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# Exchange Rate Misalignment in Pakistan and its General Equilibrium Distributional Implications

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Recent findings in the growth literature suggest that developing countries need to keep a devalued exchange rate to stimulate their economic growth. Building on these findings, we econometrically evaluate to what extent the real exchange rate of Pakistan has been aligned with its economic fundamentals, and find that the Pakistan rupee has been significantly and systematically overvalued during the last years. We then simulate the general equilibrium effects of an eventual re-alignment of the real exchange rate with economic fundamentals, and find not only an expected increase in the relative size of the tradable sector - where productivity increases tend to be faster – but also an associated improvement in the income of the poorest groups.

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## INTRODUCTION

The Framework for Economic Growth laments that sustained high growth has eluded Pakistan, and recognizes the central role that the real exchange rate policy and other sound macro management policies have in its strategy to generate growth (Planning Commission of Government of Pakistan, 2011). Supporting the Framework, Dani Rodrik claims that the management of the real exchange rate is central for economic growth (Rodrik, 2008). The normative analysis of exchange rate policy has two aspects. One is the issue of exchange rate volatility: while a stable exchange rate contributes to reduce uncertainty for exporters and other economic agents, evidence suggests that exchange rate volatility harms growth. The other aspect is the misalignment in the level of the real exchange rate. Given the low volatility of the exchange rate of Pakistan in the last decades, it is on the existence, magnitude and potential effects of misalignment in Pakistan where we think that research is desperately needed.

The more traditional line of argument calls for the exchange rate to be at its "equilibrium" level and emphasizes that overvaluation harms growth (Easterly 2005). However, more recently, Rodrik (2008) and Bhalla (2012) have convincingly argued, and econometrically tested, that undervalued exchange rates are optimal for developing countries, as they lead to periods of economic activity and employment growth. That is, not only is overvaluation harmful (which is linked to macroeconomic instability, balance of payments crises, stop-go economic growth, rent-seeking and corrupt practices), but undervaluation is conducive to growth. Rodrik (2008) uses a panel dataset of 184 countries to regress per capita GDP growth on an index of undervaluation and other covariates. He finds that undervaluation is systematically associated with periods of high growth, an effect that is large and significant for poor countries. Arguably, this is because undervaluation leads production factors to move in the direction of the tradable (export and import-competing) sectors, which tend to have higher productivity growth rates (Cottani et al 1990); or because undervaluation makes an economy more competitive, which increase domestic profitability and increases investment, which leads to growth (Bhalla, 2012).

A report from the International Monetary Fund claims that the Pakistani rupee has been overvalued in recent years (IMF 2012). In the absence of a country-specific, thorough treatment of the Pakistani rupee's alignment for recent years, we begin this study by testing this claim. We analyze Pakistan's real exchange rate to confirm and identify the magnitude of the claimed misalignment of the rupee. We investigate the behavior of the Pakistan real exchange rate, finding that it has been systematically overvalued during the last two decades given observed economic fundamentals. Widespread symptoms of overvaluation through the Pakistan economy are evident: export growth has been moving in stop-go fashion with hopes remaining pinned on remittances to keep international reserves at sustainable levels rather than on export earnings. IMF assistance has become a regular event in Pakistan, with the country receiving Fund's assistance in most years since 1978. All these observations lead to the sad conclusion that, with the existing real exchange rate policy, the country is becoming increasingly dependent on the international community.

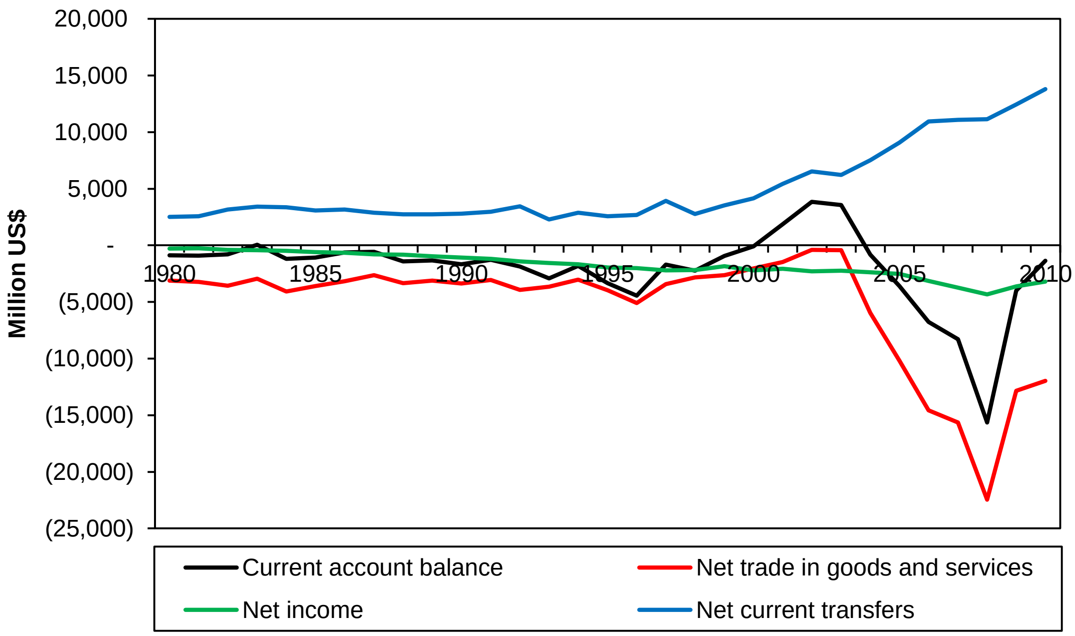
Over the 2000-2008 period, the nominal exchange rate remained exceptionally steady within a narrow band around Rs. 60 per US dollar. More recently, and in the face of worsening economic fundamentals – rising government deficit, deteriorating current account and stagnant growth, a sharp depreciation of the rupee has taken place. While macroeconomic theoretical and empirical evidence suggests that Pakistan needs to continue devaluing its currency to stimulate its growth, we are aware that price changes are never neutral and, as such, real devaluations tend to generate distributional changes by which some groups win and others lose. We analyze then the distributional effects that would be generated by a real devaluation in Pakistan. Given the relevant second-round effects generated by a sizable devaluation, this analysis can only be done in a general equilibrium framework. We simulate a devaluation with its size informed by the above econometric analysis of misalignment, and look into the associated general equilibrium changes in value added for a series of production sectors and, in turn, welfare changes that are to be expected in the long run for a series of representative household groups.

Section II provides necessary background information on the evolution of the balance of payments of Pakistan and its components. Section III presents a vector auto-regression econometric approach that assesses the misalignment of the equilibrium exchange rate of Pakistan. Section IV sheds light on the general equilibrium effects of aligning the real exchange rate with Pakistan economic fundamentals, emphasizing the expected change of the relative size of the tradable sector and income distribution. A final section concludes.

## THE EVOLUTION OF PAKISTAN'S BALANCE OF PAYMENTS

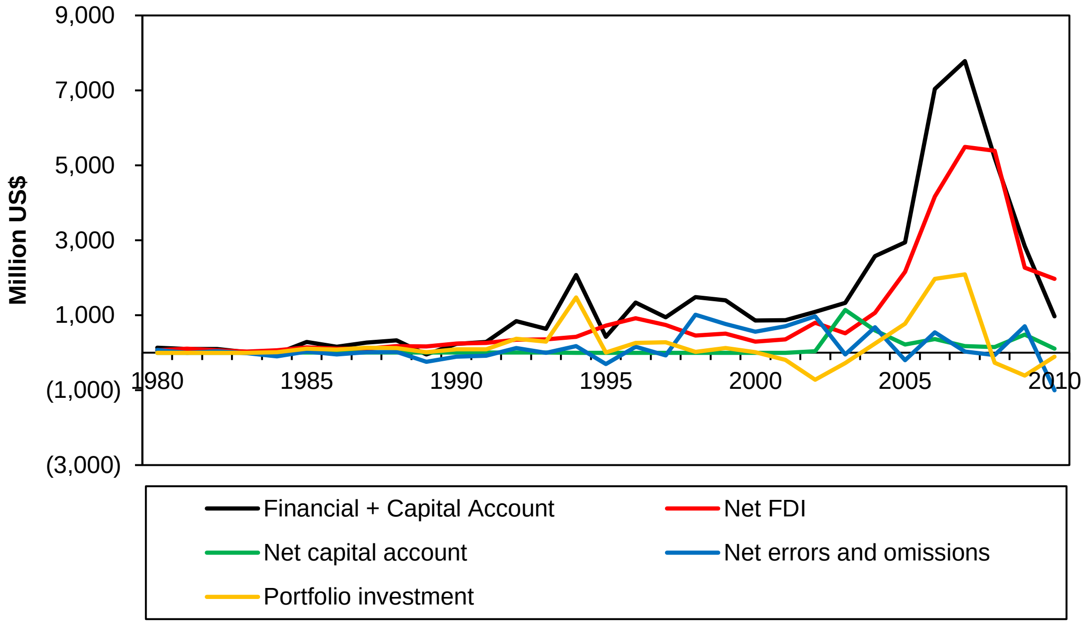
Figure 1 tracks the evolution of Pakistan's current account balance since 1980. Excluding the brief period from 2000 to 2004, Pakistan shows a persistent current account deficit, which has been outstandingly large in the 2006-2009 period. This deficit was in turn driven by the trade deficit. The sharp deterioration of the trade balance from 2004 to 2008 was associated with oil price rises, and the recent relatively good years with abundant cotton harvests that allow the country to increase its exports of cotton and textiles, major export items for the country. The negative effect of the worsening of the trade deficit on the current account of the balance of payments was offset to some degree by rising current inward transfers (remittances and foreign aid) but, in spite of this, the current account remained in deficit during most years.

**Figure 1: The Evolution of the Current Account**




Source: World Bank, World Development Indicators.

**Figure 2: The Evolution of the Capital Account**



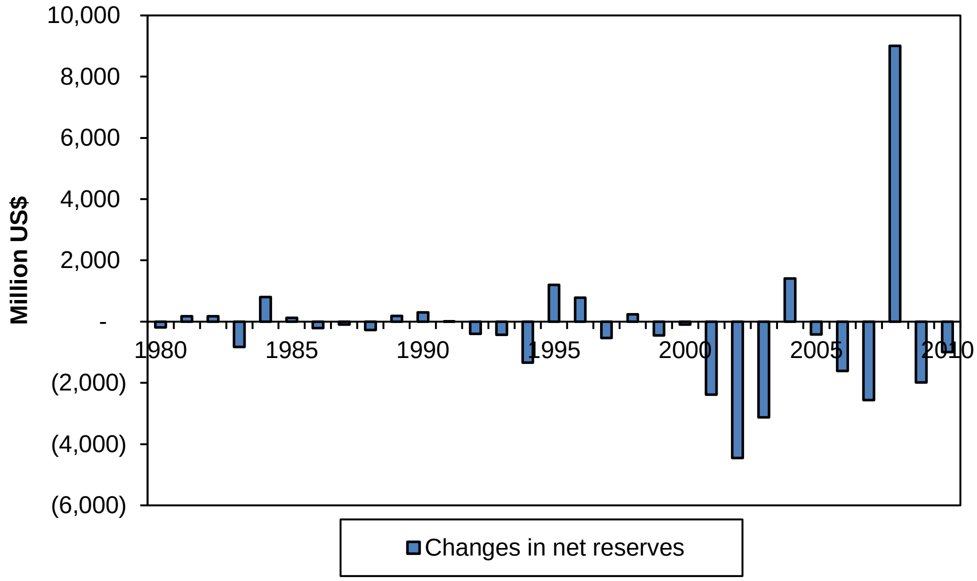

Source: World Bank, World Development Indicators.

Figure 2 shows the evolution of the capital account and its components. It shows that FDI is at present its largest component and that finances, to some extent, the current account deficit. In addition, Pakistan has had to repeatedly make use of IMF stand-by arrangements to manage its external finances and avert crisis[1].

Figure 3 tracks the change in international reserves which mirrors the overall Balance of Payment of the country: negative numbers representing an overall BoP surplus. In the year 2008, the deteriorating current and capital account position culminated in a BOP crisis, and that year seeing Pakistan's entry into a macroeconomic stabilization program with November of that year seeing an inflow of $ 3.1 billion from the IMF and other agencies (Ministry of Finance's Pakistan Economic Survey, 2008-09). We next analyze the movements of the Pakistan real exchange rate and their link to the balance of payments.

[1] Pakistan has had IMF Stand-By Arrangements and other IMF funding in 1972, 1973, 1974, 1980, 1981, 1988, 1993, 1994, 1995, 1997, 2000, 2001, 2004 and 2008.

**Figure 3: Change in Foreign Reserves**




Source: World Bank, World Development Indicators.

# ESTABLISHING THE RUPEE'S EQUILIBRIUM EXCHANGE RATE

## Literature Review

The literature of exchange rate determination contains a range of approaches to measure the equilibrium exchange rate. The approaches vary in how the "equilibrium" rate is defined. The approaches fall into two broad categories: those that take what is called the internal-external or macro-balance approach, and those that take the equilibrium rate as being directly determined by economic fundamentals. In the macro-balance approach the notion of optimality comes into play: the equilibrium rate is defined as one that is consistent with an "optimal" economic state. In contrast, the second type of approach defines equilibrium in the *behavioral* sense: the equilibrium rate is that which is consistent with observed economic fundamentals.

The former approach is also called FEER (Fundamental Equilibrium Exchange Rate). Popularized first by Williamson (1985) and later by Isard and Faruqee (1998), it defines the "equilibrium" rate as that compatible with internal and external equilibrium. This requires that researchers specify a current account balance "norm" - a desirable and sustainable target - consistent with a full-employment activity level. In this approach, the goal of the researcher is to find the exchange rate that is consistent with this position.

In contrast, the behavioral approach entails direct, reduced-form regressions where exchange rate movements are assumed to be determined by movements in economic fundamentals[2]. In this paper, we employ the behavioral equilibrium exchange rate (BEER) approach of Clark and MacDonald (1998). Under this approach, the "equilibrium" rate is determined using an econometrically estimated relationship between the exchange rate and two sets of economic fundamentals. The first set is derived from the Uncovered Interest Parity UIP condition (interest rate differential and country-risk premium) and the second set includes variables considered "systemic" determinants of the real exchange rate such as domestic versus international productivity and change in net foreign assets. A cointegration technique allows for the estimation of the long-run relation among these variables. Misalignment occurs when the actual exchange rate differs from what the econometrically estimated relation predicts in the light of the observed or "sustainable" fundamentals.  Misalignment in the behavioral approach can arise due to random disturbances, transitory factors or due to fundamentals being away from their long run or

[2] These approaches include the NATREX or natural real exchange rate of Stein (1995), the Behavioral Equilibrium Exchange Rate or BEER of Clark and MacDonald (1998), and the stock-flow equilibrium model of Faruqee (1994).

"sustainable" values. The BEER is very general and, by employing it, we avoid the need to define "sustainable" current account and GDP positions. However, fundamentals can be calibrated to their "sustainable" values to estimate the "sustainable" or "long run" equilibrium exchange rate. Thus, this method, while being "positive" in its approach, is able to incorporate the normative features of the FEER approach as well.

With regards to the exchange rate literature on Pakistan, there are two key publications from recent years that address the issue of the Pakistan Rupee's misalignment. A paper published by the State Bank of Pakistan, Hyder and Mahboob (2006), uses a behavioral approach with a range of fundamentals based on the behavioral model of Edwards (1989). This study analyzes the time period going from 1978 to 2005. While usually there would be no need to update a study done less than a decade ago, the abrupt changes in economic circumstances in Pakistan make such an update advisable. In the years following 2005, economic circumstances in Pakistan changed significantly: amidst changing political regimes, deteriorating security as well as climate-related calamities, the period 2005-10 has seen fiscal and current account deficits rise sharply, capital inflows (particularly foreign investment) reverse their sign, and overall economic growth slow, generating the need for an updated study of the exchange rate misalignment in the country.

More recently, the IMF noted the Rupee's misalignment in its Article IV consultation staff report (IMF 2012). Exchange rate assessments contained in these reports come from the IMF's Consultative Group on Exchange Rate issues (CGER) that monitors exchange rates of a number of advanced economies and more recently also a number of emerging market economies. The CGER uses both the macro-balance approach and the behavioral approach and applies these to a multi-country panel dataset as opposed to individual country time-series analyses[3]. This mix allows the IMF to avoid small sample problems but produces a homogenous cointegrating equation for a diverse group of countries (IMF 2006) that misses country-specific heterogeneity. Our econometric analysis intends to provide an updated and dedicated analysis of Pakistan alone and offers a comparison with results found in previous studies.

## The Model

We begin with the uncovered interest parity condition expressed in real terms and thus posit that the real exchange rate is a function of the real interest rate differential and risk premium. The UIP being a short-run condition, these variables are taken to impact "current" misalignment. Long run variables that are deemed to impact the systemic component of the real exchange rate are then added based on existing literature. We choose a sparse specification with systemic covariates given by i) net foreign assets, ii) a proxy for the Balassa-Samuelson effect or technological progress, and iii) terms of trade. We then apply Johansen's cointegration technique, using a Vector Autoregression (VAR). In building and estimating our model this way, we follow closely the BEER approach of Clark and MacDonald (1998).

Given the relatively small number of observations (our main results are based on annual data from 1982 to 2010) and that the VAR is applied, we specify a small number of variables. The general relation we posit is the following:

$$lreer = f(r - r^*;\ deficit;\ nfa;\ ltot;\ ltnt)$$

Where:

$\boldsymbol{lreer}$ is the natural logarithm of the real effective exchange rate (REER) of the Pakistani rupee in terms of foreign currency, such that an increase in *lreer* means a real appreciation of the rupee. Specifically, the REER for Pakistan is given by:

$$reer = \prod_j \left(\frac{P.R}{P_j.R_j}\right)^{W_j}$$

where j is an index that runs over the G7 trading partners, $P$ ($P_j$) is the Consumer Price Index in Pakistan (Country j), $R$ ($R_j$) is the nominal exchange rate of the Pakistani Rupee (country j's currency) in terms of dollars, and $W_j$ is the trade weight assigned to j from table 1 (normalized to add to 1 over the 7 countries).

[3] In addition to these two approaches, the CGER also uses a third method it calls the "External Sustainability" approach which uses accounting to calculate "the difference between the actual current account balance and the balance that would stabilize the NFA position of the country at some benchmark level" (IMF 2006). Hence, it is a type of macro-balance approach focusing on external debt sustainability.

$r - r^*$ is the difference between the domestic and the trade-weighted foreign real interest rate, leaving risk premium aside. We follow existing literature in using trade weights to calculate r*. The interest rates used are the annual average interest rates reported by the IMF adjusted for domestic or foreign inflation. A higher interest rate differential is expected to lead to an appreciation of the rupee via an increase in net capital inflow.

$deficit$ is the government's fiscal deficit as a percentage of GDP. It is our proxy for risk premium in the risk adjusted interest parity condition. A higher deficit, associated with greater risk, is expected to lead to a depreciation of the rupee.

$ltot$ is the relative terms of trade (in logs), that is, the ratio of Pakistan's terms of trade (the ratio of Pakistan's export unit price to its import unit price) to the foreign trade-weighted terms of trade. The effect of terms of trade on real exchange rate is a priori ambiguous, with income and substitution effects working in opposite directions.

$ltnt$ captures the Balassa-Samuelson effect (or productivity growth differentials between the tradable and non-tradable sectors within and across countries). In theory, ceteris paribus, higher productivity growth in the domestic tradable sector causes the relative price of tradables to fall, leading to a domestic real appreciation of the real exchange rate. Measuring this differential is not straightforward for a developing country like Pakistan since reliable data on productivity are not available. Commonly used proxies in the literature for developing countries include GDP growth[4] (implicitly assuming growth is driven by productivity growth in the tradable sector), growth in the Industrial Production Index[5] (implicitly assuming productivity growth in the tradable sector is mainly associated with the industrial sector), and a time trend[6] (which assumes that any residual trend is due to productivity). In this study, it is proxied by the ratio of the growth rate of value-added of the industrial (tradable-proxy) sector to the growth rate of value-added of the services (non-tradable-proxy) sector. This ratio is then taken as relative to the equivalent foreign (trade weighted) ratio and expressed in logs.

$nfa$ is the stock of Pakistan's net foreign assets (NFA) as a percentage of nominal GDP, in common currency. NFA can be seen as a reflection of the current account position over time; in particular, it is equivalent to the accumulated current account balance. Higher net foreign assets are expected to cause a real appreciation of the exchange rate.

While detailed definitions and data sources for each of these variables are presented in Appendix I, Figure 4 below graphs all six of our variables included in the model over the period of analysis. The real exchange rate experienced a consistent and sharp depreciation in the 1980s following the abandonment of a fixed exchange rate system in 1982. This was followed by a period of rather stable real exchange rate over the 1990s. In the 2000s, relative to earlier periods, volatility increased, but the general depreciating trend continued.

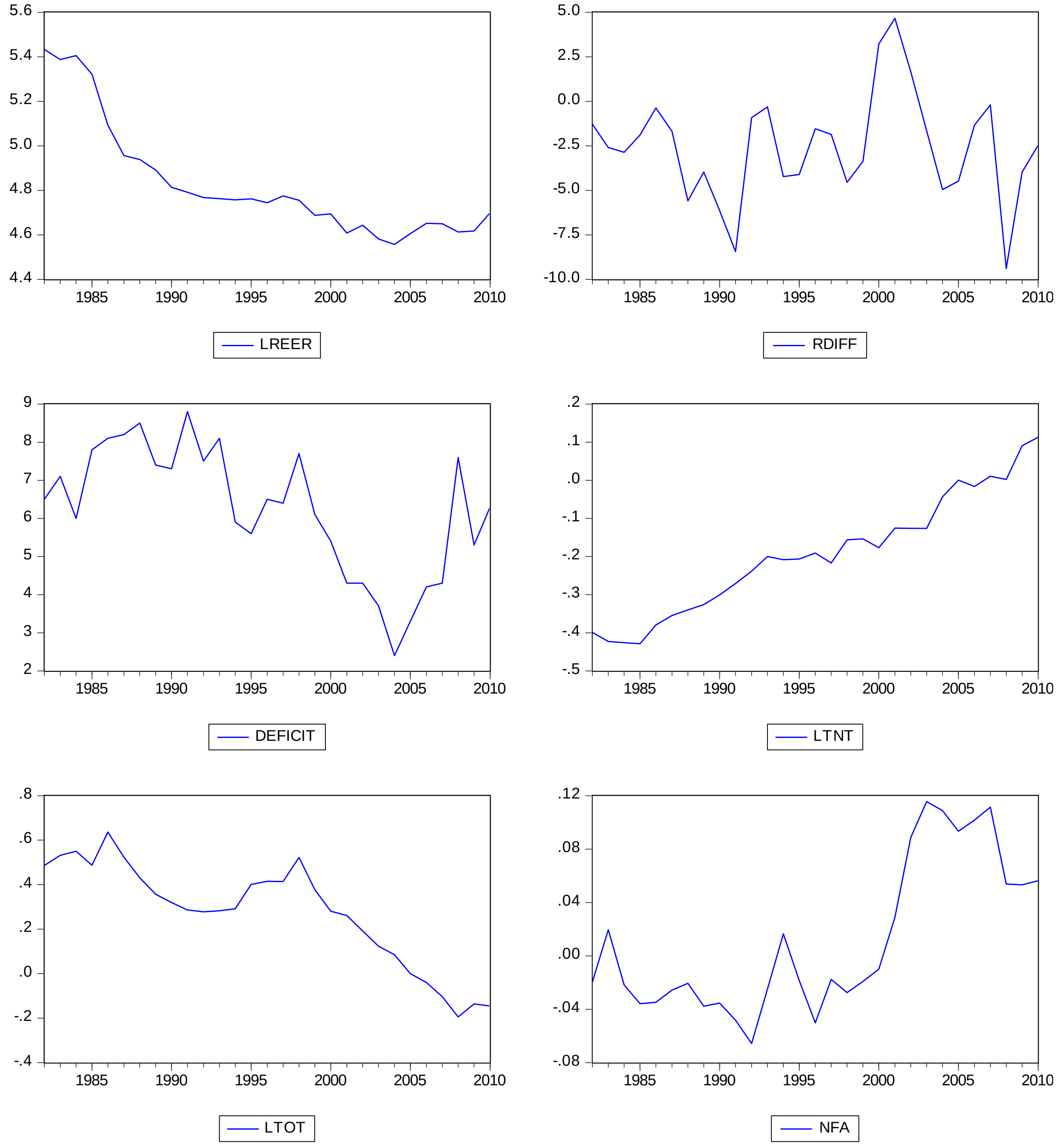
Looking at our posited explanatory variables, prima facie there is no obvious trend driving the behavior of the exchange rate. In the years since 1999, we see the real interest rate differential experience larger than average fluctuations, rising sharply in the early 2000s and falling sharply later. Similarly, the fiscal deficit also saw a large swing: falling steeply and then rising equally steeply. Among the systematic factors, terms of trade (*tot*) worsened in the years since 1999, while net foreign assets (*nfa*) of domestic residents rose sharply until 2004. Since 2004 there has been a decline. The expected sign on *nfa* is positive, with its rises accompanied by real exchange rate appreciation. Given the absence of a single observable variable driving the real exchange rate, we find a strong case to conduct a multivariate econometric approach.

[4] Edwards (1989)

[5] Cheng and Orden (2007)

[6] Cottani, Cavallo and Khan (1990)

**Figure 4: Evolution of Pakistan's Real Exchange Rate and its Economic Fundamentals, 1982-2010**




Source: Various sources. See Annex I.

## The Johansen Approach

In estimating a long-run equation for *lreer* with an OLS approach, there is the possibility of a spurious regression resulting from our variables being non-stationary. To avoid this, we use the cointegration methodology of Johansen (1995) to identify existent long-run relationships between non-stationary variables. This is a multi-regression approach where we model our variables as a vector auto-regression (VAR): a system of reduced form equations that determines each of our six variables as a function of lags of themselves and the other five variables. Thus, all variables are endogenous. The approach allows us to test for the existence of cointegration (a long run relation between non-stationary variables) and is able to identify all such relations if more than one exists. Formally, we specify our variables as an unrestricted VAR with $p$ lags:

$$x_t = \mu + \sum_i \pi_i x_{t-i} + u_t \qquad\qquad i = 1, \ldots, p$$

Where: $x_t$ is a 6-times-1 dimension vector with our 6 chosen variables, $\mu$ is a 6-dimensional vector of constants and $u_t$ is a 6-times-1 dimension vector of identically, normally distributed disturbance terms. $\pi_i$ is the 6-times-6 matrix of coefficients on $x_{t-i}$ and $p$ is the number of lags we choose to include.

From Granger's representation theorem, if non-stationary variables have a cointegrating relationship, there exists an error correction model (ECM) allowing estimation of the long run cointegrating relation(s), as well as the short run adjustment coefficients. Formally, a VAR of non-stationary variables with $p$ lags is equivalent to an ECM of the form:

$$\Delta x_t = \mu + \Pi x_{t-1} + \sum_{i=1}^{p-1} \Phi_i \Delta x_{t-i} + u_t$$

Where: $\Pi = \alpha\beta'$ such that

$\beta$ is the matrix of cointegrationg vectors and $\beta' x_{t-1}$ captures the long-run relationship between the variables.

$\alpha$ is the matrix of adjustment coefficients. Each column in $\alpha$ is associated with each cointegrating vector in $\beta$ and reflects the speed of adjustment to the equilibrium relation given by the (respective) $\beta$.

Granger's theorem asserts that we can test for cointegration by testing the rank of the matrix $\Pi$. If the rank of $\Pi$ equals $r$, and $r$ is less than the number of variables (i.e. $r < n$), then there exist $r$ number of cointegrating relations such that the $\beta' x_{t-1}$ is stationary or I(0). Alternatively, if $r = n$ or if $r = 0$ then there is no cointegration.

## Estimation Results

The approach described above requires most of our variables to be non-stationary. We employ the commonly used ADF and Phillips Peron tests for stationarity which confirm that most are indeed non-stationary in levels but achieve stationarity in first differences i.e. they are integrated of order 1 or I(1)[7]. The exception is *rdiff* which appears stationary in levels i,e. I(0) but is included nonetheless given that the UIP condition underpins our model.

[7] The Johansen (1995) approach used in this paper is not applicable if any variables are integrated of a higher order.

**Table 1: Tests of Stationarity**

| | *Levels* | | *First Differences* | |
|---|---|---|---|---|
| | *ADF* | *ADF with Trend* | *ADF* | *ADF with Trend* |
| lreer | -1.866 | -0.563 | -4.625*** | -5.909*** |
| rdiff | -3.903 (1)*** | -3.815 (1) | -6.159 (1)*** | -6.010 (1) *** |
| deficit | -2.101 | -2.904 | -7.567*** | -7.444*** |
| nfa | -1.204 | -2.914 (1) | -4.725*** | -4.683*** |
| ltot | -0.259 | -2.799 (3) | -5.262*** | -5.301*** |
| ltnt | -0.197 | -3.005 | -6.394*** | -6.371*** |
| | *DF-GLS* | *DF-GLS with Trend* | *DF-GLS* | *DF-GLS with Trend* |
| lreer | -1.568 (1) | -1.639 (1) | -0.957 (3) | -4.453** |
| rdiff | -3.531*** | -3.723** | -5.233*** | -5.423*** |
| deficit | -2.083** | -2.663 | -7.278*** | -7.355*** |
| nfa | -1.175 | -1.978 | -4.150*** | -4.577*** |
| ltot | 0.170 | -1.674 | -5.030*** | -5.268*** |
| ltnt | 0.987 | -2.933 | -5.485*** | -6.164*** |

Note – Table reports Augmented Dickey Fuller (ADF) and Elliot-Rothenberg-Stock DF-GLS unit root test statistics. The figure in parenthesis indicates number of augmented lags when present. ***, **, and * indicate a rejection of the null hypothesis of unit root presence at 1%, 5% and 10% level of significance, respectively, using MacKinnon critical values.

In specifying the model as a VAR, a VAR with 1 lag was chosen given the small number of observations and based on the various information criteria reported in Table 2. The Log Likelihood ratio understandably improves with additional lags. In choosing between 1 or 2 lags, we consider different measures of information criteria. All measures are in agreement: they are minimized (and LR is maximized) for the first order VAR.

**Table 2: Lag Length Criteria**

| *Lag* | *LogL* | *LR* | *FPE* | *AIC* | *SC* | *HQ* |
|---|---|---|---|---|---|---|
| 0 | -116.9136 | NA | 0.0004 | 9.1047 | 9.3927 | 9.1903 |
| 1 | 9.2253 | 186.8724* | 4.91e-07* | 2.4278* | 4.4435* | 3.0271* |
| 2 | 37.8778 | 29.7137 | 1.33E-06 | 2.9720 | 6.7155 | 4.0852 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 3 below reports the diagnostics of the first order VAR and indicates that it is well-specified. There is no indication of serial correlation and residuals are generally normal with the only exception of the *ltot* equation where there is some indication of non-normal residuals.

**Table 3: Diagnostics for 1st Order VAR**

| Test for Normality (Jarque-Bera) | | | | | | LM Test for SC | | Test for Hetero |
|---|---|---|---|---|---|---|---|---|
| lreer | Rdiff | debt | Ltnt | Ltot | nfa | 1st Order | 5th Order | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3.94 | 0.92 | 1.24 | 0.90 | 7.16** | 1.00 | 32.22 | 35.17 | 252.92 |
| (0.14) | (0.63) | (0.54) | (0.64) | (0.03) | (0.61) | (0.65) | (0.51) | (0.47) |

Note – Figures in parentheses are p-values. ** denotes rejection of the null hypothesis at 5% level of significance.

We then apply Johansen's trace test procedure for cointegration. For a VAR with $n$ variables there can be up to $n-1$ unique cointegrating equations. The procedure entails calculating the trace test statistic[8] for the null hypothesis that there are at most $r$ cointegrating vectors. The null is rejected when the test statistic exceeds the relevant critical value. The procedure tests the sequence of hypotheses $r = 0$, $r \leq 1$, and up to $r \leq n-1$. We derive our conclusion about the number of cointegrating relations from the first instance where we fail to reject the null.

To calculate the trace statistics, the model specification (the inclusion of time trends and/or constants) needs to be specified. We use the Pantula principle, which jointly tests for rank and model specification. This method suggests a single cointegrating relation with a constant but no time trend in the cointegrating equation. Table 4 reports the Trace Test results with this model specification. We are able to reject the null that there is no cointegrating relation but fail to reject the hypothesis there is at most one cointegrating relation. We conclude that a single cointegrating relation exists, making interpretation of the cointegrating vector straightforward.

### Table 4: Test for Cointegration

| No. of CEs | Trace Statistic | 0.05 Critical Value | p value** |
|---|---|---|---|
| None* | 110.31 | 95.75 | 0.00 |
| At most 1 | 68.92 | 69.82 | 0.06 |
| At most 2 | 33.91 | 47.86 | 0.51 |
| At most 3 | 14.85 | 29.80 | 0.79 |
| At most 4 | 6.44 | 15.49 | 0.64 |
| At most 5 | 0.66 | 3.84 | 0.42 |

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
 * denotes rejection of the hypothesis at the 0.05 level
 **MacKinnon-Haug-Michelis (1999) p-values

The resulting cointegrating vector normalized on the lreer (with standard errors and t values in parentheses and brackets, respectively) implies the following relationship:

$$lreer = 2.740 + 0.022rdiff + 0.243deficit - 1.209ltnt + 1.019ltot + 0.097nfa$$
$$\begin{array}{ccccc} (\mathbf{0.01}) & (\mathbf{0.03}) & (\mathbf{0.45}) & (\mathbf{0.32}) & (\mathbf{0.01}) \\ [\mathbf{2.07}] & [\mathbf{7.30}] & [\mathbf{-2.68}] & [\mathbf{3.14}] & [\mathbf{8.76}] \end{array}$$

The signs are as expected for the interest rate differential term (*rdiff*), the terms of trade term (*ltot*), and net financial assets term (*nfa*). However, the sign for the *ltnt* term is negative suggesting it is not accurately measuring he Balassa-Samuelson effect. The Balassa-Samuelson effect predicts that relative technological progress (or productivity growth) in the tradables sector (relative to own non-tradable sector and relative to trading partners), results in real exchange rate appreciation over time via price differentials. For this effect to occur, productivity growth needs to have strong linkages with prices and wages. The *deficit* term too has an unexpected sign suggesting it is not accurate as a measure of risk and is in fact capturing the impact of consumption patterns which, if skewed towards non-tradables, cause a real appreciation.

Since our underlying VAR appears well-specified with no serial correlation or non-normal residuals, and our present purpose of measuring misalignment requires within-sample prediction, we continue with this equation to calculate our behavioral equilibrium exchange rate. Continuing with the methodology of Clark and MacDonald, we calculate "Total Misalignment" as follows: *reer* is defined as the actual real effective exchange rate, $Z_{1t}$ $(Z_{2t})$ as the set of fundamentals expected to have

[8] See Johansen (1988)

persistent effects on the real exchange rate in the long (medium) run, $T$ the set of transitory short run variables, and $\varepsilon_t$ the effect of random disturbances, such that:

$$reer_t = \beta_1' Z_{1t} + \beta_2' Z_{2t} + \tau' T_t + \varepsilon_t$$

and the current equilibrium exchange rate (*beer*) is the exchange rate that is consistent with null transitory and random terms:

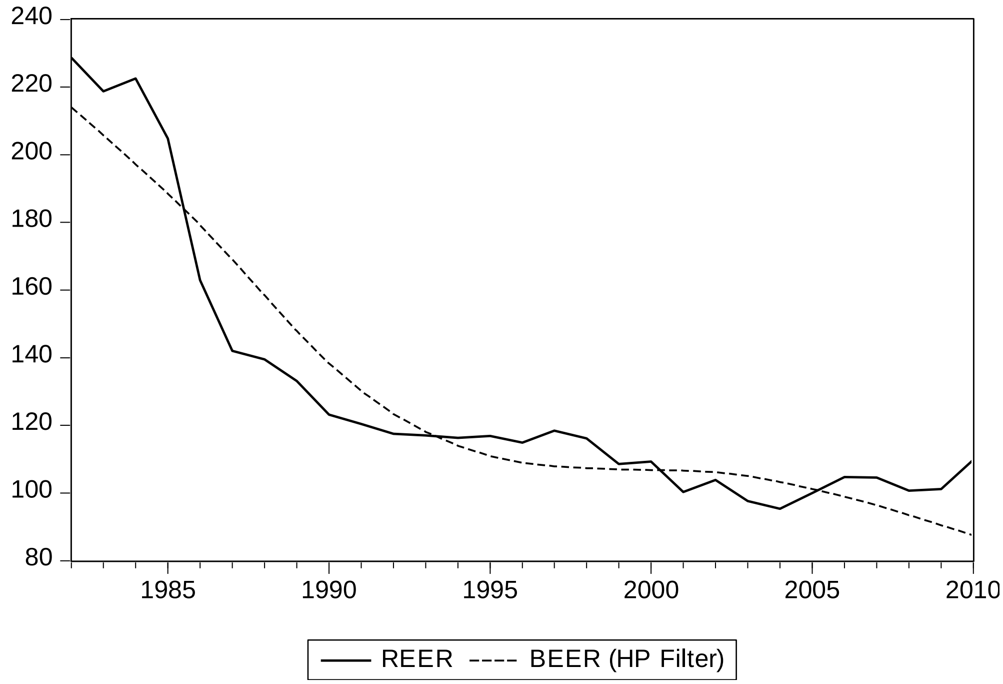
$$beer_t = \beta_1' Z_{1t} + \beta_2' Z_{2t}$$

The difference between the real exchange rate ($reer_t$) and the equilibrium exchange rate ($beer_t$) is called “current misalignment” as it captures misalignment due to transitory factors and random disturbances only. However, the fundamentals determining the exchange rate may be in disequilibrium themselves, that is, out of their sustainable, long-run levels. Our purposes require that we capture misalignment due to this as well. Proxying the sustainable values of our fundamentals ($\bar{Z}_{1t}$ and $\bar{Z}_{2t}$) by using the Hodrick-Prescott statistical filter[9] as Clark and McDonald (1998), we express “total misalignment” as the sum of current misalignment and the effect of fundamentals being away of their sustainable values:

$$Total\ Misalignment_t = (reer_t - beer_t) + [\ \beta_1'(Z_{1t} - \bar{Z}_{1t}) + \beta_2'(Z_{2t} - \bar{Z}_{2t})\ ]$$
$$= \ current\ misalignment + long\ run\ misalignment$$

Thus, “total misalignment” is the sum of current misalignment as given above and the second component which captures the effects of departures of the fundamentals from their long-run values. Summarizing our results, Figure 5 shows the long run equilibrium exchange rate compared with the actual exchange rate.

**Figure 5: Actual Real Exchange Rate (REER) vs. Long Run Equilibrium Exchange Rate (BEER- HP filter adjusted)**




(Index: Base = 2005)

Source: Authors’ estimates.

## Expanded Sample with 2011

A second analysis was also run since at the time of writing this paper, data for the year 2011 also became available for most of the variables included in our model. The exception was *ltnt*: data on sector growth rates for the G7 countries were not

[9] The filter produces a smoothed series of each of our explanatory variables by minimizing the sum of squares of the second difference.

available. Hence, in this second analysis, the construction of *ltnt* was changed to be simply the growth of Pakistan's industrial sector relative to growth in its services sector. With this modified *ltnt*, the model with 2011 included was also run. This yielded similar diagnostics, and again a single cointegrating vector. Coefficients were similar with the exception of *rdiff*: the coefficient turns negative though small and insignificant.

Total misalignment calculated under this model (with 2011 included in the sample) yielded overvaluations of much larger magnitudes: an overvaluation of 60% in 2011 and 40% in 2010. For our CGE analysis we however, continue with the less extreme estimates of misalignment found in the prior analysis excluding the year 2011.

## Discussion

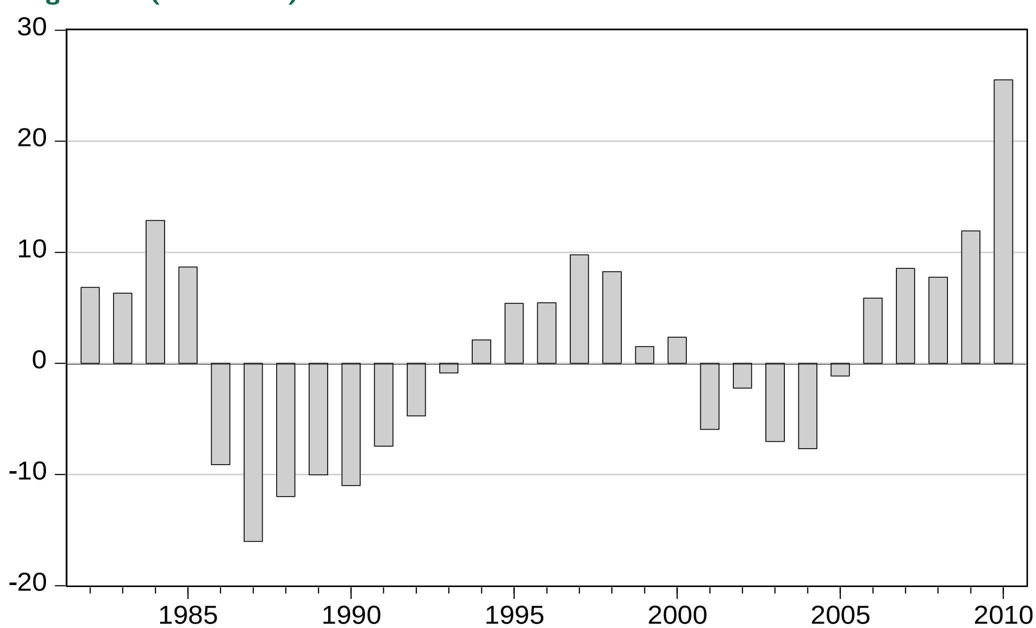
In Figure 5, the BEER evaluated at the sustainable or long run values of fundamentals provides a measure of the long run equilibrium real exchange rate. It reveals that, in recent years (starting in 2006), the rupee has been overvalued, and by a growing margin. This is due both to the BEER depreciating over these years and to the actual REER appreciating in parallel. In Figure 6 and Table 5, we calculate total misalignment as a percentage (of the BEER) which indicates that the overvaluation of the rupee was as high as 25% in 2010.

Our findings for the years 1982 up to 2000 compare very well with those of Haider and Mahboob (2005). In this period, they do find two episodes of undervaluation (from 1987 to 1995, and from 2003 to 2005) and two episodes of overvaluation (from 1981 to 1986 and from 1996 to 1998). Our results begin to disagree somewhat for the last 5 years of Haider and Mahboob's sample: they find that from 1999 to 2005 exchange rate was more or less at equilibrium while our results suggest undervaluation ranging from 1% to 7%.

For the most recent years in our sample we are able to compare our results with the IMF for 2008 and 2010. The IMF's Article IV report in 2009 (IMF 2009) reports a 2% overvaluation using the behavioral approach in 2008. From the macro-balance approach it finds 5-10 percent overvaluation. Our estimate puts overvaluation at 8% for 2008.

The next IMF's Article IV report in 2012 (IMF 2012) reports little misalignment based on the behavioral approach but finds an overvaluation of about 10% using the macro-balance approach. The IMF concludes that the Rupee is "somewhat" overvalued and recommends greater flexibility in Pakistan's exchange rate policy. Our estimates in comparison suggest a higher over-valuation of 25% in 2010.

**Figure 6: Total Misalignment (in Percent)**




Source: Authors' estimates.

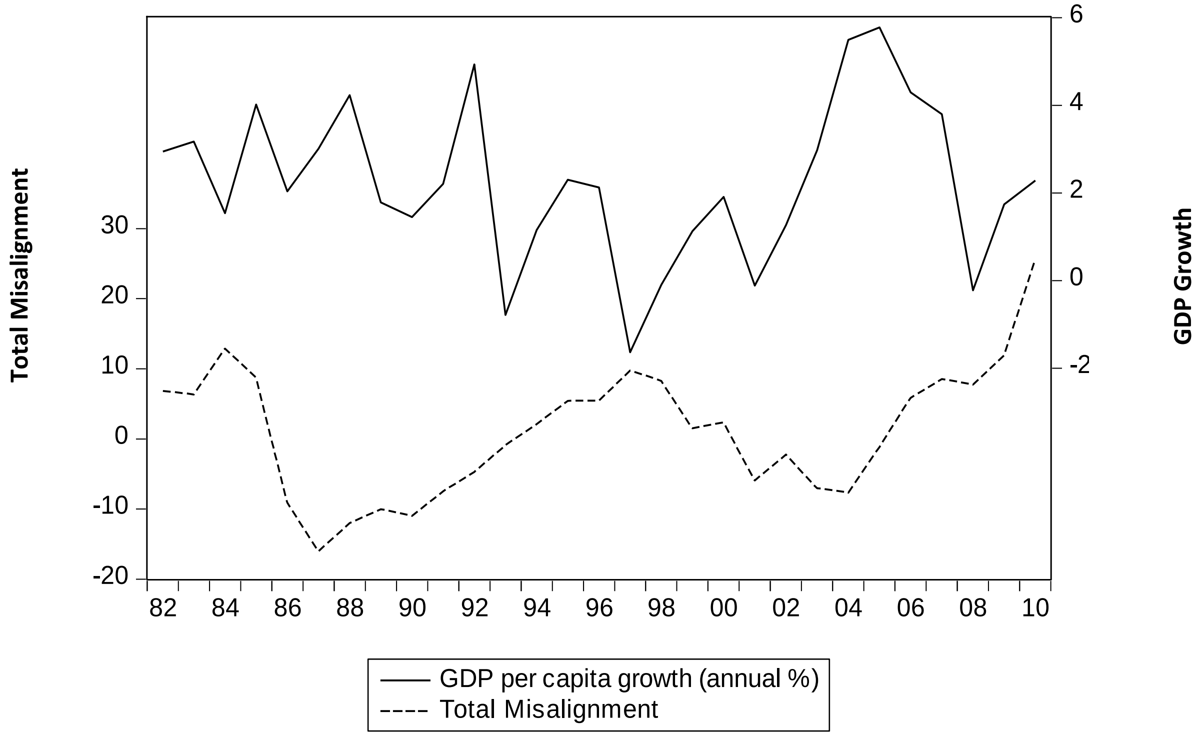
### Table 5: Total Misalignment

| Obs | Actual REER (Index: Base = 2005) | BEER (Index) | BEER (HP Adjusted Index) | Total Misalignment (Percent) |
|---|---|---|---|---|
| 1982 | 228.7 | 160.1 | 214.0 | 6.9 |
| 1983 | 218.7 | 284.1 | 205.7 | 6.3 |
| 1984 | 222.5 | 147.7 | 197.1 | 12.9 |
| 1985 | 204.8 | 191.8 | 188.5 | 8.7 |
| 1986 | 162.9 | 236.4 | 179.2 | -9.1 |
| 1987 | 142.0 | 222.5 | 169.2 | -16.0 |
| 1988 | 139.5 | 206.0 | 158.5 | -12.0 |
| 1989 | 133.1 | 126.2 | 148.0 | -10.0 |
| 1990 | 123.1 | 112.2 | 138.3 | -11.0 |
| 1991 | 120.4 | 126.3 | 130.1 | -7.5 |
| 1992 | 117.5 | 87.4 | 123.4 | -4.7 |
| 1993 | 117.1 | 146.3 | 118.1 | -0.9 |
| 1994 | 116.3 | 120.0 | 113.9 | 2.1 |
| 1995 | 116.9 | 88.9 | 110.9 | 5.4 |
| 1996 | 114.9 | 85.4 | 108.9 | 5.5 |
| 1997 | 118.4 | 117.2 | 107.9 | 9.8 |
| 1998 | 116.2 | 142.6 | 107.3 | 8.3 |
| 1999 | 108.6 | 92.7 | 107.0 | 1.5 |
| 2000 | 109.3 | 92.2 | 106.8 | 2.4 |
| 2001 | 100.3 | 97.8 | 106.6 | -5.9 |
| 2002 | 103.8 | 153.0 | 106.2 | -2.2 |
| 2003 | 97.6 | 149.0 | 105.0 | -7.0 |
| 2004 | 95.3 | 82.4 | 103.2 | -7.7 |
| 2005 | 100.0 | 77.5 | 101.2 | -1.1 |
| 2006 | 104.7 | 109.9 | 98.9 | 5.9 |
| 2007 | 104.6 | 114.9 | 96.3 | 8.6 |
| 2008 | 100.7 | 110.0 | 93.5 | 7.8 |
| 2009 | 101.2 | 67.2 | 90.4 | 11.9 |
| 2010 | 109.8 | 88.0 | 87.5 | 25.5 |

Source: Authors' estimates.

In Figure 7, we take a preliminary look at exploring the hypothesis that undervaluation is associated with growth. We map our measure of the rupee's misalignment against per capita GDP growth. We find that the two trends mirror each other up to 2008 such that during periods of undervaluation (negative Total Misalignment) per capita GDP growth tends to be higher. In the section that follows, we explore the possibility of devaluation spurring growth using CGE analysis.

**Figure 7: Real Exchange Rate Misalignment and Economic Growth in Pakistan**




Source: Authors' estimates of "Total Misalignment"; "GDP Growth" from World Bank, World Development Indicators.

# THE STRUCTURAL EFFECTS OF ALIGNING THE REAL EXCHANGE RATE

## The Analytical Framework

The analysis above suggests that the rupee was and is overvalued, with a misalignment as high as 25% in 2010, making the case for a real devaluation in Pakistan in order for its exchange rate to be consistent with its economic fundamentals. However, the misalignment with fundamentals is silent with respect to the country's income distribution. Hence, in the following, we look into what the distributional consequences of a significant devaluation in the country are. Such an analysis can only be carried out within a general equilibrium framework.

Specifically, we use the IFPRI Standard CGE model to analyze the general equilibrium effects of the devaluation, a general equilibrium model that is specifically targeted to developing countries. We calibrate its parameters using the Social Accounting Matrix for Pakistan (Debowicz et al 2012), which we update to 2010-2011 using cross-entropy methodology. As highlighted by Willenbockel (2006), comparative-static simulations using this type of model are in conception comparisons of stationary "long-un" equilibria in which the classical dichotomy is assumed to hold. Departing from the standard closures in IFPRI model, we allow the real exchange rate to be exogenous, and make foreign savings endogenous. Consistent with our interest in the long-run effects of the devaluation, factor endowments are fixed with full employment for every factor. The numeraire is provided by the consumer price index (fixed CPI). As detailed in the following box, the CGE model for Pakistan has 22 production sectors, 3 production factors (labor, capital and land), and 7 representative household groups.

**Box I. Structure of the 2008 Pakistan SAM**

**Sectors (22)**

- Agriculture (7): Wheat, Rice-IRRI, Rice-basmati, Cotton, Sugarcane, Other field crops, Other agriculture
- Industry (12): Manufacturing, Other food, Wheat milling, Rice milling, Sugar milling, Cotton processing, Textiles, Chemicals, Fertilizer, Cement, Energy, Construction
- Services (3): Trade, Transport, Other services

**Factors (3)**

- Labor, Capital and Land

**Households (7)**

- Rural (5): Large/medium farm, Small farm, Tenants, Non-farm poor, Non-farm non-poor
- Urban (2): Urban poor, Urban non-poor

**Other Institutional Accounts (4)**

- Government, Rest of world, Saving-Investment, Change in stocks. The government includes separate taxes for import taxes, direct taxes and sales taxes.

## Simulation Analysis

Reflecting the results of the econometric analysis above, we conduct two simulations:

Simulation 1: Real devaluation of 10%, based on total exchange rate behavioral misalignment for period 2007-2009.

Simulation 2: Real devaluation of 25%, based on total exchange rate behavioral misalignment for year 2010.

After implementing the simulations, we look into the endogenously generated changes in producer prices, production by sector, exports and imports, the real wages of the production factors, and household incomes for representative household groups. We find that, as the real devaluations take place, the relative prices of agricultural traded goods rise, in the 0.8-1.5 percent range for a 10 percent devaluation, and in the 2.3-4.0 percent range for a 25 percent devaluation, as shown in the following table.

**Table 6: Output Prices (Index for Base, rest as % changes)**

| | *BASE* | *DEV10* | *DEV25* |
|---|---|---|---|
| Wheat | 1.0 | 1.1 | 3.1 |
| Rice – Irrigated | 1.0 | 1.3 | 3.7 |
| Rice – Basmati | 1.0 | 1.5 | 4.0 |
| Cotton | 1.0 | 1.2 | 3.6 |
| Sugarcane | 1.0 | 1.3 | 3.7 |
| Other field crops | 1.0 | 0.8 | 2.3 |
| Other agriculture | 1.0 | -1.1 | -2.4 |
| Other Manufacturing | 1.0 | -1.6 | -4.3 |
| Other Food | 1.0 | -0.4 | 0.1 |
| Wheat Milling | 1.0 | -0.4 | -0.3 |
| Rice Milling | 1.0 | 2.7 | 7.7 |
| Sugar Milling | 1.0 | 0.1 | 1.1 |
| Cotton Processing | 1.0 | 1.9 | 6.6 |

| | | | |
|---|---|---|---|
| Textiles | 1.0 | 1.2 | 3.4 |
| Chemicals | 1.0 | 0.9 | 2.0 |
| Fertilizer | 1.0 | 2.4 | 5.9 |
| Cement and Bricks | 1.0 | -10.6 | -23.4 |
| Energy | 1.0 | -0.7 | -1.7 |
| Construction | 1.0 | -5.6 | -14.0 |
| Trade | 1.0 | -2.2 | -6.3 |
| Transport | 1.0 | -0.1 | -0.4 |
| Other Services | 1.0 | 1.2 | 3.2 |

Source: CGE simulations

These changes in output prices lead to factor and production reallocation among sectors in favor of agricultural (tradable) production and against the production of services (Table 7). However, we find that changes in output prices are not enough to explain the changes in the allocation of production factors and, in turn, value added. As can be expected, while Pakistan producers consider output prices at the time of deciding factor demands, they also consider the prices of the intermediate goods they need for production. As input prices of agricultural goods rise, ceteris paribus, profitability of agro-processed commodities falls, and hence factors move out of sectors highly intensive in tradable inputs (e.g. wheat milling and sugar milling). In parallel, following the fall of the relative price of non-tradable commodities, production of non-tradable services (energy, construction) shrinks, with a significant fall in the construction sector which falls due to the reduction in investment generated by the fall in foreign and total savings associated with the improvement of the trade balance (explained below).

**Table 7: Value added (Billions of Pakistan rupees for base, rest in percentage changes)**

| | *BASE* | *DEV10* | *DEV25* |
|---|---|---|---|
| Wheat | 235.3 | 2.1 | 4.6 |
| Rice – Irrigated | 79.0 | 0.2 | 0.5 |
| Rice – Basmati | 71.5 | 0.2 | 0.5 |
| Cotton | 125.0 | 4.7 | 12.4 |
| Sugarcane | 93.0 | -0.1 | -0.1 |
| Other field crops | 161.0 | 0.0 | 0.0 |
| Other agriculture | 1,252.3 | -0.3 | -0.9 |
| Other Manufacturing | 952.7 | -2.3 | -6.6 |
| Other Food | 66.7 | -0.1 | 0.1 |
| Wheat Milling | 295.0 | -0.1 | -0.3 |
| Rice Milling | 419.7 | 0.3 | 0.8 |
| Sugar Milling | 83.2 | -0.1 | 0.1 |
| Cotton Processing | 140.3 | 5.6 | 14.7 |
| Textiles | 77.4 | 3.6 | 10.5 |
| Chemicals | 74.4 | 0.4 | 0.8 |
| Fertilizer | 34.6 | 1.6 | 4.0 |
| Cement and Bricks | 108.1 | -9.4 | -26.9 |
| Energy | 145.9 | -0.1 | -0.3 |
| Construction | 260.4 | -12.7 | -36.1 |
| Trade | 1,829.4 | -0.2 | -0.6 |
| Transport | 1,155.9 | -0.1 | -0.4 |
| Other Services | 2,260.6 | 2.0 | 4.7 |
| Total | 9,921.6 | -0.1 | -0.5 |

Source: CGE simulations.

As the real exchange rate devalues, exports increase in every exporting sector and the trade balance improves. With a 25% devaluation, the two of the largest export sectors, processed cotton and textiles, increase their exports by 19% and 36% respectively, and other agriculture exports increase by 47% (Table 8). As shown in Table 9, imports fall in almost every importing sector, with the surprising exception of processed cotton, which rises by 2% (10% devaluation) or by 7% (25% devaluation). This result is explained by bi-directional trade in the cotton-textile production chain: cotton is partly imported from abroad for subsequent use in the production of textiles and exports. When the economy receives a signal to increase its textile exports, it fulfills its input needs partly by producing more cotton domestically, but also partly by importing more cotton from other origins (e.g. China), eventually leading to an increase in cotton imports.

**Table 8: Exports (Base in Billions of Pakistan rupees, rest in percentage changes)**

| | *BASE* | *DEV10* | *DEV25* |
|---|---|---|---|
| Other agriculture | 24.5 | 18.2 | 47.2 |
| Other Manufacturing | 264.7 | 11.3 | 27.5 |
| Other Food | 25.5 | 11.9 | 29.2 |
| Wheat Milling | 0.4 | 11.4 | 27.9 |
| Rice Milling | 119.2 | 8.1 | 18.7 |
| Sugar Milling | 5.6 | 10.8 | 26.4 |
| Processed Cotton | 314.4 | 7.6 | 19.4 |
| Textiles | 248.6 | 13.6 | 36.2 |
| Chemicals | 31.5 | 10.4 | 26.1 |
| Transport | 223.3 | 11.1 | 28.0 |
| Other Services | 242.4 | 6.3 | 15.2 |

Source: CGE simulations.

**Table 9: Imports (Base in Billions of Pakistan rupees, rest in percentage changes)**

| | *BASE* | *DEV10* | *DEV25* |
|---|---|---|---|
| Wheat | 65.4 | -10.1 | -21.6 |
| Other field crops | 9.9 | -12.8 | -27.1 |
| Other agriculture | 7.9 | -15.6 | -33.0 |
| Other Manufacturing | 1,285.2 | -6.0 | -15.4 |
| Other Food | 139.1 | -3.9 | -8.8 |
| Sugar Milling | 0.7 | -10.7 | -23.0 |
| Processed Cotton | 95.1 | 2.4 | 7.2 |
| Textiles | 3.9 | -1.0 | -1.5 |
| Chemicals | 107.8 | -2.7 | -6.6 |
| Trade | 16.8 | -16.3 | -35.4 |
| Other Services | 528.7 | -11.4 | -24.7 |

Source: CGE simulations.

Given that land is generating its entire value added in tradable commodities, and that labor and capital contribute most of their value added to non-tradable services, the change in relative prices in favor of tradable produced goods translates into a change in relative wages that benefits land in detriment of labor and capital, as shown in the following table.

**Table 10: Real wages (Base as Index for land and labor and assumed rental rate for capital, rest in percentage changes)**

| | *BASE* | *DEV10* | *DEV25* |
|---|---|---|---|
| Labour | 1.0 | -1.3 | -2.3 |
| Land | 1.0 | 1.6 | 4.7 |
| Capital | 0.2 | -2.0 | -4.4 |

Source: CGE simulations.

The changes in factor wages translate into changes in household incomes reflecting the factor endowments of representative household groups in Pakistan. As shown in the following table, for both devaluations the distributional changes generated at the household level are generally marginal, with the exception of the urban poor, who enjoy an increase in their household income of 3.5% in the case of the largest devaluation.

**Table 11: Household incomes (Base in thousand rupees per capita per year, rest in percentage changes)**

| | *BASE* | *DEV10* | *DEV25* |
|---|---|---|---|
| Large and Medium Landlord Farmers | 236.4 | -0.3 | 1.3 |
| Small Landlords and Tenant Farmers | 63.2 | -0.3 | 0.4 |
| Waged Farmers | 46.7 | -0.3 | 0.1 |
| Non-Farm Poor (Quintile 1 and 2) | 37.1 | -0.1 | 0.9 |
| Non-Farm Non Poor | 64.1 | 0.1 | 1.4 |
| Urban Poor (Quintile 1 and 2) | 36.2 | 0.8 | 3.5 |
| Urban Non Poor | 152.9 | -0.6 | -0.8 |
| Total | 78.2 | -0.3 | 0.4 |

Source: CGE simulations.

## CONCLUSION

Global evidence found by Rodrik (2008) and evidence specific to Pakistan presented above suggest that undervalued exchange rates lead to periods of economic activity growth. However, our comparison of the observed real exchange rate of Pakistan against the equilibrium real exchange rate as based on a cointegration analysis of the real exchange rate shows that the Pakistan rupee has been overvalued during the last years by large margins, contrasting with the real exchange rates of rapidly growing economies like India and China, where large undervaluation is present. Our results add to the assessment of the IMF (IMF 2012) that the exchange rate has been overvalued, though their findings suggest a lower overvaluation of about 10 percent compared to our estimates.

After quantifying overvaluation in Pakistan – finding that the Pakistani rupee has been over-valued from 2006 to 2010 by on average 10 percent and as much as 25 percent in 2010 - , we simulate the long-run general equilibrium effects of re-aligning the real exchange rate with economic fundamentals. Realigning the exchange rate with economic fundamentals would lead to mobilization of production factors from the non-tradable to the tradable sectors, generating significant growth in sectors like cotton, cotton processing and textiles, and an increase in exports (and fall in imports) consistent with stated promotion goals of the government. Fortunately, this set of factor reallocations do not lead to significant adverse distributional implications, reinforcing the argument in favor of a devaluation in Pakistan.

At the time of writing this paper (second half of 2012), we find hopeful signs of the government of Pakistan going in the direction of a devalued currency, with the rupee depreciating by 13 percent[10] against the dollar during the year, in parallel to domestic CPI inflation of about 12 percent, and world CPI inflation of about 2.5 percent. Our analysis suggests that the government should continue along these lines, devaluing the nominal exchange rate while keeping domestic inflation under control in order to sustain a competitive real exchange rate that allows the country to enter into a high-growth trajectory.

[10] Exchange rate average of Rs. 85.19 per USD in 2010 compared with Rs. 96.00 per USD at the time of writing.

# REFERENCES


Bhalla, Surjet, 2012, “Devaluing to Prosperity. Misaligned Currencies and Their Growth Consequences”, Peterson Institute for International Economics, Washington D.C.

Bayoumi, Tamim, Jaewoo Lee, and Sarma Jayanthi, 2006, “New Rates for New Weights,” *Staff Papers,* International Monetary Fund, Vol. 53 (2).

Cheng, Fuzhi and David Orden, “Exchange Rate Alignment and Producer Support Estimates (PSEs) for India”, 2007, Agricultural Economics Vol. 36, pp. 233-243, International Association of Agricultural Economists.

Clark, P. MacDonald, R., 1998, “Exchange rates and economic fundamentals: A methodological comparison of BEERS and FEERS”, IMF Working Paper 98/67, Washington: International Monetary Fund.

Cottani, J., D. Cavallo and M. S. Khan, 1990, “Real Exchange Rate Behaviour and Economic Performance in LDC’s”, Economic Development and Cultural Change 39:1.

Debowicz, D, Paul Dorosh et al 2012, “A 2007-08 Social Accounting Matrix for Pakistan”, PSSP Working Paper No. 001, International Food Policy Research Institute.

Easterly, William, "National policies and economic growth" in Philippe Aghion and Steven Durlauf, editors, Handbook of Economic Growth, Elsevier, 2005.

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

Faruqee, Hamid, 1994, “Long-Run Determinants of the Real Exchange Rate: A Stock-Flow Equilibrium Approach,” IMF Working Paper 94/90, Washington: International Monetary Fund.

Hyder, Zulfiqar and Adil Mahboob, 2006, “Equilibrium Real Effective Exchange Rate and Exchange Rate Misalignment in Pakistan”, SBP-Research Bulletin Vol. 2 No. 1, State Bank of Pakistan.

IMF Research Department, 2006, “Methodology for CGER Exchange Rate Assessments”, Washington: International Monetary Fund. Accessed at http://www.imf.org/external/np/pp/eng/2006/110806.pdf on November 30, 2012.

IMF Staff Team, 2009, “Pakistan: 2009 Article IV Consultation and First Review Under the Stand-By Arrangement”, IMF Country Report No. 09/123, Washington: International Monetary Fund.

IMF Staff Team, 2012, “Pakistan: Staff Report for the 2011 Article IV Consultation and Proposal for Post-Program Monitoring”, IMF Country Report No. 12/35, Washington: International Monetary Fund.

Johansen, Soren, 1988, "Statistical Analysis of Cointegrating Vectors," *Journal of Economic Dynamics and Control,* Vol. 12, pp. 231-254.

Ministry of Finance, Government of Pakistan (2009). Pakistan Economic Survey 2008-09. Accessed at http://www.finance.gov.pk/survey_0809.html on November 30, 2012.

Planning Commission, Government of Pakistan (2011). Pakistan: Framework for Economic Growth. Accessed at http://www.pc.gov.pk/hot%20links/growth_document_english_version.pdf on November 30, 2012.

Isard, Peter, and Hamid Faruqee, eds., 1998, “Exchange Rate Assessment: Extensions of the Macroeconomic Balance Approach,” *Occasional Paper,* No. 167, International Monetary Fund.

Rodrik, Dani, 2008, “The Real Exchange Rate and Economic Growth,” Brookings Papers on Economic Activity, 2, pp. 365–412.

Stein, Jerome L., 1995, “The Fundamental Determinants of the Real Exchange Rate of the U.S. Dollar Relative to Other G-7 Currencies”, IMF Working Paper 95/81, International Monetary Fund.

Willenbockel, D., 2006, "Structural Effects of a Real Exchange Rate Revaluation in China: A CGE Assessment", Munich Personal RePEc Archive.

Williamson, John, 1985, “The Exchange Rate System”, Policy Analyses in International Economics, Vol. 5, Institute for International Economics.

Zanello, Allessandro, and Dominique Desruell, 1997, “Primer on the IMF’s Information Notice System,” IMF Working Paper 97/71, International Monetary Fund.

# ANNEX I: VARIABLE DEFINITIONS AND DATA SOURCES

## TRADING PARTNERS AND TRADE WEIGHTS

Weights for Pakistan's trading partners were calculated using trade data from the UNCTAD's UNCTADStat database for the years 2008-10. The calculated trade weights take into account third-market competition using the methodology of the IMF's Information Notice System as described in Zanello and Desruelle (1997) and Bayoumi, Lee and Jayanthi (1999).

Trade weights were calculated for 219 countries plus "other territories" and "world n.e.s." (n.e.s. stands for not elsewhere specified) as reported in the UNCTADStat database. The IMF's standard is to restrict the number of trading partners used to calculate the real effective exchange rate to those countries that had a weight greater than 1 percent. For Pakistan, this yielded 27 trading partners. However, data limitations forced us to restrict trading partners to just the G7 countries as a proxy for "rest of world", covering 37.8% of Pakistan trade. The calculated Real Effective Exchange Rate using only the G7 countries (described below) was compared with the IMF reported Real Effective Exchange Rate for Pakistan: the two have a 99.7% correlation.

The weights assigned to this truncated list of partners were then normalized to add to 1. The table below gives list (in order of importance) of Pakistan's trading partners and their weights in Pakistan's trade.

**Table 12: Pakistan's Trading Partners and Associated Trade Weights**

| No. | Trading Partner | Weight |
|---|---|---|
| 1. | China | 19.63 |
| 2. | Germany (G7) | 8.59 |
| 3. | United States (G7) | 8.34 |
| 4. | Japan(G7) | 7.01 |
| 5. | Uruguay | 5.10 |
| 6. | Italy (G7) | 4.32 |
| 7. | France (G7) | 4.16 |
| 8. | United Kingdom (G7) | 4.01 |
| 9. | India | 3.63 |
| 10. | Korea, Republic of | 3.26 |
| 11. | Netherlands | 2.95 |
| 12. | Saudi Arabia | 2.56 |
| 13. | Belgium | 2.38 |
| 14. | Thailand | 2.38 |
| 15. | Canada (G7) | 2.17 |
| 16. | Malaysia | 2.14 |
| 17. | Singapore | 1.79 |
| 18. | China, Taiwan Province of | 1.78 |
| 19. | United Arab Emirates | 1.74 |
| 20. | Spain | 1.68 |
| 21. | Indonesia | 1.66 |
| 22. | Switzerland | 1.64 |
| 23. | Australia | 1.46 |
| 24. | Brazil | 1.46 |
| 25. | Mexico | 1.46 |
| 26. | United Republic of Tanzania | 1.35 |
| 27. | Russian Federation | 1.32 |
| | **SUM** | **100.00** |

Source: Authors' estimates based on data from UNCTAD.

Using the IMF methodology; the weight assigned (by Pakistan) to each trading partner (*j*), is given by

$$W_j = \alpha(M).W_j(M) + \alpha(P).W_j(P)$$

Where $W_j(M)$ and $W_j(P)$ are weights based on trade in manufacturing and trade in primary commodities respectively. The parameters $\alpha(M)$ and $\alpha(P)$ are the shares of manufactures trade and primary commodity trade in Pakistan's total trade.

Primary commodities are disaggregated into 25 groups and each of these 25 commodities is assumed to be homogenous across countries. In contrast, manufactures are taken as a single composite commodity but assumed to be differentiated across countries. Trade in manufactures is then subject to third-market effects where an exporting country competes against other exporters of manufacturing in third markets. Thus, the manufacturing weight comprises an import component and an export component where the export component is further split into two components: one reflecting competition in the home market and the other reflecting competition in third markets.

## REAL EFFECTIVE EXCHANGE RATE FOR PAKISTAN 1990 TO 2010

Using the weights above, the (CPI-based) Real Effective Exchange Rate (REER) for Pakistan for the period 1990 to 2010 was calculated. REER is defined in terms of foreign currency units therefore an increase in REER is a real appreciation.

The REER for Pakistan is given by:

$$q = \prod_j \left(\frac{P.R}{P_j.R_j}\right)^{W_j}$$

where j is an index that runs over the 7 G7 trading partners, $W_j$ is the trade weight assigned to j from table 1 (normalized to add to 1 over the 7 countries), $P$ is the Consumer Price Index (CPI) in Pakistan, $P_j$ is the CPI in Country j, $R$ is the nominal exchange rate of the Pakistani Rupee in terms of dollars, $R_j$ is the nominal exchange rate of country j's currency in terms of dollars.

The source of data for CPIs and the nominal (bilateral) exchange rates for Pakistan and the 27 trading partners was the World Bank's WDI database, with the following exceptions: exchange rate for the euro since 1999 is as reported by the ECB. Exchange rates for euro countries for the years before 1999 were taken from Penn World Tables.

## OTHER VARIABLES

Data for Pakistan's stock of Net Foreign Assets (nfa) was obtained from the World Bank's WDI database. nfa is measured as a percentage of GDP (also from the WDI database).

Terms of Trade (tot) is the ratio of Pakistan's export price index to its import price index, and is measured relative to the equivalent foreign (trade weighted) ratio. For Pakistan and all G7 trade partners except France, tot data is obtained directly from the WDI database. For France, tot was calculated using trade values and trade volumes from the IMF's World Economic Outlook database.

The relative price of non-tradables to tradables (tnt) was proxied by the ratio of Pakistan's industrial (tradable) sector growth rate to the services (non-tradable) sector growth rate. This ratio is taken relative to the foreign (trade weighted) equivalent. Data for industrial and service sector growth rates were all obtained from the World Bank's WDI database.

Data for interest rates was obtained from the IMF's IFS database. The average annual interest rate on government bonds is the relevant rate used. The world interest rate (r*) is approximated as the trade weighted average interest rate of the United States, United Kingdom, France, Germany, Japan and Italy.

Pakistan's annual overall fiscal deficit measured as a percentage of GDP was obtained from various issues of the Pakistan Economic Survey.

# ANNEX II: THE CGE MODEL

## CONSUMER BEHAVIOR

Following general equilibrium theory, representative consumers (i.e., households) and producers in our model are treated as individual economic agents. Representative consumers maximize their welfare or utility subject to a budget constraint. We employ a Stone-Geary utility function in which the consumer problem can be represented mathematically as follows:

$$\underset{i}{\text{Max}}\, U_h = \prod_i (C_{hi} - \gamma_{hi})^{\beta_{hi}}$$

$$\text{subject to} \quad \sum_i (P_i \cdot C_{hi}) = (1 - s_h - ty_h) Y_h$$

Each representative household $h$ in the model has their own utility function, in which $C$ is the level of consumption of good $i$, $\gamma$ is a minimum subsistence level of consumption of good $i$, and $\beta$ is the households' marginal budget share (i.e., share of the next "dollar" of income spent on each type of good). Consumption-based utility is maximized subject to a budget constraint, in which $P$ is the market price of each good, $Y$ is total household income, and $s$ and $ty$ are marginal savings and direct income tax rates, respectively. Maximizing the above utility function generates the following set of demand functions:

$$C_{hi} = \gamma_{hi} + \beta_{hi} \left[ (1 - s_h - ty_h) Y_h - \sum_{i'} (P_{i'} \cdot \gamma_{hi'}) \right] P_i^{-1} \quad where\ i' = i \qquad (1)$$

This is the well-known Linear Expenditure System (LES) of demand.

## PRODUCER BEHAVIOR

Producers are defined at the sector level. Each representative producer maximizes profits subject to a given set of input and output prices. Following neoclassical theory, we assume constant returns to scale. Accordingly, a constant elasticity of substitution (CES) function is used to determine production:

$$X_i = \Lambda_i \left( \sum_f \alpha_{if} \cdot V_{if}^{-\rho_i} \right)^{-1/\rho_i} \qquad (2)$$

where $X$ is the output quantity of sector $i$, $\Lambda$ is a shift parameter reflecting total factor productivity (TFP), $V$ is the quantity demanded of each factor $f$ (i.e., land, labor and capital), and $\alpha$ is a share parameter of factor $f$ employed in the production of good $i$. The elasticity of substitution between factors $\sigma$ is a transformation of $\rho$ (i.e., $\sigma_i$=1/(1+$\rho_i$ ) ). Profits $\pi$ in each sector $i$ are defined as the difference between revenues and total factor payments:

$$\pi_i = PV_i \cdot X_i - \sum_f (W_f \cdot V_{if})$$

where $PV$ is the value-added component of the producer price, and $W$ is factor prices (e.g., labor wages and land rents). Maximizing sectoral profits subject to Equation 2 and rearranging the resulting first order condition provides the system of factor demand equations used in the model:

$$V_{if} = \Lambda_i^{-\frac{\rho_i}{1+\rho_i}} \cdot X_i \left( \alpha_{if} \cdot \frac{PV_i}{W_f} \right)^{1/(1+\rho_i)} \qquad (3)$$

Intermediate inputs are also used in the production process. In our model we assume Leontief technology when determining intermediate demand of individual goods and when combining aggregate factor and intermediate inputs. Thus, demand for intermediates is based on fixed input-output coefficients $io_{i,j}$ defining the quantity of good $j$ used in the production of one unit of good $i$. Thus, the complete producer price $PP$ is

$$PP_i = PV_i + \sum_{i'} P_{i'} io_{i'i} \quad (4)$$

## BEHAVIORAL FUNCTIONS GOVERNING INTERNATIONAL TRADE

Given observed two-way trade between countries for similar goods, we assume imperfect substitution between domestic goods and goods supplied to and from foreign markets. An Armington specification (i.e., CES function) (Armington, 1969) is used to define the relationship between domestically-produced and imported goods:

$$Q_i = \Omega_i \left[\mu_i \cdot D_i^{-\theta_i} + (1 + \mu_i) M_i^{-\theta_i}\right]^{-1/\theta_i} \quad (5)$$

$$(1 - tc_i) P_i \cdot Q_i = PD_i \cdot D_i + PM_i \cdot M_i \quad (6)$$

$$PM_i = (1 + tm_i)\ EXR\ pwm_i$$

where *tc* is an indirect sales tax, *Q* is the composite good consumed domestically, *D* and *M* are domestically supplied and imported quantities, and *PD* is the price of domestic good *D*. Import price *PM* is determined by world imports prices *pwm,* the exchange rate $EXR$ and import tariff rates *tm* under the small country assumption.

A constant elasticity of transformation (CET) function determines the relationship between the quantity of goods produced for domestic and foreign export markets:

$$X_i = \Gamma_i \left[\tau_i \cdot D_i^{\varphi_i} + (1 + \tau_i) E_i^{\varphi_i}\right]^{1/\varphi_i} \quad (7)$$

$$PP_i . X_i = PD_i \cdot D_i + PE_i \cdot E_i \quad (8)$$

$$PE_i = (1 - te_i)\ EXR\ pwe_i$$

where *E* is the quantity of good *i* that is exported, *te* is the export tax rate, and *pwe* is the exogenous world export price.

Maximizing $P_i Q_i - PD_i D_i - PM_i M_i$ subject to Equation 5 and rearranging the resulting first order condition gives the following equation defining the ratio of *D* and *M*:

$$\frac{D_i}{M_i} = \left(\frac{\mu_i}{1 - \mu_i} \cdot \frac{PM_i}{PD_i}\right)^{1/(1+\varphi_i)} \quad (9)$$

Similarly, minimizing $PP_i X_i - PD_i D_i - PE_i E_i$ subject to Equation 7 gives the ratio of *D* and *E*:

$$\frac{D_i}{E_i} = \left(\frac{\tau_i}{1 - \tau_i} \cdot \frac{PD_i}{PE_i}\right)^{1/(\varphi_i - 1)} \quad (10)$$

## EQUILIBRIUM CONDITIONS

With full employment and factor mobility across sectors, the following factor market equilibrium conditions holds:

$$\sum_i V_{if} = VS_f \quad (11)$$

where *VS* is fixed total factor supply. However, in the model physical capital is fully employed but immobile among sectors, which means that for this production factor there is a set of sector-specific market-clearing wages.

Assuming all factors are owned by households[11], household income *Y* is determined by

$$Y_h = \sum_{if} \delta_{hf}\left(1 - tf_f\right)W_f \cdot V_{if} + TR_{h,i\prime} \tag{12}$$

where δ is a coefficient matrix determining the distribution of factor earnings to individual households, *tf* is the direct tax on factor earnings (e.g., corporate taxes imposed on capital profits), and $TR$ are net transfers received by household groups from other institutions.

Finally, commodity market equilibrium requires that the composite supply of each good *Q* equals total demand, as shown below:

$$Q_i = \sum_h C_{ih} + N_i + G_i + \sum_{i'} (io_{i'i} \cdot X_i) \tag{13}$$

where *N* is investment demand and *G* is government recurrent consumption spending.

The relationship between savings and investment demand *N*, and taxes and government spending *G*, will be specified below. However, in the absence of taxes or savings (i.e., when *ty*, *tf*, *s*, *N* and *G* are all zero), the above 13 equations simultaneously solve for the values of the 13 endogenous variables (i.e., *Y*, *C*, *X*, *V*, *Q*, *D*, *M*, *E*, *P*, *PV*, *PP*, *PD* and *W*). The general equilibrium solution defined by the equations only holds if there are no foreign transfers – implicitly a zero trade balance. This assumption is often made in simple theoretical general equilibrium models, but it is rarely used in CGE models, which need to be calibrated to observed data for a country. Later we will introduce foreign transfers and current account imbalances. Before doing this, however, we first define government *G* and investment demand *N*.

## GOVERNMENT AND INVESTMENT DEMAND

The government is treated as a separate agent with income and expenditures, but without any behavioral functions. Total domestic revenues *R* is the summation of all individual taxes:

$$R = \sum_i (tc_i \cdot P_i \cdot Q_i + tm_i \cdot pwm_i \cdot M_i + te_i \cdot pwe_i \cdot E_i) + \sum_h (ty_h \cdot Y_h) + \sum_{if} \left(tf_f \cdot W_f \cdot V_{if}\right) \tag{14}$$

Tax rates are typically exogenous in a CGE model so that they can be used to simulate policy changes. The government may also receive income from abroad, such as via foreign grants/borrowing and from holding assets. These additional income sources will be discussed below when we introduce our macroeconomic closure.

The government uses its revenues to purchase goods and services (i.e., recurrent consumption spending), to transfer to other economic agents, and to save (i.e., finance public capital investment), as shown below

$$R = \sum_i (P_i \cdot G_i) + FB + TR_{i\prime,G} \tag{15}$$

where *G* is consumption spending from Equation 13, $TR_{i\prime,G}$ are government net transfers to other institutions, and *FB* is the recurrent fiscal surplus (or deficit if negative). We assume that *G* is determined exogenously, implying that an increase in government revenues causes the fiscal surplus to expand (or deficit to contract). In reality, the government also makes transfers to (and receives incomes from) households and firms (e.g., social grants and contributions).

[11] In reality, part of factor incomes, e.g., the return to capital, can be owned by the government or foreign institutions. While this is allowed in the model that we actually implement, at this stage we ignore non-household factor ownership in order to simplify our discussion.

There is also no behavioral function determining the level of investment demand for goods and services (i.e., *N* from Equation 13). The total value of all investment spending must equal the total amount of investible funds *I* in the economy. We therefore assume that value of *N* for each good *i* is in fixed proportion to the total value of investment, as seen below

$$I \cdot \varepsilon_i = P_i \cdot N_i \tag{16}$$

where *ε* is the value share for each good *i*, and *P* is the market price determined by the equilibrium condition in Equation 13.To determine the value of *I* we must define our macroeconomic closure.

## CURRENT ACCOUNT AND MACROECONOMIC CLOSURE

A CGE model is an empirical tool based on neoclassical general equilibrium theory in which there is no room for current account imbalances. However, CGE models are often calibrated to observed data for a country. Hence, Walras Law no longer holds unless we introduce real financial flows into the model, such as incomes from holding foreign assets or the government's foreign borrowing. Current account imbalances must be accounted for since they affect the real side of the economy via the relationship between exports and imports, and between savings and investment. We start from the well-known identity linking a country's current account balance *CA* to national savings *S* and investment *I*:

$$CA = \sum_i (pwe_i \cdot E_i) - \sum_i (pwm_i \cdot M_i) - NFI = S - I = \Delta NFA \tag{17}$$

The left-hand-side of the identity states that a country's current account balance is equal to its trade balance (export minus import value) less net foreign incomes *NFI*, including transfers from non-residents to non-residents (and viceversa), and net factor payments to non-residents. A country is therefore running a current account surplus whenever the difference between its trade balance and *NFI* is positive, in which case national savings exceed national investment and there is an accumulation of net foreign assets *NFA*. Total savings in the economy is the sum of all household savings and the government's recurrent fiscal balance, as shown below

$$S = \sum_h (s_h \cdot Y_h) + FB \tag{18}$$

Macroeconomic balance in a CGE model is determined exogenously by a series of "closure rules", the first of which is the current account balance. While this is a substantive research topic within macroeconomics, it is treated as an exogenous variable within our single-country open economy CGE model. For example, one area of macroeconomics focuses on the dynamics of exports and imports, and explains how growth in *total* exports is the result of export-led growth strategies and undervalued exchange rates (see, for example, Mann, 2002). In the same vein, it is possible to introduce a nominal exchange rate into a CGE model to act as a numeraire to convert international prices measured in foreign currency (e.g., dollars) into domestic currency units. However, the nominal exchange rate is unlikely to be chosen as a policy instrument to determine trade patterns. Instead, as discussed above, the behavioral function determining trade flows in the CGE model is at the sector-level (see Equations 5-8), and the focus of the model is on the structure of exports and imports, rather than their totals.

*CA* may not be equal to *NFI* if there is a trade surplus/deficit observed in the country's data. When *CA* is greater (less) than *NFI*, the country runs a trade surplus (deficit) and total exports are greater (less) than total imports plus *NFI*. For the external account, our closure rule is to treat *CA* as an exogenous variable, thus controlling its effect on the macroeconomic behavior of the model.

Our second closure rule concerns the identity on the right-hand-side of Equation 17. By fixing *CA* we are also fixing the value of *ΔNFA*, which means that either total savings *S* or total investment *I* (but not both) should be determined exogenously. We call this choice the "savings-investment" closure, which is a term borrowed from macroeconomics. If the CGE model is "savings-driven" then *I* is automatically determined by the level of total available savings (i.e., $I = S - \Delta NFA$). We choose an "investment-driven" closure: total investment *I* would is exogenously set in proportion to a macroeconomic indicator (domestic absorption), and total savings is made endogenous by allowing marginal savings rates *s* to adjust proportionally for all households.

Finally, our treatment of the government balance in Equation 15′ is in fact the third closure rule in the model. We chose to make recurrent consumption spending *G* and fiscal saving exogenous, and allow the income tax rates to adjust accordingly.

Through our introduction of the government, investment demand and macroeconomic closures we have included five new equations into the model (Equations 14-18) and five new endogenous variables (*R*, *FB*, *N*, *I* and *S*).[12] Together, the 18 equations and variables describe a static single-country model. Our current account closure fixes the national trade balance. The government closure implies that changes in revenues alter the fiscal balance (and hence public investment) rather than recurrent spending. Finally, in our savings-driven closure, total investment adjusts to the level of total savings.

The parameters of the model were calibrated in the light of the SAM specially prepared for this project, trade and consumption elasticities from previous CGE analysis for World Bank project regarding the effect of climate change in Pakistan.

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