10.31384/jisrmsse/2021.19.1.9

Determining The Real Exchange Rate Equilibrium for Pakistan

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ABSTRACT:
The achievement of macroeconomic stability and sustained economic growth are the main targets of macroeconomic agents and policymakers. High volatility in Real Effective Exchange Rate (REER) is noticed while moving towards flexible Exchange rate regime. Three assessment methodologies are followed in the paper i.e., PPP approach, PPP approach adjusted for Penn effect and reduced form equation approach to gauge REER misalignment. VAR modelling suggest that, PPP holds for Pakistan and Penn effect is witnessed in the country for FY1980-FY2018. The determinants of REER, like "openness to GDP ratio, Govt consumption to GDP ratio, Long term Investment to GDP ratio, relative productivity and terms of trade" are responsible for depreciation in REER. While, worker remittances and FDI leads towards the REER appreciation in. It is indispensable to opt for the devaluation of PKR to gain export competitiveness, which may result in shrinkage of current account deficit. To increase the productivity of tradable items and to reduce the GOVT consumption of imported items are few steps to push REER towards equilibrium level. As per the state of art model the range of misalignment in REER is from -3.9% to 4.2% in Pakistan.

JEL Classification: *E44, F31, O24*

Keywords: *Real exchange rate, Equilibrium, Misalignment, Determinants, Methodologies*

INTRODUCTION

The central banks usually intervene in the foreign exchange market (FOREX) to handle the exchange rate volatility and to bring stability in exchange rate for achieving the macroeconomic goals like sustainable economic growth and shrinkage of current account deficit (Rodrick, 2008). Pakistan experienced greater volatility while moving from fixed exchange rate regime to floating exchange rate regime (Hussain & Jalil, 2007. Moreover, fluctuations in REER have severely affected various macroeconomic variables and financial indicators of the country such as inflation, external balances and equity prices (Hamid & Mir, 2017). Thus, it is imperative to find the equilibrium path of REER. When REER being an index of exports competitiveness of domestic currency against trading partners, is persistently away from its equilibrium level, a misalignment may be witnessed, which requires an empirical investigation due to various reasons (Isard, 2007). On one side, REER's examination is essential due to resource allocation in production and spending in an economy. On the other side, the REER is considered as measurement of competitiveness of exports of domestic country against its foreign competitor's currency (Hamid & Mir, 2017). Literature also shows that, REER misalignment may be an

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indicator of currency crises (Tipoy, Breitenbach, & Multau, 2016). The International Monetary Fund (IMF) encourages especially the developing and emerging economies to keep the REER closer to its equilibrium path. There are almost fourteen assessment methodologies in literature for this purpose (Saayman, 2010). It is suggested to use more than one methodology for better understanding of REER misalignment.

According to assessment methodologies proposed by IMF, equilibrium exchange rate calculation is a challenging task due to the fact that, different methodologies use different fundamentals, different approaches, different econometric models and data with different frequencies, which is likely to result into different equilibrium values for REER. Khalid (2015) came up with her investigation that, the equilibrium exchange rate depends on time, and under/over valuation is a concept of subjectivity, the author further added in her writings. Moreover, the estimates of disequilibria of PKR are not statistically robust and exchange rate is time variant phenomenon (Tipoy et al., 2016).

REER fluctuations are the hindrance in achieving success in macroeconomic policies like stabilizing the economic growth of country (Tipoy et al., 2016). The policy makers are interested to know about the factors/forces/fundamentals, which are responsible for fluctuations in REER. It is indispensable to find the equilibrium real exchange rate for Pakistan being a developing country (Siregar, 2011). That mostly relies on worker's remittances and exports, and facing the problem of widening current account deficit (Siregar, 2011). The REER appreciation shows the loss of competitiveness of exports compared to its trading partners resulting in widening of current account deficit (Voica et al., 2020). On the other hand, if REER depreciates, the competiveness of exports increases and current account deficit squeezes. Thus, it is important to know about the REER equilibrium level, the magnitude of misalignment and determinants of REER. For this purpose, IMF proposed six methods of assessment of REER misalignment (Isard, 2007). These assessment models are (1) Purchasing Power Parity assessment model, (2) PPP adjusted for Penn effect (adjusted for Balassa –Samuelson effect) assessment model, (3) The Macroeconomic Balance (MB) assessment model, (4) Competitiveness of the tradable goods model, (5) Estimated Exchange rate equations approach (reduced form equation approach) and (6) General equilibrium model approach.

The objective of this paper is to find the equilibrium path of REER for Pakistan by using the three equilibrium assessment models proposed by IMF. These assessment models are PPP approach, PPP adjusted for Penn effect approach and reduced form equation approach. Specifically, an attempt is made to find the REER misalignment for Pakistan and macroeconomic determinants responsible for it. This paper finds its place in research due to paramount significance of REER misalignment. In fact, the stable exchange rate contributes in attracting foreign direct investment, helps in improving the terms of trade, exports, imports, current accounts, worker remittances, and confidence of expatriates in the domestic economy. a revisit by considering more variables and latest regime and full available datasets is beneficial in this regard (Zorzi, Cap, Mijakovic and Rubaszek, 2020). The figure 1 shows greater volatility in daily nominal exchange rate motivating the researchers to work on it.

(Source: SBP, Daily data on Rs/$ shows drastic increase particularly in 2019. PKR drastically depreciated against $)

Figure 1: *Daily Movement of PKR against USD (Rs/$),*

Hence, this paper contributes in research by finding the sources of misalignment and the determination of equilibrium path of REER for Pakistan by using the selected assessment models proposed by IMF after inclusion of recent data/Information from secondary published national and International sources such as SBP publications and International Financial Statistics (IFS), an online data repository of IMF.

LITERATURE REVIEW

Wang (2020) examines the Chinese currency (yuan) in managed-floating-exchange-rate-regime by taking the monthly data from 2005 - 2019. He make use of three assessment approaches and concludes that, the price of yuan is correctly determined and its value is closer to its equilibrium path according to three different approaches. He further adds that, the USA's blame of currency manipulation is not supported empirically. Furthermore, the appreciation of exchange rate of china will not reduce the trade deficit of USA with the country that is China. After the application of fixed-effect-model in panel framework for ten advanced economies, Zorzi, Cap, Mijakovic and Rubaszek (2020) has estimated the equilibrium real exchange rate through purchasing power parity approach, Behavioral equilibrium exchange rate approach and macro- balance approach to identify the prediction power of these models. After doing the comparative analysis, they conclude that, the PPP- based model has more prediction power while having less economic depth but provides better forecast than BEER model. On the other hand, the MB model has attractive interpretation from economic point of view but poor in out of sample forecasting for REER. They finally supplement that, changing the variable's definitions or assumptions in MB model are not very helpful in improving their power of predictability of misalignment in REER (Zorzi et al., 2020).

Dunaway, Leigh and Li (2009) estimate the equilibrium REER for China by using MB approach and extended PPP assessment approach by using panel data from 1980 to 2002. They conclude that, large differences in the estimates of real exchange rates calculated and minor changes in the variables definitions, model specification and data duration cause drastic changes in the

estimates for equilibrium REER. The China's currency is under -valued by 24%. According to Hussain (2009), Pak rupee is over- valued in Pakistan because of capital inflows and public expenditures for period 1960 -2007. He concludes that, more exports of manufactured items rather than primary goods are required to become closer to the real exchange rate equilibrium. Isard (2007) describes and applies four assessment approaches on USA economy and comes up with the findings that, as per PPP approach, the Dollar is align with the equilibrium exchange rate for the time 1980-2006. Using cross-sectional data for 2006 the PPP adjusted approach also confirms the results from previous approach showing that, the dollar is 5% above the equilibrium exchange rate. The Macroeconomic balance approach is revealing that, the REER rate is over-valued by 25% for the annual data 1970-2006. Bayoumi, Faruqee and Lee (2005) develop theory-based model for equilibrium exchange rate by including ten industrial economies over the medium term from 1980 to 2001. They are of the conclusion that, foreign and domestic traded items (manufactured) are not perfect substitutes; therefore, they depend on relative supply of these items and the determinants of current accounts. Using the technique of panel DOLS estimation, they show that, the speed of convergence of exchange rate depends on the size of its misalignment. Feyzioglu (1997) observes that, the REER for Finland is highly volatile among the European Union countries. It has appreciated by 15% in 1986, depreciated by 30% and then appreciated by 20% in 1993. Using quarterly data from 1975-1995 and reduced form equation approach, they reveal that, REER appreciates with the positive shocks TOT, productivity differentials between Finland and its trading countries.

METHODOLOGY

Methodology of three approaches is given in detail in the following sub-section.

Methodology for PPP approach to gauge misalignment

It is considered as diagnostic approach and a standard against which the misalignment of exchange rate is measured (Qayyum, Khan & Zaman, 2004). The purchasing power parity hypothesis states that to achieve the equilibrium in the international commodity market for open economies, the nominal exchange rates adjusts for price level differential in two trading countries based on its assumptions. According to PPP approach, the exchange rate may be away from its PPP level due to some reasons like trade restrictions and constrained factor mobility, speculations and Central bank interventions in FOREX, productivity differences within the home country, prices stickiness, and real shocks to real exchange rate and productivity differential among the trading partners.

A theoretical model for PPP hypothesis

The PPP approach states that the domestic price of good is equal to the nominal exchange rate multiplied by the foreign price of good. Symbolically,

$$P_i^d = E^n P_i^f \quad \text{----------} \quad (1)$$

Where,

P_i^d *is the price of commodity in PKR*

E^n *is the nominal exchange rate in Pakistan and USA expressed as PKR/$*

P_i^f *is the foreign price of commodity in $*

When eq-1 is aggregated for all commodities, the expression for absolute PPP is below

$$P_t^d = E_t^n P_t^f \text{ ---------- (2)}$$

Where,

P_t^d is the price level in Pakistan expressed in domestic currency i.e. PKR

E_t^n is the nominal exchange rate in Pakistan and USA expressed as PKR/$

P_t^f is the price level in USA expressed in foreign currency i.e. $

Practically speaking the transportation cost and different tariffs create a price differential among countries, but they are kept constant under PPP approach and denoted by constant α. The absolute PPP is:

$$P_t^d = \alpha \ (E^n P^f)_t \text{ ---------- (3)}$$

After taking natural log on both sides of eq-3,

$$p_t^d = \alpha_0 + e_t + p_t^f \text{ ---------- (4)}$$

Eq-4 is re-arranged as below:

$$e_t = \alpha_0 + (p_t^d - p_t^f)_t + \mu_t \text{ ---------- (5)}$$

Eq-5 states that the price of identical market basket of commodities in both countries will be same because its difference adjusts through arbitrage. Now the econometric equation for this version of PPP is as below:

$$e_t = \alpha_0 + \alpha_1 (p_t^d - p_t^f)_t + \mu_t \text{ ---------- (6)}$$

α_0 is the natural log of nominal exchange rate in base year. It is essential to include this term because it captures the components, which are responsible for price differential in Pakistan and USA, like tariffs, transportation cost and inclusion of price indices in the model.

The existence of PPP approach in the long- run requires that the restrictions hold. In addition, and will not be rejected. For equilibrium relationship, the nominal exchange rates are co-integrated with relative prices.

Econometric methodology 1

As per literature, review and IMF sources the included variables are nominal exchange rate (er) and consumer price index for Pakistan and USA (Isard, 2007). The monthly data on variables is taken from International financial statistics considering FY1972-FY2019. The stationarity of included variables is checked through ADF (augmented Dickey Fuller) test. The results show that the variables are non-stationary at levels and log levels, while their log first differences are stationary. The natural logs have taken of CPI for Pakistan, CPI for USA and nominal exchange rate abbreviated as lppak, lpusa and ler respectively. The difference in lppak and lpusa, is called the variable "diff". The variables ler and diff both are I (1). The Johansen multivariate co-integration technique (1988) is used to test the co-integrating relationship in ler and diff. The econometric model is as below:

$$ler_t = \alpha_o + \alpha_1 (lppak - lpusa)_t + \mu_t \text{----------} \quad (7)$$

$$ler_t = \alpha_o + \alpha_1 (diff)_t + \mu_t \text{----------} \quad (8)$$

To carry out the process of VAR, the lag length selection is based upon AIC (Akaike information criterion), SIC (Schwarz information criterion) and HQ (Hannan-Quinn information criterion). These tests are in the favor of VAR (2). The test of Johanson co-integration is confirming one co-integration relationship. The results of unrestricted VAR are summarized as below:

Table 1:

Co-Integrating Results for PPP Hypothesis at Lag 2 With Variables

Co-integration Rank Test	Relationship	Prob Value	Interpretation
Trace test	r = 1	Prob=0.5706	1 co-integrating eqn(s) at the 0.05 level
Maximum Eigen value	r = 1	Prob =0.5706	1 co-integrating eqn(s) at the 0.05 level

The unrestricted VAR model witnesses the weak form of existence of PPP hypothesis for the said period. The I(1) variables has produced I(1) residuals. Thus, the model is stable with two lags as evidenced through unit circle for residuals lying inside the unit circle. To check the strong form of presence of PPP hypothesis, the restricted VAR in E-views is applied and restrictions are imposed on coefficients vector that is $\alpha_0 = 0 \; and \; \alpha_1 = 1$. *The VECM results are presented in table 2.*

Table 2

Restricted VAR results for validation of PPP in the long run

Co-integration Restrictions	Likelihood ration test	Prob Values	Interpretation
Co-integration Restrictions: B(1,2)=1, B(1,3)=0	χ^2 = 0.490786	Probability=0.483577	According to LR test the restrictions are not rejected at 5% (PPP holds in long run)
Co-integrating coefficient= -0.0011	t- value=[-2.87578]	Rule of thumb(t-value ≥ 2)	Negative and significant

Note: The imposed restrictions on coefficient vector are statistically insignificant which states that PPP hypothesis is witnessed in Pakistan. It is confirmed, that there exists a long run relationship in nominal exchange rate and the price levels of Pakistan and USA. The speed of adjustment is negative and significant, which indicates that both the variables move together to adjust for equilibrium but very slowly. The exchange rate adjusts to the difference in the Pak Inflation and USA Inflation.

The speed of adjustment of REER estimated through PPP approach is very slow toward equilibrium. It is line up with the findings of Rogoff (1996), who suggests that PPP based exchange rate equilibrium is not suitable to find misalignment in REER due to its very slow mean reversion property. The misalignment in nominal exchange rate is calculated as the difference between the nominal exchange rate (*ler*) and the PPP level of exchange rate (*ler*). The positive differences show the appreciated exchange rate while the negative differences show the depreciated exchange rate.

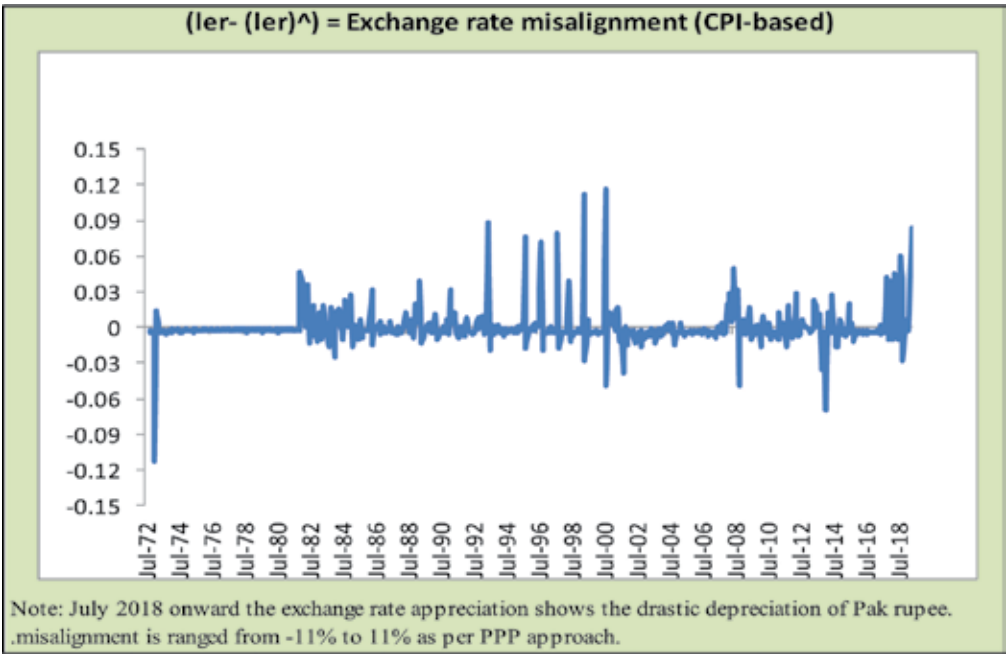

Figure 2: *Exchange Rate Misalignment (Model 8)*

Methodology for PPP adjusted for Penn (Balassa- Samuelson) effect to gauge misalignment

The concept of Penn effect (a modified approach of PPP hypothesis) is associated with Harrod (1939), and linked to Ricardo (1821). Paul A Samuelson witnesses this effect in 1964. In addition, found by Professor Bela Balassa (1964) from Yale (Isard, 2007). According to Samuelson (1964), the Penn effect states that, the relative prices of Non-tradable to prices of tradable (= $\frac{price_{Nontradables}}{price_{Tradables}}$) is higher in high-income countries and lower in low-income countries.

A theoretical model for PPP adjusted for Penn (Balassa- Samuelson) effect

According to Penn effect, an increase in real income of economy leads to increase the productivity in tradable sector faster than in non-tradable sector. Within the country, the labors are earning same wage. The increasing productivity in tradable sector causes to increase the relative cost of production in non-tradable sector and the relative price of non-tradable rises. It assumes that, the prices of tradable are same across countries and determined internationally. It further states, that the exchange rate appreciates for high-income countries and depreciates for low income countries considering all other factors as given (Samuelson, 1964). The REER may be away from EREER due to productivity differential.

Theoretically, it assumes that, the domestic country is a small open economy having tradable sector and non-tradable sector. The one price law is applicable to tradable sector assumed as similar, because it is determined internationally ($P_T^d = P_T^f$) It further assume that, domestic country has labor market equilibrium. Therefore, the wage rate in tradable sector and non-tradable sector is same and denoted by. Let the "marginal productivity of labor in tradable

sector" and "marginal productivity of labor in non-tradable sector" is represented by and respectively. The relative price of tradable sector to non-tradable sector for domestic country is illustrated as below:

$$\frac{P_N^d}{P_T^d} = \frac{{W^d}/{MPL_N^d}}{{W^d}/{MPL_T^d}} = \frac{MPL_T^d}{MPL_N^d} = \omega^{\mathrm{d}} \text{----------} \quad (9)$$

ω^{d} is the domestic relative productivity of tradable sector to non-tradable sector. The share of tradable sector and non-tradable sector is and respectively. The domestic price in composite form (is as below:

$$Y^d = (P_T^d)^{\alpha}(P_N^d)^{1-\alpha} \text{----------} \quad (10)$$

$$Y^d = \left(\frac{P_N^d}{P_T^d}\right)^{1-\alpha}(P_T^d) \text{----------} \quad (11)$$

Making use of eq-9 in eq-11, we get,

$$Y^d = \left(\omega^{\mathrm{d}}\right)^{1-\alpha}(P_T^d) \text{----------} \quad (12)$$

Eq-12 represents the domestic composite price.

Now to get the international composite price the above four equations are repeated for the foreign country,

$$\frac{P_N^f}{P_T^f} = \frac{{W^f}/{MPL_N^f}}{{W^f}/{MPL_T^f}} = \frac{MPL_T^f}{MPL_N^f} = \omega^{\mathrm{f}} \text{----------} \quad (13)$$

ω^{d} is the foreign relative productivity of tradable sector to non-tradable sector, The share of tradable sector and non-tradable sector is and respectively. The foreign price in composite form (is as below:

$$Y^f = \left(P_T^f\right)^{\alpha}\left(P_N^f\right)^{1-\alpha} \text{----------} \quad (14)$$

$$Y^f = \left(\frac{P_N^f}{P_T^f}\right)^{1-\alpha}\left(P_T^f\right) \text{----------} \quad (15)$$

Making use of eq-13 in eq-15, we get,

$$Y^f = \left(\omega^{\mathrm{f}}\right)^{1-\alpha}\left(P_T^f\right) \text{----------} \quad (16)$$

Eq-16 represents the foreign composite price.

Now using the assumption that, the real exchange rate (RER) for domestic country is derived as below:

$$RER = \frac{Y^d}{Y^f} = \frac{(\omega^d)^{1-\alpha}\left(P_T^d\right)}{(\omega^f)^{1-\alpha}\left(P_T^f\right)} = \frac{(\omega^d)^{1-\alpha}}{(\omega^f)^{1-\alpha}} = \left(\frac{\omega^d}{\omega^f}\right)^{1-\alpha} \text{-------} \quad (17)$$

Eq-17 shows that ω^d is the domestic relative productivity of tradable sector to non-tradable sector. While ω^d is the foreign relative productivity. Hence, this equation demonstrates that the real exchange rate appreciates for productivity growth in domestic country.

The relative productivity (RP) variable is taken to capture the Penn effect. Hence, a typical one- country-equation is stated below:

$$log(REER)_t = \alpha_o + \alpha_1 log(\text{RP})_t + \alpha_2(NFAGDP)_t + \alpha_3(Adnl)_t + \varepsilon_t \text{--------} \quad (18)$$

Where,

REER is the "real effective exchange rate index" for domestic economy

RP is the "relative productivity" of domestic country to the foreign country. The data on this variable is not easily available for all countries. Usually for developing countries, some proxies are used in literature. The relative productivity is mostly proxy by "the ratio of $\left({}^{CPI}/_{PPI}\right)$ of domestic country to $\left({}^{CPI}/_{PPI}\right)$ of foreign country". The concept behind this ratio is indicating that, the CPI is consumption based connected with non-tradable items and PPI is based on tradable items, hence providing a closed proxy to relative productivity (Wang, 2004). It can also be proxy by "the ratio of GDP per worker in domestic country to GDP per worker in foreign country", due to the fact that the former proxy did work well for China (Lee *et al.* 2008). Rodrik (2008) is using real GDP per capita as proxy for productivity for developing countries. Theory suggests that this variable is required to be significant in relation with REER to capture the presence of Penn effect. According to Balassa effect, the productivity usually occurs in tradable sector, which leads to increase the inflows to home country and real income rises in the home country that induces demand for non-tradable items hence $\frac{P_N^d}{P_T^d}$ rises. When it rises faster in the foreign country, the relative productivity become negative, that has adverse impact on REER, and insures the presence of Penn effect. In other words REER appreciates (depreciate) if productivity growth take place in domestic country (foreign country).

NFAGDP Is the "Net Foreign assets (NFA) ratio" of domestic country to suitable scalar. As per empirical evidences, Wang (2004) suggests to measure it by the ratio ${}^{NFA}/_{GDP}$.

Adnl involves additional related variables used in analysis, like TOT (terms of trade), Openness (the ratio of trade to GDP) etc.

is the error term of theoretical econometric model.

Econometric methodology 2

The following two econometric models are estimated. As per literature, equation # (19) is used to determine the significance of Penn effect in Pakistan. The terms of trade are also included to observe that whether its inclusion is contributing to change the magnitude of Penn effect through equation #20.

$$log(REER)_t = \alpha_o + \alpha_1 log(\text{RP})_t + \alpha_2(NFAGDP)_t + \varepsilon_t \text{----------} \quad (19)$$

$$log(REER)_t = \alpha_o + \alpha_1 log(\text{RP})_t + \alpha_2(NFAGDP)_t + \alpha_3(ltot)_t + \varepsilon_t \text{--------} \quad (20)$$

Where, the variables are real effective exchange rate, relative productivity, net foreign assets to GDP ratio and terms of trade. The stationarity of included variables are checked through the Augmented Dickey Fuller test and the results show that the variables are I (1) in levels but I (0) in log-first difference and confirming the long run relationship. The maximum likelihood test of Johansson co-integration is used to estimate the long run parameters and equilibrium relationship along with the speed of adjustment towards equilibrium. The lag length selection of order one is based on *AIC* and *BIC* criterion

The two models are estimated to test for the validation of Penn effect presence in Pakistan. It is observed that, the relative productivity (rp) variable is significant contributor for the fluctuations in real effective exchange rate. The estimated results of multivariate- maximum-likelihood test of Johansson co-integration, long run coefficients of variables and speed of adjustment is extracted from co-integrating vector and listed in following table.

Table 3:
Significance of long run coefficients in VAR model

Procedure	equation # 19 dependent variable=lreer	equation # 20 dependent variable=lreer
Models	$\alpha_o + \alpha_1 log(\text{RP})_t + \alpha_2(NFAGDP)_t$	$\alpha_o + \alpha_1 log(\text{RP})_t + \alpha_2(NFAGDP)_t + \alpha_3(ltot)_t$
Lag length	As per criterion selected at one	As per criterion selected at one
No. of co-integrating vectors is one	$H_0 : r = 0 \; vs \; H_1 : r = at\ most\ 1$ Trace statistics=39.74 (prob=0.0026)*	$H_0 : r = 0 \; vs \; H_1 : r = at\ most\ 1$ Trace statistics=56.96 (prob=0.0271)*
	Max-Eigen Statistics=24.28 (prob=0.017)*	Max-Eigen Statistics=29.11 prob=0.0429)*
Short run coefficients in VECM vector	$D(lreer)_{-1} = 0.08 \ (t = 0.46)$ $D(lrp)_{-1} = -0.34 \ (t = -0.75)$ $D(NFAGDP)_{-1} = 0.006 \ (t = 1.16)$	$D(lreer)_{-1} = 0.13 \ (t = 0.74)$ $D(lrp)_{-1} = -0.43 \ (t = -0.90)$ $D(NFAGDP)_{-1} = 0.006 \ (t = 1.19)$ $D(ltot)_{-1} = 0.020 \ (t = -0.16)$
Long run coefficients VECM vector	$(lreer)_{-1} = 1.000$ $(lrp)_{-1} = -37.51 \ (t = -4.61)^*$ $(NFAGDP)_{-1} = -0.47 \ (t = -4.51)^*$	$(lreer)_{-1} = 1.000$ $(lrp)_{-1} = -1.971 \ (t = -5.12)^*$ $(NFAGDP)_{-1} = -2.08 \ (t = -3.71)^*$ $(ltot)_{-1} = -0.33 \ (t = -0.05)$

Speed of adjustment	$coineq = -0.011 \quad (t = -2.19)^{*}$	$coineq = -0.02 \quad (t = -2.08)^{*}$
No serial correlation in error terms	LM test=6.79 $(prob = 0.66)$	LM test=24.08 $(prob = 0.09)$
No hetero-scadasticity in error terms	$\chi^2 = 54.689 \quad (prob = 0.236)$	$\chi^2 = 104.91 \quad (prob = 0.349)$
Residuals are stationary	$jarque\ Bera\ sttiatic = 2.56$ $(prob = 0.27)$	$jarque\ Bera\ sttiatic = 1.79$ $(prob = 0.41)$
The model is stable	Inverse roots of AR characteristics polynomial lies inside the unit root circle	Inverse roots of AR characteristics polynomial lies inside the unit root circle

The two equilibrium correction models having the long-run coefficients and speed of adjustment are given below:

$$\Delta(lreer_t) = -0.011[(lreel_{t-1}) - 37.51(lrp_{t-1}) - 0.47(NFAGDP_{t-1}) + 22.38] + 0.08\Delta(lreer)_{t-1} - 0.34\Delta(lrp)_{t-1} + 0.01\Delta(NFAGDP)_{t-1} - 0.02 \text{---------- (21)}$$

$$\Delta(lreel_t) = -0.020[(lreel_{t-1}) - 197.09(lrp_{t-1}) - 0.33(ltot_{t-1}) - 2.08(NFAGDP_{t-1}) + 141.95] + 0.13\Delta(lreer)_{t-1} - 0.43\Delta(lrp)_{t-1} - 0.02\Delta(ltot)_{t-1} + 0.01\Delta(NFAGDP)_{t-1} \text{---------- (22)}$$

Table 4:

Interpretations of VAR models

Interpretations for Eq-(21) (model #19)	Interpretations for Eq-(22) (model #20)
• The VAR estimates has shown that lrp and NFAGDP are insignificant in the short run with high R^2=0.95.	• The VAR estimates has shown that lrp, ltot and NFAGDP are insignificant in the short run with high R^2=0.96
Due to the fact that, in the short run these variables are deviated from their relationship with REER but the VECM results ensures that there exists a long run relationship of these variables with REER and their association is expected to return in the long run.	*Due to the fact that, in the short run these variables are deviated from their relationship with REER but the VECM results ensures that there exists a long run relationship of these variables with REER and their association is expected to return in the long run.*
• The co-integrating coefficient is (-0.0115).it shows that the speed of adjustment towards equilibrium is negative and significant. It indicates that when the difference between the logs of reer and rp are positive in one period, the reer will fall by 1% to restore the equilibrium in the next period. It is also observed that, the speed of adjustment is very slow.	• The co-integrating coefficient is (-0.020).it shows that the speed of adjustment towards equilibrium is negative and significant. It indicates that when the difference between the logs of reer and rp are positive in one period, the reer will fall by 2% to restore the equilibrium in the next period. It is also observed that, the speed of adjustment is very slow.
• The lreer is purported to depreciate by 37.5% between time t -1and t, because of 1% increase in lrp between time t-1 and t.	• The lreer is purported to depreciate by 1.97% between time t -1and t, because of 1% increase in lrp between time t-1 and t.
• The lreer is purported to depreciate by 0.469% between time t -1and t, because of 1% increase in NFAGDP between time t-1 and t.	• The lreer is purported to depreciate by 0.208% between time t -1and t, because of 1% increase in NFAGDP between time t-1 and t.

- RP is included in model to check for Penn-effect for Pakistan for the time period 1980-2019.it is concluded that Balassa-Samuelson hypothesis is witnessed in for Pakistan.

- The lreer is purported to depreciate by 0.33% between time t -1and t, because of 1% increase in ltot between time t-1 and t.

- RP is included in model to check for Penn-effect for Pakistan for the time period 1980-2019.it is concluded that Balassa-Samuelson hypothesis is witnessed for Pakistan. This effect is observed to be stronger in the presence of terms of trade.

It is concluded that REER has been appreciated (Pak rupee is depreciated) because of less productivity in Pakistan and more productivity growth in USA.

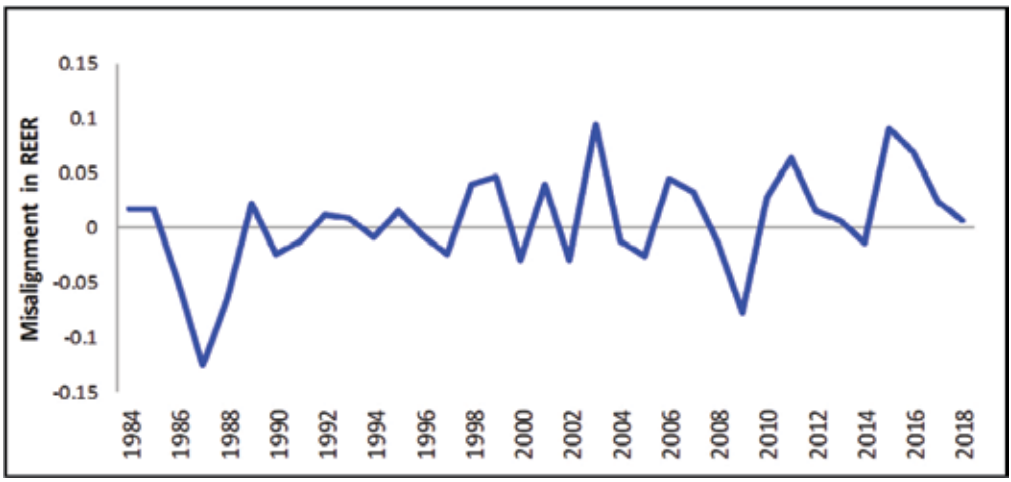

Figure 3: *Misalignment through Penn Effect (Model 19)*

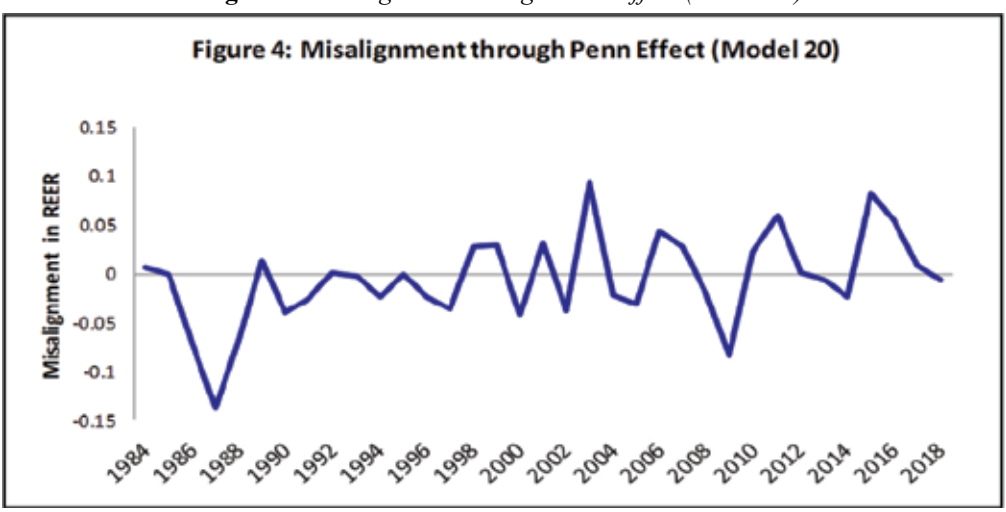

Figure 4: *Misalignment through Penn Effect (Model 20)*

(Both the figures 3 and 4 confirm the significant presence of Penn effect in Pakistan, it is witnessed that the productivity differential is one amongst the reasons of misalignment in REER)

Methodology for reduced form equation approach to gauge misalignment

According to Isard (2007), it is more appropriate for developing countries as Pakistan, IMF specially encourages the developing countries to keep REER closer to its equilibrium exchange rate. Edwards (1988) carry the seminal work on reduced-form-equation to gauge misalignment for developing countries. There exists long run as well as short run relationships between REER and its determinants; hence, the co-integration techniques are more appropriate to estimate the REER misalignment (Montiel, 1997).

A theoretical model for reduced form equation approach

This paper is using the reduced form equation approach based on the Edwards (1994)'s theoretical model. As per literature, when the economies shifted from fixed exchange rate to the free-floating exchange rate, the macroeconomic variables started to affect the REER drastically. That is why the reduced form equations are getting more popularity especially for developing countries (Edward, 1994). The macroeconomic variables such as terms of trade, long term investment, government consumption, worker remittances, trade openness, relative productively (to capture Penn effect) and foreign direct investment (proxy for capital inflow) are some of variables that may be responsible to alter REER. The theoretical model is described as below:

$$reer = f\,(opnsgdp,\ gcgdp,\ fdigdp,\ rp,\ tot,\ wrgdp,\ igdp\ )\text{---------- (23)}$$

$$(-) \quad (+/-) \quad (-) \quad (-) \quad (+/-) \quad (+) \quad (-)$$

The variables are scaled using GDP as scalar. The description of variables is given below:

Variable	Description
$opnsgdp$	is trade openness to GDP ratio calculated as $(Exports + Imports)/gdp \times 100$.
$gcgdp$	is GOVT consumption to GDP ratio $\left(\frac{gc}{gdp} \times 100\right)$
$fdigdp$	is the ratio of foreign direct investment to GDP taken as proxy for capital inflows. It is calculated as $\left(\frac{fdi}{gdp} \times 100\right)$
rp	is the relative productivity taken as ratio of per capita GDP of Pakistan to per capita GDP of USA. It is calculated as $\left(\frac{gdp_p/pop_p}{gdp_{USA}/pop_{USA}} \times 100\right)$
tot	is the terms of trade defined as ratio of Export price to Import price and calculated as $\left(\frac{p_X}{p_M} \times 100\right)$
$wrgdp$	is the ratio of worker remittances to gdp ratio calculated as $\left(\frac{wr}{gdp} \times 100\right)$
$igdp$	is the long-term investment to GDP ratio calculated as $\left(\frac{invt}{gdp} \times 100\right)$

Econometric methodology 3

The annual data from FY1980-FY2018 for the macroeconomic variables is taken from IFS and has been reconciled with the SBP sources. These variables are scaled using GDP and due to Time series properties, the natural logs of included variables are taken for analysis. Initially model no (24) is estimated with five variables, and then it is extended to inclusion of seven

variables. The variables suggested by literature are included in the model. Hence, the following two models are estimated by VAR technique through E-views.

$$lreer=f(lopnsgdp,lgcgdp,fdigdp,ligdp,RP) \text{ ---------- (24)}$$

$$lreer=f(lopnsgdp,lgcgdp,lfdigdp,ligdp,lRP,ltot,lwrgdp) \text{ ------- (25)}$$

The stationarity of all the variables are checked through ADF-test and has found to be in log-levels while their first difference is stationary in log levels.

All variables are co-integrated of order one and the error terms of the equations are stationary. So, the multivariate Johnson test of co-integration is carried out with lag 3 selected through lag selection criterion model. It is also tried to reduce the correlation among the variables by scaling with GDP. Model # 24 and model# 25 are estimated through VAR (3) and VAR (1) respectively. The co-integration test for VAR (3) is carried out through EVIEWS with the five endogenous variables (lopnsgdp, lgcgdp, fdigdp,ligdp and rp). The significant contribution of these variables in the short run in explaining lreer is checked through the Wald-test of restrictions imposed on the co-efficients in VECM. The results for model #24 are given below:

Table 5:
Testing the Significance of Short Run and Long-Run Causality Towards lreer Using Model # 24

Variables	Coefficients with three lags of each variable	Wald test results		
	H_(0)=the variable is not contributing in lreer	$\chi^2_{0.05}$	$p - value$	Remarks
D(lreer)	*c(2)=c(3)=c(4)=0*	7.173*	0.067	Lags of lreer are contributing towards lreer.
D(lopnsgdp)	*c(5)=c(6)=c(7)=0*	25.223*	0.000	Lags of lopnsgdp are contributing towards lreer
D(lgcgdp)	*c(8)=c(9)=c(10)=0*	28.868*	0.000	Lags of lgcgdp are contributing towards lreer
D(fdigdp)	*c(11)=c(12)=c(13)=0*	12.507*	0.005	Lags of fdigdp are contributing towards lreer
D(ligdp)	*c(14)=c(15)=c(16)=0*	8.137*	0.043	Lags of ligdp are contributing towards lreer
D(rp)	*c(17)=c(18)=c(19)=0*	22.688*	0.0001	Lags of rp are contributing towards lreer
Co-integrating Coefficient	*c(1)=0*	30.448*	0.000	It is negative and significant. (long run causality towards lreer)

Note: All the variables are having the short run causality towards lreer. There is also an evidence of long run causality running from macroeconomic variables towards lreer.

The estimated version of model # 24 is listed below.

$$\Delta(lreer_t) = -0.022(lreer_{t-1} - 48.79lopnsgdp_{t-1} - 18.27lgcgdp_{t-1} + 3.06fdigdp_{t-1} - 2.54ligdp_{t-1} + 23.77rp_{t-1} + 159.88) + 0.24\Delta lreer_{t-1} - 0.26\Delta lreer_{t-2} - 0.16\Delta lreer_{t-3} - 0.86\Delta lopnsgdp_{t-1} - 0.79\Delta lopnsgdp_{t-2} - 0.52\Delta lopnsgdp_{t-3} - 0.58\Delta lgcgdp_{t-1} - 0.33\Delta lgcgdp_{t-2} - 0.24\Delta lgcgdp_{t-3} + 0.05\Delta fdigdp_{t-1} + 0.04\Delta fdigdp_{t-2} + 0.04\Delta fdigdp_{t-3} - 0.26\Delta ligdp_{t-1} + 0.11\Delta ligdp_{t-2} - 0.11\Delta ligdp_{t-3} + 0.37\Delta rp_{t-1} + 0.61\Delta rp_{t-2} + 0.23\Delta rp_{t-3} - 0.03$$ ---------- (26)

Table 6:

Summarized results of VECM output for Eq # 26

Determinants of REER	Short run coefficients			Remarks
	Lag(1)	Lag(2)	Lag(3)	
Dlreer	0.24 (0.1864)	-0.26* (0.0548)	-0.16 (0.1679)	dlreer at lag2 is depreciating lreer in the short run
D(lopnsgdp)	-0.86* (0.0000)	-0.79* (0.0000)	-0.52* (0.0023)	Trade openness is significantly depreciating dlreer in the short run
D(lgcgdp)	-0.58* (0.0000)	-0.33* (0.0018)	-0.24* (0.0381)	High Govt consumption of importable is also significantly depreciating dlreer
D(fdigdp)	0.05* (0.0088)	0.04* (0.0277)	0.04* (0.0227)	Foreign direct investment a proxy to capital inflows is significantly appreciating dlreer because capital inflows are more than the current account deficit(Momtiel,1997)
D(ligdp)	-0.26* (0.0285)	0.11 (0.4664)	-0.11 (0.5189)	Investment to gdp ratio is significantly depreciating dlreer.
D(rp)	0.37 (0.0157)	0.61 (0.0008)	0.23 (0.2006)	Rp is required to be negative for Pakistan as per theory but its unexpected positive sign indicates that rp has been deviated in the short run and may be reverting back in the long run to ensure the Penn effect in Pakistan being a developing country.
Co-integrating coefficient	-0.022	(prob=0.000)		The magnitude towards equilibrium correction is 2.2%.
LM test on residuals of VECM	Lag(1)	25.41 (0.9060)		no serial correlation.
	Lag(2)	43.83 (0.174)		
	Lag(3)	42.25 (0.2201)		
Hetero-scadasticity test		$\chi^2_{0.05}$ (0.2500)		no Hetero-scadasticity
Normality test	JB test=9.533 (0.6569)			Residuals are normal

*The p-values are presented in parenthesis. * significance 5%*

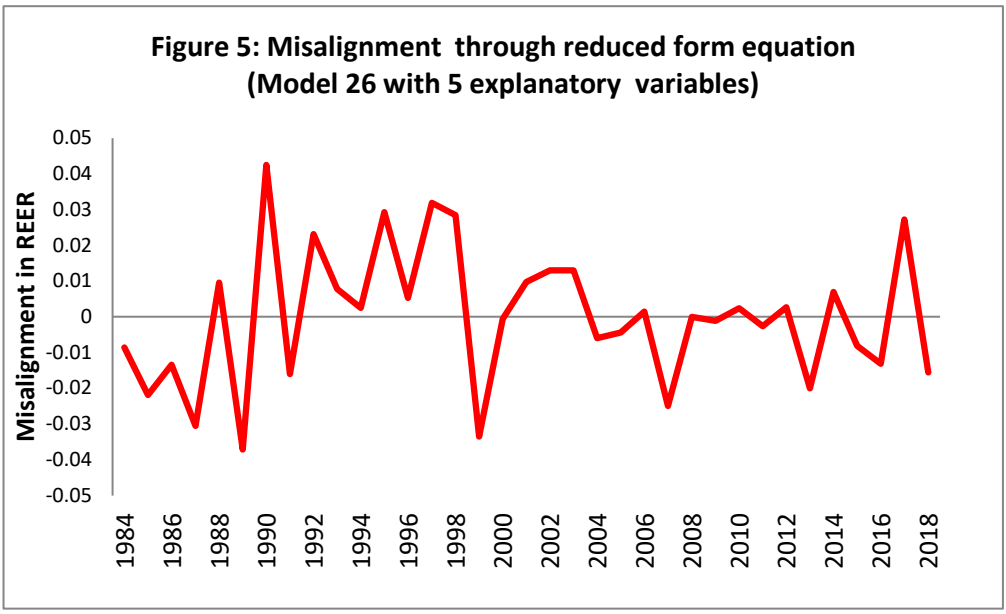

Figure 5: *Misalignment through model 26 (REER-REER)*

Misalignment ranges from -3.9% to 4.2% as per reduced form equation.

The results of VAR (1) and VECM for model #25 is presented below:

$$\Delta(lreer_t) = -0.060(lreer_{t-1} - 1.28lopnsgdp_{t-1} - 3.30lgcgdp_{t-1} + 0.52fdigdp_{t-1} - 2.79ligdp_{t-1} + 1.17rp_{t-1} - 0.41ltot_{t-1} + o.62lwrgdp_{t-1} + 14.90) + 0.42\Delta lreer_{t-1} + 0.11\Delta lopnsgdp_{t-1} - 0.20\Delta lgcgdp_{t-1} - 0.02\Delta fdigdp_{t-1} - 0.17\Delta ligdp_{t-1} + 0.40\Delta rp_{t-1} + 0.05\Delta ltot_{t-1} - 0.01\Delta lwrgdp_{t-1} - 0.03- \quad (27)$$

Table 7:
Short run causality and diagnostic checks in VECM

Determinants of REER	Coefficient of VECM for eq-27	
	Lag(1)	**Remarks**
Dlreer	0.42* (t=2.01)	dlreer at lag1 is appreciating lreer in the short run.
D(lopnsgdp)	0.11 (t=0.72)	Trade openness is insignificant.
D(lgcgdp)	-0.20 (t=-0.16)	High Govt consumption of importable is insignificant.
D(lfdigdp)	-0.02 (t=-0.58)	Foreign direct investment a proxy to capital inflows is insignificant.
D(ligdp)	-0.17 (t=-0.90)	Investment to GDP ratio is insignificant.
D(lrp)	0.40 (t=0.87)	Rp is appreciating REER

D(ltot)	0.05 (t=0.37)	Tot is insignificant.
D(lwrgdp)	-0.01 (t=-0.18)	Worker remittances variable is insignificant.
Co-integrating coefficient	r = -6 (t=-2.26)	The magnitude towards equilibrium correction is -6%.
LM test on residuals of VECM	Lag(1) p-value=0.14 Lag(2) p-value=0.24 Lag(3) p-value=0.29	No serial correlation.
Hetero-scadasticity test	$\chi^2_{0.05}$=666 (p-value=0.33)	No Hetero-scadasticity.
Normality test	o.77(p value=.67)	Residuals are normal

Note: Results show that the determinants of REER are deviating from its equilibrium in the short run.

Long run parameters are significantly contributing towards REER as shown in Table 8.

Table 8:
Long run coefficients of VECM

Determinants of REER	Long run coefficients (elasticities)	Remarks
lopnsgdp	-1.28* (-3.14)	Trade openness and trade liberalization makes the future consumption of importable items cheaper. Thus, tradable items are attractive which will lead to the depreciation of REER by 1.28%.
lgcgdp	-3.30* (-7.70)	More govt consumption of importable items may lead towards depreciation of REER by 3.30%.
lfdigdp	0.52* (11.23)	More foreign direct investment (proxy for capital inflows) will lead towards the appreciation of REER by 52%.
Ligdp	-2.79* (-7.34)	Long-term investment in home country means more spending on raw material and imported machinery that may lead towards depreciation of REER by 2.79%.
Lrp	1.71* (2.65)	It is required to be negative for Pakistan. Its positive sign indicates that more productivity growth is taking place in Pakistan rather than in USA
Ltot	-0.41* (-2.84)	. Due to outweighing of substituting effect tot may depreciate REER by 41% in the long- run.
Lwrgdp	0.62* (6.47)	Worker remittances may appreciate REER by 62% in the long- run.

Note: t-values in parenthesis. The determinants of REER are significantly contributing towards REER in the long- run with correct signs except relative productivity that captures Penn effect.

Comparative analysis and Empirical Findings

The comparative analysis of two approaches i.e., PPP adjusted for Balassa- Samuelson effect via two models and reduced form equation approach via two models, is graphically presented below

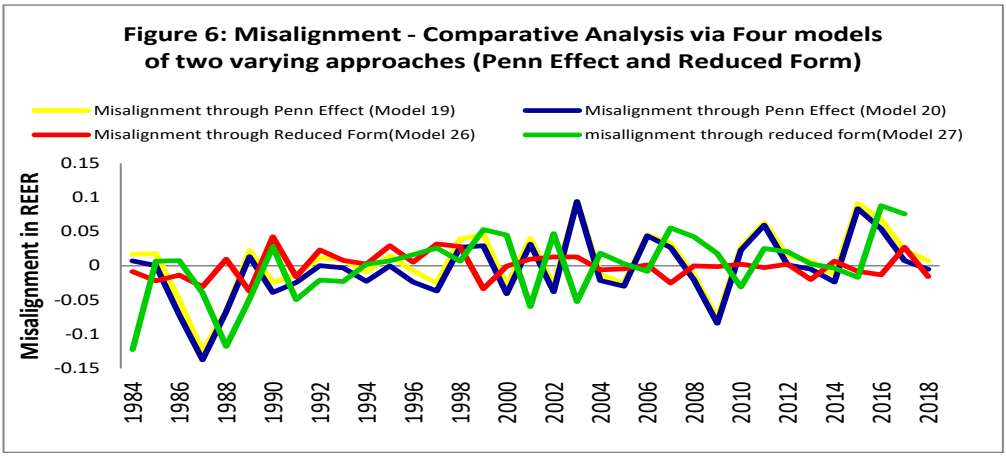

Figure 6: *Misalignment – Comparative Analysis via Four Models of two varying approaches (Penn Effect and Reduced Form)*

Few years are chosen just to know about the magnitude of misalignment as per three approaches. The table 8 shows the level of misalignment in REER as per three approaches.

Table 9:

Magnitude of misalignment as per three approaches

year	PPP- based misalignment	Penn effect adjusted misalignment		Reduced form-based misalignment	
		Model#28	Model#29	Model#35	Model#36
1985	-0.4%	1.7%	0.7%	-0.8%	-0.6%
1988	1.2%	-6.6%	1%	-4.3%	-4%
1990	-1%	1.5%	-3.9%	4.3%	-4.9%
1995	-1%	-3%	-0.2%	-0.1%	0.3%
2000	-0.4%	-2.5%	-4.1%	-0.6%	5.4%
2005	0.1%	-2.5%	-3%	-0.4%	1.9%
2010	-0.3%	-2.6%	2.3%	0.2%	1.8%
2015	-0.7%	9.1%	8.4%	-0.8%	-0.3%
2016	-0.1%	6.8%	5.4%	-1.3 %	-1.8%
2017	-0.1%	2.3%	0.8%	-2.7%	8.8%
2018	5%	1%	-0.5%	-1.5%	7.6%
Range of mis-alignment	-11% to 12%	-12% to 10%	-14% to 10%	-4% to 4.4%	-3.9 to 4.2%

The misalignment in REER (EREER), estimated through three approaches have provided different estimates, but It is not surprising due to the non- robustness nature of REER. It is time dependent, variable dependent and perspective dependent (Khalid, 2015). As per PPP approach, the misalignment in 2018 is 5%. This means that to restore equilibrium, the monthly REER is required to be depreciated. According to this approach, the speed of adjustment is very slow and the price differential across countries is one of determinants responsible for this misalignment. On the other hand, extended PPP approach has estimated that REER is not much away from its equilibrium in 2018. The fluctuations in REER are because of productivity differentials in Pakistan and rest of the world (USA is taken as proxy for the rest of the world. It is found that, the contraction in Net Foreign assets is contributing in the REER appreciation, the correction of disequilibrium is occurring at the speed of -1.1%. It is interesting to note that, as per reduced form equation, the REER is above its equilibrium and it is required to be depreciated by 7.6% in 2018. PKR witnessed drastic devaluation in 2018 onwards. Hence, REER is in the state of disequilibrium. Moreover, the speed of adjustment towards is -6%. As per literature, reduced form equations are more appropriate for the developing countries like Pakistan. Due to more sophisticated and advanced econometric techniques, this approach is providing valid estimates and determinants of REER (Isard.2007)

RECOMMENDATIONS

To achieve the macroeconomic stability and sustained economic growth, the role of equilibrium path of REER is inevitable. The price differential and productivity differential are causing misalignment in REER. The more suitable approach for gauging misalignment of REER in Pakistan is the state of Art approach i.e. reduced form equation approach. According to this method, REER is above its equilibrium level defining the REER appreciation. The anticipated determinants of misalignment are the openness to GDP ratio, Govt consumption to GDP ratio, long term Investment to GDP ratio, terms of trade, relative productivity (adjusting for Penn effect), worker remittances and Foreign Direct Investment (proxy for capital Inflows). The misalignment is ranging from -3.9% to 4.2%. Increase in the last three determinants is causing REER appreciation while remaining is contributing towards depreciation in REER. The policy of devaluation of PKR to increase the export competiveness is not working in Pakistan because the domestic demand for Imports and Domestic Supply of surplus (exportable items) are both inelastic in Pakistan. It is also causing high Inflation in the country, that out weight the positive impact of the policy (Hamid & Mir, 2017). Theory suggests that, the policy of devaluation of PKR (appreciation of REER) will work in Pakistan, if it is supplemented by demand management policy in the country. The GOVT current federal and provisional expenditure has been increased by 19.9% and 13.7% respectively in 2018-19. As per reduced form equation approach, it will be beneficial to reduce GOVT consumption as percentage of GDP. It is worth noting that the provisional GDP growth rate for 2019 is 3.29% (while the target was 6.2%), with a year-on-year average inflation (CPI based) for 2019 is 7.3%. one of the reasons for this high inflation is drastic deprecation of REER. this inflation can be controlled by moving towards equilibrium REER. It is officially announced by SBP that, total Investment (including fixed, public and private investment) is recorded as 15.4 % (while the target was 17.2%). This paper recommends that; more Investment will bring the deprecated REER towards sustainable level in REER. In Pakistan, the Exports are also decreased by 1.9%, which shows that, REER depreciation policy is not working effectively. To make it to work, demand side policies are required to be apply wisely, because more Inflation is knocking the door. Worker remittances have increased by 8.45% (to US $17.875 billion). It is recommended to take more steps to

maintain this increasing trend in the remittances, to have its positive impact on REER and ultimately on current account deficit.

FDI is dropped down by 51.7% in July-April for FY 2019 (to US$ 1.376 Billion from US$ 2.849 in FY2018, a drastic decline in DFI from Malaysia is observed during the period). It is important to take steps for making Pak economy attractive to the rest of the world to create a center of attention for FDI. As per SBP, the PKR is still under pressure and has been de-valued by 14.1% due to external Debt payment pressures. From international perspective* in FY2019, the global economic activity has slowed down to 3.6% (expected was 3.3%) due to the trade conflicts between USA and China. This tariff battle in both countries has affected approximately 2.5% of global trade. Hence, it is highly recommended to the authorities to be conscious about the trade policies with its trading Partners/competitor like USA and China.

Currently, the Government is using the contractionary fiscal policy and contractionary monetary policy to stabilize the economy and the exchange rate. It is suggested that, addition of monetary policy, fiscal policy, Interest rate, Political regimes and more explanatory variables will be helpful to explain variations in REER by using more sophisticated econometric techniques. It will also be of paramount importance to apply the other assessment models to capture misalignment in REER like macroeconomic balance approach and general equilibrium approach etc.

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