.[17]

Santos and Oliveira (2010) note that the IIS technique can detect breaks at unknown dates, in both the mean and the variance.[18] Hendry and Santos (2010, p. 9) argue that the IIS technique not only detects outliers, "but may also reveal other shifts that are hidden by being 'picked up' incorrectly by other variables." Outliers are generally located at the start and the end of the sample, and removing

[16]For example, in a sample of 100 observations, with a target size of 0.01 (1 percent), only one observation is lost.

[17]Note that a constant is recommended in the regression. In the absence of the constant, the IIS technique in Autometrics is found to perform poorly in identifying breaks and shifts in the data. Autometrics allows retaining the constant and other variables in the regression.

[18]The authors also apply step indicators to identify different regimes. Specifically, they chose eight periods of consecutive significant dummies with the same sign and similar magnitude to constitute a different regime.

them helps to reveal any shifts in the data. In general, the IIS technique is credited for detecting an unknown number of structural breaks, occurring at unknown times, with unknown duration, and occurring anywhere in the sample. Thus, the technique can detect breaks and handle a fat-tailed distribution. Next, I discuss the GETS approach in Autometrics.

2.4.2 Autometrics and GETS

Autometrics is a computer-automated package that uses the tree-search method to detect and eliminate insignificant variables.[19] The tree-search method is an improvement over the multi-path search used in GETS modeling. There are three main stages in selecting variables, beginning with estimating the initial GUM. In the second stage, a variable is eliminated subject to the new model passing the encompassing test and maintaining congruency.[20] The encompassing test ensures that the new model is a valid reduction of the GUM at the chosen α. A path terminates when there is no variable to be reduced following the criterion. In the final stage, there can be one or more terminal models and the selection can be based on a tie-breaker such as the Schwarz information criterion (SIC).

2.4.3 Autometrics With IIS and GETS

As noted above, this paper follows the econometric approach taken in Hendry and Mizon (2011). Accordingly, I first estimate an ARDL model with a single lag using annual data and four lags using quarterly data. Second, I introduce the IIS technique and GETS approach to select the impulse indicators in Autometrics and

---

[19] In a typical regression, there are, in total, 2^N (N being the number of regressors) possible models from which to select a correct model.

[20] Bauwens and Sucarrat (2010) point out five aspects of model selection to be taken together as the definition of congruency. They are

- innovation errors;
- weak exogeneity;
- parameter constancy;
- theory-consistent identifiable structures; and
- data admissibility.

present the results.[21] Third, again in line with the Hendry and Mizon paper, I allow Autometrics to select the impulses, but I also allow Autometrics to pick the lags of all regressors. The authors find that retaining (contemporaneous) theory variables in the regression and allowing Autometrics to select the lags and impulses significantly improved the results. The ARDL(p,q) model estimated in this study is shown in equation 2.19, where the order of the dependent variable (emp_t) and regressors (X_t) along with the selection of statistically-significant impulse indicators are based on the GETS approach. All estimations were carried out in PCGive 13.1.[22]

$$emp_t = \beta_0 + \sum_{i=1}^{p} \alpha_i emp_{t-i} + \sum_{i=0}^{q} \beta_i X_{t-i} + \sum_{i=0}^{T} \gamma_i 1_{(i=t)} + \epsilon_t \tag{2.19}$$

2.4.4 VAR Identification

As an alternative to the single-equation estimation, a system-based vector autoregression (VAR) model is considered. Using a VAR model allows us not only to observe the effects of a conventional monetary policy, but also to analyze how the authorities respond to pressure on the domestic currency. The possibility of reverse causality (endogeneity) can be addressed in a VAR framework. Formally, a reduced form VAR of order p is given as follows

$$z_t = A_1 z_{t-1} + ... + A_p z_{t-p} + \varepsilon_t, \tag{2.20}$$

where z_t is a vector of all domestic variables (emp_t, dc_t, mm_t, y_t) and ε_t is a vector of i.i.d. shocks. An important step in VAR estimation is the identification, more commonly known as the causal ordering, of the variables. All domestic variables

[21] In applying the IIS technique, I allow two lags in the annual data in keeping with the approach taken by the authors. I also retain all regressors including a constant.

[22] In the final stage, the authors allow Autometrics to select all regressors, their lags, and impulse dummies. This final stage is not incorporated in this study mainly because doing so eliminated most of the theory variables and often resulted in problematic errors. In all regression equations here, a constant is always included, and a target size of 0.05 is set for the annual data and 0.005 for the quarterly data.

enter the VAR specification as endogenous variables. Some ad hoc assumptions are needed to complete the identification. In line with several previous studies, the exogeneity restriction or the Choleski ordering of the variables is as shown below:

$$\varepsilon_{y_t} = e_{y_t}, \tag{2.21}$$

$$\varepsilon_{dc_t} = e_{dc_t} + e_{y_t,dc_t}, \tag{2.22}$$

$$\varepsilon_{mm_t} = e_{mm_t} + e_{y_t,mm_t} + e_{dc_t,mm_t}, \tag{2.23}$$

$$\varepsilon_{emp_t} = e_{emp_t} + e_{y_t,emp_t} + e_{dc_t,emp_t} + e_{mm_t,emp_t}. \tag{2.24}$$

In equations 2.21–2.24, income growth is treated as the least endogenous, while EMP is the most endogenous. Income (y_t) is affected in the current period only by its own shocks, while other shocks have a lagged effect. On the other hand, innovations in EMP are correlated with all other shocks and are therefore affected by contemporaneous as well as lagged feedbacks from all other shocks. Similarly, domestic credit is affected by current and past shocks of its own and income growth, while EMP has a lagged effect, which is reasonable given that authorities are likely to respond to rising EMP with some lag rather than acting concurrently.

The economic relationship underpinning the causal ordering in equations 2.21–2.24 cannot be firmly established if the alternative ordering produces significantly different implications. Therefore, an order-invariant approach as in generalized impulse response by Pesaran and Shin (1998) is also adopted as a sensitivity test.

2.5 Econometric Results

This section begins by highlighting the differences in results due to different estimation techniques. I then discuss in detail the results using both annual and quarterly data, and using the two definitions of EMP. A reference to results using the variance-equalizing approach to EMP is also offered. This is followed by some supportive evidence from the VAR estimation. Before ending the section, I present some economic analysis of the results, and also offer an evaluation of the robustness of the IIS estimates using a structural break test and forecast performance analysis.

2.5.1 Overview of the OLS and IIS Estimates

As introduced in section 2.4, the IIS technique is useful for detecting shifts, breaks, and outliers in time-series data. This helps not only in identifying the underlying structure, but also in correcting the regression error and attaining the right specification. As Hendry and Mizon (2011) suggest in their paper, I also find evidence in this study to broadly concur with their observation regarding the usefulness of the IIS technique. In general, the application of the technique improved the results, mainly in getting the theoretically correct model specification. By retaining the theoretical variables (contemporaneous value of all regressors), while allowing the IIS technique to select dummies and dynamic effects, the estimation resulted in theory-consistent effects. As will be seen, this is clearly an improvement over OLS, which in most cases resulted in incorrect specifications and either wrongly signed or insignificant coefficients. In figures 2.3–2.6, different actual and fitted series are shown. Clearly, there is evidence of better fit using the IIS technique.[23]

However, the selection of impulse dummies is found to be sensitive to the target size. By using a large target size (loose), it is possible to retain a large number of irrelevant variables. As noted earlier, the proportion of irrelevant variables corresponds to αT, and the number increases with additional regressors in the equation. Therefore, a conservative strategy is generally favored in large samples. By using a relatively large target size (0.05) in annual data and a small target size (0.005) in quarterly data, the retention of impulse dummies varied as expected. Most of the time, the impulse dummies detected big fluctuations in the dependent variable.

The selection of impulse dummies did not reveal any regime shift, mainly because they were transitory in nature, and appeared more like outliers. In modeling

[23] Note that the impulse indicator is read as, for instance, I97(3), where 97 indicates year 1997 and number 3 in parenthesis indicates the third quarter of the year.

French inflation, Santos and Oliveira (2010) use eight consecutive periods of significant impulse dummies that have the same sign and similar magnitude to characterize a regime. If such a regime existed, then a step indicator could be used to accommodate it. Castle, Doornik, and Hendry (2008) also suggest using a similar approach to identify regime shifts. I find no evidence of such a pattern in this study. A format test of whether the selection of impulse dummies identified structural breaks in the data is discussed later.

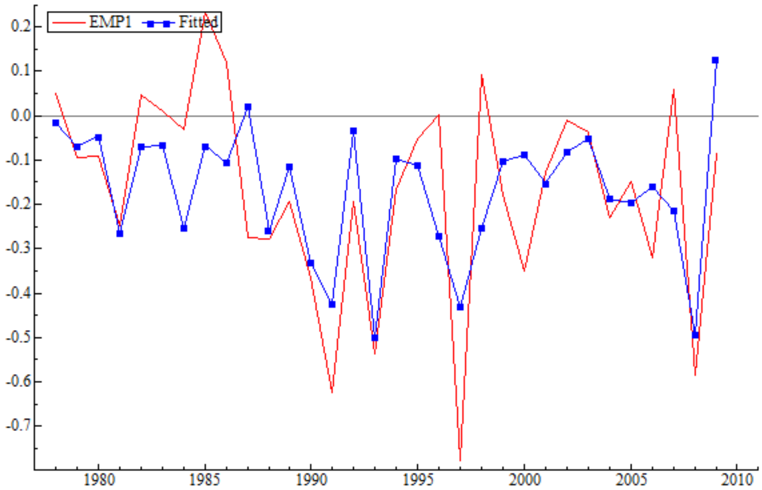

Figure 2.3: Actual and Fitted *emp*1 Using OLS in Annual Data

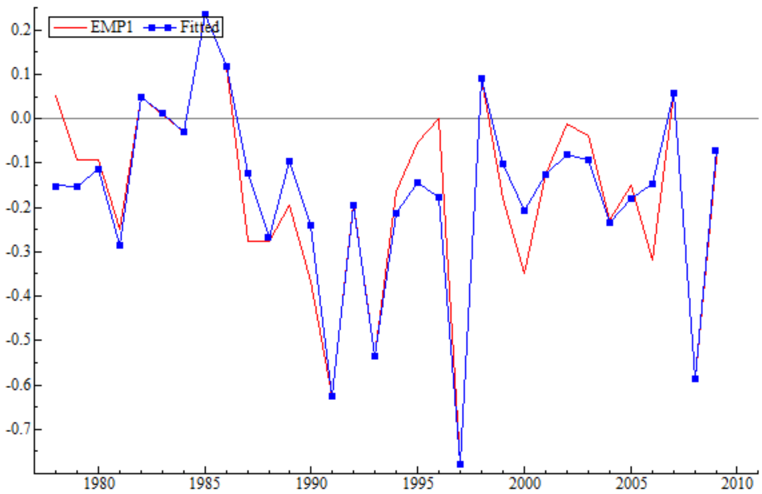

Figure 2.4: Actual and Fitted *emp*1 Using the IIS Technique

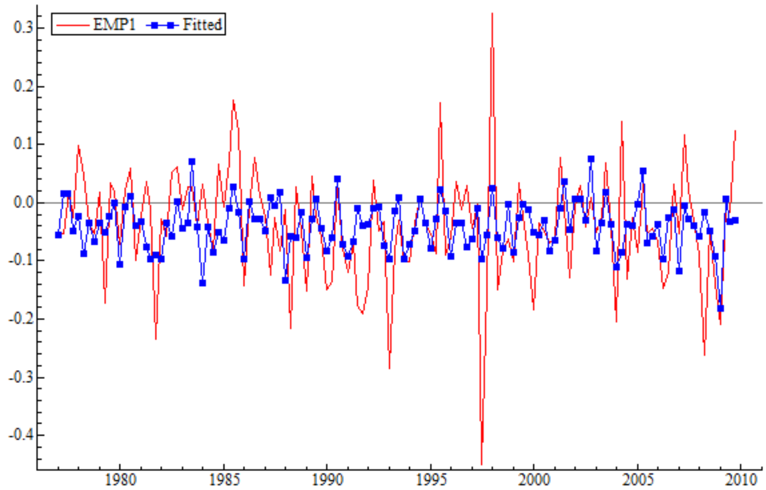

Figure 2.5: Actual and Fitted *emp*1 Using OLS in Quarterly data

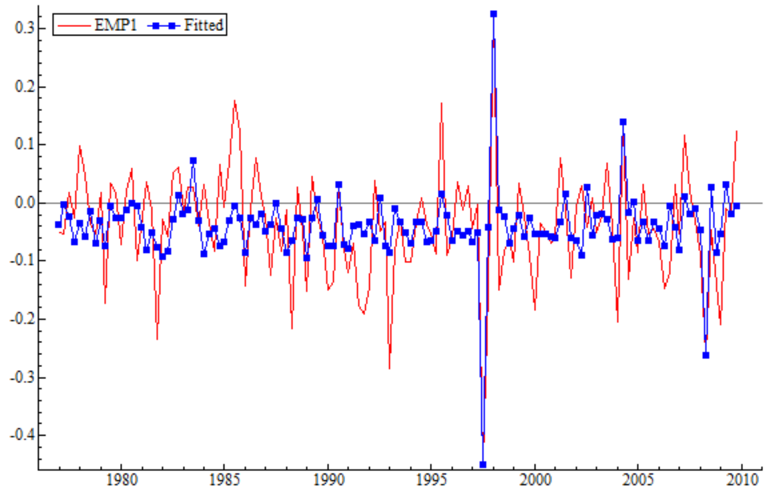

Figure 2.6: Actual and Fitted *emp*1 Using the IIS Technique

2.5.2 Results Using Annual and Quarterly Data

Estimates using annual data are presented in tables 2.7 and 2.8. The two tables differ in the definition of EMP. Similarly, tables 2.9 and 2.10 show the results using quarterly data. Further, tables 2.11 and 2.12 show the results using one of the variance-equalizing definitions of EMP. In each table, column (1) shows the results using simple OLS; in column (2), the IIS technique is introduced and the general-to-specific modeling under Autometrics is allowed to select the impulse indicators, while retaining all theory variables and their lags; in the final column (3), the IIS technique and Autometrics are applied to select lags and impulse indicators. Significant indicators are shown only in table 2.9 because they are considered for further economic analysis. Moreover, there is a large number of indicators in some estimates and therefore only the total number of significant indicators is noted in such cases. In the remainder of each table, various model specification tests are reported. Sigma, σ, is the standard deviation of the regression error.

The OLS estimates in table 2.7 show that domestic credit (dc) is wrongly signed, while the money multiplier (mm) is correctly signed. Other variables are insignificant. The model's inadequacy can be seen in the rejection of the null hypotheses of time-invariant volatility and linear specification in the residuals, respectively, under the ARCH (autoregressive conditional heteroskedasticity) and Reset tests. The latter test indicates the possibility of non-linearity in the regression error. By introducing the IIS technique, in column (2), several variables become significant, although most of them are still wrongly signed. Contemporaneous domestic credit has the predicted effect, but its second lag is negatively signed. Similarly, foreign inflation (p^f) is correctly signed only in the first lag, while the first and second lags of income growth (y) have wrong signs. The IIS technique selected six significant impulse dummies. This specification passes all residual tests and has a lower standard deviation of the regression error. In the final column (3), all of the variables have correct signs, but only domestic credit is significant, at the 10 percent level. It

Table 2.7: Estimation Results for *emp*1 (Annual Data, 1975–2009)

Variables	OLS (1)	OLS w/IIS and regressors 'fixed' (2)	OLS w/IIS and selecting dynamics (3)
Constant		-0.32**	-0.23*
		(0.14)	(0.11)
$emp1_{t-2}$	0.55*		
	(0.3)		
dc		0.47***	0.35*
		(0.15)	(0.2)
dc_{t-2}	-0.87*	-1.24***	
	(0.49)	(0.18)	
mm	2.48**	2.97***	0.72
	(0.94)	(0.33)	(0.5)
mm_{t-1}		1.07**	
		(0.38)	
mm_{t-2}		1.15***	
		(0.35)	
p^*		2.91***	-0.5
		(0.74)	(0.74)
p^f_{t-1}		-1.24**	
		(0.41)	
y_t			-1.2
			(0.9)
y_{t-1}		3.25***	
		(1.02)	
y_{t-2}		3.76***	
		(1.01)	
Significant impulse dummies		6	10
σ	0.24	0.08	0.11
R^2	0.42	0.96	0.88
$\bar{R}^2$	-0.05	0.89	0.77
AR test	0.78	0.38	1.46
	(0.47)	(0.55)	(0.26)
ARCH test	4.65**	0.53	0.31
	(0.04)	(0.47)	(0.58)
Normality	0.15	0.02	4.98
	(0.93)	(0.99)	(0.08)
Hetero			0.99
			(0.48)
Reset	3.93**	0.65	0.04
	(0.04)	(0.54)	(0.96)

[a] Dependent variable:$emp1 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}}$.

The third column presents results based on the IIS technique where all regressors are retained in the model, i.e., Autometrics does not eliminate these variables, but only selects impulse indicators. In the fourth column, all (contemporaneous) theory variables are retained, but the selection of lags and impulse dummies is based on Autometrics. Insignificant coefficients are not shown in the second and third columns.

Standard error for coefficients are shown in parenthesis, and diagnostic tests show the p-value in parentheses.

P-values: *** 1 percent, ** 5 percent, and * 10 percent

Table 2.8: Estimation Results for $emp2$ (Annual Data, 1975–2009)

Variables	OLS (1)	OLS w/IIS and regressors 'fixed' (2)	OLS w/IIS and selecting dynamics (3)
Constant			-0.03
			(0.17)
$emp2_{t-1}$		0.18**	
		(0.07)	
dc		-0.78*	0.58**
		(0.35)	(0.26)
dc_{t-2}		0.99*	
		(0.47)	
mm		2.6**	2.18**
		(1.07)	(0.77)
mm_{t-1}	-9*	-2.65**	
	(4.31)	(1.09)	
p^f		-4.96*	-4.13***
		(2.2)	(1.1)
p^f_{t-1}		5.27**	
		(2.09)	
y_t			-0.1
			(1.26)
y_{t-2}	-24**		
	(9)		
Significant impulse dummies		7	10
σ	0.97	0.18	0.16
R^2	0.57	0.99	0.99
$\bar{R}^2$	0.21	0.97	0.98
AR test	0.38	2.24	0.48
	(0.69)	(0.17)	(0.63)
ARCH test	0.002	0.06	1.74
	(0.96)	(0.81)	(0.2)
Normality	3.02	0.55	0.22
	(0.22)	(0.76)	(0.9)
Hetero			0.18
			(0.99)
Reset	11.2***	0.8	0.55
	(0.001)	(0.48)	(0.59)

[a] Dependent variable: $emp2 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}} + \Delta(i_t - i_t^*)$.

The third column presents results based on the IIS technique where all regressors are retained in the model, i.e., Autometrics does not eliminate these variables, but only selects impulse indicators. In the fourth column, all (contemporaneous) theory variables are retained, but the selection of lags and impulse dummies is based on Autometrics. Insignificant coefficients are not shown in the second and third columns.

Standard error for coefficients are shown in parenthesis, and diagnostic tests show the p-value in parentheses.

P-values: *** 1 percent, ** 5 percent, and * 10 percent

is notable that no lags are selected in this case, although there are ten significant impulse indicators. In general, adjusted R^2 is found to improve substantially in all results when using the IIS technique, and this is clearly seen here as well. The model passes all specification tests.

Table 2.8 shows results using the interest-rate augmented EMP (*emp*2). Interest rates were included in constructing the alternative EMP measure to accommodate the possible effects of differences in returns on capital and also to expand the scope of the investigation. In column (3), there are three significant coefficients with correct signs. Only income growth is insignificant, although it is rightly signed. There are ten significant impulse indicators, and the model passes all residual tests. Importantly, the correct and statistically significant effect of the policy variable, *dc*, is encouraging and is in line with the economic reasoning that followed the inclusion of interest rates in EMP.

The findings are generally similar using quarterly data. In table 2.9, the results in the last two columns (3a and 3b) differ in the use of target size (p-value) in estimation.[24] In the two columns, the variables are correctly signed and almost identical. Domestic credit and the money multiplier are highly significant. Foreign inflation is insignificant in both. Income growth has a borderline significance in column (3a) with a p-value of 0.1052, but is significant at 10 percent in column (3b). In table 2.10, the policy variable (*dc*) is rightly signed and significant in column (3). The magnitude of this coefficient is roughly similar to the one in table 2.9. Importantly, none of the other variables is significant. Moreover, a large number of impulse indicators is selected. The implications of a large number of impulse indicators are discussed later in this section.

Next, the estimates using the variance-equalizing definition of EMP generally

---

[24]The difference between the two columns is in the use of the target size (significance level), which is done to account for sensitivity associated with using a slightly tighter target size. Generally, a conservative strategy is suggested in applying different target sizes. Hendry and Mizon use 1 percent in their model selection.

Table 2.9: Estimation Results for *emp*1 (Quarterly Data, 1975Q1–2009Q4)

Variables	OLS (1)	OLS w/IIS and regressors 'fixed' (2)	OLS w/IIS and selecting dynamics(TS 0.5%) (3a)	OLS w/IIS and selecting dynamics(TS 1%) (3b)
Constant		-0.07**	-0.05***	-0.04***
		(0.03)	(0.02)	(0.02)
$emp1_{t-3}$		0.15*		
		(0.08)		
dc		0.3***	0.23***	0.21***
		(0.09)	(0.08)	(0.08)
dc_{t-3}		-0.15*		
		(0.08)		
mm	0.63***	0.67***	0.42***	0.38***
	(0.21)	(0.18)	(0.13)	(0.13)
mm_{t-1}		0.43**		
		(0.18)		
p^f			0.14	0.05
			(0.41)	(0.4)
y			-1.6	-1.73*
			(0.98)	(0.96)
I93(1)				-0.21***
				(0.08)
I97(3)		-0.37***	-0.37***	-0.37***
		(0.08)	(0.08)	(0.08)
I98(1)		0.39***	0.35***	0.35***
		(0.09)	(0.08)	(0.08)
I04(2)		0.27***	0.25***	0.25***
		(0.09)	(0.08)	(0.08)
I08(2)		-0.38***	-0.34***	-0.33***
		(0.09)	(0.09)	(0.09)
σ	0.1	0.08	0.08	0.08
R^2	0.19	0.52	0.41	0.44
$\bar{R}^2$	0.01	0.39	0.37	0.4
AR test	1.1	0.5	0.63	0.79
	(0.36)	(0.78)	(0.67)	(0.56)
ARCH test	2.2	0.25	0.16	0.13
	(0.07)	(0.91)	(0.96)	(0.97)
Normality	25.26***	0.94	0.35	0.02
	(0.00)	(0.63)	(0.84)	(0.98)
Hetero	1.25	1.11	0.65	0.77
	(0.19)	(0.33)	(0.73)	(0.63)
Reset	0.4	0.43	0.54	0.56
	(0.67)	(0.65)	(0.58)	(0.57)

[a] Dependent variable: $emp1 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}}$.

The third column presents results based on the IIS technique where all regressors are retained in the model, i.e., Autometrics does not eliminate these variables, but only selects impulse indicators. In the fourth column, all (contemporaneous) theory variables are retained, but the selection of lags and impulse dummies is based on Autometrics. Insignificant coefficients are not shown in the second and third columns. Standard error for coefficients are shown in parenthesis, and diagnostic tests show the p-value in parentheses. P-values: *** 1 percent, ** 5 percent, and * 10 percent

Table 2.10: Estimation Results for *emp*2 (Quarterly Data, 1975Q1–2009Q4)

Variables	OLS (1)	OLS w/IIS and regressors 'fixed' (2)	OLS w/IIS and selecting dynamics (3)
Constant			-0.05***
			(0.02)
dc	1.52**	0.35***	0.28***
	(0.61)	(0.12)	(0.11)
dc_{t-3}		-0.29***	
		(0.1)	
mm			0.24
			(0.16)
mm_{t-4}	-2.28*		
	(1.24)		
p^f	-9.33**		0.31
	(4.07)		(0.54)
p^f_{t-2}		-1.54**	
		(0.72)	
p^f_{t-4}	8.45**		
	(3.77)		
y_t			-1.32
			(1.18)
y_{t-1}	-134.18*		
	(74.40)		
Significant impulse dummies		21	22
σ	0.6	0.09	0.09
R^2	0.25	0.99	0.98
$\bar{R}^2$	0.08	0.98	0.98
AR test	0.32	0.66	1.16
	(0.9)	(0.65)	(0.33)
ARCH test	0.09	0.22	1.45
	(0.98)	(0.93)	(0.22)
Normality	86.58***	4.7	6.4**
	(0.00)	(0.1)	(0.04)
Hetero	0.85	0.65	1.42
	(0.73)	(0.94)	(0.2)
Reset	12.1***	0.54	1.55
	(0.00)	(0.58)	(0.22)

[a] Dependent variable: $emp2 = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{nfa_t - nfa_{t-1}}{mb_{t-1}} + \Delta(i_t - i_t^*)$

The third column presents results based on the IIS technique where all regressors are retained in the model, i.e., Autometrics does not eliminate these variables, but only selects impulse indicators. In the fourth column, all (contemporaneous) theory variables are retained, but the selection of lags and impulse dummies is based on Autometrics. Insignificant coefficients are not shown in the second and third columns.

Standard error for coefficients are shown in parenthesis, and diagnostic tests show the p-value in parentheses.

P-values: *** 1 percent, ** 5 percent, and * 10 percent

Table 2.11: Estimation Results for Variance-equalizing EMP (Annual Data, 1975–2009)

Variables	OLS (1)	OLS w/IIS and regressors 'fixed' (2)	OLS w/IIS and selecting dynamics (3)
Constant			-0.03
			(0.02)
emp_{t-1}		0.26**	
		(0.12)	
emp_{t-2}	0.55**	0.61***	
	(0.26)	(0.13)	
dc		0.06*	0.16***
		(0.03)	(0.04)
dc_{t-2}	-0.21**	-0.15***	
	(0.08)	(0.04)	
mm		0.3***	0.1
		(0.08)	(0.09)
mm_{t-1}			
p^f			-0.62***
			(0.14)
p^f_{t-1}			
y_t			-0.007
			(0.16)
y_{t-1}	1.17**	1.08***	
	(0.52)	(0.25)	
Significant impulse dummies		5	7
σ	0.04	0.02	0.02
R^2	0.49	0.94	0.86
$\bar{R}^2$	0.07	0.85	0.78
AR test	0.35	0.27	0.16
	(0.71)	(0.77)	(0.86)
ARCH test	0.22	2.19	1.8
	(0.64)	(0.15)	(0.19)
Normality	3.53	0.008	0.15
	(0.17)	(0.99)	(0.93)
Hetero			0.43
			(0.89)
Reset	3.09	1.23	2.56
	(0.08)	(0.33)	(0.11)

[a] Dependent variable:

$$emp_t = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{\sigma_e}{\sigma_{nfa}}\left(\frac{nfa_t - nfa_{t-1}}{nfa_{t-1}}\right) + \frac{\sigma_e}{\sigma_i}(\Delta i_t - i_t^*).$$

The third column presents results based on the IIS technique where all regressors are retained in the model, i.e., Autometrics does not eliminate these variables, but only selects impulse indicators. In the fourth column, all (contemporaneous) theory variables are retained, but the selection of lags and impulse dummies is based on Autometrics. Insignificant coefficients are not shown in the second and third columns.

Standard error for coefficients are shown in parenthesis, and diagnostic tests show the p-value in parentheses.

P-values: *** 1 percent, ** 5 percent, and * 10 percent

Table 2.12: Estimation Results for Variance-equalizing EMP (Quarterly Data, 1975Q1–2009Q4)

Variables	OLS (1)	OLS w/IIS and regressors 'fixed' (2)	OLS w/IIS and selecting dynamics (3)
Constant	-0.02*		-0.003
	(0.009)		(0.002)
emp_{t-1}			
emp_{t-2}			
dc	0.07***	0.04***	0.04***
	(0.02)	(0.01)	(0.01)
dc_{t-3}		-0.046***	-0.03***
		(0.01)	(0.009)
mm			0.008
			(0.02)
mm_{t-1}			
p^f		-0.18**	-0.08
		(0.08)	(0.06)
p^f_{t-4}		0.21***	0.19***
		(0.07)	(0.05)
y_t			-0.36***
			(0.12)
Significant impulse dummies		15	18
σ	0.02	0.01	0.009
R^2	0.2	0.85	0.89
$\bar{R}^2$	0.02	0.79	0.86
AR test	4.24***	0.99	1.25
	(0.00)	(0.43)	(0.29)
ARCH test	1.88	0.25	0.42
	(0.12)	(0.91)	(0.8)
Normality	77.97***	16.3***	4.15
	(0.00)	(0.00)	(0.13)
Hetero	1.75**	0.61	0.84
	(0.013)	(0.96)	(0.61)
Reset	20.08***	3.48**	2.19
	(0.00)	(0.04)	(0.12)

[a] Dependent variable:

$$emp_t = \frac{e_t - e_{t-1}}{e_{t-1}} - \frac{\sigma_e}{\sigma_{nfa}}(\frac{nfa_t - nfa_{t-1}}{nfa_{t-1}}) + \frac{\sigma_e}{\sigma_i}(\Delta i_t - i_t^*).$$

The third column presents results based on the IIS technique where all regressors are retained in the model, i.e., Autometrics does not eliminate these variables, but only selects impulse indicators. In the fourth column, all (contemporaneous) theory variables are retained, but the selection of lags and impulse dummies is based on Autometrics. Insignificant coefficients are not shown in the second and third columns.

Standard error for coefficients are shown in parenthesis, and diagnostic tests show the p-value in parentheses.

P-values: *** 1 percent, ** 5 percent, and * 10 percent

agree with the above observations. These results are shown in tables 2.11 and 2.12, for annual and quarterly data respectively. The model specification improves in the final column (3), and the policy variable is significant in both the annual and quarterly data. Nonetheless, the coefficient estimate of *dc* is significantly smaller than in the earlier estimates. Once again, a relatively large number of impulse indicators is selected. Generally, it becomes difficult to interpret the results when several variables in model are insignificant. This is generally the case in estimates in tables 2.10 and 2.12. Some of these difficulties are discussed below.

One interesting observation in all these estimates is the selection of impulse indicators and its impact on the model's performance. It is consistently found that by including impulse indicators, the model performs better in many regards. One crude comparison of this is the improvement in model's explanatory power as indicated by adjusted R^2. Similarly, the σ estimate (standard deviation of the regression error) is also better when including the impulse dummies. Except for the results in table 2.9, all other model estimates selected a relatively large number of impulse indicators, and these models show much higher R^2. This is not surprising. It is, however, a matter of concern since this also indicates the possibility of a potential flaw in model specification due to the omitted-variable effect. The selection of a large number of impulse indicators may simple be due to noisy data behavior, or it may also indicate model's irrelevancy due to omitted variables. The latter effect may suggest that the model itself may not adequately represent the given context. This possibility cannot be ruled out, especially when several explanatory variables are insignificant. Yet the primary goal in this study is to analyze the impact of policy changes on the exchange rate, and, in that regard, domestic credit is found significant in most cases. In the next section, the discussion will center on the estimates shown in table 2.9 where the selected model (using $emp1$) has 4–5 impulse indicators and a moderate adjusted R^2 of about 0.4.

2.5.3 VAR Results

Prior to estimating the VAR model as outlined in section 2.4.4, a number of tests were conducted to discern the causality pattern. It is important to point out that the suitability of the variable ordering depends on the possibility of observing such a relationship in actual data. The test results reported here are thus complementary to the earlier discussion. Tables 2.13–2.16 present the pairwise Granger-causality test results and the VAR block-exogeneity test results.

First, in the Granger-causality test, a simple bi-variate OLS regression is estimated, where each endogenous variable is regressed on its own lags and the lags of another variable. In this case, two and eight lags were used in annual and quarterly data, respectively. The F-statistics show the test results on the null of the joint coefficient restriction (set to zero) on the lags of another variable. As shown in tables 2.13 and 2.14, in each test the null of no causality cannot be rejected. Additionally, the VAR block-exogeneity test shows whether a set of endogenous variables can be treated exogenous with respect to each of the remaining variables. The results from tables 2.15 and 2.16 suggest that the block-exogeneity of the endogenous variables cannot be rejected. The failure to establish a causal pattern through these tests is worrying since there is no evidence of lagged feedback between the variables. This leaves the possibility of contemporaneous feedback as the source of endogeneity in the variables.

Next, in light of the causality test results, various VAR models were estimated, including the one discussed in section 2.4.4. Furthermore, the original Girton-Roper model (i.e., equation B.10 in the appendix to this chapter) was also estimated in a VAR framework, in which all domestic variables were treated as endogenous. In addition to trying alternative variable orderings, I also apply the order-invariant orthogonalization of shocks following the Pesaran and Shin generalized-impulse-response technique. I use two lags in annual data and four lags in quarterly data.

The results from various VAR estimations suggest that in most cases there isn't any significant effect of shocks to domestic credit on EMP. Also, in all VAR estimations there was a common issue of non-normal VAR residuals. Even including additional lags didn't rectify the problem. Recognizing the possibility of statistical inadequacy in model specification, I present one of the significant impulse response graphs in figure 2.7 for reference purposes. The graph shows an instantaneous jump in EMP in response to a shock to domestic credit. The impact, however, falls quickly and dissipates before the second period.[25] Although the rise in EMP is in line with the predicted effect, the problem is with the underlying VAR, which fails the normality test. Yet the earlier results using the IIS technique suggest that the reason for non-normality may be due to a few outliers. If the outliers can be treated as a non-recurring feature of the data, this result may be taken as additional evidence in support of earlier findings. Finally, it is also important to recognize that the VAR-type setting may be more relevant in Nepal in the last ten years, when remittances have grown significantly (from 2 percent of GDP to almost 23 percent between 2000 and 2009), and in which the possibility of endogenous evolution of variables is more likely. However, it would not be meaningful to run a VAR for such a short period of time, especially if annual data are to be considered. It may be a useful extension of this study in the future to accommodate the possible endogenous relationship.

2.5.4 Discussion

In this subsection, I focus on the results from table 2.9, not only because the estimates there satisfy the model specification tests, but also because the observed effects are theory consistent. In addition, the model shows plausible explanatory power. Earlier, it was noted that the variable y_t has a borderline significance and using a higher target size (0.01) resulted in this variable becoming significant. This result is shown in column (3b). Below, I take this as a baseline result to motivate

[25]Domestic credit also showed instantaneous jump in repose to a shock to EMP.

Table 2.13: Pairwise Granger-causality Test with Two Lags Using $emp1$ for the Period 1975 to 2009

Null hypothesis	F-Statistics	Probability
dc does not Granger Cause $emp1$	0.66	0.53
$emp1$ does not Granger Cause dc	0.2	0.82
mm does not Granger Cause $emp1$	0.01	0.99
$emp1$ does not Granger Cause mm	0.19	0.83
y does not Granger Cause $emp1$	0.34	0.71
$emp1$ does not Granger Cause y	0.52	0.6
mm does not Granger Cause dc	0.99	0.38
dc does not Granger Cause mm	0.86	0.43
y does not Granger Cause dc	2.03	0.15
dc does not Granger Cause y	1.51	0.24
y does not Granger Cause mm	0.6	0.56
mm does not Granger Cause y	0.04	0.96

[a] p^f treated exogenous

Table 2.14: Pairwise Granger-causality Test with Two Lags Using $emp1$ for the Period 1975:01 to 2009:04

Null hypothesis	F-Statistics	Probability
dc does not Granger Cause $emp1$	0.51	0.85
$emp1$ does not Granger Cause dc	0.45	0.89
mm does not Granger Cause $emp1$	0.82	0.59
$emp1$ does not Granger Cause mm	0.85	0.56
y does not Granger Cause $emp1$	0.82	0.58
$emp1$ does not Granger Cause y	0.46	0.88
mm does not Granger Cause dc	0.86	0.55
dc does not Granger Cause mm	1.66	0.12
y does not Granger Cause dc	0.53	0.83
dc does not Granger Cause y	0.45	0.89
y does not Granger Cause mm	1.37	0.22
mm does not Granger Cause y	0.32	0.96

[a] p^f treated exogenous

Table 2.15: VAR Gragner Causality/Block Exogeneity Wald Test (1975–2009)

Dependent variable: $emp1$			
Excluded	chi-sq	df	Probability
mm	2.02	2	0.36
dc	0.99	2	0.61
y	1.28	2	0.53
All	2.79	6	0.84
Dependent variable: dc			
Excluded	chi-sq	df	Probability
$emp1$	3.19	2	0.2
mm	1.73	2	0.42
y	3.74	2	0.15
All	8.24	6	0.22
Dependent variable: mm			
Excluded	chi-sq	df	Probability
$emp1$	0.61	2	0.74
dc	2.95	2	0.23
y	3.75	2	0.15
All	4.91	6	0.55
Dependent variable: y			
Excluded	chi-sq	df	Probability
$emp1$	4.14	2	0.13
mm	6.49	2	0.04
dc	2.33	2	0.31
All	7.77	6	0.26

[a] p^f treated exogenous

further discussion. As seen in the table, the differences in the two results (i.e., using target sizes 1 percent and 0.5 percent) are not very significant. The coefficient estimates in columns (3a) and (3b) are very similar, except for the additional impulse indicator, I93(1), in (3b). Other coefficients in the two columns show theoretically correct signs. Domestic credit and the money multiplier are statistically significant, while income growth has a borderline significance in column (3a), which improves in column (3b) and is significant at 10 percent. Foreign inflation is insignificant in both. This may be due to the choice of foreign CPI used in calculating foreign inflation. In this regard, a better indicator perhaps is the wholesale price index (WPI).[26] In terms of the model's performance, the σ estimate suggests a similar level of variation

[26] As a check of robustness, I used the producers price index (PPI) to represent foreign prices. There was a marginal improvement in the coefficient estimate, but it was still not statistically significant. The WPI series is not available for the whole period.

Table 2.16: VAR Gragner Causality/Block Exogeneity Wald Test (1975:01–2009:04)

Dependent variable: $emp1$			
Excluded	chi-sq	df	Probability
mm	4.23	4	0.38
dc	0.48	4	0.98
y	1.84	4	0.77
All	7.14	12	0.85
Dependent variable: dc			
Excluded	chi-sq	df	Probability
$emp1$	2.92	4	0.57
mm	1.18	4	0.88
y	0.88	4	0.93
All	5.96	12	0.92
Dependent variable: mm			
Excluded	chi-sq	df	Probability
$emp1$	2.24	4	0.7
dc	11.5	4	0.02
y	7.24	4	0.12
All	22.7	12	0.03
Dependent variable: y			
Excluded	chi-sq	df	Probability
$emp1$	3.94	4	0.41
mm	2.08	4	0.72
dc	2.71	4	0.61
All	7.91	12	0.8

[a] p^f treated exogenous

in the regression residuals in columns (2), (3a), and (3b), which is better than under OLS. Similarly, adjusted R^2 is also satisfactory in these estimates. In terms of model specification, all tests confirm randomness of the residuals. The p-values for these tests are given in parentheses. First, the AR test confirms failure to reject the null of no autocorrelation in the residuals. Second, the ARCH and heteroskedasticity tests show that the null of no time-varying volatility in the residuals cannot be rejected. Third, the normality test confirms that the residuals are asymptotically normal. Finally, the Ramsey Reset test suggests there is no non-linear behavior in the residuals.

The coefficients reported in column 3b of table 2.9 for domestic credit and the money multiplier are well below one. The negative coefficient on income growth suggests that higher income growth leads to an appreciation of the nominal ex-

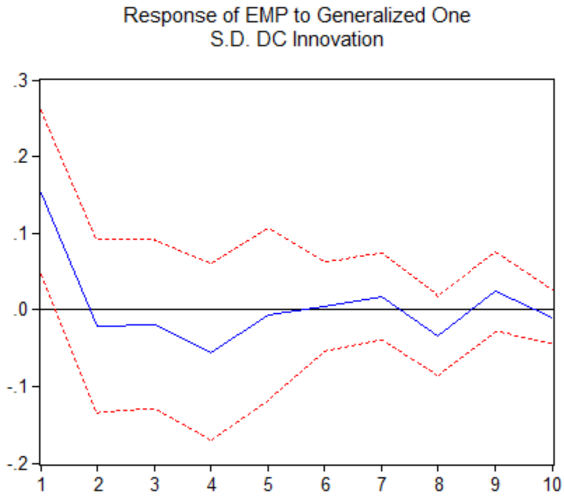

Figure 2.7: Response of *emp*2 to a Domestic-credit Shock Using the Quarterly Data
(This is a generalized impulse response using 4 lags, with foreign inflation treated as the exogenous variable.)

change rate and/or greater reserve accumulation. Higher income growth means higher money demand, which, ceteris paribus, necessitates a fall in prices to maintain real money balances, resulting in nominal appreciation. This is a typical feature in monetary models that can be explained with the PPP assumption.

Several studies in the past have failed to find full support for the predictions of the monetary model. These studies commonly cite unrealistic assumptions regarding price flexibility, which are central to the monetary model. Moreover, there can be some restrictions in the economy such as capital control and trade barriers that can lessen the impact of monetary policy on EMP. A quick reference to some previous studies is relevant here. As noted in section 2.2.3, Ginting (2007) and Yelten (2004) suggest that prices in Nepal tend to be influenced by prices in India. Clearly, the pegged exchange rate with India is a big facilitator for co-movement in prices. These findings also indicate a limitation for policy effectiveness in Nepal. Unlike the one-to-one effect of money supply on the exchange rate, it is therefore plausible to expect a lesser impact.

The partial validation of the monetary model in this study is important from a policy maker's point of view. The estimated effect of domestic credit on EMP suggests some role for monetary policy in influencing the real exchange rate in Nepal. Specifically, a contractionary monetary policy can help to reduce pressure on the domestic currency. Yet, it is important to remember that the open border presents an added challenge to the use of monetary policy because of the risk of capital flows. So far, however, the central bank has been able to exercise effective capital control.[27] In light of the present findings, it is safe to say that monetary policy in Nepal has some scope in managing/supporting the exchange-rate regime. Next,

Table 2.17: Some Macroeconomic Variables

Time	Net current a/c Flow(M, USD)	Net financial a/c Flow(M, USD)	Net foreign assets Stock(B, NPR)	CA as a percent of GDP
1997Q1	-85.38	38.45	40.45	-7.89 in 1997
1997Q2	-113.2	128.19	40.59	
1997Q3	-128.86	30.82	58.22	
1997Q4	-60.64	-25.97	65.68	
1998Q1	-21.13	17.16	47.63	-1.38 in 1998
2004Q1	39.83	-112.7	116.55	1.88 in 2004
2004Q2	3.07	-150.28	104.44	
2004Q3	29.49	-53.31	116.12	
2008Q1	180.58	-167.75	166.78	5.81 in 2008
2008Q2	332.63	-283.12	201.6	

in column (3b) of table 2.9, there are five significant impulse indicators. Except the first (I93(1)), all other indicators are in the post-liberalization period, when there was a fixed nominal peg, so EMP includes changes in foreign reserves only. Moreover, the impulse indicators in the post-liberalization period (1993 onwards) are sparsely located and appear more like outliers. The I93(1) indicator is negatively signed, suggesting a reduction in EMP as a result of policy reforms. During the first quarter of 1993, the central bank had directly intervened to adjust the parity of the NPR/INR exchange rate for the last time. The exchange rate was revalued to 1.6 from 1.65, an appreciation of about 3 percent. This followed the announcement of

[27] Lately, the central bank has issued a limit on the ATM withdrawal on transactions originating in India, after reports of substantial cash withdrawal for speculative purposes.

current account liberalization, which was in sync with the liberal orientation of the economy at the time. It is also important to note that the announcement of economic liberalization in India also occurred around this time. It is, however, unclear if there was a need to revalue the exchange rate. With the current account as a percent of GDP in 1991, 1992, and 1993 standing at -7.76, -5.33, and -6.01 respectively, and a stable stock of net foreign assets, the authorities might have considered mitigating the impact of import prices on inflation. Weakening of the Indian currency may have been the reason to appreciate the exchange rate.[28] Earlier, in 1991, the central bank had intervened to appreciate the exchange rate from 1.68 to 1.65 in response to devaluation (vis-à-vis the dollar) in India.

The remaining impulse indicators capture fluctuations in the data that do not correspond to any economically significant events in Nepal. Their inclusion can be better understood with the help of some macro data, especially the changes in the current account. In table 2.17, some selected variables for periods near those captured by the impulse indicators are shown. The current account deficit increased to 7.89 percent of GDP in 1997. This trend continued until the third quarter. Gains in the financial account, however, moderated the impact on the overall balance of payments. The stock of net foreign assets grew in the third quarter of 1997, while it fell in the first quarter of 1998. These fluctuations in net foreign assets are captured by a negative coefficient in I97(3), signifying a fall in EMP, and a positive coefficient in I98(1), indicating a rise in EMP. Similarly, the positive coefficient in I04(2) and the negative one in I08(2) may be explained by a fall and rise in the current account surplus, respectively, in the corresponding periods. A related discussion analyzing the nature of these data fluctuations is presented later in this section.

At this point, it is appropriate to discuss the possible endogeneity of the variables in Nepal's economy. Earlier, it was noted that during a currency crisis,

---

[28]For instance, in March 1993, the Indian rupee depreciated substantially against the dollar. It fell from 26.20 INR/USD to 31.26 INR/USD, a depreciation of about 19 percent.

the interaction between a policy variable and EMP is often intertwined. While the rise in EMP indicates mounting pressure on the domestic currency, the authorities often respond by injecting capital into the system to defend the peg and prevent further reserve losses. This means that credit in the system rises following increasing pressure on the currency. Until 1993, the central bank occasionally intervened in the market to change the parity of the NPR/INR exchange rate. Since then, Nepal has managed to respond to pressures on its currency through sales and purchases of foreign-exchange reserves. No direct liquidity support to the system has yet occurred. However, with the growing influence of remittances, which contribute to the stock of foreign reserves and to the deposit base of the banking system, there is a possibility of a circular relationship between EMP and domestic credit. In the full sample analyzed here, this possibility was addressed in the VAR analysis. Although the evidence was inconclusive, the impulse response analysis showed the possibility of a positive impact of domestic credit on EMP and a similar effect of EMP on domestic credit.

It would be an interesting extension of this study to directly incorporate the interaction of remittances, credit growth, and the exchange rate, especially in the last decade when remittances have grown significantly. The scope for understanding the impact of remittances on macroeconomic stability is greater in countries that are overly dependent on it. Chami et al. (2008) report that remittances generally tend to appreciate the real exchange rate, resulting in Dutch-disease type effects in the recipient countries. One topic for future research would be to see if the remittances affect countries differently in the context of different exchange-rate regimes.

Earlier, it was argued that the selected impulse indicators, except I93(1), suggested outliers in the data. If instead the indicators had picked up structural changes in the data, that would require a different treatment. In order to confirm the robustness of the estimates, a two-prong assessment approach is adopted. First, a formal structural break test is conducted. Second, a forecast evaluation is considered.

The structural break test used here is for multiple breaks in the data as proposed in Bai and Perron (1998). The test is based on minimizing the sum of squared residuals from a linear regression, when the dates of the breaks are the unknown variables to be estimated. As a useful point of reference, we can consider five break points (as implied by the IIS estimates) in the data to begin with. However, as it turns out, owing to the large number of variables (four lags of each variables) in the regression equation and a total of 132 observations, a maximum of only four break points could be considered in the test. The results are presented in Table 2.18. As seen in the table, the number of break points with the lowest BIC is zero, that is, no break point. This confirms our earlier suspicion that the impulse indicators may have captured outliers in the data and that they do not indicate any structural breaks or existence of different regimes in the data.

Table 2.18: Bai-Perron (1998) Multiple Structural Breaks Test

Breakpoints	BIC	Log-Lik	RSS	N.Coefs
0	-143.77	135.36	0.99	26
1	-76.16	165.03	0.63	52
2	-38.5	209.68	0.32	78
3	-13.58	260.7	0.15	104
4	-120.58	377.68	0.03	130

Chosen number of breaks: 0

[a] BIC is the Bayesian Information Criterion, Log-Lik is the log likelihood estimates, and RSS is the residual sum of squares. The last column shows the number of coefficients.

2.5.5 Forecast Evaluation

In order to further assess whether the IIS estimates improve upon the OLS ones, I also use the method of forecast evaluation. For this purpose, I consider a one-step-ahead forecast based on rolling regressions using OLS and IIS separately. Each model is first estimated for a period of 20 years (i.e., 80 quarters) and then a one-step-ahead forecast is recorded (for the 81st quarter). The sample is then rolled over one step while keeping the window of 80 quarters unchanged. The model is again estimated and the forecast recorded. This gives the second observation. By proceeding in this manner, a forecast series of 52 observations—beginning in the first quarter of 1997 and ending in the fourth quarter of 2009—is recorded. With the two forecast series in hand, I compute the root mean squared error (RMSE) and mean absolute error (MAE) for each of them. The RMSE based on the forecast using the OLS estimates is 0.14, while the same using the IIS estimates is 0.12. This corresponds to about 14 percent or about one-third of one standard deviation improvement over the OLS-based forecast. Similarly, the MAE using the OLS-based forecast is 0.094, while it is 0.086 using the IIS-based forecast. This improvement is about 8.5 percent or roughly one-tenth of one standard deviation over the OLS-based forecast.

Next, I apply a forecast-accuracy test to examine if the improvement in the IIS-based forecast is statistically significant. Diebold and Mariano (1995) proposed a test to compare the accuracy of two forecast series based on a loss function, which uses the loss differential (squared error loss) from the two series. The null hypothesis under the test is that of no improvement in forecast accuracy or the null of equal predictive accuracy. The test results (DM stat = 4.25, p-value < 0.01) show that this null is rejected. Thus, the difference observed in terms of forecast performance is statistically significant, and this is additional evidence of better performance of the IIS technique.

2.6 Conclusion

Many countries, especially in a non-floating exchange-rate regime, face pressure on their currency. Only a few of them suffer currency collapse. It is possible that by establishing a proper role for monetary policy, the monetary authorities can adopt corrective action preemptively to reduce pressure on the currency and avert a serious crisis. The EMP framework based on a monetary model offers a link to investigate the impact of policy changes on the exchange rate using EMP.

In this chapter, Nepal's exchange-rate regime with India was investigated using the EMP framework based on a monetary model of the exchange rate. Different definitions of EMP were used: the equally weighted approach, with and without the interest-rate differential, and EMP (with the interest-rate differential) based on the variance-equalizing weighting scheme. Despite weak fundamentals, Nepal continues to maintain a pegged exchange-rate regime with support from exogenous sources, especially remittances, which have underpinned the balance of payments in the last decade and a half. By using domestic credit as a policy tool, a positive impact of expansionary monetary policy on EMP was found. The coefficients of domestic credit and monetary policy had positive signs, but were well below one. Output growth was found to lower EMP as expected. Foreign inflation, however, was insignificant. Despite finding a less-than-the-predicted effect under the monetary model, these results suggest that monetary policy is relevant in Nepal, and a contractionary policy can reduce pressure on the home currency. The findings are relevant from a policymaker's perspective since they underscore the right direction for policy impact, despite falling well short on the magnitude of such effect.

One important dimension of the study was the application of the IIS technique. By allowing for impulse dummies for each observation, the technique enabled us to identify outliers in the data in a systematic way. The IIS technique was used to select impulse indicators and the lags of all variables using the GETS approach in Autometrics. In most of the regressions, the selection of impulse indicators significantly improved the model's performance according to various specification tests while producing theory-consistent effects. There were five impulse indicators in the chosen model, with the first one corresponding to the first quarter of 1993 when several economically significant events occured. The rest of the impulse indicators merely picked up big fluctuations in the data. The VAR results provided additional support but were not conclusive. While the structural break test didn't reveal any statistically significant breaks in the data, the IIS technique was shown to result in better predictability using one-quarter-ahead forecasts.

CHAPTER 3

STRUCTURAL SHOCKS AND BUSINESS CYCLE SYNCHRONIZATION IN NEPAL AND INDIA

3.1 Introduction

Nepal, with its pegged exchange-rate regime vis-à-vis India, faces a difficult choice of exchange-rate policy in light of an increasing trade deficit and a slowly growing economy. Theoretically, there are different choices Nepal can adopt going forward. In practice, however, the choices are limited and the options available are quite contrasting. First, Nepal can continue the current peg or, if desired, operate it as a crawling peg. Second, it can embark upon a rigid peg arrangement such as a currency board or a currency union. Third, Nepalese policymaker may also adopt a flexible exchange-rate regime. The fourth option is some kind of a managed exchange-rate regime in which the value of the domestic currency is based on a basket of currencies of the countries that have a major economic relationship with the domestic economy.

The issue of appropriate exchange-rate policy is a widely discussed topic in the literature, reflecting the importance it has in the economy. For the last five decades, the Nepalese authorities have basically chosen a peg arrangement as the nominal anchor for monetary policy, except for a brief interlude in the early 1990s when a currency basket was introduced. There is a growing recognition that the economy is overly dependent on income from remittances, which have so far financed an ever-growing trade deficit. In the aftermath of the 2008 global financial crisis, this vulnerability was exposed with official foreign-exchange reserves dipping into negative territory for a long time. To see this, note the growing gap between the trade balance in goods and services and the current account balance after the late 1990s, as shown in figure 3.1. While the trade balance continued on a sharply downward path, the current account balance, which was supported by remittances for some time, only started showing signs of trouble in 2009 and 2010. In 2008, the current account balance was in comfortable territory and had reached 5.83 percent of GDP. However, by the end of 2009, it fell to 0.14 percent and in 2010 it further slid and reached -0.81 percent of GDP.

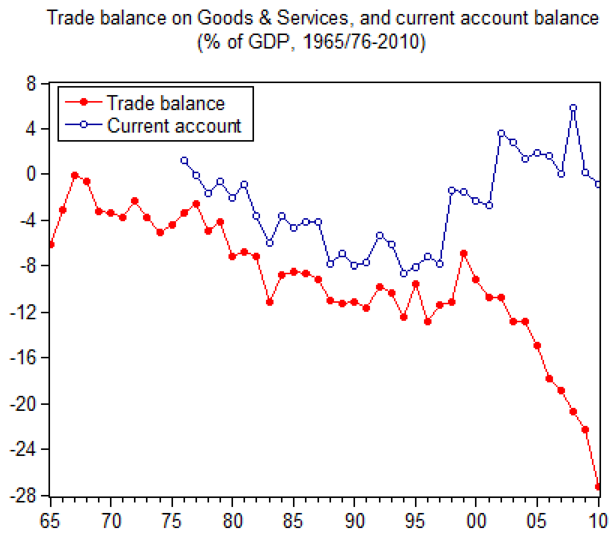

Figure 3.1: Overall Trade and Current Account Balance
(*Source*: World Development Indicators)

In practical terms, a purely flexible exchange-rate regime is perhaps not an immediate option. This is not only because of the fact that India is Nepal's major trading partner, but also because the open border between the two countries risks the possibility of creating destabilizing effects from daily volatility in the exchange rate, especially knowing that Nepal's economy is in a weak spot. On the other hand, the possibility of monetary integration through a currency board or a currency union would likely face tough political opposition, even if such an arrangement could be justified on economic merits. In fact, a monetary union remains a declared goal in the SAARC region as part of its mandate for greater economic cooperation.[1] With an open border, huge bilateral trade, and a pegged exchange-rate regime, it appears that Nepal already has considerable economic integration in place and could possibly benefit from further monetary integration with India.

The central theme of this essay is to investigate whether some of the preconditions for deeper monetary integration exist between the two countries. Particularly, the agenda for this research is to investigate the similarity or dissimilarity of structural shocks and the extent of business cycle synchronization in the two economies. In the literature, these types of analyses are often considered in countries that are contemplating a currency union. However, it should be clearly stated here that in this study the goal is to investigate the underlying conditions only and not to take a position on a particular form of such integration. This is mainly because of the prevailing level of integration between the two economies, especially from Nepal's point of view. Taking a position on a particular form of integration would be more meaningful if other possibilities, such as a flexible exchange-rate regime or a basket of currencies, are also investigated, which however is outside the scope of this study but is a part of our future research agenda.

Nevertheless, from the perspective of Nepalese policymakers, the question in this study should be of some interest. Given a weakening economy and increasing reliance on remittances, one may ask whether the current arrangement of a pegged exchange-rate regime is optimal for the economy. One alternative to the current system would be higher monetary integration with India, and the study tries to analyze if there are some underlying conditions that would satisfy the requirements for such integration. The Nepalese side should also be concerned because if there is evidence that favors such integration, Nepal would have to further compromise on policy independence.[2] Yet, at the same time, one has to consider the reality that

---

[1]SAARC is an acronym for South Asia Association for Regional Cooperation.

[2]It is traditionally held that the cost of losing policy independence in a currency union is in the failure to use the nominal exchange rate to bring changes in the real exchange rate following shocks to the economy. Adjusting the real exchange rate is viewed as necessary to bring about

Nepal doesn't have much control over its economy because of the existing level of de-facto integration with India.

Nepal's economy is highly integrated with India's for many practical reasons. Consider a few of them. For geographic and historic reasons, Nepal trades a lot with India, and has an open border with its southern neighbor.[3] By maintaining some sort of a pegged exchange-rate regime since the late 1950s, and a hard peg since 1993, the central bank has managed to keep the inflation rate very close to that of India, and has also kept the interest rate fairly close to the Indian interest rate, especially since the mid-1990s (see figure 3.2). Finally, in view of facilitating different transactions in the local market, the central bank has authorized the use of Indian rupee notes in limited quantities in the market.[4] Thus, for all practical purposes it may be said that the Indian currency is accepted as a medium of exchange.

In order to explore the conditions for further monetary integration, this chapter applies two existing strands in the literature. Both of them primarily analyze the economic structure and transmission of policy effects. A suitable region for such integration will have economies with similar structures such that the adjustment following shocks is generally synchronous in all countries. This is possible when the economies in the region share some common features. As a result, a common policy response is sufficient for restoring equilibrium in the entire region. The traditional and perhaps the most popular approach is the structural-shocks analysis in the candidate countries using the structural vector autoregression (SVAR) methodology. This analysis is further complemented by identifying a region-wide common component in structural shocks using a state-space model. Next, a business cycle investigation is also undertaken to gauge the extent of synchronization in the business cycles of the two economies. Once again, a state-space model is used to

---

equilibrium in the goods and labor markets.

[3]Although the numbers are not well documented, it is believed that there are between 2–3 million Nepalese workers in India, primarily engaged in low-paying jobs. Similarly, a significant number of workers from border towns in India have found employment in Nepalese urban towns and cities.

[4]This is more of a case in the border region, but tourists from India can easily transact in the Indian currency throughout the country. For trade transactions, the banking channel has to used.

estimate the common element, which is further analyzed to ascertain the degree of synchronization.

To the central question of whether two economies share similarities, the answer from this investigation is not quite conclusive. I have used several variables and different indicators to investigate the possibility of further monetary integration, especially from Nepal's point of view. While some indicators favor the proposition, others suggest dissimilar economic structures and therefore a costly outcome in a more integrated setting.

The rest of the chapter is organized as follows. In section 3.2, a review of the literature on monetary integration, especially the structural shocks and business cycle synchronization approaches, is offered with attention to their relevance in the Nepalese context. Section 3.3 presents a preliminary data analysis, which is followed by details on the methodology and a discussion of the results in section 3.4. Some concluding remarks are offered in section 3.5.

3.2 Brief Literature Review

Some relevant aspects of the vast literature on the concept of an optimum currency area (OCA) are discussed in this section. This is mainly because the methodological approach considered in this study is regularly applied in the study of a currency union. As already pointed, the two economies already satisfy some fundamental prerequisites for monetary integration. The pertinent issue then is whether it would be beneficial for Nepal to relinquish policy independence further. Some of the related issues are explored in this brief review.

3.2.1 Specialization vs. Diversification

In the first generation of the OCA literature (Mundel, 1961; McKinnon, 1963), a great deal of emphasis was placed on synchronized business cycles. This meant having correlated demand and supply shocks in the candidate countries. The second generation (Mundell, 1973) emphasizes the degree of risk sharing and financial integration as key requirements.[5] McKinnon (2001) points to Mundell's view that

[5] Cited from "New Views on OCA" (ECB report, 2002).

significant cross-country asset holding can mitigate the effects of asymmetric shocks by diversifying income sources, adjusting wealth portfolios, and pooling foreign-exchange reserves.[6] In the same context, Krugman (1987) contradicts the idea of benefitting from synchronized business cycles or symmetry in structural shocks. He points out that, after forming a monetary union, the stronger economic ties will eventually lead to conditions—such as specialization in production—that would then lead to asymmetric business cycles/shocks. It is therefore relevant to look into some statistics that highlight whether the two economies share any commonalities that would indicate the possibility of having symmetric shocks.[7]

Table 3.1 presents correlation coefficients between business cycle indicators for the two economies from 1975 to 2009 and two sub-periods. The full sample is split to highlight the fact that Nepal and India both underwent opening of their economies in the early 1990s. The correlation of the cyclical component of the two GDPs fell in the latter period, while correlation during the full-sample period (1975–2009) itself is quite low. In contrast, if the industrial production data from India is used, the correlation is significantly better. This shows that, in general, India's industrial sector has had more of a linkage with Nepal's economy than the overall Indian economy. The level of correlation, however, fell by a significant degree in the latter period. One reason for this decline may be that the Indian economy has undergone huge structural changes and is now well diversified with increasing contributions from the service sector and more global connections.

To get more insight into the structure of the two economies, table 3.2 offers some data on the changing composition of output. Trade as a share of GDP, the

---

[6] Cited from "New Views on OCA" (ECB report, 2002).

[7] In the 2002 ECB report, a number of prerequisites, economic and non-economic, are identified as necessary in a currency union:

- price and wage flexibility;
- mobility of factors of production including labor;
- financial market integration;
- degree of economic openness;
- diversification in production and consumption;
- similarities of inflation rates;
- fiscal integration; and
- political integration.

Table 3.1: Business Cycle Correlation

Variable	1975–1992	1993–2009	1975–2009
Y, Y^f	0.15	0.08	0.13
Y, IP^f	0.52	0.22	0.4

[a] Business cycles calculated using the HP-filtered data.
[b] Y and Y^f represent GDP in Nepal and India, while IP^f is India's industrial production.

economic-openness indicator, shows that both economies are now more open and have an increasing share of trade in their economies. Open economies, especially small ones, are vulnerable to changes in the prices of tradeable goods in the international market. Increasing trade, or the possibility of such, especially between major trading partners, is one reason to consider monetary integration. Next, the contributions of industry, manufacturing, and services to GDP are higher in India at all times, while agriculture dominates more in Nepal. The Indian economy is also more service oriented in recent times, especially in the high-value added, knowledge-based sector. There is, however, no commensurate development in Nepal. Similarly, value added by manufacturing and industry is roughly constant in both countries. While these sectors are much more diversified in India, major industrial outputs of Nepal are primitive in nature and low in value added. As per the CIA factbook, India's major export items are petroleum products, precious stones, machines, iron and steel, chemicals, vehicles, and apparel. In Nepal, the major export items are clothing, pulses, carpets, textiles, juice, pashmina, and jute goods.

Table 3.2 also shows the shares of household and government consumption expenditures as well as gross capital formation in the two economies. Household and government consumption expenditures both have higher shares in Nepal, while the shares of government consumption and gross investment (capital formation) are higher in India. This disaggregation into sub-sectors may not be enough to discern the changing structure of the economy, but is nonetheless important in highlighting similarities and differences in the two economies.

In terms of inflation, figure 3.2 shows general similarity in the movement of these variables over time. Given the pegged exchange rate with India, inflation in Nepal is generally higher. The policy interest rate was also higher in Nepal

Table 3.2: Trade, Production, and Expenditure Patterns (Averages in Given Periods)

Variable	1975–89		1990–99		2000–09	
(Percent of GDP)	India	Nepal	India	Nepal	India	Nepal
Trade	13.73	29.69	20.92	49.74	37.93	47.71
Agriculture(v.a.)	33.4	59.5	27.64	43.49	19.81	36.57
Industry(v.a.)	25.29	12.94	26.44	20.92	27.34	18.28
Manufacturing(v.a.)	16.57	4.91	16.29	8.77	15.42	8.24
Services(v.a.)	41.3	27.56	45.92	35.59	52.85	45.15
HHexp	69.63	80.23	65.89	79.24	59.93	79.8
Govexp	10.7	8.43	11.48	8.76	11.36	9.23
GCF	21.12	18.59	23.6	22.71	31.26	25.76

[a] v.a. = value added; HHexp is household final consumption expenditure; Govexp is general government final consumption expenditure; GCF is gross capital formation, formerly called gross domestic investment (*Source*: WDI)

prior to 1991, but not since. The two interest rates have moved fairly closely in the last two decades. On the development and integration of the financial sector, India's economy is clearly much more integrated with the international market, while Nepal's economy is relatively less connected. Apart from a few private investments in the financial sector, there are no significant private or public cross-holdings of financial assets and investments.[8] There are, however, strong chances that unofficial cross-border financial transactions occur, especially when the returns are significant. This possibility arises mainly because of a porous border, and the operational ease of such transactions is possible due to the convenience in the use of the Indian rupee in Nepal. Beyond this, it will be hard to argue any further instances of financial integration of the two economies. Officially, the capital account is not convertible in either country, although India is inching ever closer to opening up transactions in the capital account. To sum up, it appears that the level of financial integration that is needed to diversify investments and share risk do not exist, at present, between the two countries.

3.2.2 Endogeneity of OCA

An important development in OCA analysis is the argument that asymmetric economies may evolve over time into symmetric ones driven by the positive link between trade integration and income correlation. This is the "endogeneity of OCA" hypothesis. Countries in a monetary union gain reductions in trading costs in ad-

[8] Obviously, there are some firms in other sectors of the economy that have Indian investment.

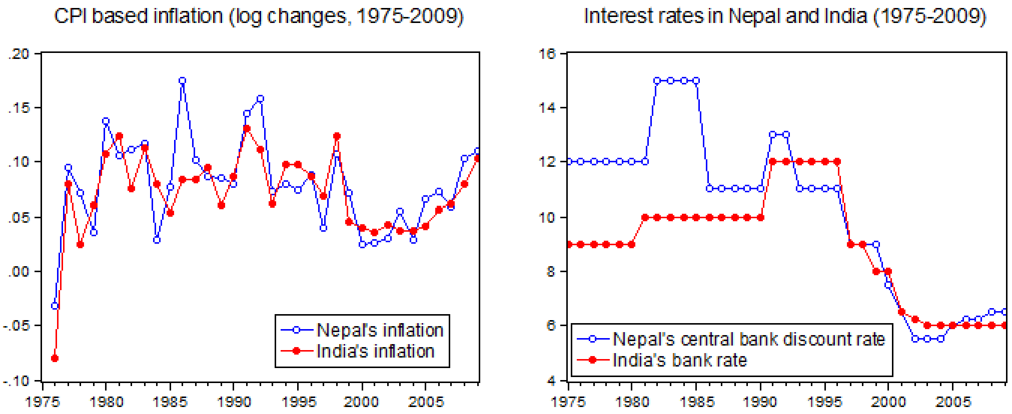

Figure 3.2: Nepal-India Inflation and Central-bank Interest Rates

dition to the elimination of exchange-rate volatility. Increasing trade relations may evolve into greater economic and financial integration, which in turn may lead to synchronization of business cycles. Frankel and Rose (1998) found evidence of this linkage in a major study. In a related study of the effects of a fixed exchange rate on trade, Klein and Shambaugh (2006) found that pegging the exchange rate substantially increased trade. Their estimate of the increase in trade is about 35 percent. They further argue that countries with an existing peg may not gain much in trade by forming a currency union.

In table 3.3, bilateral trade between India and Nepal is summarized. Nepal imports a lot more than it exports. Its average trade share with India is over 50 percent for most of the period. According to central bank data, imports from India have exceeded exports in most of the major commodity categories for a long time.[9] The important point is that, despite huge bilateral trading, Nepal's business cycle has a low correlation with India's.[10] This indicates the possibility of specialization in the two economies. Interestingly, however, as Artis (2003) suggested, the endogeneity argument holds that trade between countries—specifically trade in "components" as opposed to "varieties"—is likely to make shocks more common in the region. Indeed, Nepal's trade with India also involves a lot of inputs, especially

[9] Quarterly Economic Bulletin (2010), Vol. 45, 1 & 2, Nepal Rastra Bank

[10] See table 3.1.

Table 3.3: Nepal's Bilateral Trade Volume with India, and India's Share in Nepal's Total Trade (Million, NPR)

Variable	1975–89	1990–99	2000–09
Exports	14,827.80	40,993.50	333,294.40
Imports	39,929.10	181,139.10	918,606.60
Total trade	54,756.90	222,132.60	1,251,901.00
Average trade share	51.42%	28.27%	56.29%

low-end manufacturing goods (e.g. raw materials in garments and textiles). This may be one factor that can explain the modest level of business cycle correlation in the two.

Furthermore, some have argued that the speed of adjustment to shocks across economies is an equally important criterion.[11] Even when disturbances are asymmetric, faster adjustment to shocks may help mitigate the cost of relinquishing policy independence. Many of these issues are analyzed in this chapter before making any judgment on the feasibility of monetary integration between the two countries.

Although the focus in this chapter is primarily on analyzing the economic merits, the resolution of political/institutional considerations to support monetary integration is equally or even more challenging. Murray (1999, p. 9) summarizes this very eloquently while investigating the merits of a Canada-US currency union. In a passage that is very fitting to the India-Nepal case, he states:

> One thing is absolutely clear: Canadians would have very little say over the conduct of monetary policy under a currency union with the United States. If the United Kingdom were to join the EMU, it would be one of 12 countries setting monetary policy, all with roughly equivalent voting power. In addition, the GDP weights of the major participants would not be as seriously unbalanced as those of Canada and the United States. It is unrealistic to think that Canadians would ever have anything more than a token voice in a Canada-U.S. currency union. Expanding the size of the currency block to include all of the Americas would improve the situation, but not by enough to counterbalance the importance of the world's largest economy. Whether the United States would see any advantage in such an arrangement, and be willing to cede any of its economic power, is another question. Whether Canadians would ever accept such a colonial relationship is also unclear.

[11] See Lee et al. (2003).

3.2.3 Methodological Approach

There are some commonly used techniques in the study of monetary integration. One of them is the structural-shocks analysis based on a SVAR proposed by Blanchard and Quah (1989). In this study, I consider their approach and similar approaches in other papers, namely, Bayoumi and Eichengreen (1994), Murray, Schembri, and St-Amant (2003), and Huang and Guo (2006). The basic idea behind using SVAR techniques is to impose assumptions about the structural relationships in the economy so that model identification has some grounding in economic theory. While imposing assumptions about structural relationships might make it less ad-hoc in view of some researchers, others however question the validity of such assumptions.[12]

Consider a few assumptions generally made in this context. The proponents of the SVAR technique often assume that the economy's long-run output is not affected by demand-side policies. This means that in the long run only supply-side factors, such as factor accumulation, technological changes, and productivity growth, matter for output. It considers no role for demand-side factors to influence long-run output. However, such assumptions are necessarily quite strong given the evidence on sticky prices/wages and market imperfections such as monopolistic or oligopolistic firm behavior. Similarly, another strong assumption is that monetary shocks solely affect the long-run trend of inflation. However, it may not always be the case that monetary shocks would have a trend-altering impact on inflation and no real effects. If the economy is operating below its potential, there is less likelihood of any meaningful impact on inflation as a result of an expansionary monetary policy, and some possibility of lasting effects on real output. By making the ex ante assumption that monetary policy only alters the trend of inflation, one would be imposing a very strong opinion about the economic conditions for all time periods considered in the study.

Even when structural shocks have been considered, the traditional way to investigate them has come under some criticism. Generally, these shocks are ana-

[12]See Maza and Villaverde (2007).

lyzed using correlation coefficients. However, using a simple correlation of demand and supply shocks does not indicate whether any co-movement is due to a common element, such as a world business cycle disturbance or a regional disturbance, or whether they are idiosyncratic in nature. Any conclusion based on correlation analysis without knowing the source of co-movement may be incomplete. On the other hand, if a co-movement in shocks is regional or has a common source in candidate countries, that is further evidence of symmetry across economies. Also, a static measure like correlation does not indicate how the economies have evolved over time. As economies integrate globally, there are reasons to believe that they have undergone structural transformations. Knowing changes in the economy over time can be relevant from the point of analyzing symmetry across economies.

The investigation of structural shocks is therefore extended by considering the sources of symmetry/assymetry in the countries under investigation. Chamie, DeSerres, and Lalonde (1994) proposed this approach in studying the behavior of shocks in Eurozone countries and regions in the US. Using a state-space model, the authors found that shocks affecting regions in the US were much more symmetrical as they had a common origin, while in Europe they were more idiosyncratic. Xu (2006) also conducts a similar study for China, Hong Kong, and the US. Such decomposition of shocks into different sources helps in identifying not only the origins of symmetry/assymetry, but it also allows studying the evolution of shocks formation over time.

In the literature, there is another line of investigating monetary integration. Although the structural-shocks analysis is the predominantly favored method for examining the degree of symmetry across economies, the limitations cited above have led researchers to find alternative ways of investigation. A slightly different but a related approach in the investigation of business cycle synchronization is to use a detrended output series, i.e., the cyclical component. For example, Maza and Villaverde (2007) use a detrended output series from different regions in Spain to analyze synchronization, while Darvas and Szapary (2008) use detrended GDP and its components to study business cycle synchronization in the old and new EU members. The underlying idea is to give primacy to a cyclical analysis over the more restrictive nature of the assumptions usually applied under an SVAR.

Finally, in the context of whether to keep a single currency or accept monetary integration, some authors have reasoned along the lines of a cost-benefit analysis of adopting a single currency.[13] In this view, the benefits from adopting a single currency are primarily efficiency gains, as a result of reductions in transaction costs. For small economies, it also means an improved macroeconomic environment and a reason to enact structural reforms.[14] On the other hand, the loss of seigniorage is a direct result of giving up a national currency. As Nepal has operated under a pegged exchange-rate regime, especially a hard peg for almost 20 years now, the loss in seigniorage revenue would be perhaps less than it would be if Nepal were to be operating under a floating exchange-rate regime. This point also underscores the earlier discussion that a significant degree of monetary integration already exists between the two, and Nepal will likely not benefit much even from the inflation tax. An investigation along these lines will have to be the subject of future research.

3.3 Preliminary Data Analysis

3.3.1 Data Description

As already noted, this chapter includes a structural-shocks analysis and a business cycle investigation. The structural-shocks analysis is based on a three-variable SVAR that uses mainly output, price, and different monetary-policy instruments. For the business cycle investigation, data on GDP and its components for the two countries are used. Table 3.4 shows the variables used in the structural-shocks analysis. The money supply, domestic credit, and central-bank policy rates are used as alternative monetary-policy instruments. Similarly, in table 3.5, the variables used in the business cycle investigation are shown. In SVAR estimation, I use annual and quarterly data for the period 1975–2009. For the quarterly period, the income variable is interpolated from the annual series. In the business cycle investigation, I use annual data for the same period using different variables. The use of quarterly

---

[13] For example, see Gulde et al. (2004).

[14] Nepal may potentially benefit from strengthened discipline in fiscal and monetary policy operations by coordinating policies with a more stable, large economy.

Table 3.4: Data Used in the Structural-shocks Analysis

Variables	Name	Description
IIP^f	Industrial production	Annual and quarterly Indian industrial production; *Source*: IMF
Y, Y^f	Real GDP	Annual GDP series in constant 2000 USD; *Source*: WDI
P, P^f	CPI	Annual and quarterly CPI (2005 = 100); *Source*: IMF
M1	Money Supply	Annual and quarterly Nepal's M1 (S.A., Billion, NPR); *Source*: IMF Annual Nepal's M1 (Billion, NPR); *Source*: NRB
M1^f	Foreign money supply	Annual and quarterly India's money (S.A., Billion, INR); *Source*: IMF
DC, DC^f	Domestic Credit	Annual and quarterly series (Billion, Local Unit); *Source*: IMF
I, I^f	Interest Rate	Nepal's central bank discount rate India's bank rate (End of Period)

[a] Nepal's central bank discount rate for the missing year 1975 is assumed equal to 1976.
[b] Variables with superscript 'f' represents India.

data in this case is limited to imports and exports for which the complete series are available for 1975–2009.

3.3.2 Unit-root Tests

Various unit-root test results are presented in tables 3.6 and 3.7 for the variables used in the structural-shocks analysis. One test for the presence of a unit root in a time series is based on the augmented Dickey-Fuller (ADF) regression:

$$\Delta y_t = a_0 + \gamma y_{t-1} + a_2 t + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \varepsilon_t \tag{3.1}$$

where the null hypothesis is $\gamma = 0$ and failing to reject the null would imply existence of a unit root in the series. The ADF test which assumes no trend in the series, i.e., $a_2 = 0$, is presented with the notation 'c' under test type, while test results that include both a constant and a trend are presented with the notation '$c + t$.' The generic form of equation 3.1 is also the basis for other specific tests. In the Dickey-Fuller with GLS trending (DFGLS) test, the original series is transformed via a generalized least squares (GLS) regression before running the test. Studies have shown that this test has more power to reject the null of a unit root in the series when in fact there is no unit root than the ADF test. Next, the Phillips-Perron (PP)

Table 3.5: Data Used in the Study of Business Cycles

Variables	Name	Description
IIP^f	Industrial production	Annual and quarterly Indian industrial production; *Source*: IMF
Y, Y^f	Real GDP	Annual GDP series in constant 2000 USD; *Source*: WDI
X, X^f	Exports	Annual series in current USD; *Source*: WDI Quarterly series in current USD (1981Q1–2009Q4); *Source*: IFS-DOT
M, M^f	Imports	Annual series in current USD; *Source*: WDI Quarterly series in current USD (1981Q1–2009Q4); *Source*: IFS-DOT
Inv, Inv^f	Investment	Gross capital formation in current USD; *Source*: WDI
Cons, $Cons^f$	Consumption	Final consumption expenditure in current USD; *Source*:WDI
Ag, Ag^f	Agriculture	Agriculture, value added, in constant 2000 USD, ISIC divisions 1–5; *Source*: WDI
Ind, Ind^f	Industry	Industry, value added, in constant 2000 USD, ISIC divisions 10–45; *Source*: WDI
Manf, $Manf^f$	Manufacturing	Manufacturing, value added, in constant 2000 USD, ISIC divisions 15–37; *Source*: WDI
Srv, Srv^f	Services	Services, value added, in constant 2000 USD, ISIC divisions 50–99; *Source*: WDI

[a] Variables with superscript 'f' represents India.

test is a non-parametric test of a unit root, in which the test statistic is modified so that serial correlation does not affect its asymptotic distribution. In both the DFGLS and PP tests, the null hypothesis is the presence of a unit root in the series. Finally, the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS, 1992) test is different than the previous ones and is considered a complementary test. KPSS test for the null hypothesis that the series is stationary around a deterministic trend. All of the test results shown in tables 3.6 and 3.7 confirm that the variables either do not have a unit root, or are stationary in their expressed form (i.e., the first difference and/or growth rate).[15]

3.4 Estimation Method and Results

In this section, the investigation of structural shocks is presented in two steps. First, the SVAR technique is used to extract structural shocks from a three-variable

[15] See also the footnote to table 3.6.

Table 3.6: Various Unit-root Test Results (Annual Data)

Variable	Test type	DFGLS[a] Null: Uroot	PP Null:Uroot	KPSS Null:Stationary
dc	c	-3.83***	-4.33***	0.23
	c+t	-4.09***	-4.48***	0.11
m	c	-7.83***	-8.42***	0.21
	c+t	-8.94***	-8.83***	0.08
m_a	c	-4.61***	-5.13***	0.15
	c+t	-4.63***	-5.2***	0.1
p	c	-3.02***	-5.06***	0.19
	c+t	-3.97***	-5.37***	0.13**
i	c	-5.4***	-5.34***	0.11
	c+t	-5.46***	-5.29***	0.07
y	c	-7.32***	-7.46***	0.14
	c+t	-7.4***	-7.43***	0.13**
dc^f	c	-1.6	-4.5***	0.19
	c+t	-1.55***	-4.51***	0.16**
m^f	c	-8.19***	-11.67***	0.36**
	c+t	-8.64***	-16.26***	0.5***
p^f	c	-2.25**	-5.99***	0.14
	c+t	-3.57**	-6.36***	0.14**
i^f	c	-5.59***	-5.55***	0.26
	c+t	-5.87***	-5.74***	0.1
y^f	c	-4.7***	-5.53***	0.56
	c+t	-6.62***	-8.75***	0.1
iip	c	-4.4***	-4.87***	0.09
	c+t	-4.8***	-4.92***	0.05

[a] Lag selection in the DFGLS test is based on the Schwartz Information Criterion (SC).
[b] All variables are in growth form except i and i^f, which are in first difference. m_a is the alternative M1 for home country.
[c] Significance levels: ***1 percent, ** 5 percent, and * 10 percent

VAR. These shocks are further analyzed using correlation coefficients, variance decompositions, and impulse responses. Then, various time invariant and time varying state-space models are used to estimate the common component in these structural shocks. In the following section, a comprehensive business cycle investigation is presented. This involves several steps. Below, each of the estimation techniques is discussed in some detail.

3.4.1 Structural-Shocks Analysis

Three-variable SVAR

The basic motivation behind using a three-variable SVAR—involving output, the price level, and a monetary-policy indicator—is to extract supply shocks, pure

Table 3.7: Various Unit-root Test Results (Quarterly Data)

Variable	Test type	DFGLS[a] Null: Uroot	PP Null:Uroot	KPSS Null:Stationary
dc	c	-1.37	-12.65***	0.16
	c+t	-2.61	-12.67***	0.1
m	c	-0.7	-16.31***	0.14
	c+t	-1.94	-17.52***	0.13**
p	c	-2.6***	-10.61***	0.17
	c+t	-2.73***	-10.62***	0.13**
i	c	-11.73***	-11.72***	0.12
	c+t	-11.79***	-11.71***	0.07
dc^f	c	-1.86*	-16.48***	0.23
	c+t	-3.96***	-16.53***	0.16**
m^f	c	-10.33***	-41.11***	0.17
	c+t	-10.45***	-64.4***	0.1
p^f	c	-3.67***	-8.54***	0.16
	c+t	-4.35***	-8.54***	0.17**
i^f	c	-14.71***	-14.34***	0.34
	c+t	-14.92***	-14.55***	0.115

[a] Lag selection in the DFGLS test is based on the Schwartz Information Criterion (SC).
[b] All variables are in growth form except i and i^f, which are in first difference. m_a is the alternative M1 for home country.
[c] Significance levels: ***1 percent, ** 5 percent, and * 10 percent

demand shocks, and monetary policy shocks (policy induced demand shocks). By separating the two demand shocks, it is possible to identify the impact of policy changes, which otherwise could be attributed to more fundamental reasons such as tastes, preferences, etc.

A true model is represented by an infinite order moving average of a vector of variables

$$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + ... = \sum_{i=0}^{\infty} A_i\varepsilon_{t-i}, \tag{3.2}$$

and the matrix representation using a lag operator is $X_t = A(L)\varepsilon_t$. In equation 3.2, $X_t = [\Delta Y_t, \Delta P_t, \Delta M_t]'$ and the corresponding structural error term $\varepsilon_t = [\varepsilon_{st}, \varepsilon_{dt}, \varepsilon_{mt}]'$. The endogenous variables included in the system are domestic real GDP, Y_t, the price level, P_t, and money supply/interest rate/domestic credit, M_t.[16] The structural shocks in the system are assumed to be a domestic supply shock, ε_{st}, and a pure-demand shock, ε_{dt}, which is separated from the policy-induced demand

[16] Except for the change in the interest rate, which is in first differences, all other variables are in logarithmic changes.

effect (monetary shock), ε_{mt}. The coefficient matrix $\underset{(3\times3)}{A}$ is the impulse response function that shows the impact of the structural shocks on the endogenous variables. These innovations are assumed to be serially uncorrelated and orthonormal (i.e., an identity covariance matrix). The following system of equations shows the dynamics of structural innovation in the model:

$$\begin{bmatrix} \Delta Y_t \\ \Delta P_t \\ \Delta M_t \end{bmatrix} = \begin{bmatrix} A_{11}(L) & 0 & 0 \\ A_{21}(L) & A_{22}(L) & 0 \\ A_{31}(L) & A_{32}(L) & A_{33}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{st} \\ \varepsilon_{mt} \\ \varepsilon_{dt} \end{bmatrix}. \tag{3.3}$$

A few assumptions are necessary at this point to identify the system. First, the economy's long-run output is assumed to be influenced only by supply factors. Therefore, by assumption, only supply shocks such as productivity growth have a long-run influence on output. The cumulative effect of pure demand and policy induced shocks is assumed to be nil:

$$\sum_{i=0}^{\infty} A_{12i} = 0, \tag{3.4}$$

$$\sum_{i=0}^{\infty} A_{13i} = 0. \tag{3.5}$$

Second, the monetary shock is separated from the pure demand shock by assuming that only the former can affect the long-run trend of inflation

$$\sum_{i=0}^{\infty} A_{23i} = 0. \tag{3.6}$$

Under these very strong assumptions, a reduced form VAR is estimated in order to recover the structural shocks in equation 3.2. As the elements of X_t are assumed covariance stationary, the moving average (MA) operator in equation 3.2 can be inverted and represented by an autoregressive system. Thus, a reduced-form VAR, where all endogenous variables are regressed upon their lags and any exogenous variables, is estimated

$$X_t = B_1 X_{t-1} + B_2 X_{t-2} + ... + B_n X_{t-n} + e_t, \tag{3.7}$$

where e_t is the vector of residuals and B_i is the coefficient matrix. The VAR residual is a composite of all structural shocks, and the reduced form error is related to the structural shocks in the following way

$$Ce_t = D\varepsilon_t \text{ such that } C\Sigma C' = DD', \tag{3.8}$$

where C and D are $k \times k$ matrices to be estimated. Further, it is clear that errors extraction requires imposing identifying restrictions since the number of unknowns is greater than the number of equations, i.e., the system is under-identified. The covariance matrix, Σ, is an identity matrix with the variance normalized to one and zero covariances. Since the covariance matrix is symmetric, there are six distinct elements with this assumption.[17] Thus, an additional $\frac{k^2-k}{2}$ restrictions are needed. The three assumptions explained above suffice for this, and the structural shocks are then recovered as a linear combination of the reduced-form errors.

To infer relevant information from these shocks, various pairwise correlation coefficients are calculated. A positive correlation coefficient indicates similar shocks in the two countries and thus meets the condition for a synchronous policy response.

Time Invariant State-space Models

To complement the structural-shocks analysis from the SVAR, a shocks decomposition using a state-space model is proposed. In this method, the structural shocks from the SVAR are decomposed into two unobservable stochastic components: an idiosyncratic country shock and a region-wide common shock. This allows us to further calculate the variances of shocks in each country, which in turn are used to calculate the shares of the variances of the common shocks in the total shocks for each country. The symmetry of economies is then judged by comparing this share of the variance across candidate countries. A similar level of the share of the common-shock variance justifies synchronizing policies. Below, a formal presentation is offered in a two-country setting to get the desired decomposition.

A state-space model represents any univariate or multivariate time series

[17] The number of free elements in a $k \times k$ symmetric matrix is $\frac{k^2+k}{2}$.

through a state (or transition) equation, a measurement (observation or signal) equation, and related coefficient matrices. Hamilton (1994, p. 374) illustrates the rationale of using a state-space model in the following statement:

> The reason for rewriting an $AR(p)$ process in such a form was to obtain a convenient summary of the system's dynamics, and this is the basic reason to be interested in the state-space representation of any system.

The presentation here closely follows Xu (2006) and Chamie et al. (1994). First, the measurement equation presents the observed variables as a function of unobserved state variables

$$\begin{bmatrix} S_t^1 \\ S_t^2 \end{bmatrix} = \begin{bmatrix} \alpha_{11} & 1 & 0 \\ \alpha_{21} & 0 & 1 \end{bmatrix} \begin{bmatrix} Z_{0t} \\ Z_{1t} \\ Z_{2t} \end{bmatrix}, \tag{3.9}$$

where $S_t^i = [\varepsilon_{dt}^i, \varepsilon_{mt}^i, \varepsilon_{st}^i]'$ represents the observed structural supply, demand, and monetary shocks obtained from the SVAR estimation for country 'i' at time 't.' The unobserved Z_{0t} represents the region-wide common component, while Z_{1t} & Z_{2t} are the unobserved country-specific components of the structural shocks. Next, the state equation allows identification of the common and country-specific shocks using the Kalman filter[18]

$$\begin{bmatrix} Z_{0t} \\ Z_{1t} \\ Z_{2t} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varpi_{0t} \\ \varpi_{1t} \\ \varpi_{2t} \end{bmatrix}. \tag{3.10}$$

Since the structural shocks are assumed to satisfy model specification in an SVAR, each state equation is modeled as a white-noise process. The error terms are assumed to be serially uncorrelated. Further, two identifying restrictions are needed: a) no cross-correlation in shocks, i.e., shocks are orthogonal, and b) the variance of the

[18] For details on the Kalman filter see Harvey (1990) and Hamilton (1994).

common shock is set to unity:

$$E[\varpi\varpi'] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \sigma_{11} & 0 \\ 0 & 0 & \sigma_{22} \end{bmatrix}, \tag{3.11}$$

where σ_{ii} is the variance of the country-specific shock.

In above model, the coefficient α_{i1} measures the sensitivity of structural shocks in country i to the common component in the region. Particularly, a positive (negative) coefficient implies that the common shock is symmetric (asymmetric) for that country. Further, in order to assess the relative importance of common shocks in a particular country, its share in total shocks is calculated. To do this, first, consider a structural innovation in any country. For instance, the variance of a demand shock affecting country 1 is the sum of the variances of its common and country-specific shocks

$$Var(\varepsilon^1_{dt}) = (\alpha_{11})^2 + \sigma_{11}. \tag{3.12}$$

Since the two shocks are uncorrelated, the proportion of the variance of shocks explained by the common component is given by $\frac{\alpha_{11}^2}{(\alpha_{11}^2+\sigma_{11})}$.

Time Varying State-space Models

The state-space model presented above does not elucidate the dynamic effects in the economy if the estimated parameters are time variant. As already argued, economic integration is an on-going process and many factors play a role in its evolution. Closer output movement due to trade integration was noted as a key factor in this regard. Besides, it will be interesting to see if the two economies share a similar or different pattern in the shocks' behavior over time. In an attempt to address these possibilities, a time-variant state-space model is proposed to further investigate the shocks from the SVAR

$$S^1_t = \beta_t S^2_t + \varepsilon_t, \tag{3.13}$$

$$\beta_t = \beta_{t-1} + \omega_t, \tag{3.14}$$

where $\varepsilon_t \sim N(0,1)$ and $\omega_t \sim N(0,Q)$. S_t^1 represents the shocks from the SVAR for Nepal and S_t^2 for India. The time varying parameter, β_t, is assumed to evolve as a random walk process, and its time path indicates the evolution of synchronization in shocks, helping us determine if the economies became similar or dissimilar over time. In particular, it will measure if shocks in India affect shock formation in Nepal. A perfect synchronization would imply that the value of β_t converges to unity.

3.4.2 Econometric Results from the Structural-shocks Analysis

SVAR Results

Several SVAR models were estimated because of the use of three alternative measures—money supply, interest rate, and domestic credit—of monetary policy. Also, either real GDP or industrial production can be used to proxy India's output. As shown in table 3.1, Nepal's GDP and India's industrial production show a positive cyclical co-movement, which not only is higher than the cyclical co-movement in GDP, but also reveals the possibility of linkage of Nepal's economy with India's industrial sector. This makes India's industrial production an interesting variable to include in the SVAR, even though an industrial production index is not available for Nepal. All these variables were included in different SVAR estimations. The reason for using all different combinations is to expand the scope of investigation given that different policy tools were used in different time periods, often in conjunction, as well as to check the robustness of our results.

Table 3.8 presents the estimated correlations of the structural shocks obtained from the different SVAR models. The footnote to the table details the variables included in each estimation. For instance, D1, M1, and S1 are the shock correlations from an SVAR that includes the money supply (M1) and prices from the two countries as well as home (Nepal) GDP and foreign (India) industrial production. These correlation coefficients are calculated for the whole sample period and two subperiods. In the early 1990s, both economies took several reform measures aimed at liberalizing the economy. Thus, to keep the possibility of observing different responses over time, the sample is split into the periods 1975 to 1992 and 1993 onwards.

Estimates using quarterly data are also shown in table 3.8. Except Nepal's

Table 3.8: Correlation of Structural Shocks

Structural Shocks	1975–1992		1993–2009		1975–2009	
	a	q	a	q	a	q
D1	-0.1	0.15	-0.23	0.09	-0.19	0.1
M1	-0.45	0.29	-0.37	0.34	-0.49	0.32
S1	-0.17	-0.1	0.07	-0.04	-0.08	-0.08
D2	-0.49	0.009	0.18	-0.18	-0.17	-0.12
M2	-0.21	0.32	-0.58	0.34	-0.38	0.32
S2	-0.17	-0.17	-0.08	-0.13	-0.12	-0.16
D3	0.39		0.33		0.29	
M3	0.33		0.75		0.54	
S3	0.04		0.09		0.05	
D4	0.17	0.36	-0.2	0.04	-0.01	0.17
M4	0.46	0.15	0.32	0.28	0.34	0.21
S4	-0.07	-0.05	-0.25	-0.08	-0.12	-0.07

[a] D1, M1, and S1 represent different-shock correlation coefficients based on an SVAR that uses the domestic GDP growth and the growth in the foreign industrial production as well as inflation and the growth in M1 in the two countries.
D2, M2, and S2 represent different-shock correlation coefficients based on an SVAR that uses GDP growth rates as well as inflation and the growth in M1 in the two countries.
D3, M3, and S3 represent different-shock correlation coefficients based on an SVAR that uses domestic and foreign bank rates as policy instruments as well as GDP growth rates and inflation in the two countries.
D4, M4, and S4 represent different-shock correlation coefficients based on an SVAR that uses domestic and foreign domestic credit as policy instruments as well as GDP growth rates and inflation in the two countries.
[b] a = annual; q = quarterly

GDP, where interpolation is used to get the quarterly series, all of the series were available in a quarterly frequency. As seen in the table, there are some differences in the results using annual and quarterly data.[19] Using quarterly data in addition to annual in the estimation is motivated by the possibility of observing subtle variations in policy responses. In other words, it is often difficult using annual data to distinguish responses to policy changes in the economy from some exogenous changes that may have occurred concurrently. Even when allowing for this possi-

[19]Lag selection in an SVAR is based on lag-selection criteria in conjunction with sequential deletion of redundant lags. The default number of lags used in annual data is 2, while 12 lags were used with quarterly data. The quarterly-data VAR in most cases did not satisfy the model specification in terms of joint normality of the residuals.

bility, the results from the correlation estimates, however, suggest that there is not much similarity in the structural shocks of the two economies. Below, I discuss the results obtained using annual data only.

Three out of four SVAR estimates suggest that there is a negative correlation in the demand shocks in the full sample. Two estimates (D1 and D4) suggest that the economies became more asymmetric over time, in the post-liberal period. There is one estimate (D2) in which the correlation turned from negative to positive, indicating increasing symmetry. The full-sample estimate, however, is negative. Finally, the correlation coefficient (D3) from an SVAR that uses the interest rate as a policy instrument is positive and remained at a similar level in the two sub-periods as well as in the full sample.

The two correlation coefficients in monetary shocks (M1 and M2) suggest asymmetry, with a fairly high negative coefficient. The remaining two estimates indicate positive correlations. The three supply-shock correlation coefficients (S1, S2, and S3) show increases in the symmetry of the two economies over time, albeit at low levels. S1 turned positive from negative in the latter period, while S2 also improved from more asymmetry to less. S3 indicates almost no correlation, but nevertheless increased slightly over time. S4 indicates a decreasing correlation in the latter period. Taken together, the SVAR model that uses GDP growth, inflation, and the interest rate showed the most favorable correlations for all three types of shocks.[20] This is treated as the base case for further discussion.

It is useful, at this point, to compare these estimates with some prior studies. For Western Europe, Bayoumi and Eichengreen (1994) found that the correlation coefficient of supply shocks ranged between -0.39 and 0.68, while demand shocks varied between -0.21 to 0.65. Similarly, Murray, Schembri, and St-Amant (2003) found that the average supply-shock correlation between Canada and the regions of the US was 0.23, while between Mexico and the regions of the US it was -0.03. Likewise, the average real demand-shock correlation coefficients were 0.22 and -0.13, respectively. Saxena (2005) reports supply-shock correlations in South Asia between -0.41 and 0.29, and demand-shock correlations between -0.21 and 0.65. In Xu (2006),

[20]In table 3.8, these estimates are shown as D3, M3, and S3.

the correlation coefficient in supply shocks is 0.12 between Hong Kong and the US, -0.02 between Hong Kong and China, and -0.17 between China and the US. Similarly, the demand-shock correlations are 0.06, 0.16, and 0.10, respectively. Lastly, in the EAC region, Buigut and Valev (2005) found supply- and demand-shock correlation coefficients ranging from -0.31 to 0.54 and -0.44 to 0.4, respectively.

Comparing the estimates in this study with these previous studies suggests that they are within the range of those earlier estimates. In the literature, more emphasis is placed on the correlation of supply shocks because they are less likely to respond to demand-management policies. They also indicate more fundamental structural differences across economies. In that regard, the low correlation in supply shocks using different alternatives as seen in table 3.8 is not supportive of the idea of further monetary integration of the two economies. The concern is not so much that three out of four correlation coefficients improved in the latter period, but that the correlation is quite low using either set of estimates. In Saxena (2005), the supply-shock correlation between Nepal and India, in a two-variable SVAR, is 0.12 during 1973-2003 and 0.06 in 1995-2003, while the demand-shock correlation is 0.57 in the full-sample period. This suggests that the two economies shared little structural similarity in the post-liberalization period. In table 3.8, S3 for the period 1993–2009 shows a similar level of correlation. The common denominator in both of these studies is the finding of low correlation between the supply shocks. In terms of demand-shock correlation, the high coefficient observed in Saxena is almost non-existent when the monetary shock is separated from the pure demand shock.

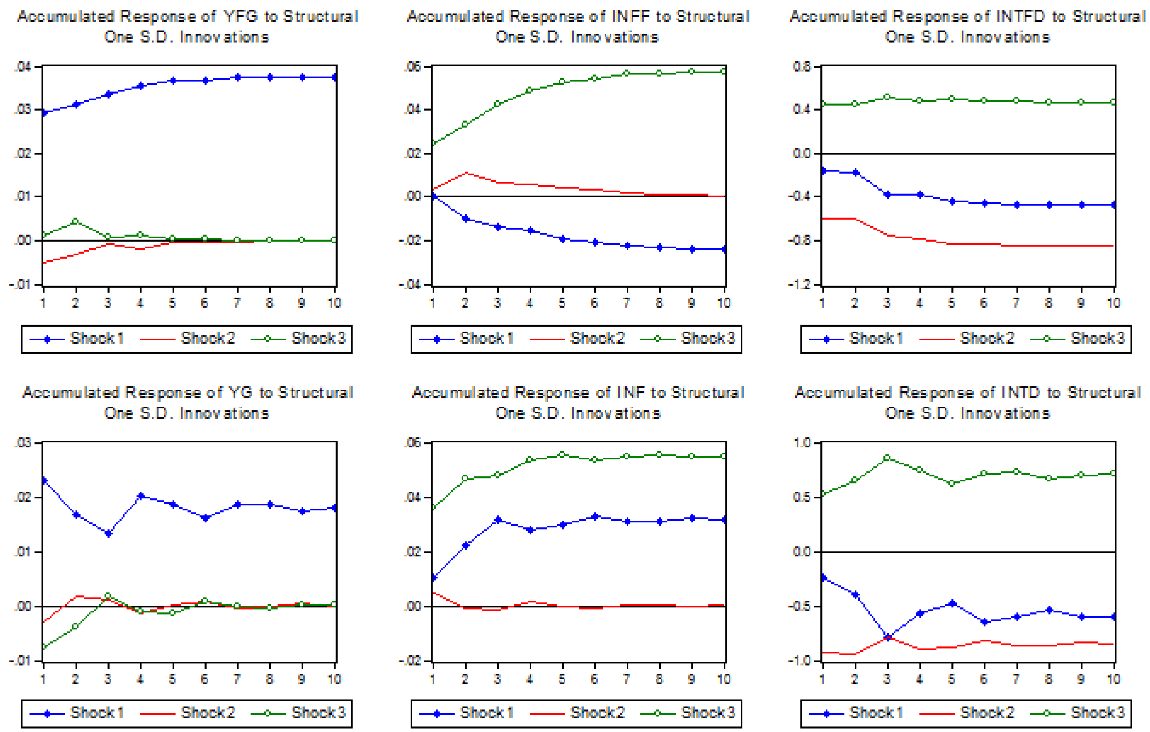

Figure 3.3: Various Impulse Responses to Different Shocks
(Upper panel-India; Lower panel-Nepal;First column: output response; Second column: inflation response; Third column: interest-rate response;Shock1 = Output shock; Shock2 = Inflationary shock; Shock3 = Monetary shock)

Also, it is necessary to note the limitations of simple correlation analysis. Simple correlations tend to be time sensitive.[21] This is clearly so as observed from the estimates in different sub-periods. Moreover, as already pointed out, the extent of correlation may be influenced by the existence of a common factor such as the regional or world business cycles, which is not revealed in the correlation coefficient of the shocks. Before investigating such a possibility, a brief analysis using some other SVAR results is presented.

Figure 3.3 shows the accumulated impulse-response graphs based on the SVAR estimates considered earlier in this section (corresponding to S3, D3, and M3 in table 3.8). Similarly, in table 3.9, results from the variance decomposition of the same SVAR are shown.

From the perspective of monetary integration, the larger the size of a shock the more disruptive it will be for the economy. Similarly, the slower the speed of adjustment after disturbances, the costlier it will be to coordinate policies. As seen in figure 3.3, the output response to a supply shock is higher in India. In Nepal, the response is more volatile. Next, output falls in response to a pure demand shock in both countries. The speed of adjustment is faster in Nepal where output recovers by the second period, while it improves in the third period in India. A monetary shock causes a small positive output response in India, which disappears by the end of the third period. In Nepal, a monetary shock causes a loss in output with adjustment and recovery by the end of the second period. The stark difference in the two policy responses in large part has its root in Nepal's supply-constrained economy.

A supply shock raises prices in Nepal, with the peak effect near the third period. In India, prices fall persistently over time. There is a clear divergence in how inflation responds to a supply shock in the two countries. Furthermore, prices rise persistently in both countries in response to a monetary shock and show almost identical effects. Finally, the interest rate falls in both countries in response to a supply shock. In Nepal, it fluctuates before settling in the sixth period, while it converges by the end of the fourth period in India. Likewise, the interest rate falls in response to a demand shock with similar speed and magnitude in both countries. In

[21] Xu (2006) makes this valid point.

Table 3.9: Variance Decomposition: Proportion of Output, Inflation, and Monetary Variability Due to Various Shocks

Year(s)	Supply shock		Demand shock		Monetary shock	
	India	Nepal	India	Nepal	India	Nepal
Output						
1	96.9	89.04	2.9	1.46	0.1	9.5
2	95.5	85.18	3.28	4.61	1.23	10.22
3	93.75	81.57	3.8	4.39	2.45	14.04
4	93.62	81.22	3.91	4.99	2.47	13.86
5	93.42	80.95	4.07	5.28	2.52	13.78
Inflation						
1	0.00	7.7	1.57	1.37	98.43	90.93
2	12.18	14.54	8.15	2.99	79.66	82.47
3	11.88	18.54	8.94	2.84	79.18	78.61
4	11.66	18.9	8.64	3.15	79.7	77.95
5	12.67	19	8.57	3.24	78.76	77.75
Interest rate						
1	4.37	4.74	61.51	72.69	34.12	22.58
2	4.43	6.48	61.47	70.22	34.1	23.3
3	10.42	16.78	58.47	60.95	31.11	22.27
4	10.4	19.14	58.44	58.96	31.17	21.9
5	10.93	19.54	58.18	57.93	30.89	22.53

[a] See footnote in table 3.8 for details on shocks definition.

general, the impulse-response analysis indicates some scope for similar adjustment mechanisms (speed and magnitude) in both economies.

Table 3.9 shows the forecast-error variance decomposition of all variables in the SVAR due to various shocks up to a five-year horizon. The number shows the share of the variability that each shock accounts for in the total variation of the endogenous variables. These variance decompositions also highlight the underlying differences in the transmission mechanism of shocks in the two economies. As seen in the table, supply shocks explain more than 80 percent of all variations in output of both countries in the five-year horizon. Buigut and Valev (2005) also report over 80 percent variation in output due to supply shocks, in the six-year horizon, in EAC countries. A similar number is reported for the East-Asia region in Zhang et al. (2004).[22] A demand shock causes a similar level of variation in both countries, while output variation due to a monetary shock in Nepal is higher than in India. When a monetary shock causes higher variation in output, policy independence is more relevant. Next, the variation in inflation is roughly similar in response to all types of shocks in the two countries. A monetary shock has a major role (over 70 percent) in explaining the variation in inflation. Finally, the bulk of the variation in the interest rate is due to demand shocks. The proportion is slightly higher in Nepal in the earlier period, but is similar in the two countries later on. In general, the variance decomposition results are not unfavorable to the idea of further monetary integration.

Estimates of the Common Component and Time-varying Relationship Using State-space Models

Using the structural shocks from the SVAR, the state-space model outlined in equations 3.9, 3.10, 3.11 was estimated. In this specification, state equations are shown to evolve as a white-noise process. During estimation, however, this model resulted in insignificant parameter estimates (α_{11}, α_{21}, σ_{11}, and σ_{22}) in all SVAR shocks. Therefore, as an alternative, a slightly different state-space model was estimated. In this new specification, state equations were modeled as a stationary autoregressive process of order one.[23] With this, several coefficients turned significant, and the estimates are shown in table 3.10. The estimates represent the coefficient for the common component in shocks and the variance estimates of idiosyncratic country-specific shocks. In order to calculate and compare the variance decompositions of the common components in the two countries, all four parameters are required to be statistically significant. As seen in the table, there are several significant estimates at conventional significance levels. Yet none of the four parameters are significant, concurrently, in any shocks. There was one exception in quarterly-data SVAR shocks. This result is presented in table 3.11 and will be

[22] Cited in Buigut and Valev (2005).

[23] The structural shocks from SVAR are assumed i.i.d. when calculating the common component. Therefore, an AR(1) specification of the unobserved components is perhaps not suitable. This remains a potential drawback in this estimation.

Table 3.10: Estimates of the Coefficients of the Common Component and the Variances of Shocks (1975–2009)

Shocks	α_{11}	α_{21}	σ_{11}	σ_{22}
Demand				
D1	0.32 (0.32)	-0.35 (0.33)	0.68** (0.27)	0.2 (0.25)
D2	0.27 (0.23)	-0.36 (0.24)	0.66*** (0.2)	0.55** (0.26)
D3	0.29 (0.19)	0.79* (0.45)	0.67*** (0.19)	0.15 (0.67)
D4	0.23 (0.84)	0.21 (0.62)	0.59 (0.47)	0.73** (0.34)
Monetary				
M1	0.63*** (0.19)	-0.46*** (0.15)	0.27 (0.19)	0.4*** (0.13)
M2	0.46*** (0.17)	-0.61** (0.25)	0.53*** (0.18)	0.29 (0.31)
M3	0.76*** (0.14)	0.57*** (0.13)	0.12 (0.13)	0.42*** (0.13)
M4	0.36** (0.18)	0.31 (0.29)	0.58** (0.25)	0.34 (0.24)
Supply				
S1	-0.0007 (0.002)	-0.0009 (0.002)	0.79*** (0.2)	0.55*** (0.14)
S2	0.87*** (0.12)	0.11 (0.17)	0.005 (0.04)	0.77*** (0.19)
S3	0.08 (0.17)	0.06 (0.15)	0.75*** (0.2)	0.76*** (0.2)
S4	0.1 (0.19)	-0.52 (0.4)	0.79*** (0.2)	0.21 (0.37)

[a] *** 1%, ** 5%, and * 10% significance level
[b] α_{11} and σ_{11} are estimates for Nepal; α_{21} and σ_{22} are estimates for India.
[c] See footnote in table 3.8 for details on shocks definition.

Table 3.11: Estimates of the Coefficients of the Common Component and the Variances of Shocks (1975Q1–2009Q4)

Shocks	α_{11}	α_{21}	σ_{11}	σ_{22}
M4	0.28* (0.15)	0.44* (0.23)	0.6*** (0.11)	0.5** (0.22)

[a] *** 1%, ** 5%, and * 10% significance level
[b] See footnote in table 3.8 for details on M4.

discussed shortly.

Although it is not possible to compare the share of variances accounted for by the common component unless all four estimates are significant, it is still possible to see the direction of impact of the common component in each country. A positive coefficient (α_{11} and α_{21}) suggests that the shocks are symmetric in the two countries. Estimates of α_{11} in table 3.10 show that the unobserved common component is positively associated with Nepal's various structural shocks. This is true for all significant estimates. In India (α_{21}), D3 and M3 have common components that are positively linked to structural shocks, while two other significant estimates of common components (in M1 and M2) are negatively related. None of Nepal's pure demand shocks has a significant common component, and only one supply shock has a significant regional element. All monetary shocks show evidence of a regional element. On the other hand, in India, there are one pure demand and three monetary shocks that have a regional element. Importantly, none of the supply shocks in India showed evidence of a common component.

In large part, the decomposition of structural shocks showed less commonality in the two economies. The evidence of a common component in monetary shocks may be seen as the outcome of a pegged exchange-rate regime. Using different policy indicators, the results consistently showed that policy shocks in India had spillover effects in Nepal. As indicated by positive coefficients of the common component, the Nepalese authorities may be responding in a similar manner to changes in India. In contrast, the absence of statistically significant common components in pure demand and supply shocks underscores two structurally different economies. Despite Nepal's huge trade with India, it appears that the two countries lack synchronicity in terms of co-movement of output. As Artis (2003) notes, trade content matters more than trade volume. If Nepal and India are trade partners in some intermediate goods, that would bring the two economies closer. Likewise, if the countries share similar export demand in the international market, they may be affected in a similar manner by changes in demand in the global market. Despite some evidence on both fronts, it appears that shocks in the two economies are dominated more by idiosyncratic factors than by common elements.

Next, using the estimates of the common component in a monetary shock (M4) in table 3.11, the share of the variance of shocks explained by the common component in the two countries is calculated. They are 0.12 and 0.28 in Nepal and

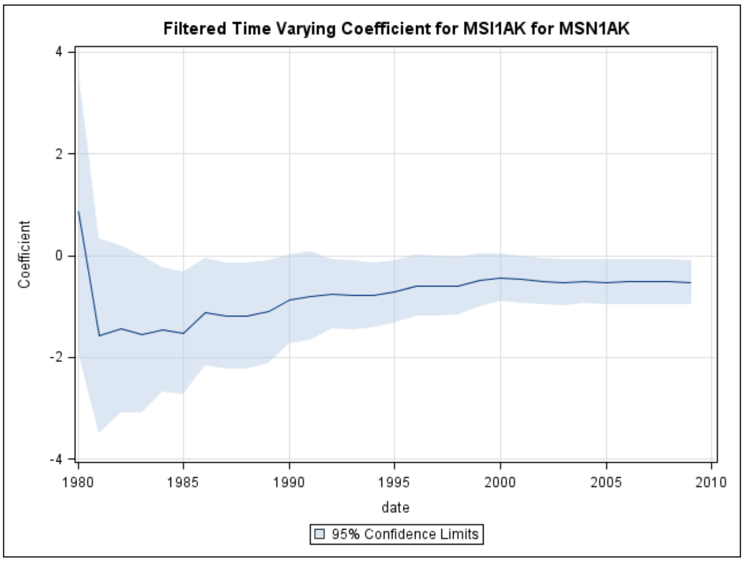

Figure 3.4: Time Varying Coefficient Using a Monetary Shock (Also Reported in Table 3.8 Under M1)

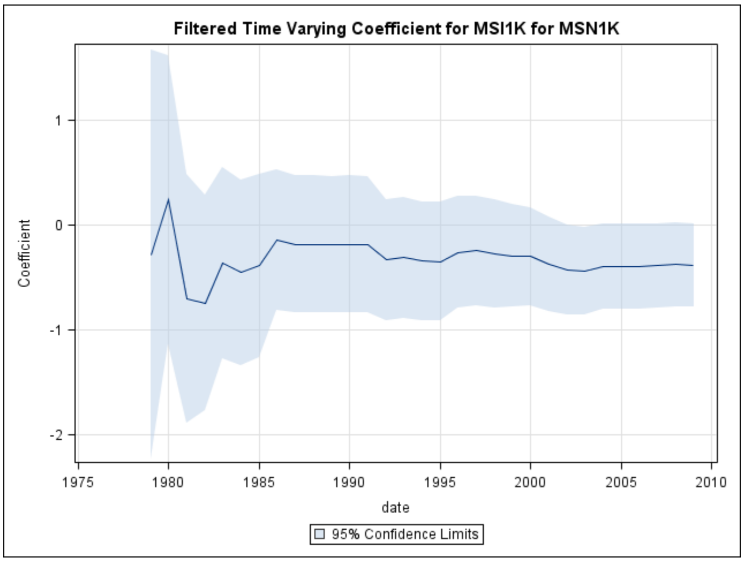

Figure 3.5: Time Varying Coefficient Using a Monetary Shock (Also Reported in Table 3.8 Under M2)

India, respectively. Nepal's monetary shock shares about 12 percent in common with that of India, while India's has a higher share of about 28 percent. It is difficult to analyze this result in the absence of similar other estimates for pure demand and supply shocks. Nonetheless, the higher share of the variation in India is perhaps indicative of the origination of the regional element.

Figures 3.4 and 3.5 show the evolution of β_t in equation 3.13 for the two monetary shocks, where β_t is the coefficient of regression of Nepal's shock on the shock from India.[24] None of the other structural shocks showed evidence (statistically significant) of time-varying evolution of β_t, and therefore they are not shown here. In figure 3.4, β_t rises slowly over time and converges to just below zero. With some fluctuations (insignificant), β_t converges to just below zero in figure 3.5. Although these results are not an indication of a strong relationship in the shocks, the graphs do not indicate any deterioration in the relationship over time, either. The major concern in the time-varying estimations, however, is the non-existence of such a relationship in either demand or supply shocks. It is not possible to infer any meaningful conclusion based on monetary shocks alone.

3.4.3 Business Cycle Synchronization

Some commonly used approaches in business cycle investigation are considered here, following the approach of Darvas and Szapary (2008) who focus on detrended GDP and its components. For this purpose, I use GDP and its sub-components—consumption, investment, imports, and exports—as well as sectoral contributions—agriculture, industry, manufacturing, and services—from India and Nepal to conduct the analysis. Constant-price (2000 USD) data is used in the analysis of GDP, agriculture, industry, manufacturing, and services. However, the unavailability of constant-price data for Nepal required using current-price (USD) data for consumption, investment, imports, and exports.

I. Correlation of common factor and cyclical component:

To begin the correlation analysis of business cycles, GDP and its component series are detrended. There are two common methods to get the cyclical component of a series: the Hodrick-Prescott (HP) filter and a band pass (BP) filter. The HP filter separates the cyclical component form the trend component of a series by minimizing its variance against the trend subject to a penalty measure that

[24]The two monetary shocks used are from SVARs that are reported in table 3.8 under M1 and M2.

constrains variations in the growth rate of the trend component.[25] Darvas and Szapary (2008) cite Canova (1998) to point out that empirical results might vary with the specific filter used in detrending. A BP filter is, therefore, used as an alternative detrending method. Darvas and Szapary also point to Stock and Watson (1998) in suggesting that the BP filter is preferable since by definition it cuts off both high- and low-frequency fluctuations. The Baxter and King (1999) method is used in applying the BP filter. In the literature, this method is generally favored in the analysis of historical data, and the filtering technique under this method is time invariant. High-frequency fluctuations may contain noise and measurement error, while low-frequency fluctuations may be due to a long-term trend component. After detrending, the cyclical series is standardized to have equal variance across countries. Smaller economies tend to have more volatile business cycles and are likely to dominate (have a higher weight) in the calculation of the common factor. This is a standard procedure often used in the literature.

In the first step of the correlation analysis, the standardized cyclical series from the two countries is used to estimate the common component. Second, a simple pairwise unconditional correlation coefficient is computed between the common component (z_t) and the individual country business cycles (z_{it}). I use a five-year, non-overlapping correlation coefficient to uncover the changing pattern of business cycle synchronization (of Nepal) over different time periods. Further, I also use a five-year rolling sample correlation coefficient to see if the result would be any different. In order to get the common component, the following state-space model is estimated:

$$y_{it} = \beta_i z_t^c + \beta_j z_{it}^s + \varepsilon_{it}, \tag{3.15}$$

$$z_t^c = \gamma z_{t-1}^c + \upsilon_t, \tag{3.16}$$

$$z_{it}^s = \gamma_i z_{it-1}^s + \upsilon_{it}, \tag{3.17}$$

where ($i/j = 1, 2$), y_{it} is detrended logarithmic GDP or its components, ε_{it} is the error term in the observation equation which follows a normal distribution $N(0, \sigma^2)$,

[25] The value of lambda (λ) is set to 100 in annual data and 1600 in quarterly data.

and the common, υ_t, and country-specific, υ_{it}, shocks are also assumed to follow a normal distribution with a zero mean and a constant variance. The common and country-specific shocks are uncorrelated with each other ($cov(\upsilon_t, \upsilon_{it}) = 0$) and, also, not correlated with ε_{it}. The β_s and γ_s are the parameters to be estimated.

It is important to note that a different form of state-space model can also be estimated. The observation equation in 3.15 has no constant term but incorporates an error term. The former is not needed since the cyclical component has a mean of zero.[26] Gregory, Head, and Raynauld (1997) set up a state-space model to estimate the common component in income, consumption, and investment in the G7 countries. Their model has three unobserved components to explain the cyclical movement in each variable. One of the unobserved components is common in each variable in every country. This is in addition to region-wide and country-specific components. Their point is to highlight the possibility of co-movement in aggregate macro variables, which they suggest is a measure of change in the overall economic activity. The model set out here is different than that of Greogry et al., but the possibility of such a co-movement in variables can't be denied, which justifies having the error term in the observation equation. The state equations are modeled as a first-order, stationary univariate autoregressive process.

Alternatively, following Maza and Villaverde (2007), I also use a slightly different state-space model as shown in equations 3.19–3.20. The difference in this formulation is the coefficient restriction in the observation equation. This is based on the assumption that all variations not explained by the common factor are explained by the country-specific factor. This type of setting is by far the most common in the literature:

$$y_{it} = \beta_i z_t^c + z_{it}^s, \tag{3.18}$$

$$z_t^c = \gamma z_{t-1}^c + \upsilon_t, \tag{3.19}$$

$$z_{it}^s = \gamma_i z_{it-1}^s + \upsilon_{it}. \tag{3.20}$$

[26] Although this is not the case with the BP-filtered data, the mean is generally closer to zero in most of the series. Moreover, using an alternative model with a constant term may not yield much insight.

II. Business cycle volatility:

The second indicator used to investigate business cycle synchronization is the volatility of business cycles in each country. While the correlation suggests the direction and extent of co-movement, the volatility helps to capture the depth of movement in each series. Along the lines of Darvas and Szapary (2008), I calculate the variance of the cyclical component of each series. As noted before, smaller economies tend to have relatively higher volatility in their business cycles. Higher variability can make policy coordination more challenging. To get better insight, it is useful to compare the pattern of variability in business cycles of the two economies, which is the goal of this analysis. The non-standardized HP and BP-filtered data are used for this purpose.

III. Persistence of the business cycle:

It is important to know the degree of persistence in the business cycle in order to determine the scope and magnitude of the policy response. Countries that are considering monetary integration are better served if they have a similar level of persistence. A first-order autocorrelation coefficient is used to compare persistence in business cycles of the two economies. Again, the non-standardized HP and BP-filtered data are used.

IV. Impulse response:

As a final indicator of business cycle synchronization, accumulated impulse response graph of the individual country business cycle to a shock to the common factor is presented. To do this, an unconditional two-variable VAR—using the common component and individual country business cycle—is estimated for each country. Darvas and Szapary (2008) argue that when the correlation is large and the volatility and persistence of business cycles are similar, then the impulse responses will not deliver different conclusions. If, however, any of these do not hold, then the impulse responses can be used as one more indicator of synchronization. A generalized impulse response for a two-year period is considered. Only the GDP series is considered for this purpose.[27]

3.4.4 Econometric Results from the Business Cycle Investigation

This section presents the results from analyzing business cycles in the two countries following the methods discussed above. In tables 3.12 and 3.13, five-year non-overlapping correlation coefficients, calculated using the common component in the two business cycles and Nepal's business cycle, are shown. The results correspond to the common component in the state-space models in equations 3.15 and 3.18, respectively.[28] These tables also show the results using the GDP components as well as the contribution from various sectors. Since this chapter is focused mainly on analyzing Nepal's economy, the correlation results are limited to highlighting the synchronization of its business cycle. Additionally, tables 3.15–3.18 show estimates of persistence and volatility in business cycles of the two economies. The impulse response graphs in figures 3.6 and 3.7 show the responses of Nepal's business cycle to shocks to the common component.

A quick note on estimation is necessary. The model estimation was attempted for all variables using both HP- and BP-filtered data. There were, however, some issues in model convergence for some variables. Thus, correlation coefficients were calculated in cases where convergence was achieved in estimating the model.

Before proceeding to the economic analysis of the correlation results, it is interesting to contrast the estimates shown in tables 3.12 and 3.13. As noted in the footnote to table 3.12, most of the estimates (marked with an asterisk under "Filter") were calculated using the common component generated from the state-space model in equation 3.15, but without the error term in the observation equation. As it turned out, there were some issues in estimating that particular state-space model, especially the non-convergence and/or termination of optimization while applying the Kalman filter. After attempting different alternative models, the closest to the model in equation 3.15 turned out to be the one without the error term

[27] Darvas and Szapary (2008) suggest a period of six quarters to generate accumulated impulse responses, which they point as the period during which monetary policy takes effect.

[28] The five-year rolling correlation coefficients did not offer any additional insight about the relationship and are therefore not presented.

Table 3.12: Correlation Coefficients Using the Region-wide Common Component and Nepal's Business Cycle Using the Model in Equation 3.15

Variable	Filter	1975–79	1980–84	1985–89	1990–94	1995–99	2000–04	2005–09
GDP	HP*	-0.26	-0.55	-0.56	-0.08	-0.3	-0.96	0.05
	BP*		0.2	0.63	-0.07	-0.12	0.91	
Inv	HP*	0.88	0.62	0.88	0.15	0.94	0.95	0.54
	BP		0.48	0.92	-0.2	0.29	0.85	
Cons	HP*	0.54	-0.22	0.77	0.8	0.57	-0.04	0.57
	BP*		-0.64	0.78	0.88	0.64	0.03	
Exports	HP	0.49	0.43	-0.53	-0.04	0.84	0.36	-0.89
Imports	HP*	-0.87	-0.79	-0.89	-0.68	-0.99	-0.88	-0.49
Ag	HP	0.99	0.99	0.99	0.99	0.99	0.98	0.99
	BP*		-0.97	-0.98	-0.98	-0.93	-0.79	
Ind	BP*		0.4	0.48	0.88	-0.23	-0.25	
Manf	HP*	0.06	0.28	0.97	0.73	-0.5	-0.41	-0.7
	BP*		0.99	0.99	0.99	0.85	0.99	
Srv	HP*	-0.99	-0.99	-0.96	-0.99	-0.97	-0.99	-0.99

[a] HP:HP-filtered data; BP:BP-filtered data
[b] HP* and BP* indicate estimates based on the state-space model in equation 3.15, but without the error term in the observation equation.
[c] Using the Baxter and King (1999) method to get BP-filtered data led to a loss in observation at the beginning and the end of the sample. In this case, three observations, each at the beginning and end, were lost.
[d] Ag = agriculture; Ind = Industry; Manf = Manufacturing; Srv = Services; Cons = Consumption; Inv = Investment

in the observation equation. As is clear from the estimates in tables 3.12 and 3.13, differences in model specification produced a wide range of results. Some estimates were identical, some very close, and others very different. It appears that the results are sensitive and not so sensitive, both at the same time, using alternative specifications. The same is true with the data using alternative filtering methods. This opens up a number of possibilities in terms of correct model specification. Although further investigation would be beyond the scope of this chapter, it remains an interesting agenda for future research.

To get a proper comparison of the estimates, table 3.14 shows the pattern in the correlation coefficients based on estimates in tables 3.12 and 3.13. It is clear that interpreting results obtained from different model specifications is quite difficult. The sensitivity of the results also highlights the ad hoc nature of the model specification, which is often the case in the literature. One more example of the lack

Table 3.13: Correlation Coefficients Using the Region-wide Common Component and Nepal's Business Cycle Using the Model in Equation 3.18

Variable	Filter	1975–79	1980–84	1985–89	1990–94	1995–99	2000–04	2005–09
GDP	HP	0.26	0.55	0.55	0.08	0.3	0.96	-0.05
	BP		0.2	0.63	-0.07	-0.12	0.91	
Inv	HP	0.88	0.62	0.88	0.15	0.94	0.95	0.54
	BP		0.49	0.92	-0.19	0.32	0.86	
Cons	HP	0.54	-0.22	0.77	0.8	0.57	-0.04	0.57
	BP		-0.44	0.78	0.88	0.64	0.03	
Exports	HP	0.89	0.26	-0.47	0.13	0.46	-0.2	0.4
Imports	HP	0.87	0.79	0.89	0.68	0.99	0.88	0.49
	BP		0.57	0.76	0.31	0.74	0.8	
Ag	HP	-0.01	0.33	-0.6	0.37	0.18	0.16	0.5
	BP		-0.97	-0.98	-0.98	-0.93	-0.79	
Ind	BP		0.4	0.48	0.88	-0.23	-0.25	
Manf	HP	0.06	0.28	0.97	0.73	-0.51	-0.41	-0.7
	BP		-0.99	-0.99	-0.99	-0.84	-0.99	
Srv	HP	0.18	0.61	0.63	-0.04	0.03	0.36	0.01
	BP		0.8	0.52	0.1	-0.05	0.47	

[a] Estimates are based on the state-space model in equation 3.18.
[b] HP:HP-filtered data; BP:BP-filtered data
[c] Using the Baxter and King (1999) method to get BP-filtered data led to a loss in observation at the beginning and the end of the sample. In this case, three observations, each at the beginning and end, were lost.

of generality in model specification is the use of a time-varying slope term in the observation equation in Babetskii, Boone, and Maurel (2004). The authors use a time-varying state-space model to determine convergence in VAR shocks.

Having acknowledged the sensitivity in results, I turn briefly to discuss the economic implications. In doing so, the focus is on the similar observations from tables 3.12 and 3.13.

In Darvas and Szapary (2008), the cyclical correlation in GDP of the new and old EU members is between -0.34 and 0.73 over two time periods, 1993–97 and 1998–2002. The authors note that Hungary, Poland, and Slovenia have achieved increased synchronization of their business cycles in GDP, industry, and exports, but not in consumption and services. In this study, using BP-filtered data, the cyclical correlation in GDP over time was found to be positive except in the 1990s. Second, the fluctuating correlation coefficients in exports do not indicate evidence

Table 3.14: Comparing Correlation Coefficients from Tables 3.12 and 3.13

Variable	Filter	Remarks
GDP	HP	Identically opposite estimates
	BP	Identical
Exports	HP	Different pattern
Imports	HP	Identically opposite
Inv	HP	Identical
	BP	Nearly identical pattern
Cons	HP	Identical
	BP	Nearly idetnical
Ag	HP	Very different pattern
	BP	Identical
Ind	BP	Identical
Manf	HP	Identical
	BP	Almost identically opposite
Srv	HP	Very different

of increased synchronization. Third, there is a high correlation in the cyclical component of investment in almost entire period. Fourth, except in the early 1980s and 2000s, the correlation in cyclical consumption is fairly high. Fifth, in agriculture, using BP-filtered data, the correlation coefficients are substantially negative over time. Sixth, in industry, the synchronization was positive and increasing up until the mid-1990s, but then turned negative for the rest of the period. Finally, using HP data, the cyclical correlation is strongly positive in manufacturing until the mid-1990s. Since the manufacturing data is a subset of the industrial data, the similar pattern in the two is perhaps expected.

There are some general observations based on the correlation analysis. The high correlation in exports from 1995 to 2004 is likely to have captured the only period of export boom in Nepal led by the exports of apparel, textile, and carpets. India has been one of the leading exporters of these goods. Thus, it is possible that global demand is the source of increased synchronization. Similarly, the high correlation in investment, for most periods, is indicative of expenditures on fixed capital in the two countries. The correlation in consumption, which includes both household and government spending, might have captured the effects of expansionary fiscal policy. Deficit financing in Nepal has been a regular feature of budgetary operation since the 1970s. The government of India was using deficit financing as early as the 1950s. By its nature, fiscal policy is idiosyncratic and country-specific circumstances largely govern its evolution. On the other hand, household consumption is largely an outcome of household income and wealth. Therefore, while the reasonably high correlation over time suggests synchronization, this result has to be taken with caution because of the changing country-specific conditions.

Next, the highly negative correlation in agriculture is quite surprising, although the result is sensitive to the choice of the filtering method. Weather and other factors make agricultural outcome heavily dependent on country-specific conditions. Yet it is reasonable to expect some synchronization in agricultural output given geographical proximity and the fact that vast majority of population in both countries still depend on an agriculture-based economy. In industry and manufacturing, there is an interesting pattern. The two economies shared similarity in the pre-liberalization era, but they became dissimilar in the post-liberalization period. As the economies diversified, especially India, in the post-liberal period, the correlation coefficients turned negative. It is possible that globalization may have deepened specialization in the two countries.[29] Lastly, the contribution from the service sector in the post-liberal period suggests less synchronization.

Persistence. Darvas and Szapary (2008) suggest that an increase in the persistence of business cycles is one indication of a diminishing role of country-specific shocks. In tables 3.15 and 3.16, persistence measures of business cycles are shown for the two periods to contrast the pre-liberalization (1975–1992) and post-liberalization (1993–2009) effects. As seen in these tables, most of Nepal's variables show conflict in the persistence results over time, using HP- and BP-filtered data. These estimates also show that in almost all of the foreign-country (India) variables, there is a rise in persistence using either data. Several home-country (Nepal) variables—industry, manufacturing, services, consumption, investment, imports, and GDP—show increases in the levels of persistence using HP data.

Next, a majority of variables in both countries show roughly similar levels of persistence, especially using HP data in either period. For instance, the autocorrelation coefficients for industry in Nepal are 0.36 and 0.45, while in India the coefficients are 0.24 and 0.66, respectively. Similar observations are true for manu-

[29]Some local factors are also relevant in this regard. The Nepalese industrial sector continues to suffer from political instability, labor issues, and severe power shortages. These factors have contributed to amplifying the divergence seen in these sectors.

Table 3.15: Persistence of Business Cycles (Annual Data)

Variable		1975–92	1993–09	Variable		1975–92	1993–09
Ag	HP	0.34	0.08	Ag^f	HP	-0.15	-0.27
	BP	-0.13	-0.31		BP	-0.3	-0.7
Ind	HP	0.36	0.45	Ind^f	HP	0.24	0.66
	BP	0.08	0.04		BP	-0.07	0.33
Manf	HP	0.55	0.62	$Manf^f$	HP	0.26	0.61
	BP	0.3	0.18		BP	0.13	0.32
Srv	HP	0.31	0.51	Srv^f	HP	0.54	0.63
	BP	-0.21	-0.02		BP	0.14	0.17
Cons	HP	0.25	0.32	$Cons^f$	HP	0.32	0.53
	BP	-0.2	-0.36		BP	0.03	0.25
Inv	HP	-0.1	0.46	Inv^f	HP	0.36	0.34
	BP	-0.42	0.08		BP	0.03	0.03
M	HP	0.36	0.64	M^f	HP	0.56	0.56
	BP	-0.05	0.15		BP	0.22	0.35
X	HP	0.53	0.48	X^f	HP	0.5	0.56
	BP	0.08	-0.19		BP	0.26	0.29
Y	HP	-0.04	0.2	Y^f	HP	0.13	0.62
	BP	-0.31	-0.18		BP	-0.22	0.26
				IP^f	HP	0.54	0.51
					BP	-0.03	0.3

[a] HP:HP-filtered data; BP:BP-filtered data
[b] Ag = agriculture; Ind = Industry; Manf = Manufacturing; Srv = Services; Cons = Consumption; Inv = Investment
[c] Variables with superscript 'f' represents India.

Table 3.16: Persistence of Business Cycles (Quarterly Data)

Variable		1975q1–1992q4	1993q1–2009q4	Variable		1975q1–1992q4	1993q1–2009q4
M	HP	0.25	0.17	M^f	HP	0.33	0.41
	BP	0.84	0.92		BP	0.77	0.9
X	HP	0.15	-0.04	X^f	HP	0.003	0.25
	BP	0.84	0.93		BP	0.93	0.93

[a] HP:HP-filtered data; BP:BP-filtered data
[b] Variables with superscript 'f' represents India.

facturing, services, consumption, imports, and exports.

Volatility. The volatility measure of the business cycle is also split into two periods in tables 3.17 and 3.18. Except for a few variables, the variance of the cyclical

Table 3.17: Volatility of Business Cycles (Annual Data)

Variable		1975–92	1993–09	Variable		1975–92	1993–09
Ag	HP	0.001	0.0002	Ag^f	HP	0.002	0.0007
	BP	0.0006	0.0002		BP	0.002	0.0006
Ind	HP	0.005	0.0003	Ind^f	HP	0.0007	0.0009
	BP	0.003	0.0002		BP	0.0005	0.0003
Manf	HP	0.008	0.001	$Manf^f$	HP	0.0013	0.002
	BP	0.003	0.0005		BP	0.0009	0.0007
Srv	HP	0.0008	0.0004	Srv^f	HP	0.0003	0.0002
	BP	0.0004	0.0002		BP	0.0001	0.00006
Cons	HP	0.006	0.002	$Cons^f$	HP	0.007	0.004
	BP	0.002	0.0007		BP	0.004	0.0008
Inv	HP	0.007	0.015	Inv^f	HP	0.009	0.017
	BP	0.004	0.006		BP	0.005	0.007
M	HP	0.008	0.013	M^f	HP	0.02	0.014
	BP	0.003	0.004		BP	0.007	0.004
X	HP	0.01	0.018	X^f	HP	0.007	0.01
	BP	0.005	0.007		BP	0.004	0.003
Y	HP	0.0004	0.0001	Y^f	HP	0.0005	0.0004
	BP	0.0004	0.0001		BP	0.0004	0.0001
				IP^f	HP	0.001	0.0008
					BP	0.0004	0.0004

[a] HP:HP-filtered data; BP:BP-filtered data
[b] Ag = agriculture; Ind = Industry; Manf = Manufacturing; Srv = Services; Cons = Consumption; Inv = Investment
[c] Variables with superscript 'f' represents India.

Table 3.18: Volatility of Business Cycles (Quarterly Data)

Variable		1981q1–1992q4	1993q1–2009q4	Variable		1981q1–1992q4	1993q1–2009q4
M	HP	0.015	0.015	M^f	HP	0.008	0.008
	BP	0.015	0.02		BP	0.005	0.005
X	HP	0.03	0.01	X^f	HP	0.006	0.005
	BP	0.02	0.009		BP	0.003	0.002

[a] HP:HP-filtered data; BP:BP-filtered data
[b] Variables with superscript 'f' represents India.

component fell over time and this holds using either HP or BP data. Volatility increased for investment in both countries, while it also increased in home imports and exports. On the argument that smaller countries have higher volatility in their business cycle, the estimates here suggest that that is the case only in services and exports. In fact, the opposite is true in some other variables. Nonetheless, the level of volatility is generally closer in the two economies. Given most variables show a decline in the volatility, that further indicates a diminished role of country-specific shocks.

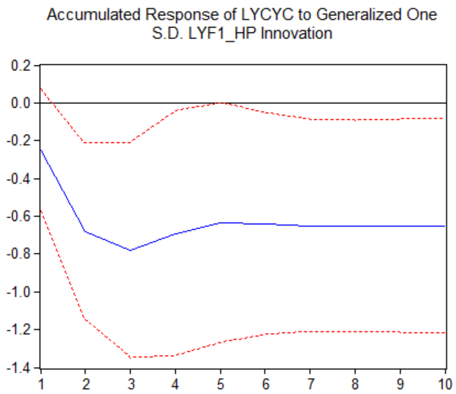

Figure 3.6: Response of Nepal's Business Cycle to a Common Shock from the Model in Equation 3.15 (Using HP data)

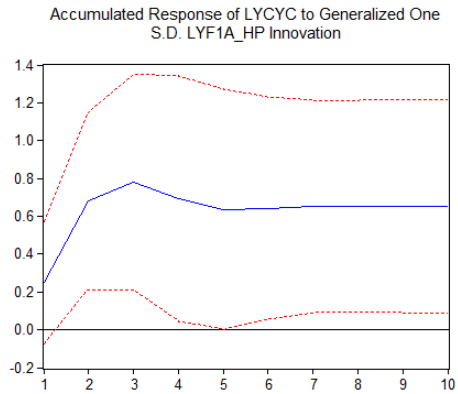

Figure 3.7: Response of Nepal's Business Cycle to a Common Shock from the Model in Equation 3.18 (Using HP data)

Impulse Responses. The two impulse response graphs in figures 3.6 and 3.7 show identically opposite responses in Nepal's business cycle given a shock to the common component in GDP.[30] Similar to the contradiction seen in the correlation analysis, the differences in model specification resulted in different outcomes here as well. Figure 3.6 shows the response using the common component generated from the model in equation 3.15, while in figure 3.7, the response is based on the common component from the model in equation 3.18. In the first graph, output falls in response to a shock to the common component with the effect leveling out by the end of the second period. In contrast, the impulse response in figure 3.7 shows rising output with the peak effect by the end of the second period. When the economies are synchronized a positive shock to the common component is expected to result in cyclical, and not counter-cyclical, effects in the candidate countries. Clearly, the first graph suggests divergence, while the second suggests convergence, in the two

[30]Note that the impulse responses here are based on a VAR that has two cyclical components. They include a common component in business cycles of GDP in two countries, and each individual country business cycle.

economies. It is difficult to settle on one conclusion without further investigation.

3.5 Conclusion

This essay investigated the prospects for further monetary integration by examining the underlying economic conditions between India and Nepal. The motivation for this question is based on several related factors. First, Nepal has adopted a pegged exchange-rate system with India as its monetary policy anchor. Second, Nepal has had a growing trade deficit for goods and services, while its economy has been growing more slowly than the Indian economy. Third, remittances have increasingly financed the trade deficit and have played a crucial role in preventing macroeconomic instability. In the aftermath of the global financial crisis of 2008, the vulnerability associated with overreliance on remittances came to light. Nepal saw a decline in remittance receipts, which turned the current account balance negative (see figure 3.1). Fourth, many believe that the current peg is overvalued and that the situation is untenable in the long run. Finally, Nepal and India share an open border, allowing for easy cross-border flows of resources. Thus, as an alternative to the existing exchange-rate system, this essay investigated the possibility of further monetary integration between the two, by exclusively focusing on economic merits.

There were two parts in this investigation. In the structural-shocks analysis, several three-variable SVAR models were estimated using different economic and monetary policy variables. The structural shocks were further investigated by separating the common component in them using a state-space model. In the second part, a business cycle investigation was undertaken using GDP and its sectoral contribution in the two economies. The analysis was conducted using several indicators.

Based on the correlation estimates of structural shocks in the two economies, it would be hard to say that they share similarity in shocks. The correlation was low and negative in supply shocks. Some shocks showed slight increases in comovements over time. The most positive result was obtained using the interest rate as the policy instrument, along with home and foreign GDP growth, and inflation. Separating these shocks into the unobserved region-wide common component and country-specific component revealed significant estimates mainly for monetary shocks. All of the monetary shocks in Nepal were found to be positively associated with the common component. These favorable results could be the outcome of the pegged-exchange rate regime in Nepal and the existing degree of integration between the two economies. The concern, however, was about the insignificant estimates using supply and demand shocks.

In the business cycle investigation, the results were found quite sensitive to the choice of the model used in the estimation and also the use of the detrending method.[31] The correlation between the common component and Nepal's business cycle showed some variables with positive co-movements over time. This was the case with exports and investment. The correlations in the industrial and manufacturing sectors declined in the post-liberalization period. Importantly, however, the correlation coefficient for GDP was not positive for the entire period. There was a general decline in the volatility of business cycles and mixed results were found for the level of persistence in different variables.

Taken together, the results are not conclusive enough to support the idea of further or more formal monetary integration on economic grounds. Apart from some evidence of asymmetry, there is not a general deterioration in the symmetry of the two economies over time. Given the background on the geoeconomic relationship of the two countries, however, it is natural to expect increasing economic symmetry over time. Some previous studies suggest that countries in the South Asia region share similar industry profiles, similar trade compositions, and close geographical proximity, all of which can help to create interlinked industrial production.[32] Some evidence to corroborate this observation was found in this study for Nepal and India, especially in the business cycle analysis using industrial and manufacturing data in the pre-liberalization era. In the post-liberalization era, however, Nepal's economy started to bear significant effects from the decade-long civil conflict and is yet to fully come out of the peril.

Thus, any hope toward progress in the future has to be taken with some

[31] Darvas and Szapary (2008) also found inconsistency in results using HP- and BP-filtered data. However, they suggest that such differences were not large enough to alter their conclusions.

[32] For example, Banik et al. (2009) makes this point in the case of India, Pakistan, and Bangladesh.

caution in light of the findings in this study. The only silver lining perhaps is that Nepal will soon complete its political transition and concentrate its efforts toward increasing economic ties with India. Until then, Nepal may consider weighing its options on managing the exchange-rate regime. Some options to be assessed are a) consider existing arrangement but allow adjusting the parity level, i.e., to devalue as required; b) consider a peg based on a basket of currencies; and c) consider a managed float or a fully flexible regime.

APPENDIX A

CHAPTER 1

$$
\begin{array}{cccc}
\Delta(LREER_t) = & \underset{(0.1)}{-0.01LREER^{***}_{t-1}} & \underset{(0.2)}{-0.07LPROD_{t-1}} & \underset{(0.04)}{-0.19RDEBT_{t-1}} \\
\underset{(0.05)}{+0.09M1DA_{t-1}} & \underset{(0.23)}{-0.59TBG_{t-1}} & \underset{(0.009)}{-0.005LREM_{t-1}} & \underset{(0.16)}{-0.41\Delta(LREER_{t-1})} \\
\underset{(0.17)}{-0.32\Delta(LPROD_{t-1})} & \underset{(0.04)}{-0.05\Delta(RDEBT_{t-1})} & \underset{(0.04)}{-0.004\Delta(M1DA_{t-1})} & \\
\underset{(0.2)}{-0.24\Delta(TBG_{t-1})} & \underset{(0.008)}{-0.01\Delta(LREM_{t-1})} & \underset{(0.75)}{-0.13} & \underset{0.003}{-0.002trend} \\
\bar{R}^2 = 0.64, n = 32 & & &
\end{array}
\tag{A.1}
$$

Table A.1: Variable Construction: Import- and Export-demand Equations

Variables	Time	Description
Exports (X) & Imports (M)	Quarterly/Monthly (1981–2008 and 1993–2008)	Logarithm of Nepal's total exports and imports deflated using the GDP deflator to create data in real terms. The quarterly and monthly GDP deflators were used and were derived by interpolating, using a cubic spline, from the annual series.
Domestic income (Y)		Industrial production (IP) of India is used as the proxy for domestic income since there is no high frequency data on Nepal's GDP nor is there any industrial production data. (The alternative to using the Indian IP data is to create higher frequency Nepalese GDP data through interpolation.) At best, this is a crude approximation. Nevertheless, there is some evidence of business-cycle synchronization between the two economies. Using annual data (1975–2008) on Nepal's real GDP and India's IP, the two economies are found to have a business-cycle correlation of 0.41, although this correlation in the two real GDPs is quite small, 0.13. Business cycle decomposition was carried out using the HP filter.
Foreign income (Y*)		This is a weighted average of the industrial production of the major trading partners, weighted using the same share as used in the calculation of the real effective exchange rate. Domestic and foreign income are both seasonally adjusted.
Real effective exchange rate		Quarterly and monthly bilateral exchange rates and CPI series are used. Nepal's bilateral exchange rates with France and Germany are derived using the US dollar cross-rate with Euro in the relevant period. Similarly, Nepal's quarterly and monthly bilateral exchange rates with India are calculated by enacting changes in the nominal series on various dates as detailed in central bank's various reports. Germany's CPI has been rescaled to match the base year in 1991 with that of West Germany. Importantly, the REER series here is given in domestic units per foreign unit, so any upward movement is depreciation of the real effective exchange rate.
Volatility (V)		a) Moving standard deviation: $\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_{t+i-1}-x_{t+i-2})^2}$ where n is the number of period over which the standard deviation is calculated. b) Conditional standard deviation based on a GARCH model.

Table A.2: Detailed Descriptions of the Data

Variables	Time	Notes
Exchange Rate		
INR-NPR	1975–2008	*Source*:Nepal Rastra Bank
USD-NPR		Nominal exchange rate series (Period average, Source: IFS)
USD-FFR		FFR and DEM exchange rates derived from Euro for period 1999–2008 using cross-rates EUR-DEM = 1.95583 and EUR-FFR = 6.55957
USD-DEM		
USD-JPY		NPR-Nepalese Rupee; INR-Indian Rupee
USD-SGD		FFR-French Franc; DEM-Germany Deutsche Marks
USD-THB		JPY-Japanese Yen; SGD-Singapore Dollar
USD-GBP		THB-Thai Bhat; GBP-Pound Sterling
CPI		
West Germany	1975–1990	Rescaled to match the base year to that of unified Germany in 1991.
Unified Germany	1991–2008	
Net claim on govt.(Debt)		
Germany	1975–1998	In DEM
	1999–2008	Data in Euro converted to equivalent DEM using the cross rate.
France	1975–1997	In FFR
	1998–2008	Data imputed for missing year 1998 using the average of debt-to-gdp ratio for years 1997 & 1999. Data in Euro converted to equivalent FFR using the cross rate for 1999–2008. All other data on government claim is in respective currencies (Unit = Billion). *Source*: IFS
GDP		
GDP per capita	1975–2008	All GDP per capita data are in constant 2000 USD terms (using PPP based exchange rates). *Source*: WDI
GDP		All GDP data are in local currency (Unit = Billion), nominal terms. Germany and France's data are derived from Euro into DEM and FFR.
Money Supply		
India	1975–2008	Money (currency in circulation), seasonally adjusted (Unit = Billion)
Germany	1975–1998	In DEM, M1 seasonally adjusted
	1999–2008	Data imputed from the Euro-area money supply using the proportion of German GDP in Euro-area GDP.
France	1975–1976	Data from Eurostat, converted from ECU to DEM using 1 ECU = 1 EUR and EUR-DEM cross rate.
	1977–1998	In FFR, M1 seasonally adjusted
	1999–2008	Data imputed from the Euro-area money supply using the proportion of French GDP in the Euro-area GDP
UK	1975–1982	M4 data imputed based on the growth rate of M0, which is derived by backing out growth rate from year 1983.
	1983–2008	M4 seasonally adjusted
		M1 in Euro area includes currency in circulation and overnight deposits. M4 in UK includes notes and coins in circulation plus deposits with UK banks. All data in local currency (Unit = Billion) and are from IFS, except Singapore's money supply which is from WDI.

Table A.3: Descriptive Statistics of Variables Used in the BEER Estimation

Variables	LREER	LPROD	RDEBT	TBG	M1DA	LREM
Mean	-1.12	-3.82	0.74	-0.1	-0.013	0.38
Median	-1.15	-3.84	0.73	-0.1	0.04	-0.56
Maximum	-0.91	-3.66	1.07	-0.025	0.3	4.94
Minimum	-1.26	-3.89	0.20	-0.21	-0.52	-2.4
Std.Dev	0.11	0.06	0.20	0.04	0.18	2.31
Skewness	0.41	1.58	-0.39	-0.47	-1.35	0.7
Kurtosis	1.63	4.81	3.1	3.44	4.65	2.12
Jarque-Bera	3.65	18.88	0.88	1.56	14.12	3.71
Probability	0.16	0.00	0.64	0.46	0.00	0.16
Sum	-38.07	-129.99	25.23	-3.42	-0.44	12.8
sum Sq. Dev.	0.42	0.10	1.28	0.06	1.08	176.59
Observations	34	34	34	34	34	34

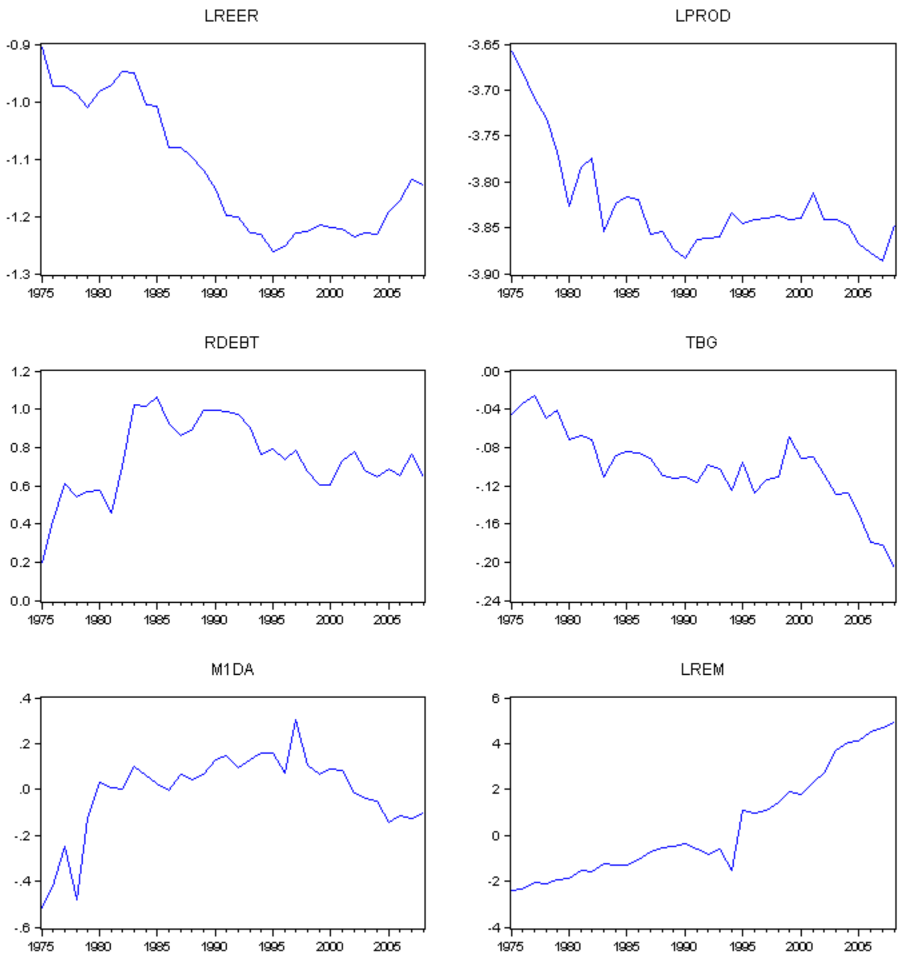

Figure A.1: Nepal's Real Effective Exchange Rate and the Fundamentals

Table A.4: VECM Estimation of the BEER without the Trend Term in the Cointegrating Relationship

Cointeg. Eq:	CointEq1					
$LREER_{t-1}$	1					
$LPROD_{t-1}$	1.98(1.27)					
$RDEBT_{t-1}$	-2.5(-9.8)					
TBG_{t-1}	-9.38(-5.33)					
$M1DA_{t-1}$	1.8(6.56)					
$LREM_{t-1}$	-0.03(-1.18)					
C	9.7					
Error Correction	D(LREER)	D(LPROD)	D(RDEBT)	D(TBG)	D(M1DA)	D(LREM)
CointEq1	0.06(3.94)	-0.001(-0.06)	0.2(2.9)	0.02(1.74)	0.06(0.8)	0.47(1.19)
$\Delta(LREER_{t-1})$	-0.26(-1.48)	0.17(0.66)	-1.86(-2.23)	-0.36(-2.43)	-1.59(-1.67)	-0.73(-0.15)
$\Delta(LPROD_{t-1})$	-0.16(-0.83)	-0.21(-0.71)	1.24(1.31)	-0.13(-0.78)	-1.53(-1.43)	-0.35(-0.07)
$\Delta(RDEBT_{t-1})$	-0.04(-1.23)	-0.06(-1.04)	0.49(2.81)	-0.014(-0.45)	-0.06(-0.28)	-0.22(-0.22)
$\Delta(TBG_{t-1})$	0.18(0.74)	-0.07(-0.2)	-0.32(-0.28)	-0.18(-0.89)	-0.41(-0.31)	-1.99(-0.31)
$\Delta(M1DA_{t-1})$	-0.012(-0.31)	0.002(0.04)	-0.2(-1.08)	-0.049(-1.46)	-0.45(-2.09)	-0.62(-0.58)
$\Delta(LREM_{t-1})$	0.006(0.85)	0.004(0.33)	-0.03(-0.77)	-0.01(-2.23)	-0.07(-1.62)	-0.35(-1.72)
c	-0.008(-1.95)	-0.006(-0.92)	0.001(0.06)	-0.005(-1.58)	0.007(0.31)	0.3(2.65)
R-sqd.	0.55	0.1	0.44	0.41	0.32	0.25
Adj R-sqd.	0.41	-0.16	0.28	0.24	0.12	0.03
Sum sq. resids	0.009	0.019	0.204	0.006	0.264	6.53
Sum sq. resids	0.02	0.02	0.15	0.003	0.57	5.15
S.E.equation	0.02	0.03	0.09	0.02	0.11	0.52
F-statistic	4.11	0.39	2.69	2.4	1.59	1.14
Log likelihood	85.8	73.27	35.48	90.67	31.36	-19.98
Akaike AIC	-4.86	-4.08	-1.72	-5.17	-1.46	1.75
Schwarz SC	-4.5	-3.72	-1.35	-4.8	-1.1	2.12
Mean dependent	-0.005	-0.005	0.007	-0.005	0.009	0.23
S.D. dependent	0.025	0.026	0.11	0.02	0.11	0.53
Det. res cov.(dof adj)	2.88E-16					
Det res cov.	5.12E-17					
Log likelihood	327.74					
AIC	-17.11					
SC	-14.64					

Table A.5: VECM Estimation of the BEER with the Trend Term in the Cointegrating Relationship

Cointeg. Eq:	CointEq1					
$LREER_{t-1}$	1					
$LPROD_{t-1}$	-2.34(-0.97)					
$RDEBT_{t-1}$	4.12(10.42)					
TBG_{t-1}	16.35(5.93)					
$M1DA_{t-1}$	-3.38(-6.47)					
$LREM_{t-1}$	-0.28(-3.46)					
$trend$	0.11(5.88)					
C	-12.71					
Error Correction	D(LREER)	D(LPROD)	D(RDEBT)	D(TBG)	D(M1DA)	D(LREM)
CointEq1	-0.04(-4.6)	0.002(0.15)	-0.12(-3.1)	-0.013(-1.77)	-0.04(-0.9)	-0.11(-0.46)
$\Delta(LREER_{t-1})$	-0.25(-1.61)	0.18(0.74)	-1.78(-2.26)	-0.35(-2.43)	-1.59(-1.75)	1.63(0.35)
$\Delta(LPROD_{t-1})$	-0.13(-0.74)	-0.2(-0.71)	1.39(1.54)	-0.11(-0.68)	-1.5(-1.45)	1.44(0.27)
$\Delta(RDEBT_{t-1})$	-0.04(-1.05)	-0.06(-1.06)	0.51(2.98)	-0.02(-0.38)	-0.05(-0.23)	-0.38(-0.38)
$\Delta(TBG_{t-1})$	0.21(0.94)	-0.08(-0.24)	-0.26(-0.23)	-0.18(-0.88)	-0.37(-0.28)	-3.67(-0.55)
$\Delta(M1DA_{t-1})$	-0.03(-0.72)	0.005(0.09)	-0.24(-1.28)	-0.05(-1.53)	-0.47(-2.13)	-0.3(-0.27)
$\Delta(LREM_{t-1})$	0.0001(0.01)	0.004(0.36)	-0.05(-1.27)	-0.016(-2.4)	-0.07(-1.7)	-0.32(-1.45)
c	-0.006(-1.63)	-0.006(-0.93)	0.008(0.39)	-0.005(-1.4)	0.009(0.41)	0.32(2.74)
R-sqd.	0.6	0.1	0.46	0.41	0.32	0.21
Adj R-sqd.	0.49	-0.16	0.3	0.24	0.12	-0.02
Sum sq. resid	0.01	0.02	0.2	0.01	0.26	6.86
S.E.equation	0.02	0.03	0.09	0.02	0.1	0.53
F-statistic	5.2	0.39	2.92	2.43	1.62	0.92
Log likelihood	87.95	73.29	36.07	90.73	31.46	-20.77
Akaike AIC	-4.9	-4.08	-1.75	-5.17	-1.47	1.8
Schwarz SC	-4.63	-3.71	-1.39	-4.8	-1.1	2.16
Mean dependent	-0.01	-0.01	0.01	-0.01	0.01	0.23
S.D. dependent	0.02	0.02	0.11	0.02	0.11	0.53
Det. res cov.(dof adj)	2.41E-16					
Det res cov.	4.29E-17					
Log likelihood	330.58					
AIC	-17.22					
SC	-14.7					

APPENDIX B

CHAPTER 2

Girton and Roper (1977) model of exchange market pressure (EMP)

The Girton-Roper EMP model places central focus on money demand and supply, and the equilibrium is given by equation B.1. Money demand is expressed as an exponential function.

$$H_i = F_i + D_i = P_i Y_i^{\beta_i} exp(-\alpha_i \rho_i), \tag{B.1}$$

where

- H_i is the supply of base money by the central bank of country i;
- F_i is base money backed by the purchase of foreign assets;
- D_i is base money created by domestic credit expansion;
- P_i is the price level;
- Y is real income;
- ρ is the index of interest rates;
- β is the income elasticity; and
- α is the interest-rate coefficient.

Taking the logarithms and then differentiating with respect to time yields the following expression

$$lnH_i = ln(F_i + D_i) = lnP_i + \beta lnY_i - \alpha_i\rho_i, \tag{B.2}$$

$$\frac{1}{H_i}\frac{dH_i}{dt} = \frac{1}{H_i}\frac{d(F_i + D_i)}{dt} = \frac{1}{P_i}\frac{dP_i}{dt} + \beta\frac{1}{y_i}\frac{dY_i}{dt} - \alpha\frac{dP_i}{dt}. \tag{B.3}$$

The foreign reserve component of base money is determined by the net purchase of foreign assets expressed in the home currency

$$F_i(t) = \int_{-\infty}^{t} E_i(t)R_i'dt, \tag{B.4}$$

where

- $R_i(t)$ is the stock of international reserves (primary assets) held by the authorities in country i;
- $R_i'(t)$ is the time derivative of R_i indicating the net purchase of reserves at time t;
- $E_i(t)$ is the parity or i currency value of primary-reserve assets at time t.

By substituting the time derivative of equation B.4, namely $\frac{dF_i}{dt} = E_i dR_i'$, in equation B.2, yields the following

$$h_i = r_i + d_i = \pi_i + \beta_i y_i - \alpha_i\rho_i', \tag{B.5}$$

where

- $h_i = \frac{dH_i}{dt}$ is the growth rate of base money;
- $r_i = \frac{E_i}{H_i}\frac{dR_i}{dt}$ is the growth rate of the foreign-reserve component of base money;
- $d_i = \frac{1}{H_i}\frac{dD_i}{dt}$ is the growth rate of domestic credit;
- $\pi_i = \frac{1}{P_i}\frac{dP_i}{dt}$ is the rate of inflation in country i;
- $y_i = \frac{1}{Y_i}\frac{dY_i}{dt}$ is the growth rate of real income; and

- ρ'_i is the change in the interest rate.

The two-country interaction can be represented by subtracting the monetary equilibrium condition B.5 for country j from country i

$$r_i - r_j = -d_i + d_j + \beta_i y_i - \beta_j y_j + \pi_i - \pi_j - \alpha(\rho'_i - \rho'_j), \tag{B.6}$$

where the interest rate coefficients are assumed equal in two countries ($\alpha = \alpha_i = \alpha_j$). Now, by introducing $\theta_{ij} = \pi_i - \pi_j + e_{ij}$ (e_{ij} is the rate of appreciation of currency i in terms of currency j) and using the change in the uncovered interest-rate differential, i.e., $\delta_{ij} = \rho'_i - \rho'_j$, equation B.6 is rewritten as follows

$$r_i - r_j + e_{ij} = -d_i + d_j + \beta_i y_i - \beta_j y_j + \theta_{ij} - \alpha\delta_{ij}. \tag{B.7}$$

Further, assume that the asymmetry (in terms of being able to independently pursue monetary policy) between the two country forces the adjustment burden on the country that is trying to stabilize its exchange rate. This condition justifies transferring center country's balance of payments, r_j, from left to right

$$r_i + e_i = -d_i + h_j + \beta_i y_i - \beta_j y_j + \theta_i - \alpha\delta_i, \tag{B.8}$$

where $h_j = d_j + r_j$. The authors estimate a short form of equation B.8 without the terms θ_i and $\alpha\delta_i$. Some authors have chosen to estimate a different version. Garcia and Malet (2005) do not assume equal interest rate coefficients and also allow for $\theta_{ij} = \pi_i - \pi_j + e_{ij}$ in their estimation. As an alternative to the EMP model presented earlier, I also estimate the following equations:

$$r_i + e_i = -d_i + h_j + \beta_i y_i - \beta_j y_j \tag{B.9}$$

$$r_i + e_i = -d_i + d_j + \beta_i y_i - \beta_j y_j + \theta_{ij} - \alpha_i\rho'_i + \alpha_j\rho'_j \tag{B.10}$$

Table B.1: Various EMP Construction

Paper/Authors	Definition
Eichengreen et al. (1994, 1995)	$EMP = \frac{1}{\sigma_e}\frac{\Delta e_{i,t}}{e_{i,t}} - \frac{1}{\sigma_r}(\frac{\Delta rm_{i,t}}{rm_{i,t}} - \frac{\Delta rm_{us,t}}{rm_{us,t}}) + \frac{1}{\sigma_i}\Delta(i_{i,t} - i_{us,t})$ σ_e = std. dev. of $\frac{\Delta e_{i,t}}{e_{i,t}}$ rm_{it} = ratio of the international reserves to money stock/base for country i in period t σ_r = std. dev. of $(\frac{\Delta rm_{i,t}}{rm_{i,t}} - \frac{\Delta rm_{us,t}}{rm_{us,t}})$ σ_i = std. dev. of the nominal interest rate differential
Sachs et al. (1996)	$EMP_{i,t} = (\frac{\frac{1}{\sigma_e}}{\frac{1}{\sigma_e}+\frac{1}{\sigma_r}+\frac{1}{\sigma_i}})\frac{\Delta e_{i,t}}{e_i, t} - (\frac{\frac{1}{\sigma_r}}{\frac{1}{\sigma_e}+\frac{1}{\sigma_r}+\frac{1}{\sigma_i}})\frac{\Delta r_{i,t}}{r_i, t} + (\frac{\frac{1}{\sigma_i}}{\frac{1}{\sigma_e}+\frac{1}{\sigma_r}+\frac{1}{\sigma_i}})\Delta i_{i,t}$ σ_e = std. dev. of $\frac{\Delta e_{i,t}}{e_{i,t}}$ σ_r = std. dev. of $\frac{\Delta r_{i,t}}{r_{i,t}}$ σ_i = std. dev. of $\Delta i_{i,t}$
Kaminsky et al. (1998)	$EMP_{i,t} = \frac{\Delta e_{i,t}}{e_{i,t}} - \frac{\sigma_e}{\sigma_r}\frac{\Delta r_{i,t}}{r_{i,t}}$
Wyplosyz (2001)	$EMP = \frac{1}{\sigma_e}\frac{\Delta E}{E} - \frac{1}{\sigma_{rsv}}[\frac{\Delta rsv}{rsv} - \frac{\Delta rsv^f}{rsv^f}]$
Pentecost et al.(2001)	$\hat{e} + \beta(\Delta i_m - \Delta i_m^f) - \hat{r}$
Hegerty (2009)	$EMP = \frac{e_t - e_{t-1}}{e_{t-1}} - \eta_1 \frac{rsv_t - rsv_{t-1}}{m_{t-1}} + \eta_2\Delta(r - r^f)$ $= -\frac{\sigma_e}{\sigma_{r-rf}}(\frac{rsv_t - rsv_{t-1}}{m_{t-1}}) + \frac{\sigma_e}{\sigma_{r-rf}}\Delta(r - r^f)$
Aizenman et al. (2010)	$EMP_{i,t} = \frac{\Delta e_{i,t}}{e_{i,t-1}} - \frac{\Delta IR_{i,t}}{IR_{i,t-1}}$ $EMP_{i,t} = \frac{\Delta e_{i,t}}{e_{i,t-1}} - \frac{\Delta IR_{i,t}}{\frac{M_{i,t-1}}{e_{i,t-1}}}$ $EMP_{i,t}^{std.} = \frac{1}{\sigma_{i,\Delta e}}[\frac{\Delta e_{i,t}}{e_{i,t-1}} - \mu_{i,\Delta e}] - \frac{1}{\sigma_{i,\Delta Res}}[\frac{\Delta IR_{i,t}}{IR_{i,t-1}} - \mu_{i,\Delta Res}]$

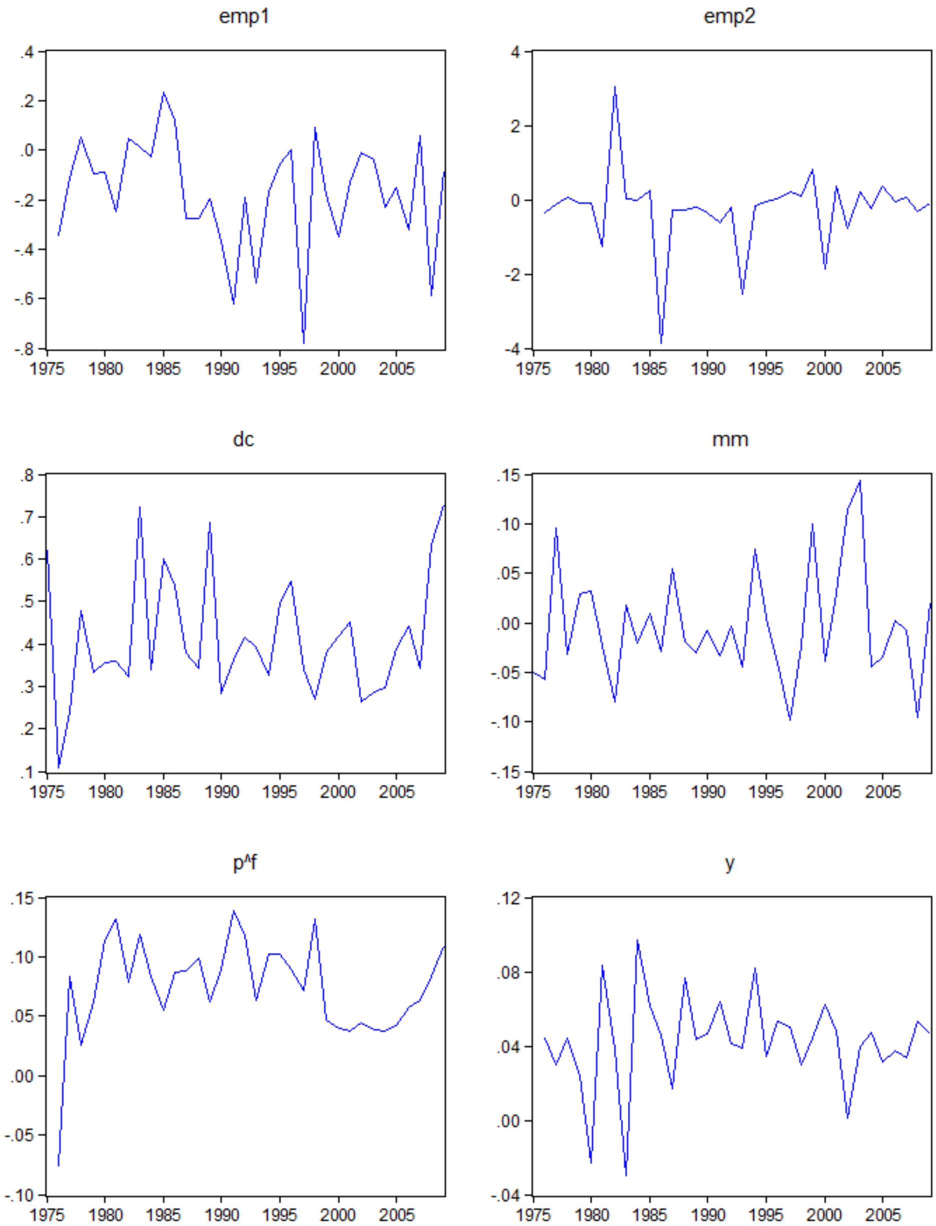

Figure B.1: Plots of All Variables Using Annual Data (1975–2009)

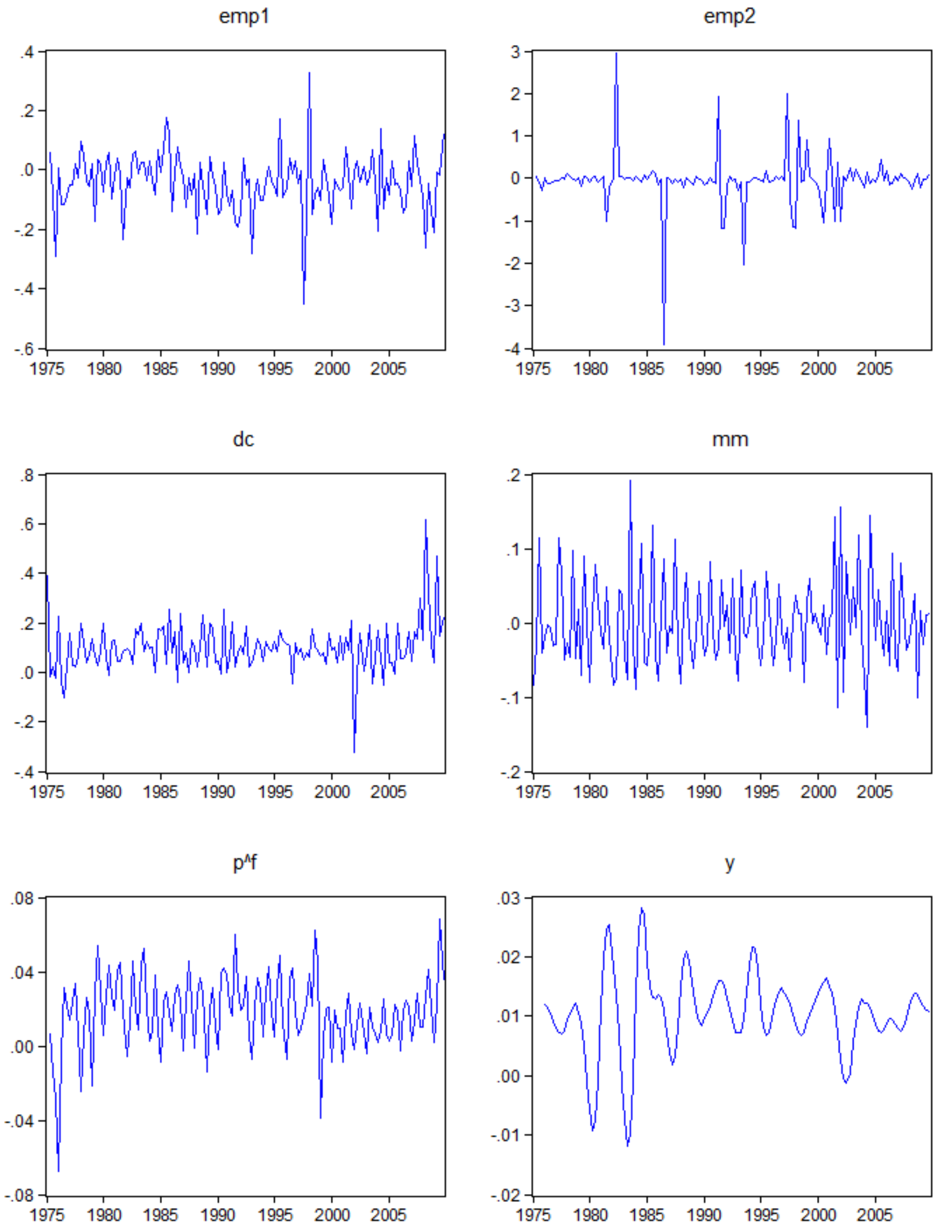

Figure B.2: Plots of All Variables Using Quarterly Data (1975Q1–2009Q4)

REFERENCES

Aizenman, J., J. Lee, and V. Sushko (2010). "From the Great Moderation to the global crisis: Exchange market pressure in the 2000s." NBER Working Paper No. 16447.

Artis, M.J. (2003). "Reflections on the optimal currency area (OCA) criteria in the light of EMU." *International Journal of Finance and Economics* 8(4), 297–307.

Babetskii, I., L. Boone, and M. Maurel (2004). "Exchange rate regimes and shocks asymmetry: The case of the accession countries." *Journal of Comparative Economics* 32(2), 212–229.

Bahmani-Oskooee, M. and R. Shiva (1998). "A method of detecting whether a central bank engages in the black market for foreign exchange: Evidence from Iran." *Economics Letters* 60(1), 97–103.

Baig, M.A., V. Narasimhan, and M. Ramachandran (2003). "Exchange market pressure and the Reserve Bank of India's intervention activity." *Journal of Policy Modeling* 25(8), 727–748.

Balassa, B. (1964). "The purchasing-power parity doctrine: a reappraisal." *Journal of Political Economy* 72(6), 584–596.

Banik, N., B. Biswas, and K.R. Criddle (2009). "Optimum currency area in South Asia: A state space approach." *International Review of Economics and Finance* 18(3), 502–510.

Bauwens, L. and G. Sucarrat (2010). "General-to-specific modelling of exchange rate volatility: A forecast evaluation." *International Journal of Forecasting* 26(4), 885–907.

Baxter, M. and R.G. King (1999). "Measuring business cycles: Approximate band-pass filters for economic time series." *Review of Economics and Statistics* 81(4), 575–593.

Bayoumi, T. and B. Eichengreen (1994). *One Money or Many?: Analyzing the Prospects for Monetary Unification in Various Parts of the World.* International Finance Section, Department of Economics, Princeton University.

Blanchard, O.J. and D. Quah (1989). "The dynamic effects of aggregate demand and supply disturbances." *American Economic Review* 79(4), 655–673.

Buigut, S.K. and N.T. Valev (2005). "Is the proposed East African monetary union an optimal currency area? A structural vector autoregression analysis." *World Development* 33(12), 2119–2133.

Canova, F. (1998). "Detrending and business cycle facts." *Journal of Monetary Economics* 41(3), 475–512.

Castle, J.L., J.A. Doornik, and D.F. Hendry (2012). "Model selection when there are multiple breaks." *Journal of Econometrics, in press*.

Chami, R. (2008). "Macroeconomic consequences of remittances." *IMF Occasional Paper* 259.

Chamie, N., A. DeSerres, and R. Lalonde (1994). "Optimum currency areas and shock asymmetry." Bank of Canada, Working Paper 94-1.

Chinn, M.D. (2006). "A primer on real effective exchange rates: Determinants, overvaluation, trade flows and competitive devaluation." *Open Economies Review* 17(1), 115–143.

Clark, P.B., N. Tamirisa, S. Wei, A. Sadikov, and L. Zeng (2004). "A new look at exchange rate volatility and trade flows." *IMF Occassional Paper* (235).

Clark, P. B. and R. MacDonald (1998). "Exchange rates and economic fundamentals: A methodological comparison of BEERs and FEERs." IMF Working Paper WP/98/67.

Cline, W. (2008). "Estimating consistent fundamental equilibrium exchange rates." The Peterson Institute for International Economics, Working Paper Series No. 08-6.

Connolly, M. and J.D. Da Silviera (1979). "Estimating exchange market pressure in postwar Brazil: An application of the Girton-Roper monetary model." *American Economic Review* 69, 448–54.

Darvas, Z. and G. Szapáry (2008). "Business cycle synchronization in the enlarged EU." *Open Economies Review* 19(1), 1–19.

De La Cruz Martinez, J. (1999). "Mexico's balance of payments and exchange rates: A cointegration analysis." *North American Journal of Economics and Finance* 10(2), 401–421.

Edwards, S. (1988). "Real and monetary determinants of real exchange rate behavior: Theory and evidence from developing countries." *Journal of Development Economics* 29(3), 311–341.

Eichengreen, B., A.K. Rose, and C. Wyplosz (1994). "Speculative attacks on pegged exchange rates: An empirical exploration with special reference to the European Monetary System." *The New Transatlantic Economy*, 249–312.

Eichengreen, B., A.K. Rose, C. Wyplosz, B. Dumas, and A. Weber (1995). “Exchange market mayhem: The antecedents and aftermath of speculative attacks.” *Economic Policy* 10(21), 249–312.

Ericsson, N.R. (2010). “Empirical model selection: Friedman and Schwartz revisited.” Unpublished Paper.

Frankel, Jeffrey A. and Andrew K. Rose. “The endogeneity of the optimum currency area criteria.” *Economic Journal* 108(449), 1009–25.

Garcia, C. and N. Malet (2007). “Exchange market pressure, monetary policy, and economic growth: Argentina, 1993-2004.” *Developing Economies* 45(3), 253–282.

Ginting, E. (2007). “Is inflation in India an attractor of inflation in Nepal?” IMF Working Paper WP/07/269.

Girton, L. and D. Roper (1977). “A monetary model of exchange market pressure applied to the postwar Canadian experience.” *American Economic Review* 67(4), 537–548.

Gochoco-Bautista, M.S. and C.C. Bautista (2005). “Monetary policy and exchange market pressure: The case of the Philippines.” *Journal of Macroeconomics* 27(1), 153–168.

Gregory, A.W., A.C. Head, and J. Raynauld (1997). “Measuring world business cycles.” *International Economic Review*, 677–701.

Gulde, A.M., E. Jafarov, and V. Prokopenko (2004). “A common currency for Belarus and Russia?” IMF Working Paper WP/04/228.

Hamilton, J.D. (1994). *Time Series Analysis*, Volume 10. Cambridge University Press.

Harvey, A.C. (1990). *Forecasting, Structural Time Series Models and the Kalman Filter*. Cambridge University Press.

Hegerty, S.W. (2009). “Capital inflows, exchange market pressure, and credit growth in four transition economies with fixed exchange rates.” *Economic Systems* 33(2), 155–167.

Hendry, D.F., S. Johansen, and C. Santos (2008). “Automatic selection of indicators in a fully saturated regression.” *Computational Statistics* 23(2), 337–339.

Hendry, D.F. and G.E. Mizon (2011). “Econometric modelling of time series with outlying observations.” *Journal of Time Series Econometrics* 3(1), 6.

Hendry, D.F. and C. Santos (2010). “Automatic tests of super exogeneity.” Discussion Paper Series 476, Department of Economics, University of Oxford.

Hodgson, J.S. and R.G. Schneck (1981). “Stability of the relationship between monetary variables and exchange market pressure: Empirical evidence.” *Southern Economic Journal*, 941–958.

Huang, Y. and F. Guo (2006). "Is currency union a feasible option in East Asia? A multivariate structural VAR approach." *Research in International Business and Finance* 20(1), 77–94.

Hubbard, R. Glenn (1995). "Is there a "credit channel" for monetary policy?" *Federal Reserve Bank of St. Louis-Review*.

Iimi, A. (June 2006). "Exchange rate misalignment: An application of the behavioral equilibrium exchange rate (BEER) to Botswana." IMF Working Paper WP/06/140.

Johansen, S. (1988). "Statistical analysis of cointegration vectors." *Journal of Economic Dynamics and Control* 12(2-3), 231–254.

Johansen, S. (1992). "Cointegration in partial systems and the efficiency of single-equation analysis." *Journal of Econometrics* 52(3), 389–402.

Johansen, S. and B. Nielsen (2008). *An analysis of the indicator saturation estimator as a robust regression estimator*. In The Methodology and Practice of Econometrics: A Festschrift in Honour of David F. Hendry, Oxford University Press, Oxford, forthcoming.

Kaminsky, G., S. Lizondo, and C.M. Reinhart (1998). "Leading indicators of currency crises." *Staff Papers-International Monetary Fund* 45(1), 1–48.

Kaminsky, G.L. and C.M. Reinhart (1999). "The twin crises: The causes of banking and balance-of-payments problems." *American economic review*, 473–500.

Khawaja, M.I. (2007). "Exchange market pressure and monetary policy: Evidence from Pakistan." Pakistan Institute of Development Economics, Working Paper.

Kim, I. (1985). "Exchange market Pressure in Korea: An application of the Girton-Roper monetary model: Note." *Journal of Money, Credit and Banking* 17(2), 258–263.

Klein, M.W. and J.C. Shambaugh (2006). "Fixed exchange rates and trade." *Journal of International Economics* 70(2), 359–383.

Krugman, P. (1987). "Adjustment in the World Economy." NBER Working Paper No. 2424.

Kumah, F.Y. (2007). "A Markov-switching approach to measuring exchange market pressure." IMF Working Paper WP/07/242.

Kwiatkowski Peter, CB et al. (1992). "Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?" *Journal of Econometrics* 54(1-3), 159–178.

Leahy, M.P. (1998). "New summary measures of the foreign exchange value of the dollar." *Federal Reserve Bulletin* 84, 811.

Lee, J.W., Y.C. Park, and K. Shin (2003). "A currency union in East Asia." Discussion Paper 571, Osaka University Insitute of Social and Economic Research.

Lokshin, M., M. Bontch-Osmolovski, and E. Glinskaya (2010). "Work-related migration and poverty reduction in Nepal." *Review of Development Economics* 14(2), 323–332.

Loukoianova, E. and P. Iossifov (2007). "Estimation of a behavioral equilibrium exchange rate model for Ghana." IMF Working Paper WP/07/155.

MacDonald, R. and D. Bundesbank (2000). *Concepts to Calculate Equilibrium Exchange Rates: An Overview.* Deutsche Bundesbank.

MacDonald, R. and P. Dias (February 2007). "Behavioural equilibrium exchange rate estimates and implied exchange rate adjustments for ten countries." Workshop on Global Imbalances Organized by Peterson Institute for International Economics.

MacDonald, R. and L.A. Ricci (2004). "Estimation of the equilibrium real exchange rate for South Africa." *South African Journal of Economics* 72(2), 282–304.

Maskay, N.M. (2000). *The Exchange Rate Policy of Nepal vis-à-vis the Indian Currency.* Nepal Foundation for Advanced Studies, Kathmandu.

Mathur, P. (1999). "An exchange market pressure model for India." *Indian Economic Review* 34, 127–148.

Maza, A. and J. Villaverde (2007). "A state-space approach to the analysis of economic shocks in Spain." *Journal of Policy Modeling* 29(1), 55–63.

McKenzie, M.D. and R.D. Brooks (1997). "The impact of exchange rate volatility on German-US trade flows." *Journal of International Financial Markets, Institutions and Money* 7(1), 73–87.

McKinnon, R.I. (1963). "Optimum currency areas." *American Economic Review* 53(4), 717–725.

Melecký, M. and L. Komárek (2007). "The behavioral equilibrium exchange rate of the Czech Koruna." *Transition Studies Review* 14(1), 105–121.

Milesi-Ferretti, G.M. and A. Razin (1997). "Current account sustainability: Selected East Asian and Latin American experiences." NBER Working Paper No. 5791.

Modeste, N. (2005). "The impact of the foreign debt burden on exchange market pressure in Guyana, 1968-2000: An application of the error correction methodology." *The Journal of Developing Areas* 38(2), 25–39.

Mongelli, F.P. and Eurpean Central Bank (2002). *"New" Views on the Optimum Currency Area Theory: What is EMU Telling Us?* European Central Bank.

Mundell, R.A. (1961). "A theory of optimum currency areas." *American Economic Review* 51(4), 657–665.

Murray, J. (1999). “Why Canada needs a flexible exchange rate.” Bank of Canada, Working Paper 99-12.

Murray, J., L. Schembri, and P. St-Amant (2003). “Revisiting the case for flexible exchange rates in North America.” *North American Journal of Economics and Finance* 14(2), 207–240.

Patnaik, I. (2003). “India’s policy stance on reserves and the currency.” Working Paper 108, Indian Council for Research on International Economic Relations.

Pentecost, E.J., C. Van Hooydonk, and A. Van Poeck (2001). “Measuring and estimating exchange market pressure in the EU.” *Journal of International Money and Finance* 20(3), 401–418.

Pesaran, H.H. and Y. Shin (1998). “Generalized impulse response analysis in linear multivariate models.” *Economics letters* 58(1), 17–29.

Pesaran, M.H., Y. Shin, and R.J. Smith (2001). “Bounds testing approaches to the analysis of level relationships.” *Journal of Applied Econometrics* 16(3), 289–326.

Pollard, S.K. (1999). “Foreign exchange market pressure and transmission of international disturbances: The case of Barbados, Guyana, Jamaica, and Trinidad and Tobago.” *Applied Economics Letters* 6(1), 1–4.

Prasad, E., A. Subramanian, and R. Rajan (2007). “Foreign capital and economic growth.” *Brookings Papers on Economic Activity* 2007(1), 153–230.

Sachs, J.D., A. Tornell, and A. Velasco (1996). “Financial crises in emerging markets: The lessons from 1995.” NBER Working Paper No. 5576.

Samuelson, P.A. (1964). “Theoretical notes on trade problems.” *Review of Economics and Statistics* 46(2), 145–154.

Santos, C. and M.A. Oliveira (2010). “Assessing French inflation persistence with impulse saturation break tests and automatic general-to-specific modelling.” *Applied Economics* 42(12), 1577–1589.

Saxena, S.C. (2005). “Can South Asia adopt a common currency?” *Journal of Asian Economics* 16(4), 635–662.

Sharma, K. (1995). “Trade and manufacturing in Nepal.” *The Asian Economic Review*, 58–86.

Stavárek, D. and M. Dohnal (2009). “Exchange market pressure in Central Europe: An application of the Girton-Roper model.” *MPRA Paper*.

Stock, J.H. and M.W. Watson (1998). “Business cycle fluctuations in US macroeconomic time series.” NBER Working Paper No. 6528.

Tanner, E. (2000). “Exchange market pressure and monetary policy: Asia and Latin America in the 1990s.” *IMF Staff Papers*, 311–333.

Tanner, E. (2002). "Exchange market pressure, currency crises, and monetary policy: Additional evidence from emerging markets." IMF Working Paper WP/02/14.

Weymark, D.N. (1995). "Estimating exchange market pressure and the degree of exchange market intervention for Canada." *Journal of International Economics* 39(3-4), 273–295.

Weymark, D.N. (1998). "A general approach to measuring exchange market pressure." *Oxford Economic Papers* 50(1), 106.

Wohar, M.E. and B.S. Lee (1992). "An application of the Girton-Roper monetary model of exchange market pressure: The Japanese experience, 1959-86." *Indian Journal of Economics* 72, 379–407.

Wyplosz, C. (2001). "How risky is financial liberalization in the developing countries?" G-24 Discussion Paper No. 14, United Nations Conference on Trade and Development and Center for International Development, Harvard University.

Xu, X. (2006). "A currency union for Hong Kong and mainland China?" *Journal of International Money and Finance* 25(6), 894–911.

Yelten, S. (2004). "Choosing the correct currency anchor for a small economy: The case of Nepal." IMF Working Paper WP/04/142.

Zanello, A., D. Desruelle, and (Washington) International Monetary Fund (1997). "A primer on the IMF's information notice system." IMF Working Paper WP/97/71.

Zhang, Z., K. Sato, and M. McAleer (2004). "Asian monetary integration: A structural VAR approach." *Mathematics and Computers in Simulation* 64(3-4), 447–458.