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CAPITAL INFLOWS AND REAL EXCHANGE RATE MISALIGNMENT: THE INDIAN EXPERIENCE

NILOUFER SOHRABJI*

Abstract

This paper analyzes the link between capital flows and real exchange rate overvaluation which in turn is associated with financial crises. The equilibrium real exchange rate is estimated for India using Edwards (1989) model and cointegration and error correction methodology. From this, misalignment in the real exchange rate is computed and analyzed through a vector autoregression. The results show that capital flows are an important contributor to real exchange rate misalignment. This explains the overvaluation of the rupee associated with increased foreign investment in recent years. Thus, the continued emphasis on foreign investment raises concerns for a financial crisis in India.

Keywords: *Capital inflows, cointegration, error correction model, India, real exchange rate misalignment*

JEL Classification: *C32, F31, F32 and F41*

I. INTRODUCTION

Capital flows finance current account deficits and provide much needed investment in a country. For example, the rise of the Asian tigers has been linked to openness including rising foreign investment. As a result, financial liberalization has become part of an overall growth and development strategy for many developing countries. However, capital flows can also create problems for an economy. This paper focuses on one such concern, the link between capital flows and misalignment of the real exchange rate.

Misalignment indicates that the real exchange rate deviates from its equilibrium. If the real exchange rate is more valuable than its equilibrium it is considered to be overvalued and vice versa. This paper is concerned with overvaluation. An overvalued real exchange rate can lead to distortions in resource allocation and thus affect the economic structure of the economy. This has

* The author is indebted to participants of the International Atlantic Economics Society conference in Boston, MA in October 2009 and anonymous referees. All errors remain mine. Please send correspondence to: Simmons College, 300 The Fenway, Boston, MA 02215, U.S.A. *E-mail: sohrabji@simmons.edu*

repercussions on economic growth, trade balances and the overall competitiveness of an economy. Overvaluation has been a problem for several developing countries with fixed exchange rate regimes. Moreover, overvaluation has played a role in financial crises such as Mexico in 1994, Turkey in 1994 and 2001 and countries that suffered during the East Asian financial crisis in 1997-1998.

This paper analyzes the relation between capital inflows and real exchange rate misalignment for India. To do so, the equilibrium real exchange rate is estimated using Edwards (1989) theoretical framework and error correction methodology. Misalignment is computed as the difference between the actual real exchange rate and this computed equilibrium real exchange rate. A vector autoregression (VAR) of misalignment with its determinants is estimated and the impact of capital inflows and other factors is analyzed through the impulse response function and variance decomposition. This paper finds evidence to indicate that capital inflows lead to overvaluation of the real exchange rate. Given the high and continuing increases in foreign investment in recent years this signals a concern for the Indian economy.

The paper is organized as follows: the next section provides background on trade, foreign investment and exchange rates in India. Section III presents the relevant literature which is followed by a discussion of the theoretical framework and econometric methodology used in real exchange rate determination. Section V provides the results of empirical estimation of the equilibrium real exchange rate. Using these results, misalignment is computed and the relation between capital inflows and real exchange rate misalignment is analyzed in section VI and the last section concludes.

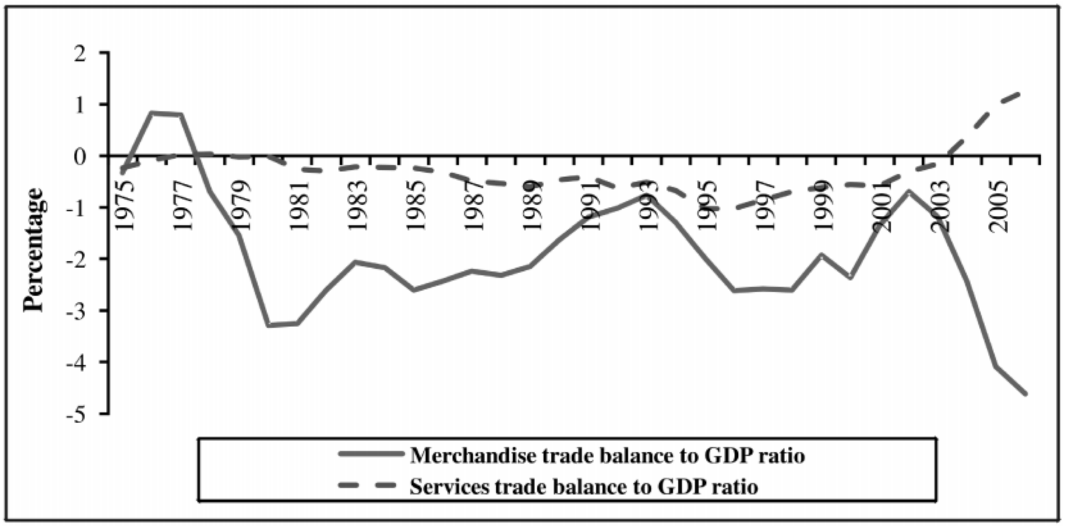
II. BACKGROUND

Beginning in the 1950s and continuing for a few decades, India pursued very protectionist policies that rendered foreign trade and investment as insignificant components of the economy. During the 1970s it became clear that import substitution policies were not effective and India began dismantling some of its barriers and opening up the country to foreign trade.

As can be seen from figure 1 (which maps foreign trade from 1975 onwards), India started off with a merchandise trade surplus in the mid-1970s but experienced sharply deteriorating merchandise trade deficits at the end of the 1970s. This trend continued through the 1980s. Although of smaller magnitude, there were deficits in services trade as well which got increasingly worse in the 1980s (figure 1). Foreign investment however, continued to be restricted during this period (figure 2).

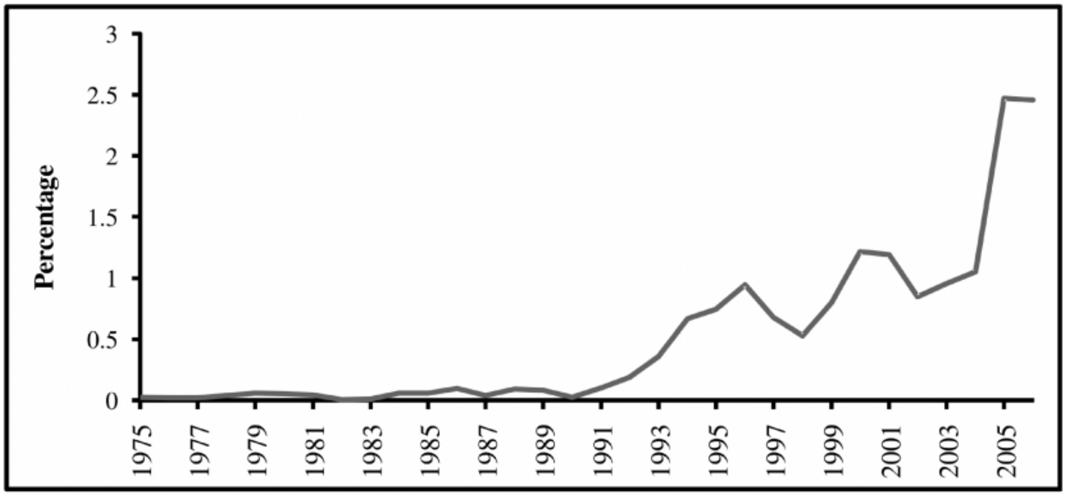
During this period and until the early 1990s, India had a fixed exchange rate regime. Figure 3 shows the trend in the nominal and real exchange rate in India from 1975 onwards. Between 1975 and 1980 the nominal exchange rate was stable at approximately Rs. 8 per dollar. The real exchange rate was expectedly higher and showed slightly more movement but was mostly steady with a range from Rs. 18.8 to Rs. 21.1 per dollar. The 1980s saw consistent increases in both the nominal

Figure 1: foreign Trade as a percentage of GDP



Source: IMF, International Financial Statistics database

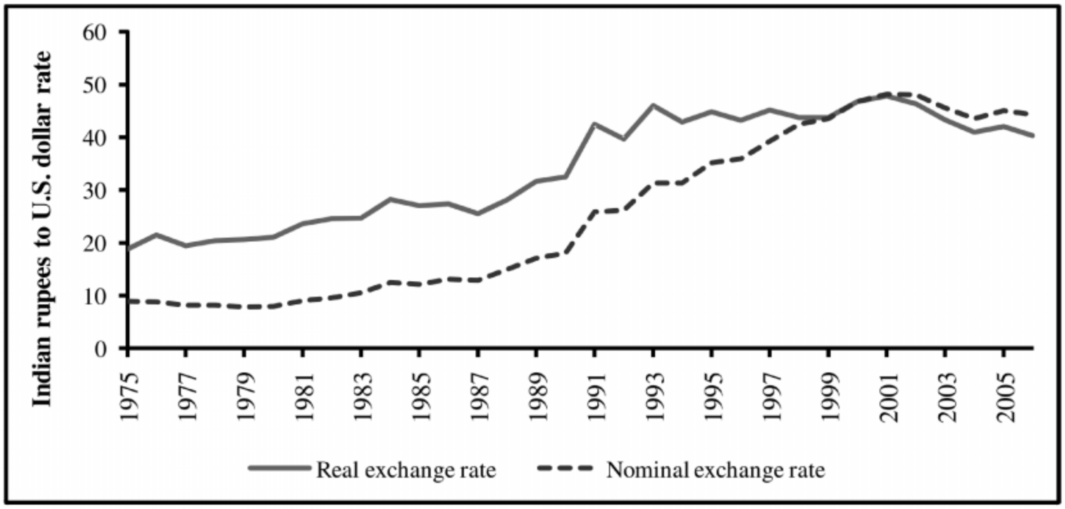
Figure 2: Net Foreign Investment as a Percentage of GDP



Source: IMF, International Financial Statistics database

and real exchange rate. The nominal exchange rate ranged from approximately Rs. 8 to about Rs 18 per dollar through the 1980s while the real exchange rate varied from Rs. 21 to Rs. 32 per dollar. These were much larger fluctuations given that the currency was still fixed. Given the large trade deficits through the 1980s (figure 1) there were fears that the observed appreciation indicated an overvalued rupee. The concerns were well founded as India faced a major balance of payments crisis in 1991.

Figure 3: Real and Nominal Exchange Rate



Source: IMF, International Financial Statistics Database

The crisis of 1991 brought about major reforms including a shift to a flexible exchange rate regime and trade and investment liberalization. One immediate impact was greater movement in the exchange rate (figure 3). The increased volatility was to be anticipated given the shift to a flexible exchange rate regime. Another expected change was the increasing importance of trade and foreign investment. Exports and imports of merchandise and services increased significantly in the 1990s and 2000s. However, while merchandise imports exceeded exports leading to continuous deficits in that account, services trade registered a surplus by 2004 (figure 1). However, since services remain a smaller component, India experienced an overall trade deficit for the entire period.

Moreover, for the first time, foreign investment became a significant factor for India (figure 2). Prior to 1991, foreign investment was miniscule, accounting for less than 0.1% of GDP. Since 1991 foreign investment has continuously increased and by 2006 exceeded 2.5% of GDP. A comparison of foreign investment and exchange rate graphs shows that the period of high growth in foreign investment is associated with an appreciating real exchange rate (figures 2 and 3). The data supports the literature of the impact of foreign investment on real exchange rate appreciation. This paper however seeks to examine the impact of foreign investment on misalignment, specifically overvaluation.[1] The relevant literature is discussed in the following section.

III. LITERATURE

This paper relates to two different branches of literature, the relation between capital flows and real exchange rate changes on one hand and equilibrium real exchange rate and misalignment estimation on the other.

Athukorala and Rajapatirana (2003) examine the different factors that affect the real exchange rate and conclude that increased capital inflows lead to exchange rate appreciation for Asian and Latin American economies. This is supported by Dua and Sen (2007) who find the same relation for India. Sjaastad and Manzur (2003) find that capital inflows in relatively protected countries cause greater appreciation of the real exchange rate. This relation is observed in both fixed and flexible exchange rate regimes. In flexible exchange rate regimes, capital flows by increasing the demand for domestic currency lead to a nominal and thus a real exchange rate appreciation. In fixed regimes the impact is seen through an increased demand for goods which leads to higher prices and thus a real exchange rate appreciation. Athukorala and Rajapatirana (2003) find evidence of the impact of capital inflows on real exchange rate appreciation irrespective of the exchange rate regime.

An appreciating real exchange rate is not necessarily a problem. It only becomes a concern if appreciation also indicates that the real exchange rate is becoming overvalued. This implies that only the real exchange rate is increasing in value while the equilibrium exchange rate is either unchanged or not increasing as much. If capital flows cause an increase in the value of the equilibrium real exchange rate, then the observed real exchange rate appreciation need not imply a misalignment. This paper uses the framework discussed in Athukorala and Rajapatirana (2003) to analyze the relation between capital flows and real exchange rate misalignment for India.

To compute misalignment, this paper draws on the literature of equilibrium real exchange rate determination. The theoretical framework for equilibrium real exchange rate determination is provided by Edwards (1989). Edwards (1989) model extended by Elbadawi (1994) shows the factors that contribute to changes in the real exchange rate which is used to estimate the real exchange rate for India from 1976-2006. Cointegration and error correction methodology is used to differentiate between the long-run or "fundamental" factors and short-run factors. The fundamental factors are used to estimate the equilibrium real exchange rate.

There is a vast literature that uses the theoretical and econometric framework for equilibrium real exchange rate determination. It includes Feyzioğlu (1997) for Finland, Alper and Saglam (1999), Atasoy and Saxena (2006) and Dagdeviren, Oğuş Binatlı and Sohrabji (2011) for Turkey, Mkenda (2001) for Zambia, MacDonald and Ricci (2003) for South Africa, Mathisen (2003) for Malawi, Égert and Lahrèche-Révil (2004) for five Central and Eastern European Countries, Kemme and Roy (2005) for Poland and Russia, Eita and Sichei (2006) for Namibia, Paiva (2006) for Brazil, Zalduendo (2006) for Venezuela and Iossifov and Loukoianova (2007) for Ghana. This paper follows the literature in estimating the equilibrium real exchange rate for India. The theoretical framework and econometric methodology are discussed in the following section.

IV. EQUILIBRIUM REAL EXCHANGE RATE DETERMINATION

The real exchange rate is defined as the relative price of traded to nontraded goods. In a small open economy, this is approximated as the following,

$$RER = NER \left(\frac{P^F}{P^D}\right) \tag{1}$$

where *RER* is the real exchange rate, *NER* is the nominal exchange rate defined as ratio of domestic currency to foreign currency and P^F and P^D are the foreign and domestic price indices respectively. Using this definition, an increase in *RER* implies a real exchange rate depreciation and a decline indicates a real exchange rate appreciation.

Edwards (1989) theoretical framework shows the impact of the factors on the real exchange rate. Fundamental factors (*F*) are given by the equation below:

$$F = f\begin{pmatrix} \text{terms of trade, openness, capital flows, government consumption,} \\ \text{investment, technological progress} \end{pmatrix} \tag{2}$$

Terms of trade changes can have a direct income effect (related to demand for nontradables) as well as an indirect substitution effect (related to supply of nontradables). An improvement in the terms of trade leads to an increase in income. The resulting increase in demand for all goods (including nontradables) leads to an increase in the price of nontraded goods and thus an appreciation in the real exchange rate. However, an improvement in terms of trade may also result in increased resources for producers and thus increased production of all goods (including nontradables). Greater supply of nontraded goods leads to a decline in its price and thus an exchange rate depreciation. Thus, if the direct effect dominates then an improvement in terms of trade would result in a real exchange rate appreciation while if the indirect effect is stronger, the real exchange rate will depreciate.

An increased level of *openness* leads to a greater supply of foreign goods. If this results in a decline in the price of nontraded goods, increased openness can lead to a real exchange rate depreciation. *Capital flows* are associated with a real exchange rate appreciation. Higher capital inflows imply greater total assets, which increases general demand (including demand for nontraded goods). The resulting increase in the price of nontraded goods leads an appreciation of the real exchange rate.

There is ambiguity regarding the impact of *government consumption* on the exchange rate. If increased government consumption is spent on nontraded goods the real exchange rate will appreciate and if government consumption is more geared toward traded goods there is a depreciation of the real exchange rate. The impact of *investment* on the real exchange rate depends on whether higher investment leads to greater spending on traded goods or toward nontraded goods. Increased spending of the former implies that higher investment leads to a depreciation of the real exchange rate while greater spending on nontraded goods leads to an appreciation.

Finally, *technological progress* also has an ambiguous impact on the real exchange rate depending on which sector sees the productivity impact. According to the Balassa effect, productivity increases are seen mostly in the traded goods sector and thus technological progress is expected to lead to an appreciation in the real exchange rate.

Cointegration and error correction methodology are used to empirically estimate the equilibrium real exchange rate. The procedure is as follows. First, the series are tested for unit roots which are done using Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatowski, Phillips, Schmidt and Shin (KPSS) tests. If it is established that the series are I(1) in levels and stationary in first differences then the series are tested for cointegration. Lag length is determined by the Likelihood Ratio (LR) test, Akaike information criterion (AIC) and Schwarz criterion (SC). Also, tests are conducted for serial correlation, heteroskedasticity and normality. If these diagnostic tests show no problems then cointegration tests are conducted using the Johansen test statistics (trace and eigenvalue). If cointegration is established, real exchange rate can be estimated using the error correction model (ECM).

ECM captures the effect of both, long-run or fundamental factors as well as short-run or temporary factors on the real exchange rate. The ECM equation to be estimated is given as

$$\Delta RER_t = \gamma\left(RER_{t-1} - \Pi' F_{t-1}\right) + \Gamma_1' \Delta F_t + \Gamma_2' \Delta Z_t \tag{3}$$

where ΔRER is the change in the real exchange rate, F and Z refer to the fundamental and temporary factors respectively and Π, Γ_1 and Γ_2 are vectors of coefficients to be estimated and γ is the error correction term. This error correction term determines the speed of adjustment of deviations between the actual and the equilibrium real exchange rate.

The vector of fundamental factors can be separated into its permanent and transitory components. The permanent components of the fundamental factors can be used with the coefficients to compute the equilibrium real exchange rate as follows.

$$ERER = \Pi' F^P \tag{4}$$

where F^P is a vector of the permanent component of fundamental factors that impact the real exchange rate discussed in the model and Π is a vector of coefficients to be estimated. Data and estimation results are discussed in the following section.

V. DATA AND EQUILIBRIUM REAL EXCHANGE RATE RESULTS

The econometric work noted earlier is estimated using annual data from 1975 to 2006 which is available from the International Financial Statistics database. The dependent variable is the real exchange rate which as discussed earlier was defined as the nominal exchange rate times the price ratio of the foreign and domestic country. U.S. CPI is used for the foreign price index and the nominal exchange rate is expressed as the rupee to U.S. dollar rate. Real GDP per capita is used as a proxy for technological progress. The variables are described in table 1.

Table 1
Variables and Data Construction

Variable name	*Data construction*	*Data series*
Real exchange rate	$\ln\left(E\frac{P^{U.S.}}{P^{India}}\right)$	E - nominal exchange rate (Indian rupee to U.S. dollar rate) $P^{U.S.}$ - U.S. CPI (base year = 2000) P^{India}- Indian CPI (base year = 2000)
Terms of trade	$\ln\left(\frac{P_X}{P_M}\right)$	P_X- price index of exports (base year = 2000) P_M - price index of imports (base year = 2000)
Openness	$\ln\left(\frac{X+M}{GDP}\right)$	X - value of exports (rupees) M - value of imports (rupees) GDP - gross domestic product (rupees)
Investment	$\ln\left(\frac{FC}{GDP}\right)$	FC - gross fixed capital formation (rupees) GDP - gross domestic product (rupees)
Capital flows	$\left(\frac{KF}{GDP}\right)$	KF - foreign investment (dollars converted to rupees using E) GDP - gross domestic product (rupees)
Government spending	$\ln\left(\frac{GC}{GDP}\right)$	GC - government consumption expenditures (rupees) GDP - gross domestic product (rupees)
Technological progress	$\ln\left(\frac{RGDP}{Popn}\right)$	RGDP - computed using nominal GDP and GDP deflator (base year = 2000) Popn - population
Nominal exchange rate growth	$\Delta\ln(E)$	E - nominal exchange rate (Indian rupee to U.S. dollar rate)
Excess domestic credit growth	$\Delta\ln(DC)_t - \Delta\ln(GDP)_{t-1}$	DC - domestic credit (rupees) GDP - gross domestic product (rupees)

Notes: Annual data from 1975 to 2006 is used. All data is available from International Financial Statistics database.

The first step, testing for unit roots, is done using ADF, PP and KPSS. Two versions of the tests (assuming a constant and a constant and trend) are conducted for the series in levels and first differences (presented in table 2) and show that fundamental variables are I(1) in levels and stationary in first differences.

Table 2
Unit Root Tests

Variable	*ADF*		*PP*		*KPSS*	
	t_{μ}	t_{τ}	γ_{μ}	γ_{τ}	η_{μ}	η_{τ}
RER	-1.32 [1]	-1.83 [2]	-1.80 (3)	-1.91 (1)	0.63* (4)	0.13** (4)
Δ *RER*	-7.89* [0]	-7.90* [0]	-7.89* (0)	-7.64* (2)	0.20 (4)	0.06 (3)
Terms of trade	-1.67 [0]	-2.83 [0]	-1.24 (8)	-2.74 (4)	0.61* (4)	0.14** (3)
Δ *Terms of trade*	-5.55* [0]	-5.45* [0]	-5.64* (3)	-5.52* (3)	0.07 (3)	0.07 (3)
Openness	2.24 [0]	-0.13 [0]	2.24 [0]	-0.13 [0]	0.68* (4)	0.18* (4)
Δ *Openness*	-2.41*** [1]	-5.31* [0]	-4.44* (2)	-5.31* (1)	0.44** (3)	0.08 (0)
Capital flows	-1.74 [0]	-2.08 [0]	-1.54 (5)	-2.30 (3)	0.44** (3)	0.13** (3)
Δ *Capital flows*	-4.56* [0]	-4.54* [0]	-4.55* (3)	-4.54* (4)	0.08 (5)	0.08 (5)
Investment	0.86 [2]	-2.28 [0]	-0.38 (2)	-2.22 (2)	0.65* (3)	0.14** (3)
Δ *Investment*	-7.62* [0]	-7.84* [0]	-7.62* (0)	-8.27* (2)	0.24 (2)	0.12 (3)
Govt spending	-1.67 [1]	-1.16 [1]	-1.90 (3)	-1.04 (2)	0.40** (4)	0.14** (4)
Δ *Govt spending*	-3.93* [0]	-4.12* [0]	-4.00* (2)	-4.14* (1)	0.24 (3)	0.06 (2)
Tech progress	-3.03* [0]	-0.24 [0]	-4.14* (2)	-0.04 (1)	0.74* (4)	0.20* (4)
Δ *Tech progress*	-4.78* [0]	-6.13* [0]	-4.80* (2)	-6.27* (3)	0.61* (3)	0.08 (2)
NER growth	-2.62** [3]	-2.17 [1]	-5.45* (3)	-5.38* (3)	0.17 (3)	0.17* (3)
Excess DC growth	-2.61*** [1]	-2.39 [1]	-4.35* (3)	-4.43* (3)	0.25 (4)	0.15* (4)
Residuals	-4.78* [1]	-5.31* [1]	-6.41* (3)	-5.89* (3)	0.31 (5)	0.08 (3)

Notes: *, ** and *** indicate statistical significance at the 5%, 10% and 15% respectively. *t*, γ and η are statistics corresponding to the Augmented Dickey-Fuller test (ADF), Phillips-Perron (*PP*) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests respectively. The subscripts (μ, τ) indicate inclusion of a constant or constant and trend term respectively. The null hypothesis for ADF and PP are that the series is nonstationary while the null for the KPSS test is that the series is stationary. For the ADF test, the numbers in square brackets correspond to lags where maximum lags were set at 3 and lag length was determined by AIC. For the PP and KPSS tests, the numbers in brackets correspond to lag truncation determined by Newey-West criteria and Schwert formula respectively.

The correct lag length in the underlying VAR is determined to be 1 lag.[1] Diagnostic test results reported in table 3 show that the VAR is not serially correlated and is homoskedastic and normal.[2]

Table 3
Diagnostic Test Results

Test	*Test statistic*	*p-value*
Serial correlation (*LM* statistic)	40.02	0.82
White heteroskedasticity test (χ^2)	13.70	0.84
Skewness test (χ^2)	0.08	0.78
Kurtosis (χ^2)	3.64	0.06**
Normality (Jarque-Bera statistic)	3.72	0.16

Notes: The null hypothesis for the diagnostic tests are that the residuals do not have serial correlation, are homoskedastic and are normally distributed. ** indicates rejection of the null hypothesis at 10% level of significance.

The Johansen cointegration test results are reported in table 4. Given the small sample size, the Reinsel-Ahn(1988) correction is used on the statistics which are reported in table 4. Tests for no cointegrating equation and at most one cointegrating equation are presented. There is evidence of one cointegrating equation at the 5% level of significance using both tests.

Table 4
Johansen Cointegration Test Results

Null hyp.	*Alt. hyp.*	*Adj.* λ_{trace}	*95% C.V.*	*Adj.* λ_{max}	*95% C.V.*
r = 0	r > 0	133.26*	124.24	52.76*	45.28
r ≤ 1	r > 1	80.49	94.15	31.24	39.37

Notes: r is the number of cointegrating equations. Adjusted statistics are computed by multiplying the trace and eigenvalue statistics with the Reinsel Ahn (1988) small-sample correction factor given as $(T - pk) / T$ where T is the sample size, p is the number of variables and k is the number of lags. These are compared with the 95% critical values. * denotes rejection of the null of no cointegration at 5% level of significance.

Given cointegration, movement in the real exchange rate is estimated using an error correction model. Results are reported in table 5. The error correction term can be used to determine the speed of adjustment of the deviation of the real exchange rate from its equilibrium. The coefficient is -0.25 (table 5) which shows that it takes about a year to eliminate 50% of deviation between the actual and equilibrium real exchange rate.[4]

All variables (fundamental factors as well as short-term factors) are statistically significant. Theoretically, an improvement in terms of trade had an ambiguous impact on the real exchange rate. The results show that an improvement in the *terms of trade* is associated with a depreciating real exchange rate. Expectedly, the same impact is seen for increased *openness* which suggests that greater trade liberalization leads to a substitution from nontraded towards traded goods.

Also as expected, increased *capital flows* are associated with an appreciating real exchange rate. Increased *government spending* lead to a depreciation of the

Table 5
Error Correction Model Results

Variable	*Coefficient*	*SE*
Constant	4.27	(1.28)
Terms of trade	0.35*	(0.09)
Openness	0.98*	(0.11)
Capital flows	-4.18*	(1.19)
Govt spending	1.47*	(0.19)
Investment	-0.45*	(0.19)
Tech progress	-0.89*	(0.20)
Coint. coefficient	-0.25*	(0.05)
Constant (VAR)	-0.04*	(0.01)
NER growth	0.82*	(0.06)
Excess DC growth	0.30*	(0.14)
Adjusted	0.89	

Note: * indicates statistical significance at 5% level of significance.

real exchange rate which indicates that this increased spending is geared toward traded goods. Conversely, it appears that increased *investment* leads to greater spending on nontraded goods and thus there is a real exchange rate appreciation. Finally, improved *technological progress* which is proxied with real GDP per capita is associated with a real exchange rate appreciation and thus provides support for the Balassa effect.

The ECM also included short-term factors such as *nominal exchange rate growth* and *excess domestic credit*. Both these variables have the expected positive signs. Thus, we find that a nominal exchange rate depreciation and loose monetary policy are associated with a real exchange rate depreciation.

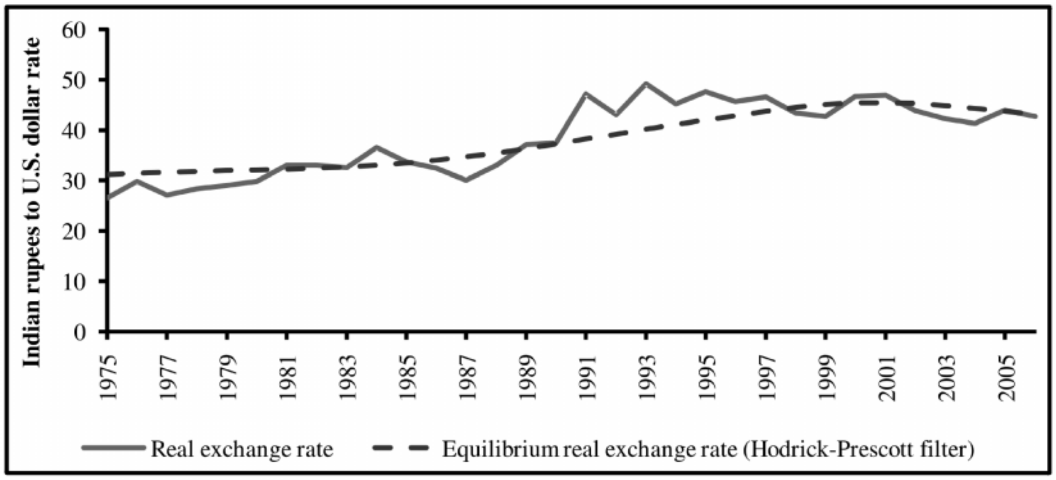
The equilibrium real exchange rate and thus misalignment can be determined from the empirical results discussed above. The impact of capital flows on misalignment is analyzed in the following section.

VI. CAPITAL FLOWS AND REAL EXCHANGE RATE MISALIGNMENT

As noted earlier the equilibrium real exchange rate is determined by only the permanent component of fundamental factors. This paper uses the Hodrick-Prescott filter to compute the equilibrium real exchange rate. The actual and equilibrium real exchange rate are graphed in figure 5.

When the actual real exchange rate lies below the equilibrium, the real exchange rate is considered to overvalued and vice versa. The major period of overvaluation observed in the Indian real exchange rate is in the early to mid-1990s (figure 4). This is the period immediately following the 1991 crisis and subsequent reforms in India. One of the major reforms undertaken, which is the focus of this paper, was foreign investment liberalization. Figure 2 shows a big jump in foreign investment between 1991 and 1997 (albeit the foreign investment to GDP ratios remain fairly small). On the other hand, the high levels of foreign investment in the 2000s do not coincide with an overvalued real exchange rate indicating a changing relation between the two.

Figure 4: Actual and Equilibrium Real Exchange Rate



Sources: IMF, International Financial Statistics database and author's computations

While the data shows an association between foreign flows and overvaluation, the relationship needs to be formalized. Misalignment is defined as,

$$Misalignment = \frac{RER - ERER}{ERER} \tag{5}$$

where *RER* is the real exchange rate and *ERER* is the equilibrium real exchange rate. The equilibrium real exchange rate in turn is computed from equation 4.

To analyze the impact of foreign capital flows on misalignment, this paper employs the same theoretical framework used by Athukorala and Rajapatirana (2003) for real exchange rate changes. All factors that contribute to changes in the real exchange rate can reasonably impact misalignment. However, if any of these factors has a similar impact on actual and equilibrium real exchange rate then it does not affect misalignment. To analyze the relevant factors and specifically to examine if capital flows are a contributor to misalignment, this paper estimates a VAR with misalignment and fundamental factors that contribute to exchange rate changes.

The first step is to identify the appropriate lag length for the VAR which is found to be one lag using LR, AIC and SC. Preliminary results suggest that investment and government spending are not statistically significant factors and are thus left out. The results for the VAR are presented in table 6.

Table 6
Misalignment Vector Autoregression Results

Variable	*Coefficient*	*SE*
Constant	-0.27	(0.28)
Terms of trade	0.07^{+}	(0.06)
Openness	0.15^{*}	(0.06)
Capital flows	-1.80^{*}	(0.74)
Tech progress	-0.13^{*}	(0.09)
NER growth	0.87^{*}	(0.09)
Excess DC growth	0.22^{*}	(0.16)
Adjusted	0.86	

Notes: The Cholesky ordering of the VAR is: lopen, ltot, kflows, tech, misal. * indicates statistical significance at 5% level of significance. $^{+}$ indicates that although not statistically significant at usual levels of confidence, exclusion of the variable based on adjusted R^2 and Akaike and Schwarz criterion is rejected.

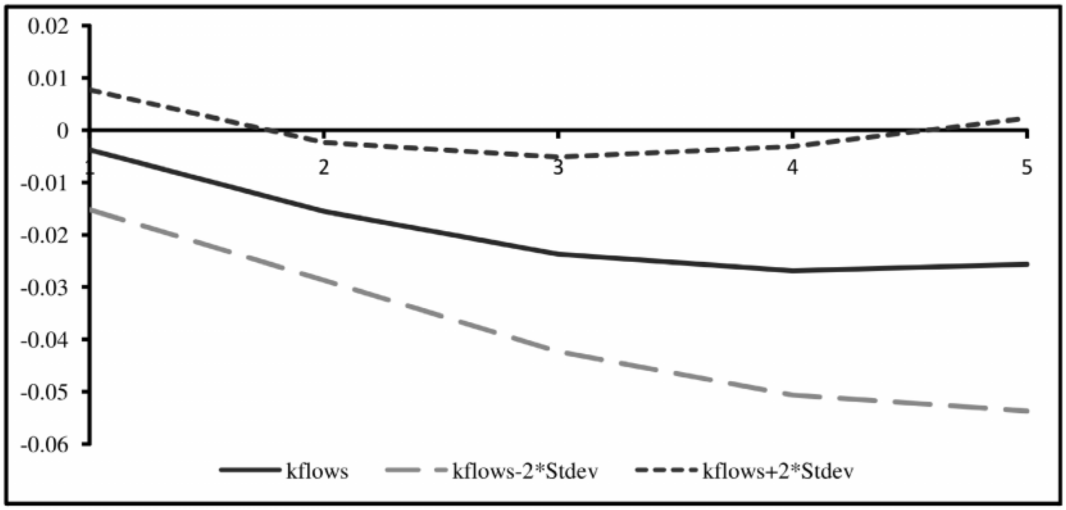
Of the fundamental variables, *capital flows*, *openness*, and *technological progress* have a statistically significant impact on misalignment and have the expected signs. While the *terms of trade* variable is not statistically significant, exclusion of the variable is rejected by the examining the adjusted R^2 and other criterion (AIC and SC). *Nominal exchange rate* and *excess domestic credit* changes are also statistically significant in the expected direction. The results indicate that increased capital flows and technological progress lead to an overvaluation of the real exchange rate. Improved terms of trade, increased openness, nominal depreciation and growth in domestic credit are associated with an undervalued real exchange rate.

To study the role of capital flows on misalignment, this paper uses impulse response functions and variance decomposition of the VAR. The dynamics of a shock to one variable in the VAR on the others in the system are captured by the impulse response function. Essentially, an impulse response function describes the response of $y_{i,t+s}$ (*misalignment*) to a one-time impulse/shock in $y_{j,t}$ (*capital flows*) with all other variables dated t or earlier held constant. The variance decomposition shows us the proportion of movement in a variable (*misalignment*) that is due to shocks in all variables in the system including itself. Both the impulse response function and the variance decomposition are dependent on the ordering of the VAR. Reasonably misalignment would be the last variable in the system because it is affected by these factors. Unfortunately, there is no theoretical basis for the order of the VAR regarding the rest of the variables. VARs with different ordering of the series were estimated. Results were robust and thus, only one set of results are reported based on the following ordering: *openness, terms of trade, capital flows, technological progress and misalignment*.

The impact of capital flows on misalignment is analyzed by examining the impulse response function and variance decomposition presented in figure 5 and table 7 respectively. The impulse responses of *misalignment* for a one unit shock to *capital flows* show that a one unit positive shock to capital flows leads to an overvaluation in the real exchange rate (figure 5). Moreover, the overvaluation lasts for a few years and tapers off after the fourth year (figure 5).

The variance decomposition results show (expectedly) that most of the variation in misalignment can be explained by the variable itself (table 7). Of the other variables, *openness* and *capital flows* play critical roles. In the first period capital flows explain a relatively minor variance of 1.30% (compared to 3.86% explained by openness). However, by the second period capital flows explain 13.76% (compared to 10.81% explained by openness) of the variation and the role of capital flows continues increasing.

Figure 5: Impulse ResponseS of Misalignment to Capital Flows



Source: Author's estimates

Table 7
Variance Decomposition Results for Misalignment

Period	*Openness*	*Terms of trade*	*Capital flows*	*Tech progress*	*Misalignment*
1	3.86%	0.31%	1.30%	1.14%	93.39%
2	10.81%	1.06%	13.76%	1.92%	72.45%
3	11.79%	1.00%	30.31%	1.56%	55.34%
4	10.04%	0.85%	43.38%	1.20%	44.52%
5	8.29%	1.68%	50.81%	1.28%	37.93%

Note: *The Cholesky ordering of the VAR is: openness, terms of trade, capital flows, tech progress, misalignment.*

Overall, the VAR, impulse response function and variance decomposition results show that capital flows are an important factor in real exchange rate misalignment and can last a few years. However, the results also show that foreign investment is not the only major factor. Openness and to a lesser degree technological progress also have a role in real exchange rate misalignment. Openness leads to real exchange rate undervaluation while technological progress (similar to capital flows) causes a real exchange rate overvaluation. The variance decomposition results show that openness explains greater variance in misalignment than capital flows initially although this does change over time. These results suggest that while investment liberalization can cause overvaluation in the real exchange rate, trade liberalization may reverse some of that effect. This can explain the trend in misalignment observed in figure 4. Both trade and investment were liberalized during the reforms following the 1991 crisis. During the 1990s when trade was growing rapidly, the real exchange rate is undervalued. While foreign investment was also growing in that period, it was of much smaller magnitude than trade. On the other hand, foreign investment became very significant in the 2000s which may explain real exchange rate overvaluation in that period despite major increases in trade. Another factor might have been the high level of growth in that period which also led to an overvalued real exchange rate.

VII. CONCLUSION

This paper examines the relation between capital flows and misalignment of the real exchange rate for India between 1975 and 2006. The equilibrium real exchange rate is determined using Edwards (1989) model, cointegration and error correction methodology. This is used to compute misalignment of the real exchange rate. The results show that the Indian real exchange rate was undervalued for most of the 1990s while there was overvaluation in the 2000s.

To study the factors that impact real exchange rate misalignment, a VAR with misalignment and the factors impacting it is estimated. This paper finds that openness, capital flows, technological progress are important factors affecting real exchange rate misalignment. Specifically, openness leads to undervaluation while capital flows and technological progress cause the real exchange rate to be overvalued.

The variance decomposition results show the relative importance of different factors in explaining variation in misalignment. The results show that openness and capital flows have an important and contradictory impact on real exchange rate misalignment. These two factors are significant in the 1990s and 2000s. The trade and investment liberalization reforms undertaken in India after the 1991 balance of payments led to significant increases in trade and investment. The undervaluation in the real exchange rate in the 1990s can be explained by the dominant impact of increased trade. While foreign investment was increasing, it remained a small component.

The 2000s show a different story. While trade continued its rise, foreign investment saw a significant increase. The observed real exchange rate overvaluation in that period supports the estimated relative importance of foreign investment in explaining real exchange rate misalignment. With further increases expected in foreign investment (although curtailed by the global financial crisis) it is likely that the real exchange rate faces the ongoing risk of continuing overvaluation. This can lead to making the country's exports uncompetitive and further exacerbate the already rising trade deficit. Thus, it makes the country more vulnerable to a financial crisis

Notes

1. While appreciation indicates that the real exchange rate is increasing in value, overvaluation implies that the rising real exchange rate exceeds its equilibrium value.
2. This is based on LR and SC. AIC finds the appropriate lag length to be 2 lags.
3. There is evidence of kurtosis at 10% level of significance, but since this is a lesser concern this paper proceeds with the empirical estimation.
4. As Mathisen (2003) notes, the formula for 50% adjustment is $1/\gamma$ where γ is the speed of adjustment coefficient.

References

Alper, C. E., and I. Saglam (1999), "The Equilibrium Real Exchange Rate: Evidence from Turkey", *MPRA Working Paper* No. 1924.

Atasoy, D. and S. C. Saxena (2006), "Misaligned? Overvalued? The Untold Story of the Turkish Lira", *Emerging Markets Finance and Trade*, Vol. 42, No. 3, 29-45.

Athukorala, P. C. and S. Rajapatirana (2003), "Capital Inflows and the Real Exchange Rate: A Comparative Study of Asia and Latin America", *The World Economy*, Vol. 26, No. 4, 613-637.

Dua, P. and P. Sen (2006), "Capital Flow Volatility and Exchange Rates – The Case Of India", Working Papers 144, *Centre for Development Economics, Delhi School of Economics*.

Edwards, S. (1989), *Real Exchange Rates, Devaluation and Adjustment: Exchange Rate Policy in Developing Countries*, MIT Press, Cambridge.

Égert, B. and A. Lahrèche-Révil (2004), "Estimating the Equilibrium Exchange Rate of the Central and Eastern European Acceding Countries: The Challenge of Euro Adoption. *Review of World Economics*, Vol. 139, No. 4, 683-708.

Eita, J. H. and M. M. Sichei (2006), "Estimating the Equilibrium Real Exchange Rate for Namibia", *University of Pretoria Department of Economics Working Paper Series*.

Elbadawi, I. (1994), "Estimating Equilibrium Long-run Exchange Rates" in Williamson, J. (ed.) *Estimating Equilibrium Exchange Rates*, Institute of International Economics, Washington, D.C.

Feyzioğlu, T. (1997) "Estimating the Equilibrium Real Exchange Rate: An Application to Finland", *IMF Working Paper* WP/97/109.

Iossifov, P. and E. Loukoianova (2007), "Estimation of a Behavioral Equilibrium Exchange Rate Model for Ghana", *IMF Working Paper* WP/07/155.

Kemme, D. M. and S. Roy (2005), "Real Exchange Rate Misalignment: Prelude to a crisis?", *William Davidson Institute Working Paper* No. 797.

MacDonald, R. and L. A. Ricci (2003), "Estimation of the Equilibrium Real Exchange Rate for South Africa", *IMF Working Paper* WP/03/44.

Mathisen, J. (2003), "Estimating the Equilibrium Real Exchange Rate of Malawi", *IMF Working Paper* WP/03/104.

Mkenda, B. K. (2001), "Long-Run and Short-Run Determinants of the Real Exchange Rate in Zambia", *Göteborg University, Department of Economics, Working Papers in Economics* No. 40.

Dagdeviren, S., A. Oğuş Binatlı and N. Sohrabji (2011), "Misalignment Under Different Exchange Rate Regimes: The Case of Turkey", *Working Paper* available at *http://ssrn.com/abstract=1368935*.

Paiva, C. (2006), "External Adjustment and Equilibrium Exchange Rate in Brazil", *IMF Working Paper* WP/06/221.

Reinsel, G. C. and S. K. Ahn (1988), "Asymptotic Distribution of the Likelihood Ratio Test for Cointegration in the Nonstationary Vector Autoregressive Model, *Working Paper University of Wisconsin Madison*.

Sjaastad, L. A. and M. Manzur (2003), "Import Protection, Capital Flows, and Real Exchange Rate Dynamics", *Journal of Applied Economics*, Vol. 6, No. 1, 177-203.

Zalduendo, J. (2006), "Determinants of Venezuela's Equilibrium Real Exchange Rate", *IMF Working Paper* WP/06/74.