# ADJUSTMENT OF EXTERNAL IMBALANCES: DOES THE EXCHANGE RATE MATTER? - EVIDENCE FROM BRAZIL, CHINA AND INDIA

by

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## ABSTRACT

This thesis investigates the nature of the dynamic relationship between external balances and exchange rate dynamics in a macroeconomy. Specifically, this study focuses on how various measures of external balances serve as economic buffers to mitigate the effect of exchange rate shock to the economy. It examines the dynamic relationship between external balances and exchange rate shock via the application of cointegrated vector autoregression method and innovation accounting with generalized impulse responses and forecast error variance decompositions.

The data sample spans the period 1986-2008 and includes three important developing countries: Brazil, China and India. Empirical evidence shows that for China and India, understanding of the exchange rate dynamics is helpful in predicting the movement of external balances. But for Brazil, the reverse path is true. Results of generalized impulse responses suggest that external balances demonstrate a predictable and systematic pattern after a one-time exchange rate shock. Specifically, the results indicate that exchange rate shock generates a positive response in current account adjustment and has a negative impact on capital gains. The latter soon gives rise to a small drop in current account balance due to temporary income shock and capital mobility. Taking account of the overall current account and capital gains

adjustment (one positive and one negative), change in net foreign assets (NFA) position is largely cushioned from exchange rate shock. Integrating the results of generalized impulse responses and Granger causality tests, it is easy to find that there exists a feedback mechanism which significantly contributes to the adjustment of external imbalances. Moreover, terms of trade and domestic productivity serve as transmission channels which play a critical role in the system. From a policy perspective, in coping with enlarged global imbalances, exchange rate as well as terms of trade and domestic productivity should receive more attention in policy decisions to stabilize the economy.

# Chapter 1

# INTRODUCTION

## 1.1 Motivation

The international economic environment nowadays is characterized by ever larger external imbalances (e.g. widening current account positions). This keeps triggering a controversial debate on its likely causes and adjustment of current account balance and net foreign assets (NFA) both in academia and policy institutions (Lane and Milesi-Ferretti 2002; Obstfeld and Rogoff 2005a and 2005b; Bems et al. 2007; Gourinchas and Rey 2007; Marcel et al. 2008; Bussiere et al. 2010). Current account balance equals the sum of balance of trade (exports minus imports of goods and services), net factor income and net transfer payments, while NFA equals the value of the assets that a country owns abroad, minus that of the domestic assets owned by foreigners. These two are important balance of payment identities. In this thesis, the emphasis is placed on the impact of exchange rate shock on current account balance and NFA. I distinguish the exchange rate from other asset prices following the approach of Marcel et al. (2008) in the sense that exchange rate affects external

balances in a fundamentally different way than equity price. In contrast, Obstfeld and Rogoff (2005b) argue that the triggers which drive the adjustment of current account in the U.S. and the way in which the burden of adjustment is allocated across Europe and Asia would have huge impact for global exchange rates.

Traditionally, the net foreign asset position of a nation is determined by current account balance, given the equation of balance of payment identity (change in NFA position equals current account balance plus capital gains). For instance, a country which has a current account surplus (i.e. positive net export) will at the same time experience a parallel increase in NFA position. However, as noted by Gourinchas and Rey (2007), large and persistent current account deficits do not necessarily imply the deterioration in the NFA position. The valuation effects would exert a stabilizing role in this process as stated by Lane and Milesi-Ferretti (2007). Valuation effects are actually changes in the value of a country's gross external assets and liabilities due to the fluctuations of asset prices and exchange rates. Also, asset prices are relevant for the determination and adjustment of current account balance through wealth effects. The logic underlying the effect of asset prices is that a rise in equity price increases the income of households, and thus consumption and foreign imports. This would further induce the deterioration in a country's current account balance. So the transition path

from current account balance to NFA as well as the implication of NFA on current account balance behavior will be discussed in my thesis.

The central argument in my thesis is that exchange rate and each of the three measures of external balances (current account balance, capital gains and change in NFA position) is closely related. Theoretically, current account balance will have a positive response given a one-time shock of exchange rate while capital gains will behave negatively in response of the same shock. Given the equation of balance of payment identity, change in NFA position should be cushioned from exchange rate shock. In this thesis, I intend to address whether external balances demonstrate this predictable and systematic patterns in response to exchange rate shock. In addition, the roles of domestic productivity and terms of trade in this stabilizing process are also investigated since they are closely related to changes in the valuation effects. Detailed evidence on the economic significance of the dynamic relationships between these variables will be provided.

Although there are numerous studies investigating the links between international payments and exchange rate, they largely focus on developed countries (e.g. Organization for Economic Co-operation and Development (OECD) countries (Lane and Milesi-Ferretti 2002), United States (Gourinchas and Rey 2007; Marcel et

al. 2008; Obstfeld and Rogoff, 2005a and 2005b)). In contrast, I intend to place more emphasis on three important developing countries: Brazil, China and India.

The Brazilian economy is marked by its foreign trade trends and policy manipulations (Lima and Santos, 1998). In the early 1980s, it experienced a worsening of external payments position and its policy makers used a lot of measures to restore external balance. Three of the policy measures applied include: forcing exchange rate depreciation, tightening import controls, decreasing domestic demand. These attempted stabilization policies were very successful, which contributed to transforming Brazil from a relatively closed economy to a significant liberalized and growing economy. Thus, the working mechanism between external balances and other factors (exchange rate, terms of trade and domestic productivity) is really worth addressing.

For China, current account surplus and NFA position have expanded considerably in the past two decades. Surprisingly, the low capital-labor ratio is corresponding with large NFA position (Ma and Zhou, 2009). At the same time, the long term undervalued Chinese Yuan keeps boosting corporate savings and benefiting the current account balance in the form of export growth. Meanwhile, it decreases domestic investment by raising the prices of imported capital goods. A stronger Chinese Yuan is expected to trim the current account surplus and decrease NFA

position. Through the analysis below, I intend to explain how exchange rate fluctuation plays a role in the trade channel as well as valuation channel for China.

India has experienced a boom and bust cycle since the 1980s. A strong domestic demand keeps attracting large volumes of imports. The rising current account deficit has been largely financed by short-term capital inflows and this gives rise to a surge of capital chasing growth. The ever larger reliance on external capital to finance current account deficit, together with the exacerbating high asset and commodity prices, have become an emerging risk for India's economic growth (Poddar, 2010). Thus, it is important to examine the nature of the linkage between exchange rate and external balances in this economy.

## 1.2 Objectives

The following two interrelated issues are primarily investigated in this paper: first, whether there exists a long run equilibrium for exchange rate and each measure of external balance (e.g. current account balance, capital gains and changes in NFA); second, given the existence of an equilibrium, how do the three measures of external balances respond to exchange rate shock? My empirical methodologies are based on time series approach, specifically cointegration techniques and error correction modeling. Error correction models are estimated to capture the equilibrium.

Furthermore, to investigate the relevance of the shock to the movements in external balances, the magnitude and direction of the responses of one variable to the others will be calculated. I will also assess the relative contributions of exchange rate, domestic productivity, and terms of trade in the error variances of external balances.

## 1.3 Contribution

I expect the findings from this study could help illuminate the nature of the linkage between external balances and exchange rate dynamics. To begin with, the main analytical contribution relies on exploring the impact of exchange rate shock on these three external balances (current account balance, capital gains, and change in NFA position) with the incorporation of domestic productivity and terms of trade. Previous studies (see Lane and Milesi-Ferretti 2004) have examined some aspects of this issue before, but they follow a different line of inquiry by focusing on cross-sectional correlation between changes in real exchange rates and change in NFA position. This current analysis differs from this strand of literature at a methodological level. I would adopt a time series approach, examining the cointegration relationships of these variables and ascertaining the existence of long run equilibrium. By estimating the cointegration relationships, different long-run correlation patterns among these variables will be uncovered. The later part of analysis is also distinct, and

lies in the estimation of direction and magnitude of different shocks to the external balances. Moreover, the results from forecast error variance decompositions will reveal the comparison between exchange rate and terms of trade in contributing to the forecast error variance of the three external balances. Also, the results will address the question of whether exchange rate has more explanatory power for external balances.

Furthermore, this thesis would contribute to the empirical literature by providing a most detailed picture of the linkages of external balances, exchange rate, terms of trade, and domestic productivity. Other than exploring the dynamic bi-relationship between external balances and exchange rate and addressing their long run equilibrium, I will also examine whether the information of exchange rate dynamics is helpful in predicting the movement of external balances. The roles of terms of trade and domestic productivity will also be captured.

# Chapter 2

# LITERATURE REVIEW

## 2.1 Exchange Rate and External Balances

The ever growing global financial imbalances have led to a resurgence of interest in the relationship between real exchange rate and international payments, especially changes in net foreign assets, although there is a vast literature on the *transfer problem* (e.g. correcting current account imbalance). Masson et al. (1994) describe the role of exchange rate as a mechanism of adjustment as follows. For current account position alteration, exchange rate operates by changing domestic savings and investment. For the changing in the stock of net foreign asset, it results from valuation effects where at varying exchange rates, the values of aggregation of assets and liabilities in different currencies are altered.

Gagnon (1996) finds that both short run and long run relations between CPI-based and WPI-based real exchange rate and NFA are positive, using panel regressions in error correction form. Broner et al. (1997) use the largest Latin American countries to estimate real exchange rate cointegrated relation. Based on their

models, they reach the conclusions that NFA affects real exchange rate through the effect on terms of trade.

Lane and Milesi-Ferretti (2004) demonstrate a strong cross-sectional correlation between changes in real exchange rates and changes in net foreign assets, in both developing and industrialized countries. Based on the evidence from a fixed effects panel estimation, they find that in the long run, raising net external positions is closely related with appreciating real exchange. With respect to trade balance, various business cycle shocks would generate short run co-movement between exchange rate and trade balance. Obstfeld and Rogoff (2005a) provide a U.S. example suggesting that a reversal of a current account deficit is associated with a depreciation of the effective U.S. dollar exchange rate.

Gust and Sheets (2009) develop an open-economy DGE model to address whether partial exchange rate pass-through to trade prices plays an important role in the prospective adjustment of global external imbalances. They find that when there is a low pass through, real economic variables tend to respond less to a given shock, which indicates the foreign counterparts would absorb a portion of the shock. Another important observation is that when pass through is low, a given quantum of improvement in the nominal trade balance requires a correspondingly larger fluctuation in the real exchange rate.

## 2.2 Current Account Balance and Net Foreign Assets

Branson and Henderson (1985) and Alberola et al. (2000) argue that a country would have real depreciation in exchange rate along the transition path in order to run trade surpluses to converge to the desired long-run net foreign assets. Moreover, according to Devereux and Sutherland (2010), the response of current account balance and change in NFA to each other not only depends upon the expected excess returns on a country's portfolio due to differences in the covariance risk associated with each country's traded equity, but also is influenced by the way national portfolios are structured. Lane and Milesi-Ferretti (2007) propose that the valuation effects exert a stabilizing role in this transition process from current account balance to NFA. Ghironi et al. (2007) analyze the importance of valuation effects in a quantitative manner, suggesting that the size of financial frictions, substitutability across goods, and the persistence of the shocks play important roles in the international transmission mechanism. However, they do not investigate the roles of valuation effects on NFA. In my thesis, a proper question to ask is not whether the valuation effects are important, but whether there exist feedback mechanisms that operate smoothly to ensure that the valuation effects take place.

A conventional wisdom emerging from standard intertemporal models with perfect capital mobility states a temporarily positive income shock would generate

current account responses and the amount is equal to the magnitude of the savings generated by the shock. One implication of NFA for current account behavior is that an existing portfolio allocation would have impact on the current account response following a temporary shock if investment risk is high and diminishing returns are weak (see Kraay and Ventura (2000)). Bussiere et al. (2003) follow a different line of inquiry by focusing on cyclical factors. They distinguish the impact of permanent and temporary shocks and model the current account by examining the long run factors of savings and investment while allowing for short run, cyclical influences. They reach the conclusion that the cyclical impact on the current account is modified by initial net foreign asset positions. With regard to the other case, as noted by Cooper (2001), the example of the U.S. demonstrates that ongoing international portfolio diversification can be identified as a driving force behind its deficit. However, the diversification does not require any net capital flows. That means even if foreigners and U.S. residents swap assets, it will not have a significant impact on the current account balance.

### 2.3 The Role of Terms of Trade and Domestic Productivity

The relationship between exchange rate and external balances, and the transmission channel of current account balance and net foreign assets do not need to

be identical across economies due to the differences in some country-specific characteristics like terms of trade and domestic productivity. Depending on the price elasticity of demand for both exports and imports, trade deficit is sometimes associated with an improvement in the terms of trade. At the same time, a trade deficit always creates an increasing demand for the foreign currency which would result in the depreciation in the domestic currency. Although there is no direct connection between exchange rate and terms of trade, the movement of terms of trade is a potential source of fluctuation in the exchange rate. It is also widely understood that while terms of trade may be exogenously determined for smaller countries, the endogenous one is likely to predominate for larger countries (see Lane et al. 2002). On the other hand, Backus et al. (1994) find that the relationship between trade balance and terms of trade depends critically on the source of fluctuations (past, current or future movements of terms of trade).

In addition to terms of trade, domestic productivity is included as an explanatory variable as well, since domestic productivity can explain some interesting phenomena that conventional wisdom does not account for (see Corsetti and Pesenti 1999). With respect to exchange rate, the Balassa-Samuelson hypothesis states that total labor productivity differentials between traded and nontraded goods contribute to the dynamics in real exchange rate (see Canzoneri et al. 1999). Another strand of

literature has been concentrating on current account balance and domestic productivity. To use the U.S. as an example, some scholars argue that at least part of U.S. external deficit is due to the rise in U.S. productivity (see Bems et al. 2007, Bussiere et al. 2010). The reason is that rising productivity will generate more incentives for importing. Aguiar and Gopinath (2007) classify productivity shocks into two types: transitory shocks and trend shocks. If the data series show a dramatic response of consumption to income and a corresponding large deterioration of net exports, the shock that drives this will be identified as a change in trend. However, if for the same increase in output, the rise in consumption is less and a slight decrease in net exports in observed, the shock that drives this will be identified as a transitory output shock. Nguyen (2010) finds that the impact of current account on net foreign asset position is cushioned by transitory shock. The effect of transitory shock moves in the opposite direction of current account, and shrinks the impact of current account on net foreign asset position. However, in response to trend shocks, this impact is amplified. The effect moves in the same direction as current account, and reinforces the impact on net foreign asset position. The reason is that consumers would act differently in the face of transitory shock and trend shock to income.

# Chapter 3

# ANALYTICAL FRAMEWORK

To guide the empirical framework, I adopt the theoretical framework developed by Lane and Milesi-Ferretti (2002 and 2004).

## 3.1 Basic Framework

The following equilibrium equations describe the steady state of a standard intertemporal open-economy model:

$$TB = -r^{*} NFA + c \quad (1)$$

$$\text{RER} = -\alpha \text{TB} + \beta \text{X} \quad (2)$$

where TB is trade balance to GDP ratio, $r^{*}$ is the rate of return on external assets and liabilities, NFA is the stock of net foreign assets as a ratio to GDP, c is a constant, RER is the real exchange rate, and X are other factors that might affect the exchange rate.

Equation (1) shows that, given an increase in net foreign assets, a country will run a decreasing trade balance. Equation (2) states that trade balance and real exchange rate have a negative relationship.

The following equation can be obtained from the combination of Equations (1) and (2).

$$\text{RER}=\alpha\, r^{*} NFA+\beta \text{X}+c \tag{3}$$

Equation (3) indicates a positive relationship between real exchange rate and NFA.

3.2 More General Framework

To extend Equation (1), the following is a long run condition for trade balance assuming the rates of return on external assets and liabilities are equal (see Lane and Milesi-Ferretti, 2002).

$$\text{TB}_t = -\left[\frac{(1+r_t)-(1+g_t)(1+\dot{e}_t)}{(1+g_t)(1+\dot{e}_t)}\right] NFA_{t-1} + c + \varepsilon_t \tag{4}$$

where $r_t$ is the real rate of return on foreign assets and liabilities, $g_t$ is the rate of real GDP growth, $\dot{e}_t$ is the rate of real exchange rate appreciation, and $\varepsilon_t$ captures the temporary deviations from the equilibrium.

Including domestic productivity and terms of trade in Equation (4), we can obtain the following simplified equation:

$$\mathrm{RER}_t = f(TB_t, PR_t, TOT_t) + \mu_t, \quad f_{tb} < 0, f_{pr} > 0, f_{tot} > 0 \tag{5}$$

where PR is GDP per worker as a proxy for domestic productivity, TOT is terms of trade and $\mu_t$ is a disturbance term.

The implication of this model is that any outcome that is contrary to the conventional wisdom (e.g. a persistent trade deficit drives a weak exchange rate) might be attributed to the other factors such as domestic productivity and terms of trade.

The same as Equation (5), the following equation shows the long run relationship between real exchange rate and NFA, controlling for the impact of domestic productivity as well as terms of trade.

$$\mathrm{RER}_t = f(NFA_t, PR_t, TOT_t) + \mu_t, \quad f_{nfa} > 0, f_{pr} > 0, f_{tot} > 0 \tag{6}$$

3.3 Relationship between NFA and Current Account Balance

Disregarding asset valuation change, we can get an approximation of the change in NFA having the current account balance and capital gains.

$$\Delta NFA \cong CA + CG \tag{7}$$

where *CA* is current account balance and *CG* is capital gains.

Intuitively, if a change in NFA position is zero, the overall balance of payments (the sum of current account balance and capital gains) is zero. So given an initial stock of net external assets, one would easily get an approximate estimate of current stock of net foreign asset by adding current account balance and capital gains.

# Chapter 4

# METHODOLOGICAL ISSUES

Historically, there were various approaches used in the estimation and forecasting of macroeconomic models. However, these approaches could not adequately address the problems regarding the endogeneity of the policy variables (Sims, 1980) and these approaches were subject to the Lucas critique (Lucas, 1976) which states that it is difficult to predict the effects of a change in economic policy depending on the relationships observed in historical data. The conceptual difficulties with these models led to the development of VAR models by Sims (1980) and subsequent introduction of the cointegration approach by Engle and Granger (1987).

## 4.1 Cointegration Test

For the analysis of time series data, the empirical study begins with testing the existence of unit roots in the data series as well as the cointegration relationships between the variables. Cointegrating relations may be interpreted as co-movement among trended time series (long-run economic equilibrium). The idea underlying cointegration issue in this study is to examine the behavior of exchange rate and

external balances which are brought back to the long run equilibrium, in spite of moving apart in the short time period.

The order of integration needs to be determined before the cointegration test. Only until the data series are stationary after first differencing, can they be tested for cointegration. The Johansen and Juselius (1990) maximum likelihood procedure would be used for the cointegration test rather than the Engle-Granger single-equation procedure. The time series is modeled as reduced rank regression where the maximum likelihood estimates are computed with Gaussian errors. This model is based on an error correction representation.

$$\Delta Y_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-1} + \varepsilon_t \tag{8}$$

where $Y_t$ is an $(n \times 1)$ column vector of $p$ variables, $\mu$ is an $(n \times 1)$ vector of constant terms, $\Gamma$ and $\prod$ represent coefficient matrices, and specifically, $\prod$ is known to be the impact matrix and contains long-run relationships information. $\Delta$ is a difference operator, and $\varepsilon_t$ is i.i.d. p-dimensional Gaussian error with mean zero and variance matrix $\Lambda$.

The next step is to compute the likelihood ratio test statistic (the trace statistic), by using the residuals from the estimation of Equation (8). It is expressed as:

$$Trace = -T \sum_{i=r+1}^{n} \ln(1-\lambda_i) \tag{9}$$

,

where $\lambda_t$ are the estimated values of the characteristic roots obtained from the estimated $\Pi$ matrix. The hypothesis for the trace test is that the rank of $\Pi$ is less than or equal to $r$ cointegrating vectors. In other words, there exist at most $r$ cointegrating vectors.

The asymptotic critical value (C (5%)) for the likelihood ratio test in this case is from the simulation done by MacKinnon-Haug-Michelis (1999). When the estimated likelihood ratio test results exceed the critical values, the null hypothesis is rejected.

If the evidence from the trace statistics suggests that the variables in the system are cointegrated, it is appropriate to estimate the models with error correction terms which could be used to capture long run relationships. The basic idea is that when there exists a long run equilibrium among variables, shocks to certain variables can lead to short run departures from this long run equilibrium, but there also exist short run dynamics that can adjust and reestablish the long run relationship. An appropriate lag length should be obtained to ensure that the error terms in the vector error correction model are Gaussian. The Schwarz information criterion (SIC) is used to calculate the optimal lag length.

However, the individual coefficients of error correction model are difficult to interpret. Thus, most researchers use innovation accounting based on impulse

responses and forecast error variance decompositions. I first would adopt generalized impulse response functions proposed by Koop et al. (1996) and Pesaran and Shin (1998) to scrutinize the magnitude of the causal structure.

## 4.2 Impulse Response Analysis

Impulse response analysis captures the effects on the future state of a dynamic system given a one-time standard shock. When a VAR is stationary, it has a convergent vector $MA(\infty)$ representation.

$$Y_t = \mu + \varepsilon_t + \psi_1 \varepsilon_{t-1} + \psi_2 \varepsilon_{t-2} + \cdots \tag{10}$$

The matrix $\psi_s = \frac{\partial Y_{t+s}}{\partial \varepsilon_t}$ and the $(i, j)^{th}$ element of $\psi_s$ can be described as:

$$\psi_s^{(i,j)} = \frac{\partial y_{i,t+s}}{\partial \varepsilon_{j,t}} \tag{11}$$

The plot of $\psi_s^{(i,j)}$ describes the response of $y_{i,t+s}$ to a one-time unit shock to the $j^{th}$ innovation $\varepsilon_{j,t}$ while all other innovations are held constant.

Sims (1980) firstly carries out the dynamic analysis of VAR models using orthogonalized impulse responses and how it is orthogonalized is chosen according to Cholesky decomposition. This approach, nevertheless, is not invariant to the ordering of the variables in the VAR. In my analysis, I would adopt generalized impulse responses brought by Koop et al. (1996) and developed by Pesaran and Shin (1997).

This approach fully considers the historical patterns of correlations observed in different shocks. In contrast within impulse response functions for structural models, generalized impulse responses do not require to identify any structural shocks. In a recent study, Awokuse (2008) advocates the use of generalized impulse response functions (GIRF) in the analysis of macroeconomic time series data. He argues that the GIRF approach is preferable to the traditional application of Choleski or Bernanke (1986) factorization of the reduced form error covariance matrix. Choleski method is sensitive to the ordering of the variables when the residual covariance matrix is nondiagonal. Bernanke factorization method could overcome this problem since it is less restrictive. However, it still requires prior knowledge of the interdependences among the variables in the system.

For generalized impulse responses, we have

$$GIR_{ij}(s) = \psi_s^{(i,.)} E(\varepsilon_t \left| \varepsilon_{j,t} = \sqrt{\sigma_{jj}} \right.) = \psi_s^{(i,.)} \begin{pmatrix} \sigma_{1j} / \sqrt{\sigma_{jj}} \\ \vdots \\ \sigma_{nj} / \sqrt{\sigma_{jj}} \end{pmatrix} \tag{12}$$

If $\varepsilon_t$ is joint normal, then

$$GIR_{ij}(s) = \frac{1}{\sqrt{\sigma_{jj}}} \psi_s^{(i,\bullet)} \Omega_\varepsilon^{(\bullet,j)} = \frac{1}{\sqrt{\sigma_{jj}}} (\psi_s \Omega_\varepsilon)^{(i,j)} \tag{13}$$

where $\psi_s^{(i,\bullet)}$ is the $i^{th}$ row of $\psi_s$ and $\Omega_\varepsilon^{(\bullet,j)}$ is the $j^{th}$ column of $\Omega_\varepsilon$.

## 4.3 Forecast Error Variance Decomposition

While impulse response function describes the impact of exchange rate shock on external balances, an equally important question is to ask how much of the forecast error variance of each external balance can be explained by exogenous shocks from other variables in the system. To address this issue, variance decompositions are commonly used to determine how important each shock has been on average in determining fluctuations in key variables of interests. This approach is an econometric tool used by many researchers in the VAR context for assessing the driving force of key variables. Theoretically, variance decomposition (VD) provides a decomposition of the forecast error variance error variance of the variables in the VAR for various forecast horizons.

## 4.4 Granger Causality Test

Granger causality examines the forecasting relation between two variables. The test is used to determine whether one time series is useful in forecasting another. This method was proposed by Granger (1969) and popularized by Sims (1972). A time series $X$ is said to Granger cause $Y$ if lagged values of $X$ (also including lagged values of $Y$) provide statistically significant information about predicting the future values of $Y$.

To test the existence of Granger causality of $X$ to $Y$, the first thing is to conduct a regression of $\Delta Y$ on lagged values of $\Delta Y$ ( $\Delta Y$ is the first difference of the variable $Y$ ) in order to find out a set of significant lagged values for $\Delta Y$ (via t-statistics). Then the regression is augmented with lagged levels of $\Delta X$. If any particular lagged value of $\Delta X$ is significant according to a t-test and that particular lagged value of $\Delta X$ with other lagged values of $\Delta X$ jointly increases explanatory power to the model (via F-statistics). Then $X$ Granger causes $Y$.

In the previous empirical studies, it may be found that two variables Granger cause each other, or that neither variable Granger cause the other. Despite its name, Granger causality does not imply true causality. It just determines whether one time series is useful in forecasting another.

# Chapter 5

# DATA ISSUES

## 5.1 Data Source

My sample spans the period 1986-2008 and includes three important developing countries: Brazil, China and India. The data source for the current account balance is IMF's World Economic Outlook Database[1]. The data on the capital gains come from IMF's International Financial Statistics[2]. The data for net foreign assets (NFA) and net barter terms of trade index are obtained from World Bank-World Development Indicators[3]. And the data for real exchange rate come from USDA Economic Research Service which are based on the monthly real exchange rates, on a 2005 base[4]. The data on domestic productivity are obtained from Penn World Table Version 6.3[5] and I use real GDP per worker at 2005 constant prices as a proxy. All data on external balances are computed as a percent of GDP and are log transformed.

[1] http://www.imf.org/external/pubs/ft/weo/2010/02/weodata/index.aspx
[2] http://www.imfstatistics.org/imf/
[3] http://data.worldbank.org/indicator
[4] http://www.ers.usda.gov/Data/ExchangeRates/
[5] http://dc1.chass.utoronto.ca/pwt/alphacountries.html

5.2 Definitions of Variables

- Net foreign assets is an important balance of payment identity. It is the value of the assets that a country owns abroad, minus the value of the domestic assets owned by foreigners.
- Capital gains is a profit that results from investments into a capital asset, such as stocks, bonds or real estate.
- Current account is the sum of the balance of trade (exports minus imports of goods and services), net factor income (such as interest and dividends) and net transfer payments (such as foreign aid).
- Terms of trade is defined as a ratio comparing export prices to import prices.
- Domestic Productivity is measured by real GDP per worker.
- Exchange Rate is regarded as the value of one country's currency in terms of one U.S. dollar here.

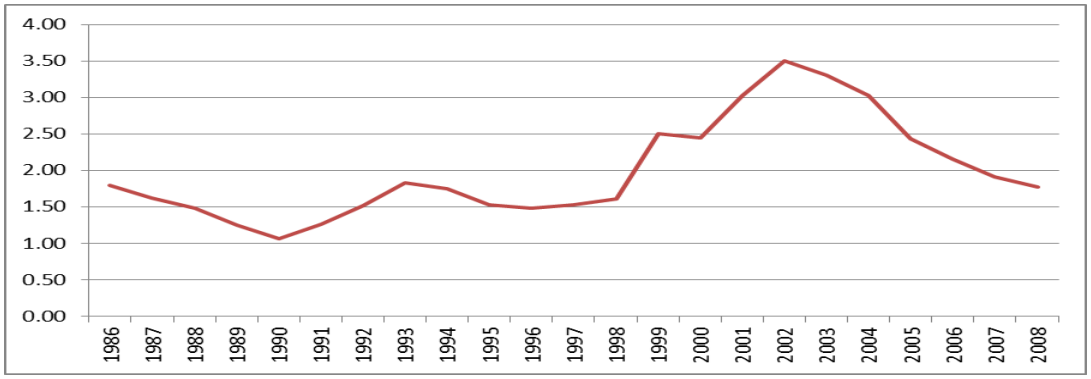
5.3 Countries Selected

**Brazil**

According to Figure 5.1, Brazil has experienced wide exchange rate fluctuations since 1986. However, the current account balance did not observe a reversal until the year 2003 (see Figure 5.2). Why did current account balance mostly

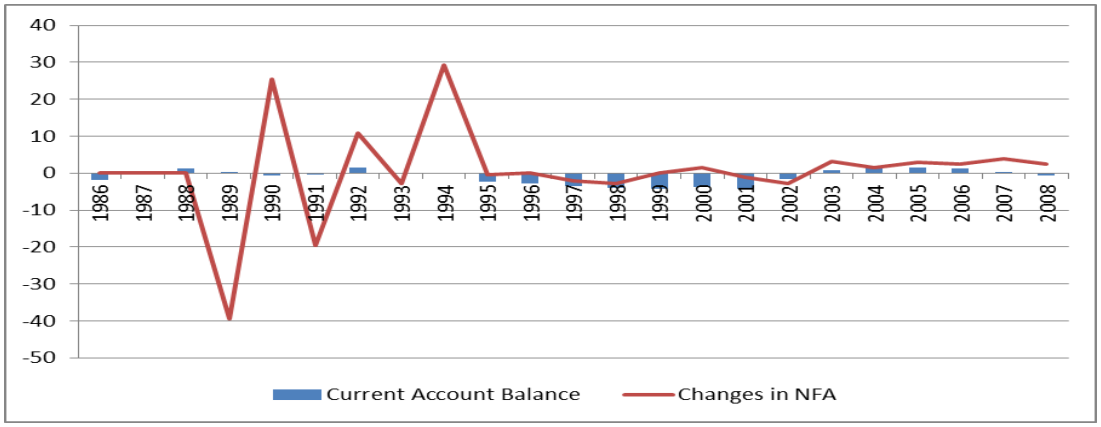
have a deficit when exchange rate fluctuated with a trend of depreciation, but finally revert to a surplus in 2003 when exchange rate started to appreciate? There might be some other factors that contribute to this conversion. I will link several economic fundamentals (terms of trade and domestic productivity) to the relation of exchange rate and current account balance to justify this current account adjustment.

For change in NFA position, the volatility was heavy in the period of 1988 to 1995. At the same time, the balance of payment on current account was relatively small. These give rise to the question of whether the amount of change in NFA position has a negative correlation with the amount of current account balance.




Source: USDA Economic Research Service

**Figure 5.1: Real Annual Exchange Rate for Brazil**




Source: World Bank – World Development Indicator and IMF International Financial Statistics

**Figure 5.2: Current Account Balance (%GDP) and Changes in NFA (%GDP) for Brazil**

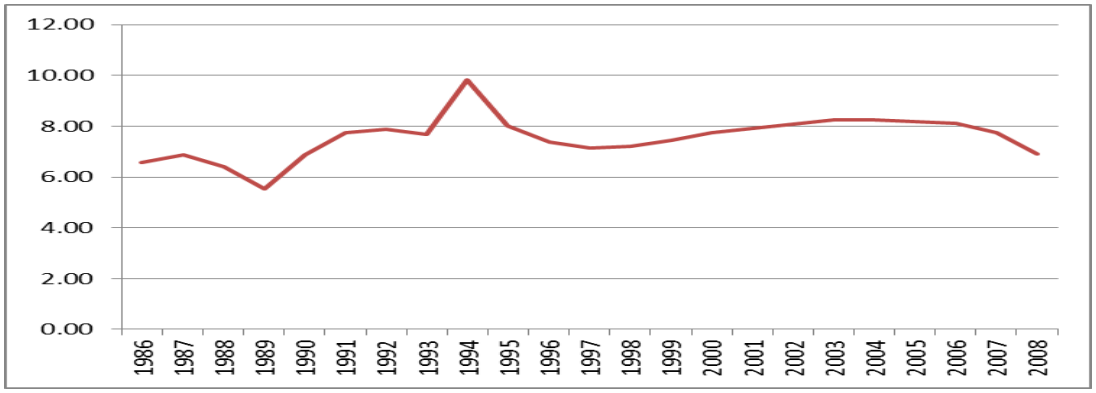
## China

China has accumulated a lot of direct investment recently while it also holds large official reserves on the asset side. As gauged by the size of external position in the balance sheet, China gradually had a high stake in the world. The change in NFA position came to a smooth adjustment after a heavy fluctuation in the year 1991.

Current account balance was observed to have a surplus after mid-90s. Ma and Zhou (2009) proposed three explanations for this. The first one was linked to precautionary motives. During 1990s, there was limited access to credit for consumers

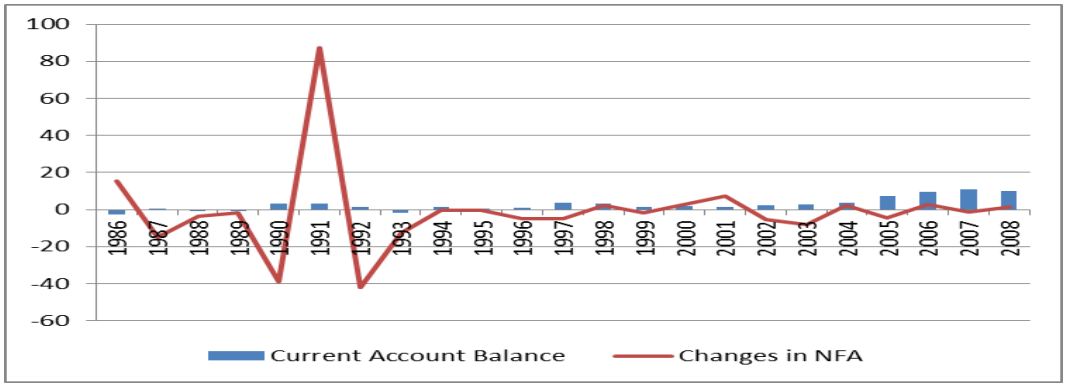
and job security was low. So consumers postponed their consumptions. The second one was associated with ever increasing profit of corporations. This gave rise to a high corporate savings rate. The last one was due to high government savings. Chinese government had buoyant revenues and relatively less spending.

Chinese exchange rate was pegged to U.S. dollar through most of its recent history. After China initiated its participation in the foreign trade, China devalued its currency to increase the export competitiveness. Starting from 2005, Chinese government gradually increased the flexibility of its exchange rate, in order to allow Renminbi to become a reserve currency in the future. So Renminbi has kept increasing its value since then. However, in the process of its appreciation, current account balance has not been observed to drop.




Source: USDA Economic Research Service

**Figure 5.3: Real Annual Exchange Rate for China**



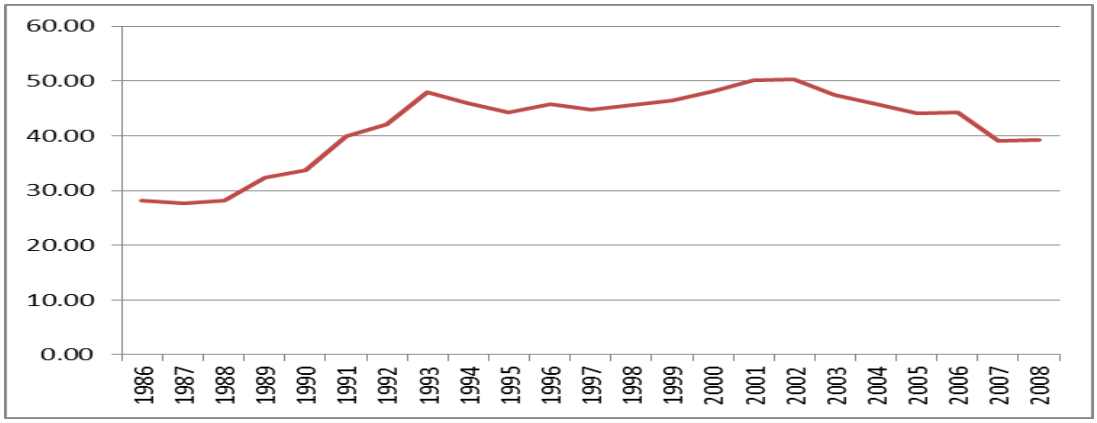

Source: World Bank – World Development Indicator and IMF International Financial Statistics

**Figure 5.4: Current Account Balance (% GDP) and Changes in NFA (% GDP) for China**

## India

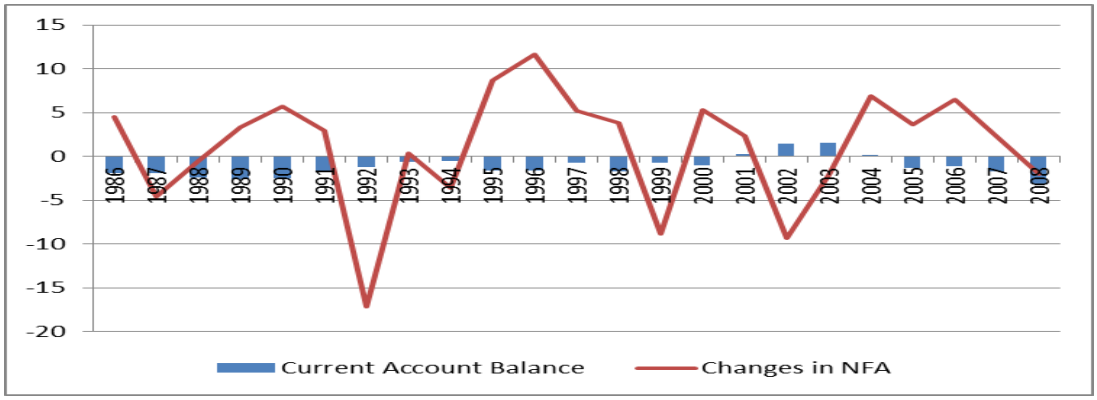
Before 1991 when the economic liberalization took place in India, the economy was isolated from the world market (Martin and Kronstadt, 2007). The current account balance had a relatively heavy deficit. After then, the volume of India's international trade has increased dramatically. The balance of payment on current account has been improved, although still largely negative except for the years 2002 and 2003. The large import of oil is seen as a main driver for Indian current account deficit. The size of current account deficit shrank with the depreciation of its

currency before 2002. However, the rupee (Indian currency) has been appreciating against the U.S. dollars since 2002 and current account balance has been reversed to be a deficit again. These are in accordance with the theoretical prediction that the appreciation of exchange rate is associated with deterioration in current account balance while the depreciation of exchange rate is connected with improvement in current account balance.




Source: USDA Economic Research Service

**Figure 5.5: Real Annual Exchange Rate for India**




Source: World Bank – World Development Indicator and IMF International Financial Statistics

**Figure 5.6: Current Account Balance (%GDP) and Changes in NFA (%GDP) for India**

# Chapter 6

## EMPIRICAL RESULTS

The main analytical contributions of this thesis are the examination of the long-run relation between three measures of external balances and exchange rate, and the assessment of the possible transmission mechanisms. The dynamic feedback is also inside the scope of my analysis. Before the core analysis, unit root tests (ADF and KPSS) are performed to check if the data series are stationary. Although these two unit root tests present slightly different results, they provide support that all variables are at least I(1) (see Table 6.1 for details) which enables these data series to be tested for possible cointegrated relations.

**Table 6.1: Unit Root Tests for Brazil, China and India**

| | Brazil | | China | | India | |
|---|---|---|---|---|---|---|
| Variables | ADF | KPSS | ADF | KPSS | ADF | KPSS |
| level | | | | | | |
| Current Account | -2.045 | 0.119 | -0.928 | 0.544** | -1.339 | 0.240 |
| Capital Gains | -2.956* | 0.129 | -5.758*** | 0.500** | -4.048*** | 0.046 |
| Changes in NFA | -2.997* | 0.114 | -4.020*** | 0.478** | -4.215*** | 0.060 |
| Terms of Trade | -1.885 | 0.262 | -4.836*** | 0.509** | -5.592*** | 0.039 |
| Domestic Productivity | 0.300 | 0.170** | -2.512 | 0.126* | -0.344 | 0.162** |
| Exchange Rate | -1.712 | 0.398* | -2.374 | 0.332 | -2.225 | 0.400* |
| | | | | | | |
| 1st difference | | | | | | |
| Current Account | -3.284*** | 0.098 | -4.632*** | 0.183 | -3.414** | 0.217 |
| Capital Gains | -12.648*** | 0.119 | -5.401*** | 0.500** | -6.346*** | 0.315 |
| Changes in NFA | -13.050*** | 0.117 | -5.162*** | 0.500** | -6.512*** | 0.241 |
| Terms of Trade | -4.148*** | 0.311 | -5.116*** | 0.068 | -8.349*** | 0.165 |
| Domestic Productivity | -1.918 | 0.543** | -1.823 | 0.338 | -3.263** | 0.369* |
| Exchange Rate | -2.988** | 0.127 | -4.805*** | 0.259 | -3.372** | 0.449** |

Note:

1. For the variables current account balance, capital gains, changes in NFA, terms of trade and exchange, since no clear trend is observed, the specification of ADF test and KPSS test is intercept and no trend. For the variable domestic productivity, since there is clear positive trend, the specification of ADF test and KPSS test is intercept and trend.

2. The test critical values for ADF test with intercept and without trend are -3.770 (1% level), -3.005 (5% level), -2.642 (10% level). The test critical values for ADF test with intercept and with trend are -4.468 (1% level), -3.645 (5% level), -3.261 (10% level). The asymptotic critical values for KPSS test with intercept and without trend are 0.739 (1% level), 0.463 (5% level), and 0.347 (10% level). The asymptotic critical values for KPSS test with intercept and without trend are 0.216 (1% level), 0.146 (5% level), and 0.119 (10% level).

Overall, the results in Table 6.2 provide support for cointegrated relations for each of the three countries: Brazil, China and India. Each external balance is examined separately with terms of trade, exchange rate and domestic productivity for cointegrated relations.

For Brazil, in the system of current account balance, terms of trade, exchange rate and domestic productivity, we can reject the hypothesis of cointegration rank less or equal to three. Thus, Brazil has four cointegrated relations in the system with current account balance. However, in the system of capital gains, the hypothesis of cointegration rank equaling zero can be rejected, but that of cointegration rank less or equaling to one cannot be rejected. Thus we reach the conclusion that Brazil has one cointegrated relation in the system with capital gains. The same with capital gains, the system with change in NFA has one cointegrated relation.

Following the same analysis as for Brazil, China has one cointegrated relation in the systems of current account balance, capital gains and change in NFA position separately. However, in the system of current account balance for India, there is no cointegration relationship detected at 5% significance level. But it is around 10% significance level. In this case, I relax the requirement of 5% significance level and allow for the cointegrated relation. India has one cointegrated relation for the systems with capital gains and change in NFA position.

**Table 6.2: Results of Cointegration Tests for Brazil, China, and India**

| | Brazil | | | |
|---|---|---|---|---|
| Cointegration Rank | CA | CG | CIN | C.V. (5%) |
| r=0 | 79.283** | 75.120** | 72.304** | 47.856 |
| r≤1 | 43.055** | 32.802 | 29.223 | 29.797 |
| r≤2 | 22.921** | 15.017 | 13.148 | 15.495 |
| r≤3 | 10.409** | 1.998 | 1.474 | 3.841 |
| | China | | | |
| Cointegration Rank | CA | CG | CIN | C.V. (5%) |
| r=0 | 60.555** | 63.407** | 68.404** | 47.856 |
| r≤1 | 25.024 | 22.690 | 22.771 | 29.797 |
| r≤2 | 7.973 | 9.591 | 8.946 | 15.495 |
| r≤3 | 2.213 | 1.883 | 1.935 | 3.841 |
| | India | | | |
| Cointegration Rank | CA | CG | CIN | C.V. (5%) |
| r=0 | 42.105 | 54.699** | 56.145** | 47.856 |
| r≤1 | 23.908 | 25.563 | 25.813 | 29.797 |
| r≤2 | 8.172 | 9.410 | 9.648 | 15.495 |
| r≤3 | 0.203 | 0.001 | 0.019 | 3.841 |

Note:

1. Current account balance, capital gains and change in NFA position are represented by CA, CG and CIN.

2. For these three countries, each external balance (current account balance, capital gains, and change in NFA position) is examined with terms of trade, exchange rate, and domestic productivity for cointegrated relations.

3. ** denotes rejection of the hypothesis at the 0.05 level of the trace test. P-values are obtained from MacKinnon-Haug-Michelis (1999).

6.1 Results from Vector Error Correction Estimates

**Brazil**

Table 6.3 shows three normalized cointegrating vectors for current account balance (CA), capital gains (CG) and change in NFA position (CIN). Exchange rate, domestic productivity and terms of trade are represented by EX, PR, and TOT.

For current account balance, the cointegrating equation is as follows:

$$CA - 6.868EX - 23.455PR - 0.246TOT + 236.489 = 0 \quad (24)$$

where current account balance (CA) is positively related with exchange rate, domestic productivity and terms of trade.

For capital gains, the cointegrating equation is:

$$CG + 7.701EX + 70.397PR - 0.485TOT - 696.416 = 0 \quad (25)$$

where capital gains (CG) is negatively related with exchange rate and domestic productivity, but positively related with terms of trade.

For change in NFA position, the cointegrating equation is:

$$CIN + 3.184EX + 50.811PR - 0.695TOT - 499.549 = 0 \quad (26)$$

where change in NFA position (CIN) is negatively related with exchange rate and domestic productivity, but positively related with terms of trade.

In sum, when other conditions are constant, given an increase in exchange rate (depreciation), current account balance improves while capital gains

drops. Comparing with the coefficients of exchange rate in the equations (25) and (26), the adjustment speed of exchange rate is faster for capital gains than for change in NFA position.

**Table 6.3: Results of Vector Error Correction Model Estimates for Brazil**

| | Current Account Balance | Capital Gains | Change in NFA Position |
|---|---|---|---|
| Cointegrating Equation | | | |
| | 1 | 1 | 1 |
| EX(-1) | -6.868 | 7.701 | 3.184 |
| | (1.958) | (1.909) | (1.551) |
| | [-3.507] | [ 4.034] | [ 2.053] |
| PR(-1) | -23.455 | 70.397 | 50.811 |
| | (5.078) | (12.338) | (10.628) |
| | [-4.619] | [ 5.706] | [ 4.781] |
| TOT(-1) | -0.246 | -0.485 | -0.695 |
| | (0.049) | (0.091) | (0.078) |
| | [-5.021] | [-5.350] | [-8.960] |
| C | 236.489 | -696.416 | -499.549 |

Note:

1. EX: exchange rate; PR: domestic productivity; TOT: terms of trade.

2. The figures in ( ) are standard errors and the figures in [ ] are t-statistics.

**China**

Table 6.4 below summarizes the results of vector error correction model estimates for China. The coefficients for current account balance, capital gains and change in NFA are normalized to be one.

For current account balance, the cointegrating equation is as follows:

$$CA - 1.428EX + 7.889PR + 2.016TOT - 67.014 = 0 \quad (27)$$

where current account balance is positively related with exchange rate, but negatively related to domestic productivity and terms of trade.

For capital gains, the cointegrating equation is:

$$CG + 17.789EX - 30.390PR - 5.101TOT + 228.634 = 0 \quad (28)$$

where capital gains is negatively related with exchange rate, but positively related with domestic productivity and terms of trade.

For change in NFA position, the cointegrating equation is:

$$CIN + 45.355EX - 40.412PR - 6.136TOT + 256.380 = 0 \quad (29)$$

where change in NFA position is negatively related with exchange rate, but positively related with domestic productivity and terms of trade.

The same as Brazil, the depreciation of exchange rate is associated with an improvement of current account balance, a drop in capital gains and change in NFA

position. Moreover, the speed of adjustment of exchange rate in change in NFA position is higher than that in capital gains.

**Table 6.4: Results of Vector Error Correction Model Estimates for China**

| | Current Account Balance | Capital Gains | Change in NFA Position |
|---|---|---|---|
| Cointegrating Equation | | | |
| | 1 | 1 | 1 |
| EX(-1) | -1.428 | 17.789 | 45.355 |
| | (5.183) | (12.546) | (14.194) |
| | [-0.276] | [ 1.418] | [ 3.195] |
| PR(-1) | 7.889 | -30.39 | -40.412 |
| | (1.382) | (3.071) | (3.528) |
| | [ 5.709] | [-9.897] | [-11.454] |
| TOT(-1) | 2.016 | -5.101 | -6.136 |
| | (0.197) | (0.474) | (0.539) |
| | [ 10.225] | [-10.756] | [-11.387] |
| C | -67.014 | 228.634 | 256.38 |

Note:
1. EX: exchange rate; PR: domestic productivity; TOT: terms of trade.

2. The figures in ( ) are standard errors and the figures in [ ] are t-statistics.

**India**

Table 6.5 shows the results of vector error correction model estimates for India. However, these estimates are different from those of Brazil and China.

For current account balance, the cointegrating equation is as follows:

$$CA + 4.017EX - 2.495PR - 0.059TOT + 7.845 = 0 \quad (30)$$

where current account balance is negatively related with exchange rate, but positively related to domestic productivity and terms of trade.

For capital gains, the cointegrating equation is:

$$CG - 38.167EX - 6.869PR - 1.63TOT + 203.388 = 0 \quad (31)$$

where capital gains is positively related with exchange rate, domestic productivity and terms of trade.

For change in NFA position, the cointegrating equation is:

$$CIN - 65.750EX - 42.084PR - 3.423TOT + 619.147 = 0 \quad (32)$$

where change in NFA position is positively related with exchange rate, domestic productivity and terms of trade.

In sum, for India, the appreciation of exchange rate will lead to an improvement of current account balance while capital gains and change in NFA position drop. Also, the speed of adjustment of exchange rate for change in NFA position is faster than for capital gains.

**Table 6.5: Results of Vector Error Correction Model Estimates for India**

| | Current Account Balance | Capital Gains | Change in NFA Position |
|---|---|---|---|
| Cointegrating Equation | | | |
| | 1 | 1 | 1 |
| EX(-1) | 4.017 | -38.167 | -65.75 |
| | (1.461) | (10.906) | (23.308) |
| | [ 2.749] | [-3.500] | [-2.821] |
| PR(-1) | -2.495 | -6.869 | -42.084 |
| | (1.538) | (11.43) | (24.306) |
| | [-1.623] | [-0.601] | [-1.731] |
| TOT(-1) | -0.059 | -1.63 | -3.423 |
| | (0.044) | (0.329) | (0.705) |
| | [-1.338] | [-4.962] | [-4.856] |
| C | 7.845 | 203.388 | 619.147 |

Note:

1. EX: exchange rate; PR: domestic productivity; TOT: terms of trade.

2. The figures in ( ) are standard errors and the figures in [ ] are t-statistics.

As a summary, the results of Brazil and China are consistent with the theoretical predictions. The coefficients of current account balance, capital gains and change in NFA position all have the right signs. However, for India, the coefficients do not have the expected signs. Thus, generalized impulse responses, forecast error variance decompositions and Granger causality analysis will be conducted to further explore the relationship between external balances and exchange rate.

## 6.2 Results of Generalized Impulse Responses

The generalized impulse responses describe the impact of one exogenous shock (innovation) in one variable on the other variables in the system. The discussion in this section would attempt to provide answers to the following questions.

*1) Exchange rate shock would lead to current account adjustment and valuation effect change. Would this shock be positive or negative towards the external balances?*

*2) Would current account balance have a negative impact on real exchange rate, as suggested by equation (2)?*

*3) Would domestic productivity and terms of trade exert positive influence on real exchange rate in the systems of current account balance, as indicated in equation (5)?*

The generalized impulse responses are generated from the vector error correction models. The empirical findings from these results are compared with the estimations of vector error correction models and theoretical predictions.

For Brazil, as demonstrated by Figure 6.1 upper left graph, a one-time shock to exchange rate would generate a positive response in current account balance in all horizons. For capital gains (Figure 6.2 upper left graph) and change in NFA position (Figure 6.3 upper left graph), the response is positive in the horizon one to four (corresponding to the year from 1986 to 1995), but turns out to be negative starting for horizon four (roughly corresponding to the year 1995). These results are consistent with the findings in the estimates from the vector error correction models, which also confirm the theoretical predictions. For the response of exchange rate toward the shock of current account balance (Figure 6.1 lower right graph), it turns from being positive to negative (in the horizon three); the latter is in line with equation (2). As for the influence of terms of trade and domestic productivity on exchange rate in the system of current account balance, Figure 6.1 lower right graph shows that they both have negative impact, which could not serve as empirical supports for equation (5).

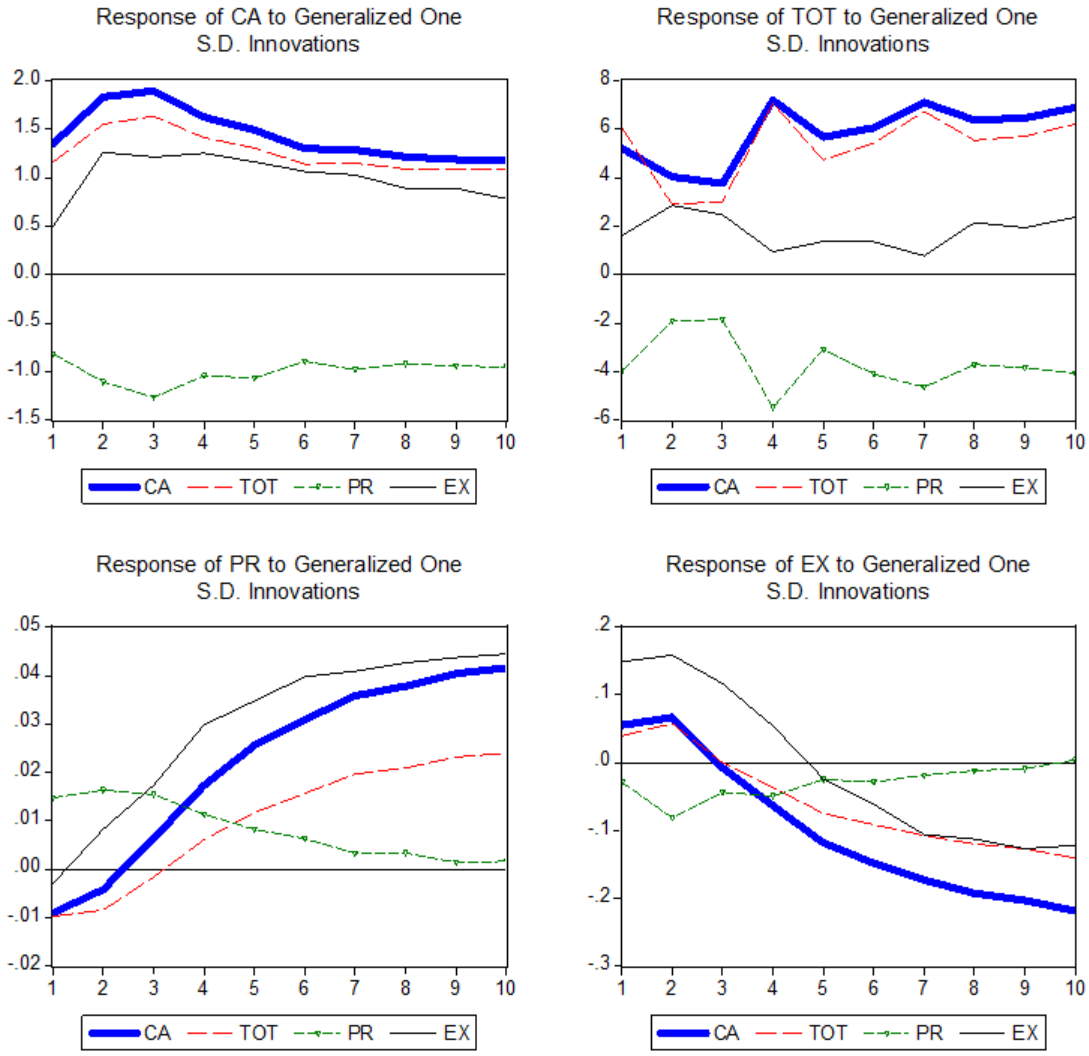



**Figure 6.1: Results of Generalized Impulse Responses for Brazil (Current Account Balance)**

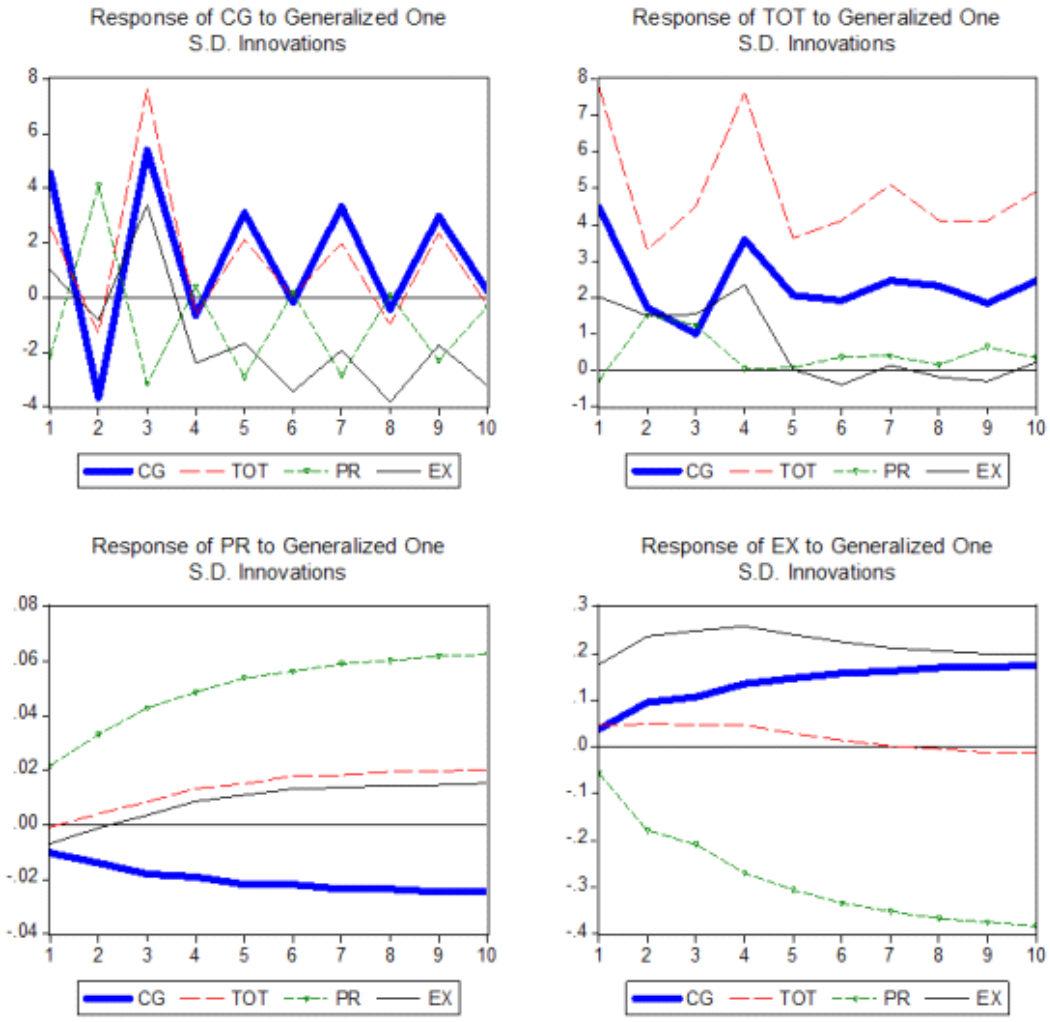



**Figure 6.2: Results of Generalized Impulse Responses for Brazil (Capital Gains)**

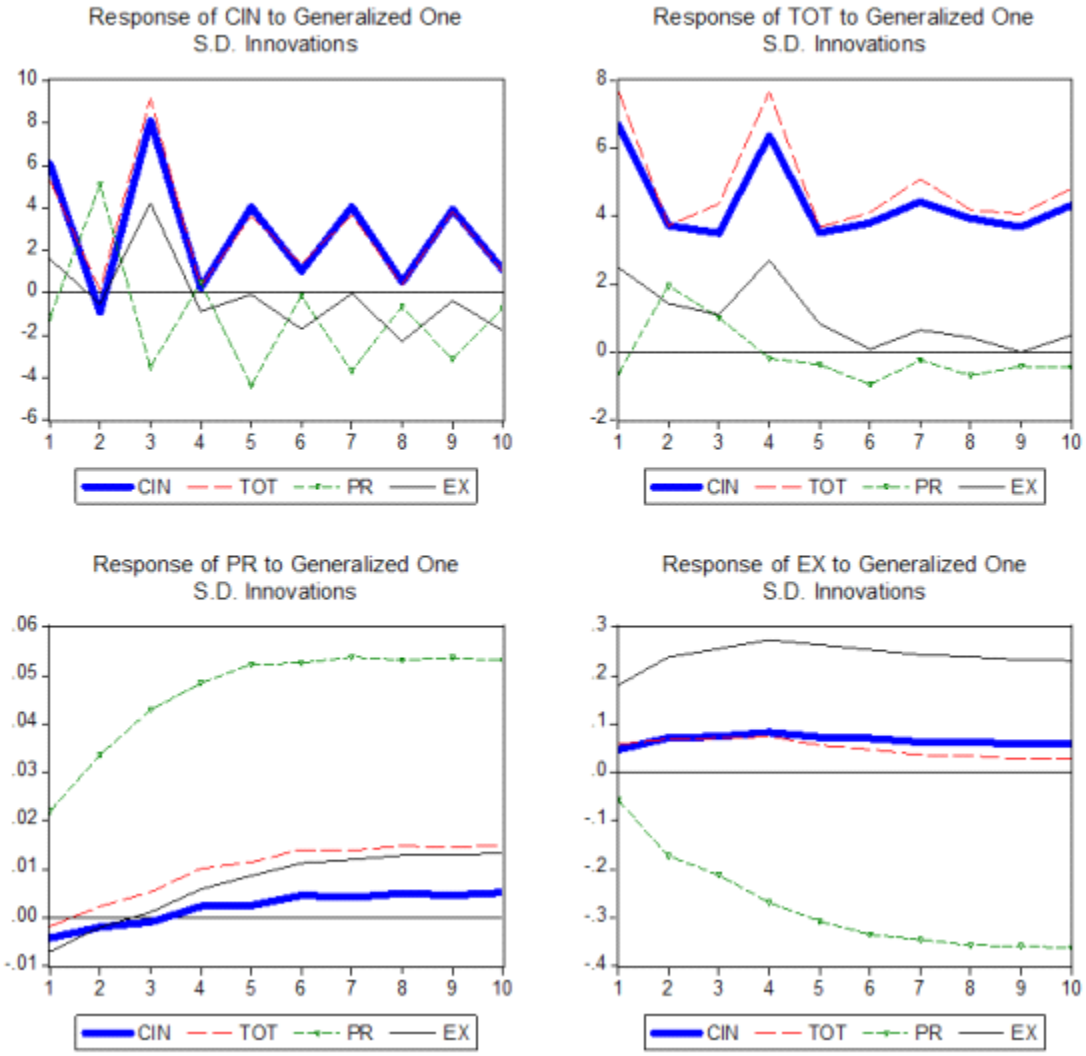



**Figure 6.3: Results of Generalized Impulse Responses for Brazil (Change in NFA)**

For China, the response of current account balance to a one time exchange rate shock (Figure 6.4 upper left graph) fluctuates around zero most of the time, while the responses of capital gains (Figure 6.5 upper left graph) and change in NFA position (Figure 6.6 upper left graph) are negative except at horizon two (corresponding with the year 1990). The same as Brazil, the responses of external balances to exchange rate shock are consistent with the findings of vector error correction model estimates. For the response of exchange rate toward the shock of current account balance (Figure 6.4 lower right graph), it starts to be positive. However, in horizon five (corresponding with the year 1998), it reverts to be negative, which is in line with equation (2). Also Figure 6.4 lower right graph shows that terms of trade has a positive impact on exchange rate while domestic productivity most of the time demonstrates a negative one, in the system of current account balance.

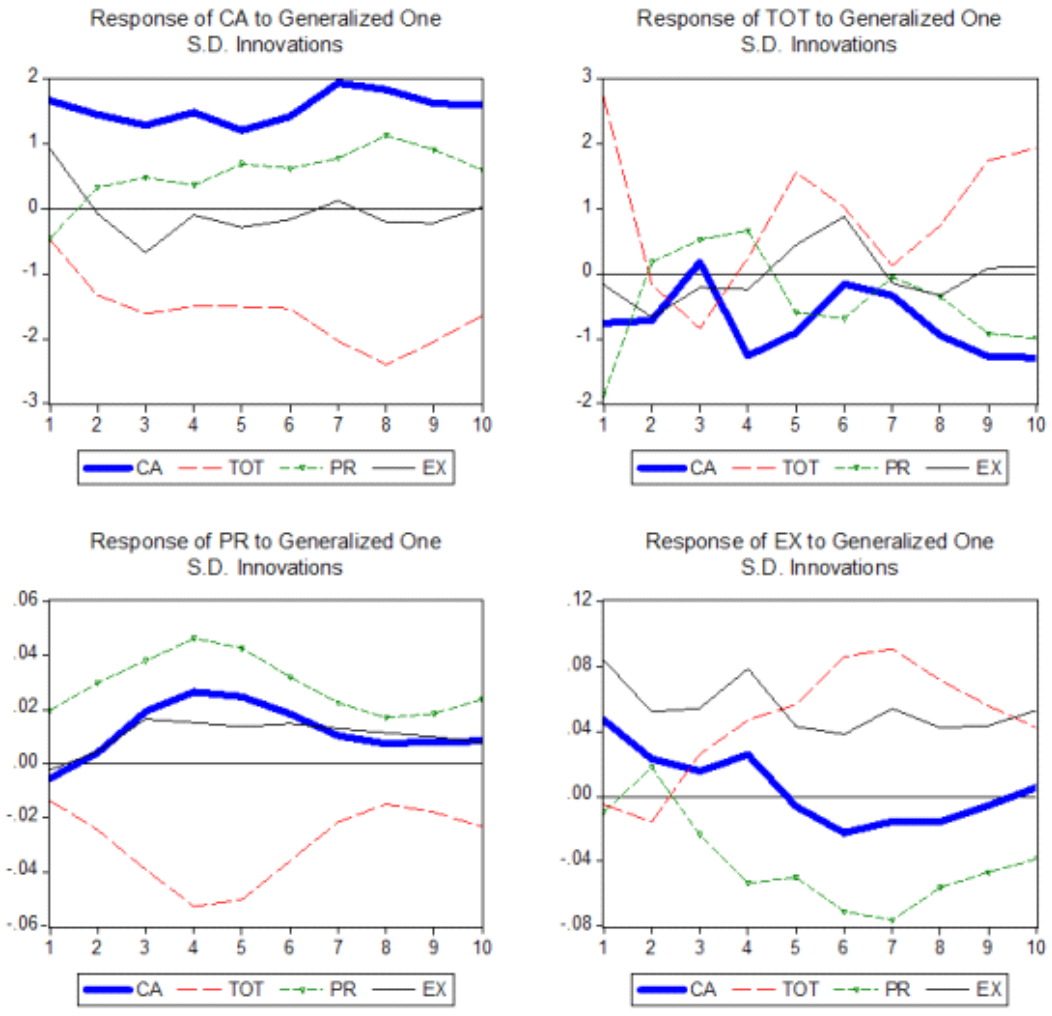



**Figure 6.4: Results of Generalized Impulse Responses for China (Current Account Balance)**

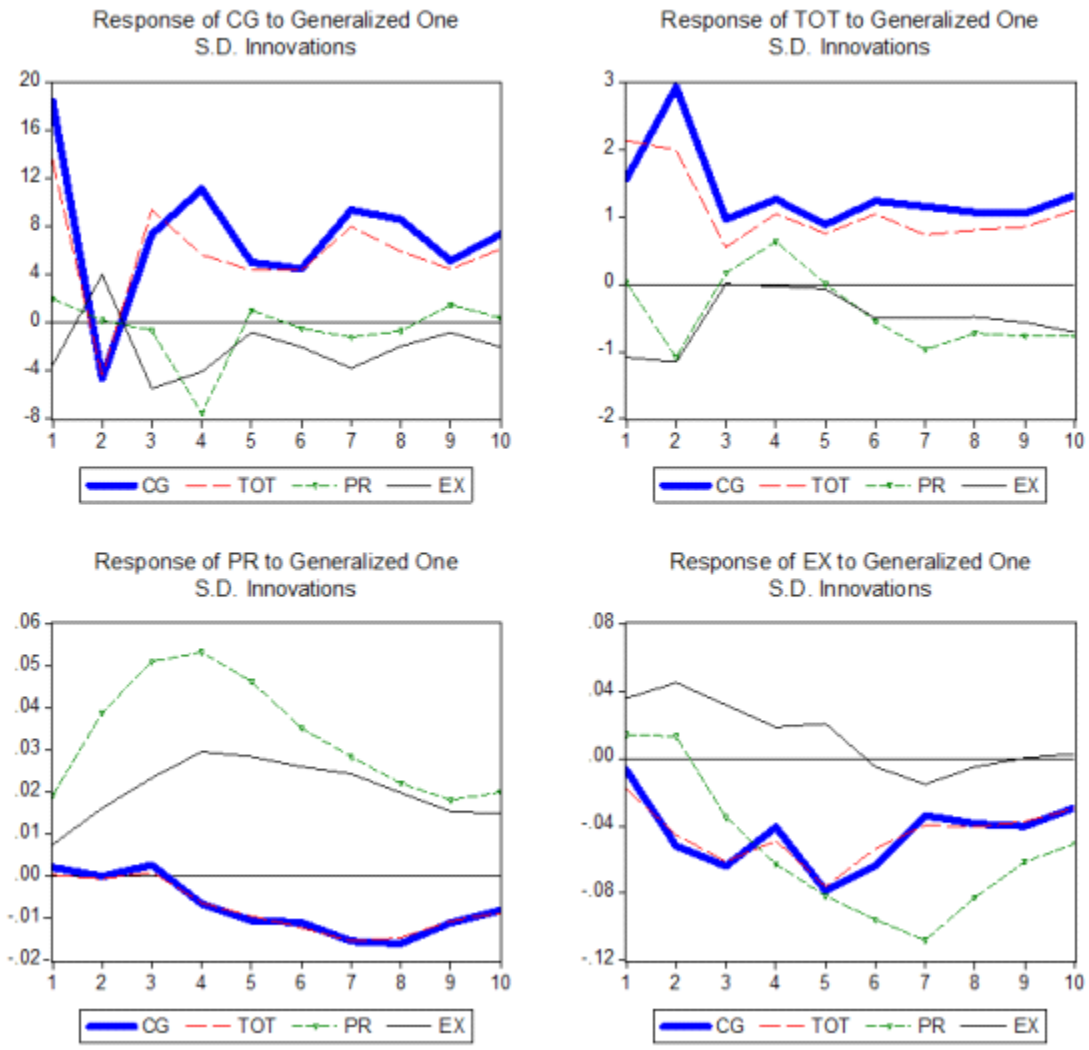



**Figure 6.5: Results of Generalized Impulse Responses for China (Capital Gains)**

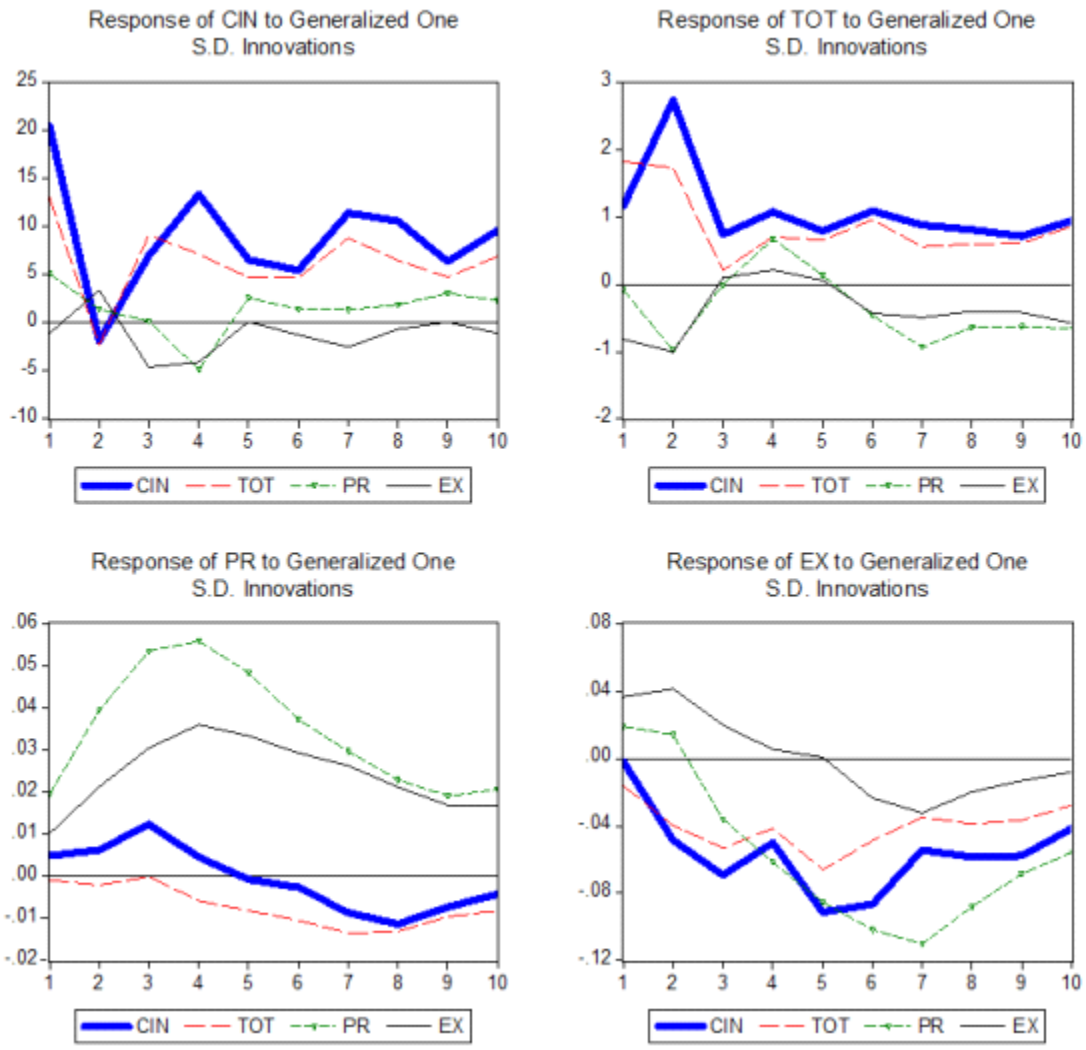



**Figure 6.6: Results of Generalized Impulse Responses for China (Change in NFA)**

For India, the response of current account balance (Figure 6.7 upper left graph) to exchange rate shock is positive, but the responses of capital gains (Figure 6.8 upper left graph) and change in NFA position (Figure 6.9 upper left graph) are negative. These are not in conformity with the estimates of vector error correction models, but are in line with the theoretical predictions. Similar to Brazil, the response of exchange rate to a one time innovation of current account balance (Figure 6.7 lower right graph) is positive at first, but soon turns negative starting from horizon 3 (corresponding with the year 1993), which provides empirical evidence for equation (5). Moreover, Figure 6.7 lower right graph demonstrates that terms of trade has a positive impact on exchange rate, however for domestic productivity, it is less obvious. The impact is negative in the first six horizons (corresponding with the year from 1986 to 2000). But after horizon six, the impact turns out to become positive.

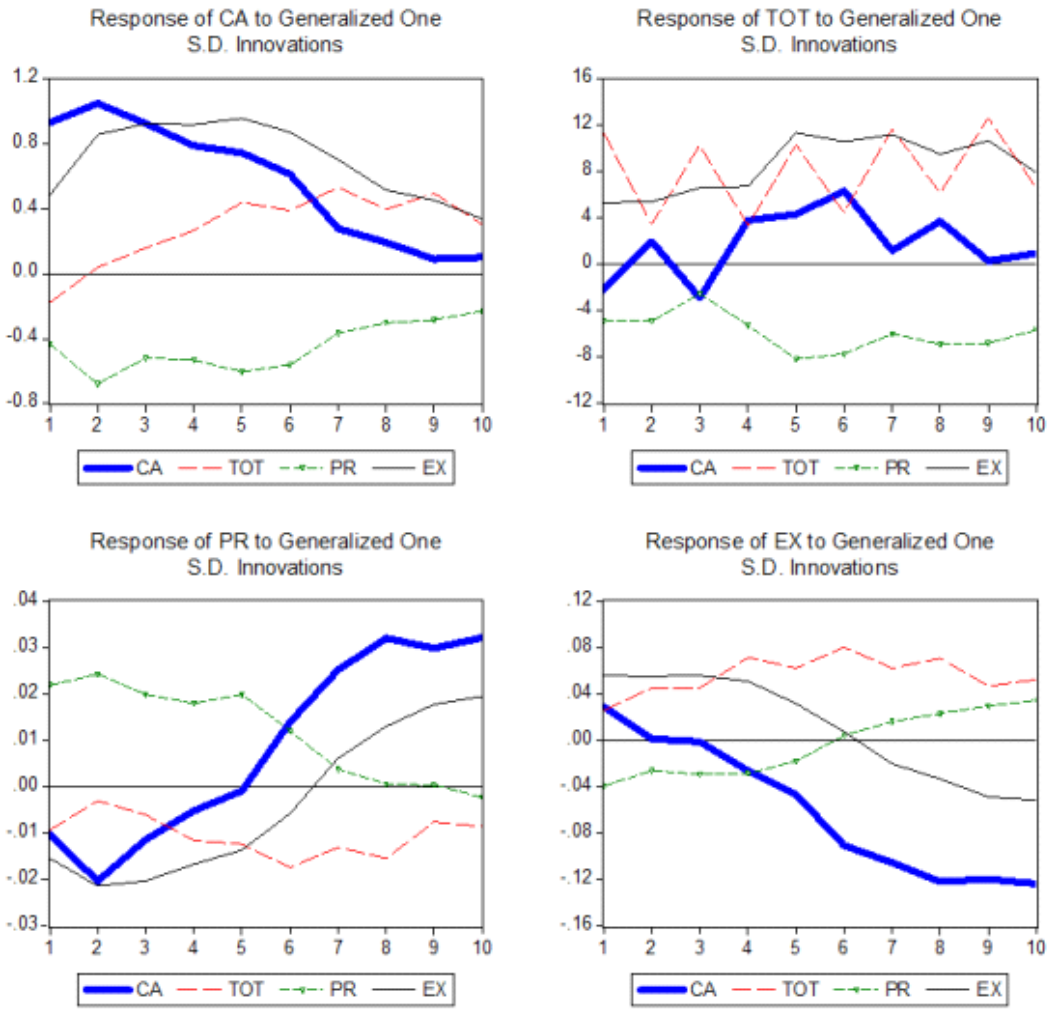



**Figure 6.7: Results of Generalized Impulse Responses for India (Current Account Balance)**

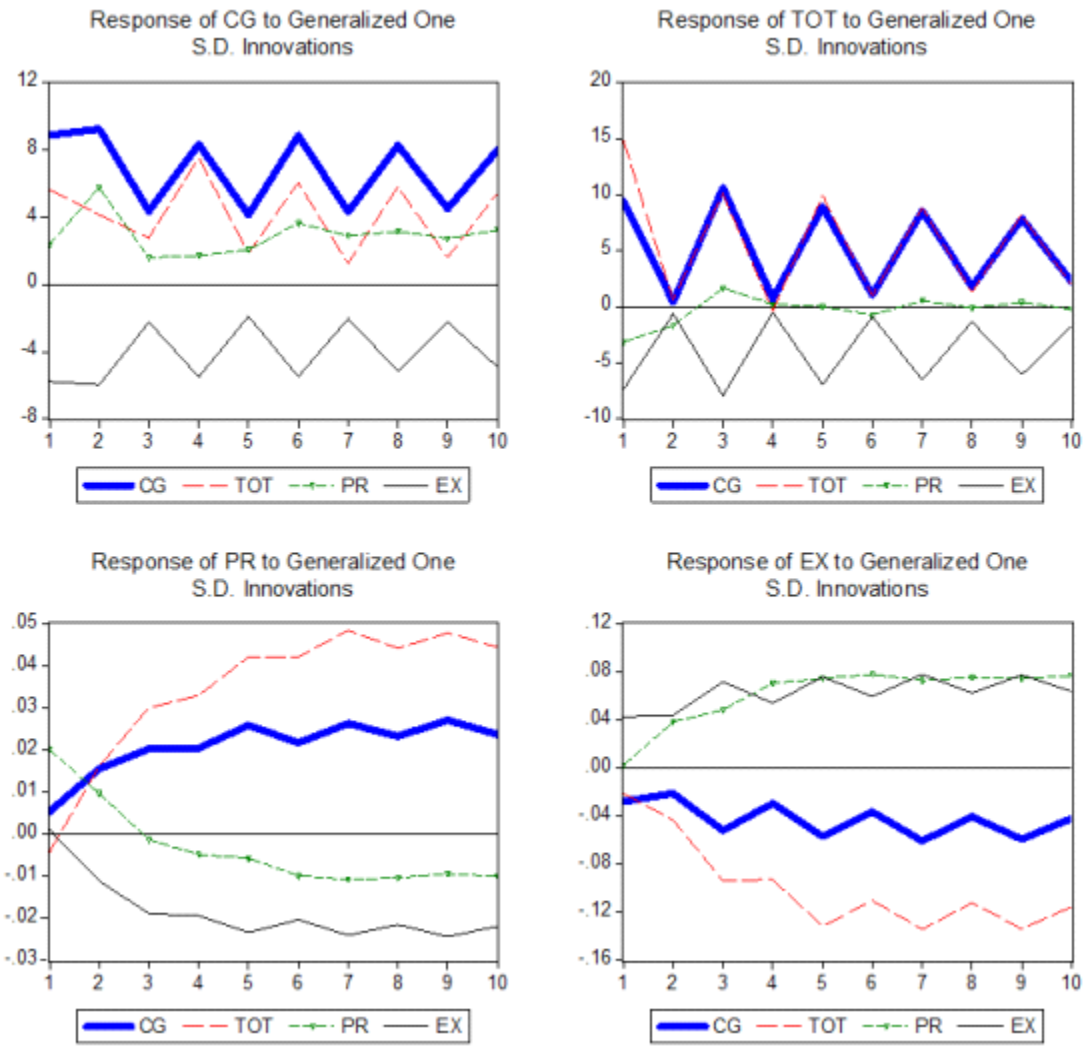



**Figure 6.8: Results of Generalized Impulse Responses for India (Capital Gains)**

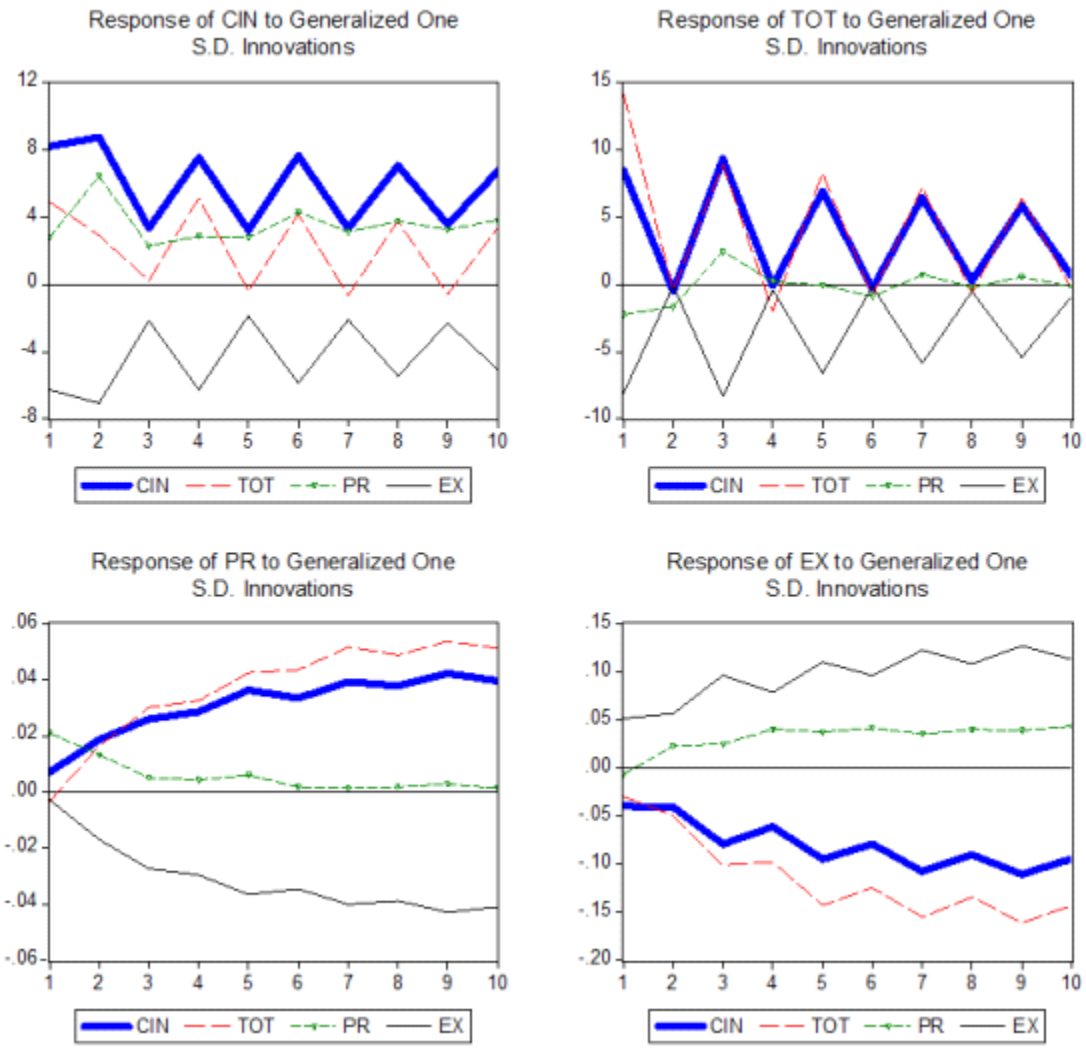



**Figure 6.9: Results of Generalized Impulse Responses for India (Change in NFA)**

In sum, the whole pattern for the three countries Brazil, China and India is almost the same. As demonstrated by the graphs of impulse responses, a one-time shock of domestic productivity would generate a negative response of exchange rate (appreciation). The appreciation of exchange rate will cause the deterioration in current account balance. This is the direct impact of exchange rate on current account balance.

There is also an indirect impact of exchange rate on current account balance, through the channel of capital gains. Given a one-time shock of exchange rate, the response of capital gains is negative. So the appreciated exchange rate is corresponding with an improvement in capital gains, and the rising of capital gains leads to an increase in current account balance due to capital mobility and temporary income shocks. For China, the overall response of current account balance toward exchange rate shock moves smoothly around zero. But for Brazil and India, the overall response of current account balance is positive which indicates the direct impact plays a major role. Taking account of the overall current account adjustment and capital gain movement (one positive and one negative), change in NFA position is largely cushioned from exchange rate shock.

With respect to the impact of current account movement on exchange rate for China, it demonstrates a positive response at first, and at the half horizon the

impact becomes negative, which is in conformity with equation (2). For the other two countries, the response is positive at the beginning, and it soon becomes negative.

In the system of current account balance, the responses of exchange rate to one-time shocks of terms of trade and domestic productivity are largely different for the three countries. For Brazil, both the responses of domestic productivity and terms of trade are negative which is not in line with equation (5). For China, the response of terms of trade is positive, as implied by equation (5). However, the response to that of domestic productivity is mostly negative, which is in contrast with equation (5). As for the case of India, the response of domestic productivity is negative at first, and turns out be positive later. In line with equation (5), the response of terms of trade is mostly positive. .

## 6.3 Results of Forecast Error Variance Decompositions

The results of forecast error variance decompositions provide evidence on the relative importance of each exogenous shock in explaining the error variance of one variable. The questions addressed in this section are:

*1) Would terms of trade be observed playing bigger role in the trade channel while exchange rate has more influence in the valuation channel?*

*2) Overtime, would exchange rate have more explanatory power with regard to external balances?*

Figures 6.10-6.12 contain results of forecast error variance decompositions (FEVD) associated with the error correction models. Generally, it shows the contribution of each source (each variable) of innovations to the variance of forecast error for each endogenous variable at horizons from 1 to 10 (corresponding to the years from 1986 to 2005). For Brazil (see Figure 6.10 upper left graph), current account is exogenous in contemporaneous time since 100 percent of its own variation is attributed to itself at first. Starting from horizon 6, exchange rate innovation almost reaches 15% in variance decomposition of current account balance compared with almost 0% of terms of trade. In the system of capital gains (Figure 6.10 upper right graph), the explanatory power of exchange rate rises to 40% at the end of the horizon. However, in contributing to the forecast error variance of change in NFA position, terms of trade plays a bigger role although at the end exchange rate rivals terms of trade a little bit. Overtime, exchange rate has an ever larger contribution to the variations of the three external balances.

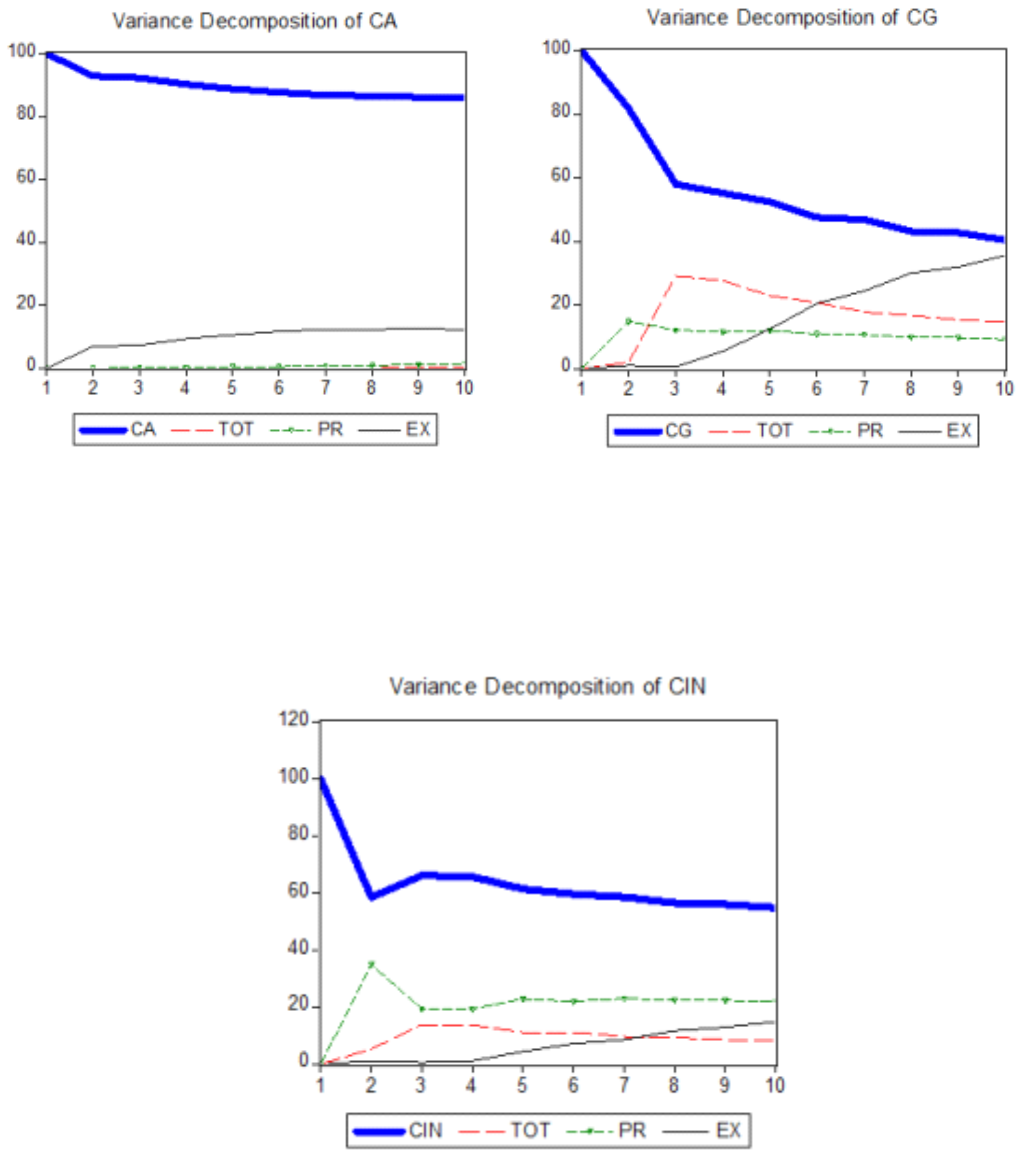



**Figure 6.10: Results of Variance Decompositions for Brazil**

For China, exchange rate plays a bigger role than terms of trade in contributing to the variance of current account balance (Figure 6.11 upper left graph) at early horizons. However, variation of current account balance is more accounted for by terms of trade than by exchange rate starting from horizon four (corresponding with the year 1996). Over 35 percent of the variability of current account balance is attributed to current account balance while another 20 percent is determined by exchange rate. For capital gains and change in NFA position, they are nearly exogenous. Variations in these two variables are mostly determined by their own innovations. Domestic productivity and terms of trade are the only two variables that account for the observed variations in capital gains and change in NFA position respectively. Exchange rate only accounts for a notable portion of the variation in the current account balance (20%) and much less for the variations of capital gains and change in NFA. And the explanatory power of exchange rate is observed a decline in the variations of all three external balances overtime.

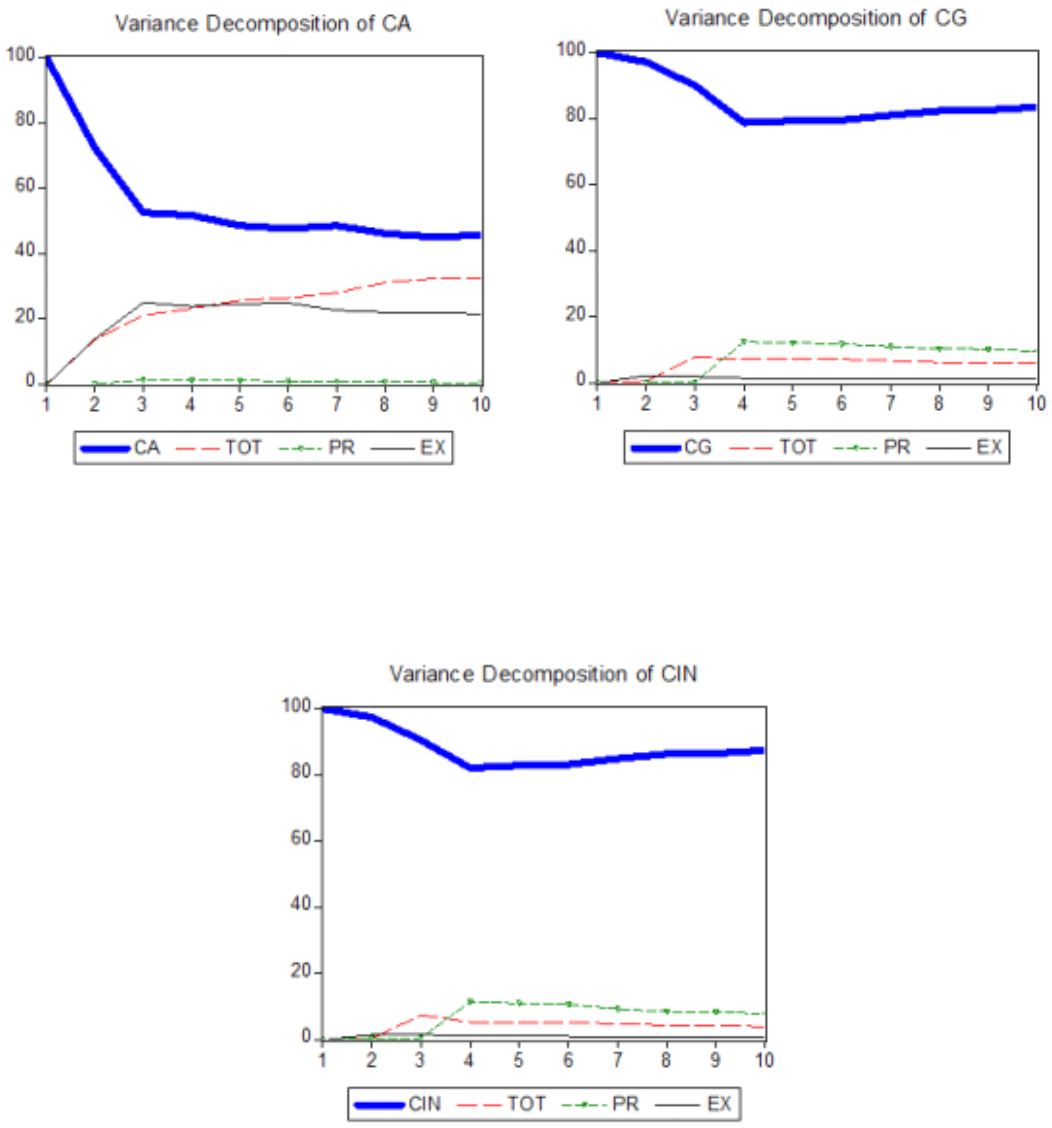



**Figure 6.11: Results of Variance Decompositions for China**

For India, in the system of current account balance (Figure 6.12 upper left graph), exchange rate accounts for a notable portion (about 18%) of the variation of current account balance. Figure 6.12 upper right graph shows that variation in capital gains is mostly determined by its own variation. Domestic productivity, terms of trade and exchange rate contribute only 5% of the variance of capital gains. With respect to the variation of change in NFA position (Figure 6.12 lower graph), terms of trade has relatively more explanatory power than exchange rate. At horizon 10, over 10% variation is determined by terms of trade. In contrast, exchange rate only contributes to less than 5% of the variation. Similar to China, exchange rate only accounts for a notable portion of the variation in the current account balance (18%) and much less for the variations of capital gains and change in NFA position. And the explanatory power of exchange rate is observed to decline in the variations of capital gains and change in NFA position overtime.

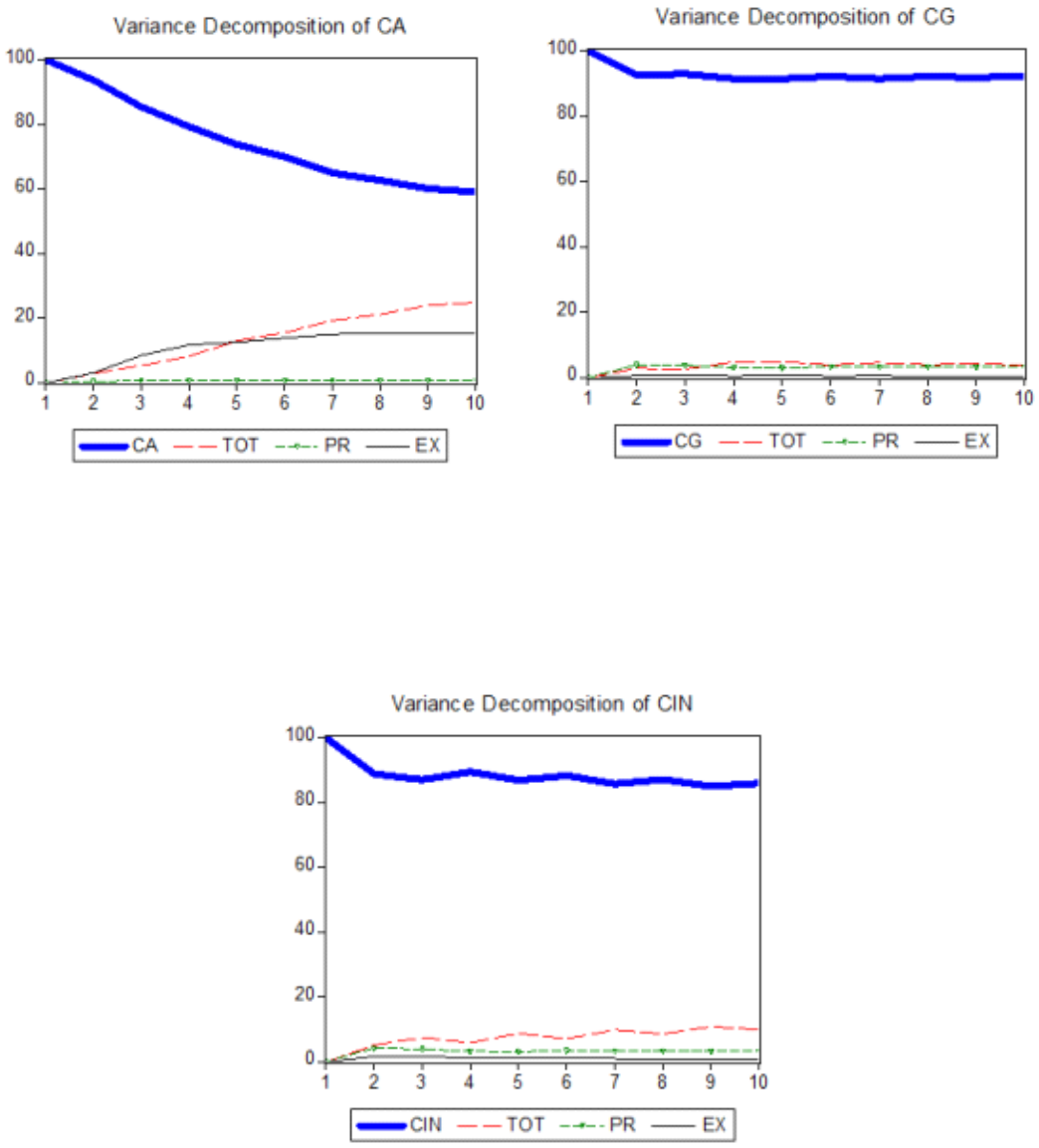



**Figure 6.12: Results of Variance Decompositions for India**

## 6.4 Results of Granger Causality Tests

Granger Causality tests are applied to determine whether one variable helps predict the other variables in the system. The results for Brazil, China and India are summarized as descriptive graphs for better view. Overall, the questions that need to be addressed in this section are:

*1) Would the understanding of the exchange rate dynamics be helpful in predicting the movement of external balances or is the reverse true?*

*2) How these three external balances are coordinated and affect each other?*

The results of Granger causal relationship among the three external balances are reported in Table 6.6. They are given as the probability for the joint significance of the lagged independent variables in the equations. The results highlight the differences in the causal relations in the three external balances. For Brazil and India, trade effect and capital gains contribute to the formation of NFA. However, for China, no active causal relations are found in these three external balances.

**Table 6.6: Results of Granger Causality Tests for Brazil, China and India**

| | Dependent Variable | | | | | |
|---|---|---|---|---|---|---|
| Independent Variable | EX | PR | TOT | CA | CG | CIN |
| Brazil | | | | | | |
| EX | | 0.774 | 0.591 | 0.538 | 0.636 | 0.711 |
| PR | 0.017** | | 0.231 | 0.965 | 0.090* | 0.092* |
| TOT | 0.241 | 0.629 | | 0.264 | 0.035** | 0.040** |
| CA | 0.064 | 0.040** | 0.408 | | | |
| CG | 0.699 | 0.542 | 0.134 | | | |
| CIN | 0.708 | 0.497 | 0.062* | | | |
| China | | | | | | |
| EX | | 0.572 | 0.533 | 0.144 | 0.010*** | 0.026** |
| PR | 0.612 | | 0.093* | 0.116 | 0.436 | 0.862 |
| TOT | 0.915 | 0.624 | | 0.529 | 0.058* | 0.100* |
| CA | 0.381 | 0.269 | 0.128 | | | |
| CG | 0.523 | 0.040* | 0.388 | | | |
| CIN | 0.498 | 0.026* | 0.511 | | | |
| India | | | | | | |
| EX | | 0.223 | 0.819 | 0.028** | 0.046** | 0.062* |
| PR | 0.465 | | 0.956 | 0.349 | 0.034** | 0.063* |
| TOT | 0.357 | 0.204 | | 0.324 | 0.690 | 0.662 |
| CA | 0.530 | 0.060** | 0.794 | | | |
| CG | 0.720 | 0.848 | 0.693 | | | |
| CIN | 0.670 | 0.910 | 0.588 | | | |

Note:

1. The null hypothesis of Granger causality test is independent variable does not Granger cause dependent variable.

2. The value in Table 6.6 is the value of probability. So ***, **, and * denote rejection of the hypothesis at the 0.01, 0.05 and 0.1 level.

For Brazil, the Granger Causality results suggest that there is no Granger causality from NFA to exchange rate (p=0.708). However, there is evidence supporting Granger causality from current account balance to exchange rate (p=0.064). Also as is illustrated in the graph, domestic productivity acts as a channel for current account balance influencing capital gains and change in NFA position. The results highlight the importance of terms of trade in influencing capital gains (p=0.035) and change in NFA position (p=0.040). It is also obvious that domestic productivity Granger causes exchange rate (p=0.017). The reason is that domestic productivity affects the relative price of non-tradables which would be translated into a change in exchange rate.

Integrating the results of generalized impulse responses and Granger causality test, it is easy to find that there exists a feedback mechanism from exchange rate to current account balance. First, a shock in current account balance will generate a negative response of exchange rate. Then the negative response of exchange rate will exert a negative impact on current account balance. So the initial positive fluctuation in current account balance can be cushioned through the feedback mechanism.

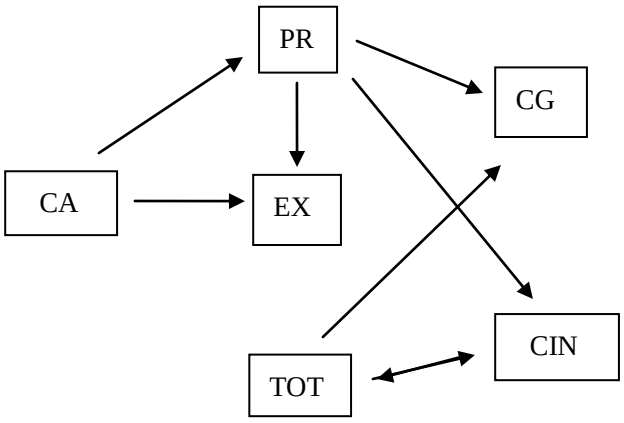



**Figure 6.13: The Graph Summarized from Results of Granger Causality Test for Brazil**

For China, Granger Causality results establish links between exchange rate and capital gains (p=0.01), and exchange rate and change in NFA position (p=0.026) respectively. These two links result from valuation effects where the values of aggregation of assets and liabilities in different currencies at varying exchange rates are altered. Productivity is closely related to terms of trade (p=0.093) since the former determines China's comparatively manufacturing competency in the world market which contributes to the valuation of terms of trade in a significance level. Unlike Brazil, there is little empirical evidence supporting the role of exchange rate in adjusting current account balance (p=0.144) which is in agreement with Chinn and Wei (2008). As with the case of capital gains and change in NFA in influencing

domestic productivity (p=0.04 and p=0.026), this is because large net inflow of equity securities can serve as an indicator of local financial sufficiency which gives rise to an improvement in domestic productivity.

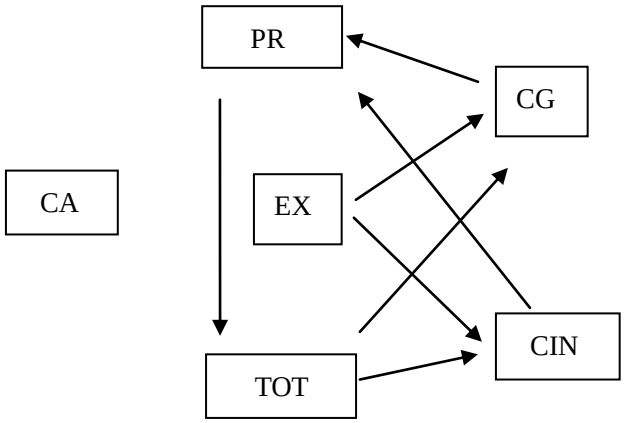



**Figure 6.14: The Graph Summarized from Results of Granger Causality Test for China**

For India, there is strong evidence showing exchange rate Granger cause current account balance (p=0.028), capital gains (p=0.046) and change in NFA position (p=0.062). The same as Brazil, domestic productivity acts as a channel for current account balance impacting capital gains and change in NFA position. What is interesting is that exchange rate plays a direct role in enhancing the prediction of capital gains and change in NFA position. It also influences these two in an indirect way, through the chains of current account balance and domestic productivity.

Moreover, the volatility in exchange rate serves as an indicator of the favorability of export environment (p=0.028) which entails a dominant role in domestic productivity (p=0.06). The effect takes place through current account balance.

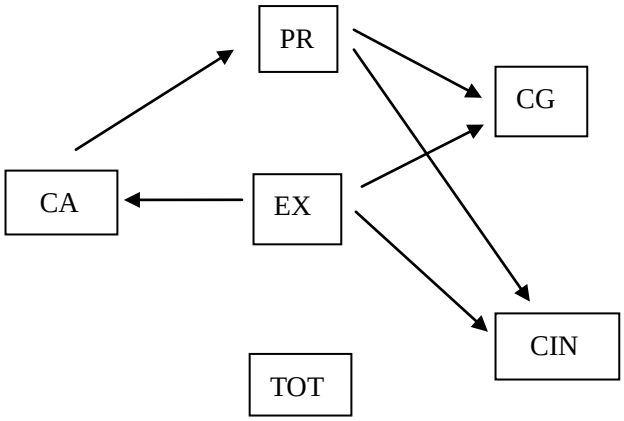



**Figure 6.15: The Graph Summarized from Results of Granger Causality Test for India**

In sum, for China and India, the understanding of the exchange rate dynamics is helpful in predicting the movement of external balances. But for Brazil, the reverse path is true. Also, an interesting finding is that domestic productivity serves as a transmission channel from current account balance to capital gains and change in NFA. Evidence from Brazil and India supports close relationship between domestic productivity and exchange rate. The volatility in exchange rate serves as an indicator of the favorability of export environment which entails a dominant role in domestic

productivity. In the reverse path, domestic productivity affects the relative price of non-tradables which would be translated into a change in exchange rate.

# CONCLUSION

Although the impact of exchange rate shock on external balances has been an issue of great interest in academia and policy institutions, the relationship between them is still ambiguous. This study focuses on the relationship between exchange rate dynamics and external balances, and hopefully the results would provide insights on how to keep control of the external position as well as how to manage valuation effect.

Specifically, the results indicate that exchange rate shock generates a directly positive response in current account adjustment and negative impact on capital gains. The latter soon gives rise to a small drop in current account balance due to temporary income shock and capital mobility. Taking account of the overall current account and capital gains adjustment (one positive and one negative), change in NFA position is largely cushioned from exchange rate shock, as demonstrated in the results of generalized impulse responses. In sum, for all three countries in the analysis, their external positions show a predictable, systematic pattern during phases after a one-time exchange rate shock.

Another helpful work is to examine the impact of current account balance movement on exchange rate. For China, it demonstrates a positive response at first, and at the half horizon the impact becomes negative, which is in conformity with equation (2). For Brazil and India, the response is positive at the beginning, and it soon becomes negative. In the system of current account balance, the responses of exchange rate to one-time shocks of terms of trade and domestic productivity are largely different for the three countries, which demonstrate that the short term mechanism plays a different role for each country.

There is good reason to be skeptical that valuation channel relies on exchange rate in solving adjustment problems, since evidence from the results of forecast error variance decompositions indicates that terms of trade has more explanatory power in both trade channel and valuation channel. However, the good news is that for all of the three countries, the proportional contribution of exchange rate rises in the forecast error variance of current account balance, capital gains and change in NFA overtime.

For China and India, the understanding of the exchange rate dynamics is helpful in predicting the movement of external balances. But for Brazil, the reverse path is true. Also, an interesting finding is that domestic productivity serves as a transmission channel from current account balance to capital gains and change in NFA.

Evidence from Brazil and India supports close relationship between domestic productivity and exchange rate. The volatility in exchange rate serves as an indicator of the favorability of export environment which entails a dominant role in domestic productivity. In the reverse path, domestic productivity affects the relative price of non-tradables which would be translated into a change in exchange rate. From a policy perspective, since external positions demonstrate a predictable and systematic pattern during phases after a one-time exchange rate shock, the volatility of exchange rate is not a severe problem. Integrating the results of generalized impulse responses and Granger causality tests, it is easy to find that there exists a feedback mechanism which significantly contributes to the adjustment of external imbalances, especially for Brazil. My emphasis on the roles played by exchange rate in affecting external balance dynamics also raises the question of whether terms of trade and domestic productivity interfere in this process. The results demonstrate that terms of trade and domestic productivity serve as transmission channels which play a critical role in the system. In all, from a policy perspective, in coping with enlarged global imbalances, exchange rate as well as terms of trade and domestic productivity should receive more attention in policy decisions to stabilize the economy.

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