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ASYMMETRIES IN PASS-THROUGH OF CHANGES IN EXCHANGE RATE TO INFLATION IN PAKISTAN

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Abstract. We have investigated the effect of exchange rate changes to headline inflation in Pakistan using ARDL modeling approach. We have decomposed the change in nominal effective exchange rate for Q3:1992 to Q2:2017 period into positive and negative components and generated respective cumulative sums to explore if general price level adjusts differently to appreciation and depreciation. Our estimated markup model's results show that pass-through of Pak Rupee depreciation to headline inflation rate is significant and is different for high inflation regime compared to low inflation regime. Pass-through of appreciation is found to be insignificant. Specifically, 1% depreciation in exchange rate increases inflation in Pakistan by 0.62% (0.48%) in the long run in high (low) inflation environment. These results vindicate price setting survey's findings that (i) domestic firms follow monopolistically competitive structures resulting an incomplete pass-through; and (ii) depreciation is more important being reason for increasing the price compared to appreciation being reason for decreasing the price for manufacturing as well as services sector firms in Pakistan. We think asymmetry in exchange rate pass-through and its state dependency may exacerbate the trade-off between inflation and economic

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growth for the case of Pakistan and thus have implications for monetary policy conduct in Pakistan.

Keywords: Exchange Rate Pass-through, Inflation, Nonlinear ARDL Model, Asymmetric

JEL Classification: F31, E31, C32

I. INTRODUCTION

Exchange rate is a key price in an economy and it provides a major link between domestic economy and the rest of the world both in goods/services as well as assets market. Thus, a competitive and a less volatile exchange rate is desirable. Changes in value of exchange rate have profound implications for general price level and thus inflation in an open economy. The process by which the changes in exchange rate transmit to domestic prices is called exchange rate pass-through (ERPT). This effect works through various channels including: (i) direct effect of exchange rate fluctuations on the prices of imported consumer goods (ii) indirect effect on retail prices through imported intermediates, like crude oil[1], and effect on retail prices of substitutes of traded goods. Accordingly, policy makers have a strong interest in knowing how swiftly, or otherwise gradually, changes in exchange rate affect changes in prices. A plethora of studies has investigated this question. For example, Taylor (2000), Takhtamanova (2010), Marazzi et al. (2005), Otani et al. (2003) and Shioji (2012) specifically studied ERPT and found it to be incomplete. For developing world, the evidence shows that ERPT is relatively higher (Goldfajn and Werlang (2000), Eun et al. (1999), Webber (1999), Caselli and Roitman (2016)). ERPT can also be different for different countries depending upon various factors (Tunc, 2017). Notable studies exploring ERPT for Pakistan include Ahmed and Ali (1999), Choudhari and Khan (2002), Hanif et al. (2016), Hyder and Shah (2005), Siddiqui and Akhtar (1999)[2]. Most of these studies find that pass-

[1] See Castro and Nino, 2018 for details.

[2] See the summary of these Pakistan specific studies and estimated coefficients in Appendix-A1. Similarly, other panel data studies whose sample included Pakistan are mentioned separately in Appendix-A2.

through of exchange rate to prices in Pakistan is incomplete and limited. The modeling approaches mostly assume symmetric pass-through. These studies on ERPT in Pakistan do not explicitly model asymmetries and/or check for non-linearity that may be present in pricing behavior. However, asymmetries and nonlinearities have been observed in a survey conducted by SBP on price setting of firms and are explained by various nominal rigidities (Choudhary et al., 2011). Empirical studies like Mann (1986), Goldberg (1995), Pollard and Coughlin (2004), Przystupa and Wrobel (2011), Delatte and Villavicencio (2012), Stoian and Marurasu (2015), Caselli and Roitman (2016), and Forero and Vega (2015) explored asymmetries in the ERPT and found depreciation to have higher pass-through than that for appreciation in the countries studied. These authors have provided a variety of reasons ranging from higher profit margin absorption during appreciation regimes (Mann, 1986) to downward price rigidities (Stoian and Marurasu, 2015). Wickermasinghe and Silvapulle (2004), Campa et al. (2005), Khundrakpam (2007), and Rincon and Rodriquez (2016), on the other hand, found that pass-through is higher subsequent to episodes of appreciation than it is for episodes of depreciations. Some of these studies also tested linear ERPT to inflation and rejected it. For example, Cheikh (2012) examined the non-linearity of ERPT to inflation for 12 Euro Area countries and found ERPT to be nonlinear in 8 out of 12 countries. Ozkan and Erden (2015) provided an evidence of low ERPT in developing countries that enjoy low inflation. In an individual country study, Castro and Nino (2018) most recently observed that ERPT to inflation is state dependent in Colombia.

To the best of our knowledge, besides survey evidence (by Choudhary et al. 2011) indicating asymmetric ERPT, no study exists which has investigated the asymmetries in ERPT to inflation in Pakistan. As for the studies conducted prior to 2011, most have assumed symmetry and linearity in ERPT to inflation in Pakistan. Note that knowing to what extent changes in exchange rate affect domestic prices in case of appreciation and depreciation is an important policy question. Swift and complete pass-through in cases of depreciation and appreciation (symmetric) could have a central bank worry less about effects of currency depreciation since depreciation in one period could be offset by pass though in episodes of appreciations subsequently. This provides a natural hedge to central bank's reserve position. The opposite (higher

pass-through of depreciation but less in case of appreciation) could put central bank under pressure to defend the currency. Thus, exploring the asymmetries in pass-through of exchange rate changes to prices is important to help policy makers better understand price formations in domestic economy.

Section II summarizes the literature. In section III, we provide a theoretical and econometric framework for the study. Section IV describes data and its sources. Section V presents empirical findings and related discussion. Section VI concludes the study.

II. REVIEW OF LITERATURE

In this section, we review studies that have explored symmetries or asymmetries and/or linearity /non-linearity in ERPT to prices. We include country specific studies and studies focusing on advance and developing economies.

In a recent survey on ERPT, Tunc (2017) finds that there is consensus in the literature that ERPT to prices has declined after adoption of inflation targeting in many countries (see also Edwards, (2006) and Coulibaly and Kempf (2010)). Tunc (2017), however, argued that ERPT differs from country to country depending upon degree of openness (Hau (2002), Campa and Goldberg (2005), Barhoumi (2006), Ghosh (2009), and Ozkan and Erden (2015)), inflation level (Taylor, (2000), Choudhri and Hakura (2006) and Lopez-Villavicencio and Mignon (2016)), the degree of price stickiness (Devereux and Yetman, 2010), exchange rate volatility (Kohlscheen, 2010), size of current account deficit (Kilimc et al., 2016), composition of imports (Campa and Goldberg, 2005), substitutability of imported and domestically produced goods (Menon, 1996), level of dollarization in the economy (Reinhart et al., 2014), and the proportion of foreign firms in the country (Frankel et a., 2012). However, all these studies ignore asymmetries in ERPT to inflation.

Empirical literature on ERPT to inflation in Pakistan is limited and their results vary. Choudhari and Hakura (2006) observed long run ERPT for Pakistan to be negative; Choudhri and Khan (2002) found it nil; Hyder and Shah (2005) estimated it to be low and short lived, Ahmed and Ali, (1999) reported ERPT to be significant but gradual, whereas Webber (1999) reported it as ‘perverse’ being above 100 percent (109 percent). It

is important to note that these studies on Pakistan assumed symmetric ERPT of depreciation and appreciation and that could be one of the reasons for such diverging results.

There can be two cases for existence of asymmetries in ERPT to inflation case-i: when appreciation can be more disinflationary[3] compared to degree of inflation acceleration after depreciation, and case-ii: when depreciation can be more inflationary compared to degree of disinflation after appreciation[4]. Both these cases have ample empirical support but the evidence is more tilted towards latter. In the following paragraphs, we discuss empirical studies, which departed from the assumption of symmetry and explored if pass-through is different in case of depreciation of exchange rate compared to the case of appreciation.

The earliest empirical work on pass-through of exchange rate to the prices of tradables can be tracked to Mann (1986). He investigated the ERPT for US economy in the context of US dollar depreciation during 1977-1980 and appreciation during 1980-85. He examined macro level pass-through of change in the value of dollar on imported / exported goods' prices as well as industry specific behavior pertaining to prices and profits margins. It was found that suppliers absorbed the dollar appreciation (of 1980-85) to profit margins (instead of passing it through to lower import prices) more than the period of depreciation (1977-80). Resultantly, during the period of appreciation, prices of a few imported goods (such as certain steel and construction machinery) fell while those of other imported goods (like footwear, textiles, apparels etc.) remained stable as against the period of depreciation when prices increased fairly sharply for all imported goods.

Goldberg (1995) investigated two trade issues of 1980s pertaining to US automobile industry – quota restrictions and exchange rate pass-through. Using micro data of Consumer Expenditures Surveys, author decomposed the price changes during 1983-87 and assessed the significance of trade restrictions, quality upgrading, and ERPT in

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[3] This occurs due to inability of exporting firms to sell abroad following appreciation, which results in fall of domestic prices due to excess supply in domestic market.

[4] This occurs when firms pass on the effect of high input cost but show rigidity in cutting prices when input costs reduce.

determining prices of domestic and imported automobiles. He found that in the presence of quotas, import prices were insensitive to exchange rate movement. Without quota, ERPT on import prices was asymmetric: The effect on prices was larger in case of depreciation compared to appreciation of currency. Goldberger attributed these result to price elasticities of demand.

Rather than assuming it to be independent of the direction of the exchange rate, Pollard and Coughlin (2004) studied almost 30 US industries to evaluate asymmetric pass-through hypothesis at micro level. They found that over half of the firms studied responded asymmetrically to appreciation and depreciation, and that the direction of the asymmetry varied.

Przystupa and Wrobel (2011) assessed if import and consumer prices in Poland exhibited pricing to market behaviour, and whether these prices reacted asymmetrically to exchange rate changes during the period of study (Q1:1997 to Q1:2008). Despite the symmetric ERPT to import prices, pass-through to consumer prices was found to be asymmetric: consumer prices responded almost four times higher to depreciations compared to appreciations during the period of study.

Delatte and Villavicencio (2012) have investigated the asymmetric effect of ERPT in four major developed countries estimating a nonlinear ARDL regression which they specified based on markup pricing model. Authors observed that there was a significant role for exchange rate in the determination of prices in the long run in Germany, Japan, UK and USA; and that prices reacted differently to appreciations and depreciations. Depreciations were passed through more than appreciations over the period of study (Q1:1980 to Q3:2009).

Stoian and Marurasu (2015) investigated possible asymmetric effects of episodes of appreciation versus deprecation of Romanian (nominal effective) exchange rate on different measures of price indices using a range of econometric methods. The study identified significant asymmetry with respect to sign (as well as size) of change in exchange rate in the context of its pass-through to producers' prices inflation and core inflation and that pass-through of depreciation was higher than that of appreciation in both the indicators of inflation. The authors interpreted

their findings as evidence of downward rigidity in prices and upward rigidity in supply of goods in Romania.

Caselli and Roitman (2016) investigated the role of asymmetries in reaction of domestic prices to changes in nominal exchange rate for a panel of 28 emerging economies. They documented remarkable asymmetries in ERPT: post 12 months reaction of inflation to depreciation was 38 percent compared to less than 10 percent for appreciation episodes.

Forero and Vega (2015) studied the response of headline inflation in Peru to exchange rate innovations while distinguishing between positive and negative shocks over January 1992 to December 2014. They observed that the effect of a depreciation shock, after one year, is about twice as much as an appreciation shock; and that this asymmetry was statistically significant. In addition to generally discussed downward price rigidities, they offered macroeconomic reasons (wealth effect and expenditure switching effect) as explanations for weaker response of price to appreciation than to depreciation.

Thus, the aforementioned studies show that passes through of depreciation to inflation is higher than that for appreciation in the countries studied[5]. Authors have provided different reasons of this result in their respective studies ranging from higher profit margin absorption during episodes of appreciation (Mann, 1986) to downward price rigidities (Stoian and Marurasu, 2015).

Some studies provide empirical evidence that is contrary to the case discussed above, that is, pass-through of appreciation is higher than that of depreciation. Each country experience has its own explanations. In the following paragraph, we summarize these studies as well.

Wickermasinghe and Silvapulle (2004), examined ERPT to Japanese manufactured import prices using asymmetric model differentiating accumulated appreciations and depreciations over the period of January

[5] An exception was the study by Yang (2007) which set to address the question of whether exchange rate pass-through into the import price is symmetric between appreciation and depreciation of the home currency. He found the mixed evidence for stability of exchange rate pass-through to import prices.

1975 to June 1997. They found ERPT to be significantly different: appreciations being passed through strongly (98 percent) than the depreciations (83 percent).

Campa et al. (2005), investigated asymmetries in the response of prices to shocks in exchange rate by looking at adjustment of national currency import prices towards their long run equilibrium under increase/decreasing cost shocks. Using an error correction mechanism, they found that the deviations from long run equilibrium due to exchange rate appreciation results in faster adjustment than those caused by exchange rate depreciation. It was not clear in their study if post appreciation adjustment was also higher compared to post depreciation adjustment.

Khundrakpam (2007) used dummy variable approach to investigate asymmetries in ERPT to prices in India over the period of August 1995 to March 2005. He found the estimated coefficient of pass-through for appreciation to be higher than that for depreciation both in short and long run. The author grounded his expectation of such result in inward looking industrialization history of India. His argument was that after liberalization foreign firms responded to the competition from locally rooted firms by passing on the gains on imported input costs -after local currency appreciation- to retail prices in order to capture the market share.

Some of the aforementioned studies also investigated non-linearities in ERPT to inflation. These include Pollard and Coughlin (2004), Correa and Minella (2010), Przystpa and Wrobel (2011), Bussiere (2013), Stoian and Marurasu (2015), and Caselli and Roitman (2016). With the exception of Przystpa and Wrobel (2011), these studies found evidence of nonlinearities in ERPT to inflation. As mentioned earlier, Cheikh (2012), Ozkan abd Erden (2015) and Castro and Nino (2018) also examined and observed nonlinearity in ERPT to inflation in developed, developing, and individual country studies respectively[6].

[6] Campa et al. (2005), investigated nonlinearities in the response of prices to shocks in exchange rate at sectoral level. Their evidence of nonlinearities pertained to certain industries only and they could not reject the linearity for agriculture and commodity imports.

To the best of our knowledge, existing literature on Pakistan has assumed symmetric and linear ERPT even though there is compelling evidence to the contrary as discussed above. Considering the aforementioned literature and weakly competitive nature of goods market in Pakistan (as observed by Choudhary et al. 2011), there is a need for investigation of asymmetries in the pass-through of exchange rate appreciation/ depreciation to domestic inflation in Pakistan. We fill these research gaps and contribute to the literature. As part of this investigation, we will also test if ERPT is state dependent in Pakistan as postulated by Ozkan and Erden (2015) for developing countries.

III. THEORETICAL AND ECONOMETRIC FRAMEWORK

We are inclined to borrow the conceptual framework for this study from markup model by Duesenberry (1950). According to this model, prices are set by firms adding a markup to the cost of inputs[7]. It is also worth mentioning that according to the survey on price setting behavior of firms in Pakistan (Choudhary et al. 2011); most firms in Pakistan set their prices using some sort of mark up over the cost.

A simple markup model can be expressed as a mark-up over total unit cost; which depends on unit labor cost, exchange rate and energy prices. (Brouwer and Ericsson (1998). The long run relationship of the domestic consumer price level to its determinants, according to mark up model, can be expressed as follows:

$$P = \mu . S^{\beta_1} . (ULC)^{\beta_2} . (ELEC)^{\beta_3}$$

Allowing variables in this equation to be integrated of at most order 1, price can be modeled in a co-integrating long-run regression as follows

$$p_t = \beta_0 + \beta_1 s_t + \beta_2 elec_t + \beta_3 ulc_t + \varepsilon_t \qquad (1)$$

where s_t refers to exchange rate, ulc_t is the unit labor cost, and $elec_t$ is electricity charges (as representative of energy price in the country[8]).

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[7] More than half of the firms surveyed in Choudhary et al., 2011 reported using a markup pricing model.

[8] The share electricity generation in Pakistan from hydroelectric, nuclear and thermal sources was 30, 6, and 64 percent respectively in 2017. Thus, using electric charges as proxy for energy

Equation (1) is the form of an error correction model (ECM). While writing equation (1) in ECM form, we have also included other determinants of inflation found significant in Hanif (2014) and Hanif (2016).

$$\Delta p_t = \mu + \rho_p p_{t-1} + \rho_s s_{t-1} + \rho_o elec_{t-1} + \rho_u ulc_{t-1} + + \sum_{i=1}^{p} \Psi_i' \Delta p_{t-i} + \sum_{i=0}^{p} (\Phi_i' \Delta s_{t-i} + \Theta_i' \Delta elec_{t-i} + \Xi_i' \Delta ulc_{t-i} + \Omega_i' gap_{t-i}) + \upsilon_t \quad (2)$$

Equation (2) captures changes in price (inflation) using distributed lag structure of price level and other independent variables in long as well as short run. However, this form of ARDL model needs to be augmented to include the possibility that price formation may be different in episodes of appreciating exchange rate as opposed to the episodes when exchange rate is depreciating as elaborated in the literature review. Specifically there can be two types of asymmetries in ERPT: (i) pass-through of depreciation being greater than appreciation and (ii) pass-through of appreciation being greater than depreciation. The first type of asymmetry assumes that prices are downward rigid and firms mostly pass on the prices to preserve their margins. For the second type asymmetry, (Khundrakpam, 2007) argued that foreign rooted firms may respond to the competition from local firms by passing the gains from imported input costs as a result of currency appreciation to retail prices in order to capture the market share. In addition to this argument, we postulate the following in support of second type of ERPT to inflation. In case of appreciation, exporting firms may fail to export (due to loss of competitiveness on account of overvalued exchange rate) which results in excess supply in the country and thus a downturn in prices amid inputs importing firms higher demand to fill slack in capacity to produce cheap goods[9]. In case of depreciation, exporting firms may again fail to export (due to loss of competitiveness on account of higher input prices) which

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cost appropriately controls for the direct or indirect effects of oil price upon inflation in the country. Further, we have also found this proxy to be better among competing proxies both intuitively and in statistical terms.

[9] Profit maximizing firms may act strategically based on expected future exchange rate. Froot and Klemperer (1988)

results in excess supply in the country and thus diluting the overall increase in general prices due to impact of depreciation in exchange rate on imported capital and consumer goods. In these scenarios, appreciation may be more disinflationary compared to degree of inflation acceleration after depreciation[10]. Delatte and Villavicencio (2012) shows that it is possible to estimate asymmetries in pass-through of exchange rate in the long as well as short run by decomposing exchange rate exchange rate (S_t) into its positive (s_t^+) and (s_t^-) negative partial sums. Having done so modifies the equation (2) as follows

$$\Delta p_t = \mu + \rho_p p_{t-1} + \rho_s^+ s_{t-1}^+ + \rho_s^- s_{t-1}^- + \rho_o elec_{t-1} + \rho_u ulc_{t-1} + \sum_{i=1}^{p-1} \Psi_i' \Delta p_{t-i} + \sum_{i=0}^{p} (\phi_i^{+'} \Delta s_{t-i}^+ + \phi_i^{-'} \Delta s_{t-i}^- + \Theta \Delta elec_{t-i} + \Xi \Delta ulc_{t-i} + \Omega_i' gap_{t-i}) + \upsilon_t \quad (3)$$

Wherein $\beta_1^+ = \frac{\rho_s^+}{-\rho_p}$ estimates the long-run pass-through of exchange rate appreciation while $\beta_1^- = \frac{\rho_s^-}{-\rho_p}$ estimates the pass-through of depreciation. If the test $\beta_1^+ = \beta_1^-$ is rejected then the ERPT in the long run is said to be symmetric. Similarly, for short run, we can test the null hypothesis $\phi_{i-1}^{+'} = \phi_{i-1}^{-'}$ in equation (3) Rejection of this null hypothesis amounts to the evidence that there is difference in short run price adjustments in response to appreciation and depreciation and thus existence of asymmetries is confirmed. In the next section, we estimate equation (3) and work out parameters β_1^+ and β_1^- for long run and $\phi_{i-1}^{+'}$ and $\phi_{i-1}^{-'}$ to test the hypotheses of long and short run asymmetries in ERPT to prices in Pakistan.

IV. DATA

The sample period used in this study is Q3-1992 to Q2-2017. The dependent variable in equation (2), inflation is year-on-year (YoY) change in the consumer price index of Pakistan. The main variable of interest is exchange rate. Electricity charges are local currency cost of

[10] Of course, these are strategic decisions in which elasticity of demand of underlying product and market power of the firm also matter.

electricity in Pakistan. Unit labor cost is measured by average wages of skilled and unskilled labor working in Pakistan. Finally, output gap (gap) is the measure of deviation of economy's performance from its potential level. Economic performance is proxy by large-scale manufacturing index for Pakistan. Table-1 summarizes the data sources.

TABLE 1

List of Variables

Variables	Notation	Definition	Source
Price	P	Consumer Price Index	PBS
Exchange Rate	S	Nominal Effective Exchange Rate (Index)[#]	SBP
Labor Cost	ULC	Index based on sub-indices of skilled and unskilled labor provided by PBS.	Authors' estimate , PBS
Electricity Charges	Elec	Electricity charges (as a proxy for cost of energy). The index is developed by building a series based on electricity data from Pakistan Energy Book year, which are publically available.	Author's estimates
Output Gap	g	Difference between actual and estimated trend components of Large Scale Manufacturing (LSM) production Index	Authors' Estimate, PBS
Dummy Variable (High Inflation)	DUMH	Indicator (=1) when YoY inflation >= median inflation	-
Dummy Variable (Low Inflation)	DUML	Indicator (=1) when YoY inflation < median inflation	-

V. RESULTS AND DISCUSSION

We have presented graphs of these variables in Figure-1 (Panel A through C) in Appendix-B in order to have a look at their behavior over time. All the variables used in this study are seasonally adjusted. Variables at level are in (natural) logarithm form. The joint evolution of YoY change in NEER and Headline inflation clearly demonstrated that they co-moved during the period of study as evident from Figure-2 in Appendix-B. In the same figure, one can see that inflation is following the changes in NEER.

We conducted unit root tests on all the variables used in this study (Table-2).

TABLE 2

Augmented Dickey Fuller (ADF) Unit Root Tests

Variable	Test Statistics
P	-0.65
S	-1.99
ELEC	-1.53
ULC	-0.17
S+	0.96
S-	-1.99
gap	-3.08*
Δp	-4.09*
Δs	-6.86*
Δelec	-7.10*
Δulc	-3.26*
Δs+	-6.52*
Δs-	-7.25*

Note: Lags selected using AIC. Max lag = 4. Intercept included. Inclusion of time trend was based on statistical significance.

* indicates statistical significance at 5%.

As evident from the results, all of the variables are integrated of order 1 at levels and are stationary at first difference[11]. Output gap is found to be stationary (as expected).

Before going to investigate symmetry/linearity of ERPT using a markup model it is important to see if this type of model holds for Pakistan. On estimating equation (1) and testing for long run relationship through cointegration test, we find that markup pricing model works in Pakistan. Encouraged by this result, we now proceed to use NARDL model to determine if ERPT to inflation in Pakistan is symmetric or asymmetric. For this purpose, we estimated equation (3) and results are presented in Table 3.

[11] The bounds test requires that level variables are either I(0) or I(1).

TABLE 3

An Asymmetric ARDL Model for Inflation

Inflation	Coefficient	t-statistic	P-value
p_{t-1}	-12.53	-1.92	0.06
s^{+}_{t-1}	-3.29	-0.53	0.59
s^{-}_{t-1}	5.92	1.98	0.05
$elec_{t-1}$	2.26	1.06	0.29
ulc_{t-1}	4.63	1.19	0.24
Δp_{t-1}	0.72	12.69	0.00
Δp_{t-2}	-	-	
Δp_{t-3}	-	-	-
Δp_{t-4}	-	-	-
Δs^{+}_{t-1}	-	-	-
Δs^{+}_{t-2}	0.03	0.34	0.74
Δs^{+}_{t-3}	-	-	-
Δs^{+}_{t-4}	-	-	-
Δs^{-}_{t-1}	-0.10	-1.73	0.09
Δs^{-}_{t-2}	-	-	-
Δs^{-}_{t-3}	-	-	-
Δs^{-}_{t-4}	-	-	-
$\Delta elec_{t-1}$	-	-	-
$\Delta elec_{t-2}$	-	-	-
$\Delta elec_{t-3}$	-	-	-
$\Delta elec_{t-4}$	0.03	2.12	0.04
Δulc_{t-1}	-	-	-
Δulc_{t-2}	0.25	4.23	0.00
Δulc_{t-3}	-	-	-
Δulc_{t-4}	-	-	-
gap_{t-1}	-	-	-
gap_{t-2}	-0.67	-3.15	0.00
gap_{t-3}	-	-	-
gap_{t-4}	-	-	-
_constant	14.19	1.74	0.09
R^2	0.88		
Adj R^2	0.87		
N	92		

Note: (a) Lags in the ARDL model are chosen according to a general-to-specific approach starting from max lag = 4.
- Means insignificant at 10 percent.
Price, accumulated appreciation/depreciation, unit labour cost, and electricity charges are included, irrespective of their statistical significance, with lag 1 being part of ARDL model.

Based on these estimates, we have estimated the long run (LR) coefficients of appreciation (β_1^+) and depreciation (β_1^-) provided in Table 4 along with the corresponding short run coefficients. Result from the bound test to assess the null hypothesis that coefficients of all level variables are jointly zero $\rho_p = \rho_s = \rho_{elec} = \rho_u = 0$ is also given in Table-4.

TABLE 4

Short / Long Run Estimates of Asymmetric Exchange Rate Pass-Through to Inflation

	Coefficient	test-statistics
Short Run		
$\emptyset_{t-2}^+$	0.04	0.34
$\emptyset_{t-1}^-$	-0.10	-1.73
Long Run		
β_1^+	-0.26	0.25
β_1^-	0.47	5.31*
F_{PSS}	7.85*	
R^2	0.88	
χ_{sc}^2	8.33*	

Note: β_1^+ is the long-run coefficient associated with the appreciation in exchange rate while β_1^- is associated with the depreciation.

F_{PSS} is F-Statistics (see Table CI (iii) in Pesaran, Shin and Smith (2001). Its critical value at 5% for K=4 is 4.01

χ_{SC}^2 is Breusch-Godfrey LM test of serial correlation.

* indicates statistical significance at 5%.

Result from the bound test suggests that the null hypothesis of no cointegration is rejected. This is confirmation that markup pricing model holds in Pakistan. Thus, consumer price index in Pakistan has long run relationship with accumulated appreciation in NEER, accumulated depreciation in NEER, electricity charges and unit labour cost.

Absolute value of all the estimated coefficients pertaining to ERPT to inflation in Pakistan are less than unity and hence it is incomplete in Pakistan. There could be different reasons for incomplete pass-through in Pakistan. At times a change in exchange rate is too small to have impact on prices. Moreover, demand structures of different sectors necessitates

different and in some cases, less than proportionate pass-through to prices. Market structures also lead to incomplete ERPT following very nature of variable mark-ups in a weakly competitive market structure.

It is important to note that prices in a part of CPI basket in Pakistan (about 12 percent) are administered, which may result in incomplete pass-through. Notwithstanding higher frequency of price changes in Pakistan (compared to UK and USA), prices are not completely flexible in the country. Until recently, policy makers have been using various measures to correct trade-imbalances including the cash margins and import duties and thus rendering exchange rate changes rather less effective. Above all, CPI does not include traded goods only. In case of Pakistan, only about one-fifth of goods can explicitly be classified as traded goods while one-third are clearly from the services sector that is known as nontraded in the literature. Thus, we can say, finding of incomplete ERPT is intuitive.

Both the coefficients pertaining to short run are insignificant. These findings are consistent with empirical results of Choudhri and Khan (2002) pertaining to Pakistan that in the short run the effect of change in exchange rate on inflation is insignificant. However, despite the statistical observation that both the short run coefficients are insignificant, we cannot ignore the fact that the coefficient of short run impact of depreciation on inflation is of reasonable size (0.10) and it deserves attention. As this is for one quarter, it equals the long run size in just 5 quarters, assuming linearity. Moreover, the statistical insignificance of the short run effect of depreciation on inflation in our study is also a borderline case[12].

In the long run, 1% depreciation increases inflation by a 0.47% whereas the same magnitude of appreciation decreases the inflation by 0.26%. Pass-through from depreciation is statistically significant whereas pass-through from appreciation is statistically insignificant. Moreover, notwithstanding the statistical significance of deprecations' pass-through and insignificance of appreciations' pass-through , consumer prices

[12] The p-value for the short coefficient pertaining to depreciation is 0.09, which is only slightly higher than the standard used at 0.05. By using 10 percent as a 'standard' one can say this to be significant. That is why we think it is a borderline case.

responded almost double to depreciations compared to appreciations in Pakistan during the last quarter century period as in the case of Peru (see Forero and Vega, 2015). Thus, depreciation increases inflation more than appreciation reduces it. Our findings are consistent with the survey findings (reported in Table-8) of Choudhary et al. (2011) wherein the authors observed that adjustment of price was more important in episodes of depreciation than appreciations. From international comparison, we can see that our findings are in line with the observations in i) Mann (1986), and Pollard and Coughlin (2004) about USA, ii) Przystupa and Wrobel (2011) about Poland, iii) Delatte and Villavicencio (2012) about Germany, US and Japan iv) Stoian and Marurasu (2015) about Romania and v) Caselli and Roitman (2016) about 28 emerging countries that 'the reaction of inflation to depreciation is stronger compared to appreciation'. Whereas, our findings are in contrast to the observations in Wickermasinghe and Silvapulle (2004) in the case of Japan, ii) Campa et al. (2005) in the case of EU-15 countries, iii) Khundrakpam (2007) in the case of India, and iv) Delatte and Villavicencio (2012) in the case of UK that 'the appreciation's pass-through is higher than that of depreciation'.

The fact that depreciation more strongly transmits to consumer prices than do appreciations in long run in Pakistan may imply that producers tend to absorb most of an appreciation in order to increase their mark-up while they pass significant portion of depreciation to consumers in order to limit the reduction of their mark-up. This is possible if the market power of firms is large enough to behave like this. These finding confirms Choudhary et al. (2011) observation that manufacturing firms in Pakistan are working in a market structure that is weakly competitive.

We find that estimated coefficient of long run impact of depreciation on inflation in Pakistan is statistically significantly different from zero whereas that of appreciation is not (different from zero). Reading statistically significance of one estimated coefficient and insignificance of the other one together; we would like to infer that these two coefficients are different[13] and hence ERPT is not symmetric in case of

[13] One may argue to use Wald test to test the equality of the two estimated coefficients (as in Delatte and Villavicencio, 2012). We believe that this approach is not correct since our model includes both I(0) and I(1) regressors whereas Wald test is conventionally valid when the variables in a specification are all I(0). There is need to develop a separate mechanism for

Pakistan in the long-run. We have already seen that for the short run we failed to reject the null hypothesis of zero ERPT to inflation in Pakistan and thus there is no question of whether short run ERPT is symmetric or asymmetric.

Although pass-through is incomplete but we still believe, it is high for Pakistan when compared with similar peer countries14. Choudhary et al. (2011) also provide survey evidence to show the pass-through is higher in Pakistan: On average Pakistani firms, changed price thrice in a year compared to European firms where frequency of price change was 1.4 times a year.

We can observe the pattern of asymmetries over time with the help of dynamic multipliers. The dynamic multipliers associated with unit change in accumulated appreciations and depreciations, up to 60 quarters[15], are available in Figure-3[16] in Appendix-B. The depreciation is responded swiftly (by inflation) than appreciation.

We divide the sample into high and low inflation regimes to see how depreciation and appreciation passes through to inflation during these two regimes. These sub-samples are built on the basis of median inflation rate during the overall period of this study, which turns out to be 7.99 percent. We define high inflation regime as the one where inflation exceeded or equaled 7.99 percent. Otherwise, it classifies as low inflation regime. The estimated coefficients from the model (estimated in Table-3 earlier) are available in Table-5 below.

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testing equality of two estimate coefficients in ARDL type model following the procedure of IPS bounds test.

[14] Since there is no past study on Pakistan allowing asymmetries in ERPT to inflation, one may compare our results with peer countries.

[15] One for appreciation (depreciation) stabilizes after 18-21 (16-19) quarter.

[16] Since long run relationship can be asymmetric, the pattern of this asymmetry can be derived from the nonlinear ARDL presented above from the positive and negative dynamic multipliers associated with unit changes in s^+ and s^- as follows: $m_h^+ = \sum_{j=0}^{h} \frac{\partial p_{t+j}}{\partial s_t^+}$, $m_h^- = \sum_{j=0}^{h} \frac{\partial p_{t+j}}{\partial s_t^-}$, $h = 0,1,2 \ldots$ Where m_h^+ refers to dynamic multiplier of appreciation and m_h^- refers to that of depreciation.

TABLE 5

Short and Long Run Estimates of Asymmetric Exchange Rate Pass-Through in Pakistan

	High Inflation Regime	Low Inflation Regime
Short Run Estimates		
$\emptyset_{t-2}^{+}$	0.01	0.01
$\emptyset_{t-1}^{-}$	-0.06	-0.06
Long Run Estimates		
β_1^{+}	-0.48	-0.08
β_1^{-}	0.62**	0.48**

Note: β_1^{+} is the long-run coefficient associated with the appreciation in exchange rate while β_1^{-} is associated with the depreciation. ** indicates statistical significance at 10%.

Like in full sample results, the pass-through of depreciation is found to be statistically different from zero whereas one from appreciation is insignificant both for the high as well as low inflation regimes. Unsurprisingly, the estimated pass-through for depreciation to inflation is higher in high inflation regime compared to the one for low inflation regime. Note, however, that pass-through of depreciation is statistically significant whereas that from appreciation is not[17]. Possible source of nonlinearity in ERPT to inflation may be in the cycles in international commodity price changes (see Timmer (2008) and Zoli (2009) for details). There may be non-linearity with reference to the magnitude of the change in exchange rate and possible impact on inflation in the country. In other words, there may be some threshold level of change in exchange rate to have sizable effect on inflation and it may be the case

[17] We have also estimated model in equation (2) with assuming symmetric pass-through both in short run as well as long run. The results are available in Appendix-C (see Table- C2). This result underscores the importance of accurately specifying the model to be estimated for assessment of ERPT to inflation. The dynamic multiplier associated with symmetric model with unit change exchange rate is also available in Figure-4 of Appendix-B. The evolution of dynamic multiplier show that imposition of long run symmetry assumption suggests the adjustment process is sluggish which in fact is not as was evident in Figure- 3 of Appendix-B. In addition, we have also provided results pertaining to two other hybrid models. Results of Hybrid Model-1 (assuming SR Symmetric and LR Asymmetric) are available in Table-C3of Appendix-C whereas results of Hybrid Model-2 (assuming SR Asymmetry and LR Symmetric) are available in Table-C4

that during low inflation regime there are low inflation differential with the foreign country inflation and thus 'below the threshold level' requirement of correcting the exchange rate which may not have an impact inflation. Moreover, the possible threshold levels of exchange rate change to have significant effect on inflation are true for both appreciation and depreciation in exchange rate. We can associate the insignificance of pass-through of appreciation in Pakistan to relative characteristics of the distribution of appreciations compared to that of depreciations in the country as is evident from the smaller magnitudes of scale, shape and symmetry related estimates of distributions of appreciation and depreciations. (See Table-C1 in Appendix-C)

Finally, we explore if the estimated coefficients of pass-through of depreciation and appreciation are dependent on the inflation environment. Results of this state dependency tests are available in Table-6.

TABLE 6

State Dependency Test for Asymmetric ERPT to Inflation

Pass Though of	Test statistic
Appreciation	0.38
Depreciation	4.14*

H_0 = Difference between LR coefficients in high and low inflation regime equals zero
*indicates statistical significance at 5%.

We already found the estimated coefficient of ERPT pertaining to appreciation to be statistically insignificant both for high and low inflation regime. Here, we simply reconfirm that both are not different for different inflation regimes. Main interest lies now in the estimated coefficient of ERPT pertaining to depreciation. Result in the Table 6 shows that we reject the equality of the pass-through of depreciation to inflation during low and high inflation regimes –it is high during high inflation regime and low in low inflation regime. It may be one of the reasons why central banks tend to respond without large inside lag (by increasing the policy rate) when economy is going through a high inflation regime.

To sum up this section, our estimation results show that there may be considerable impact of exchange rate on inflation in Pakistan. Although

pass-through is incomplete, we found that that pass-through is lower after appreciation than after a depreciation. This result holds when we divide the sample into high and low regimes. When we tested for state dependency, we find that pass-through is stronger in high inflation environment.

Our results have implications for monetary policy framework as well as monetary policy conduct. As higher ERPT in case of depreciation compared to appreciation may exacerbates the trade-off between inflation and economic growth[18], the monetary authorities need to incorporate ERPT asymmetries in their policy settings. This, off course may require a complete new approach to DSGE modeling to consider relevant channel(s) for depreciation and appreciation of exchange rate to model asymmetries. For the case of Pakistan specifically, SBP has announced to switch to flexible inflation targeting soon. We expect that adopting flexible inflation targeting will help achieve lower inflation in the long run. Combining this with state dependency of pass-through of depreciation to inflation in Pakistan, we can say that exchange rate pass-through of depreciation to inflation will be lower in Pakistan after adoption of FIT, which helps lowering the long run inflation.

Before closing this section, it is important to mention that we evaluated our estimated model using internal and external validity tests, as mentioned in Stock and Watson (2011). For the external validity, we used the specific knowledge of a sort of underlying populations of interest by relying upon results of the Choudhary et al. (2011) to justify using markup model for Pakistan. For internal validity, we tried our best to address the issue of 'Omitted Variable Bias.' We started with a larger set of explanatory variables (discussed in the literature on inflation in Pakistan) to reach a plausible model (see Table-C5 of Appendix-C). In addition to the internal and external validity, we also assessed the overall fit of plausible model by bootstrapping as suggested by Bollen and Stine (1992). Comparison of estimated and bootstrap standard errors (and t-values) of the coefficients show robustness of the plausible model (see Table-C6 of Appendix-C).

[18] See Forero and Vega, 2015 for details.

VI. CONCLUSION

Using markup-pricing model, we have applied a simple method for exploring an asymmetric relationship using an ARDL model to investigate exchange rate pass-through to inflation in Pakistan for the period during Q3-1992 until Q2-2017. Results suggest that there is a significant role for the exchange rate in the determination of prices in Pakistan in the long run. Although pass-through of exchange rate to inflation is incomplete, we found that it lower (and insignificant) in case of appreciation than for depreciation (which is significant). The evolution of dynamic multiplier show that long run asymmetry hastens the adjustment process. This result holds when we divide the sample into high and low regimes. When we tested for state dependency, we find that pass-through is stronger in a high inflation environment compared to low inflation.

Our results have implications for monetary policy because this type of asymmetry exacerbate the trade-off between inflation and economic growth. Moreover, higher ERPT of depreciation in high inflationary regime may require monetary authority to respond a bit aggressively to this type of exchange rate movement so that inflation target is achieved.

There is a need to expand this analysis to see if ERPT to inflation is progressive in the sense that higher the size of depreciation higher the ERPT and vice versa.

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APPENDIX A

TABLE A1
Studies on Exchange Rate Dynamics Focusing on Pakistan Only

Title	Reference	ERPT Elasticity	Data Type	Model and Other Variables
Exchange Rate and Inflation Dynamics	Ahmed and Ali (1999)	0.15 (Long Run Only)	Time series data for Pakistan. Quarterly data starting 1982-II till 1994-IV	Linear Estimation using Two-Stage least Square method. Consumer Price Index (Dependent variable), world prices index, unit value index of imports, GDP, nominal exchange rate, Money Supply Growth.
The Exchange Rate and Consumer Prices in Pakistan: Is Rupee Devaluation Inflationary?	Choudhary and Khan (2002)	Approximately zero in Short Run Long Run Pass-through not estimated. Only four lags are available	Time Series data for Pakistan. 1982:1 till 2001:2	Single Equation Linear Estimation estimating Change in log CPI after controlling for Exchange Rate and Foreign Price Index (FPCI.) Linear estimation using VAR in the same specification and treating change in FPCI as exogenous
Global Commodity Prices and Inflation in a Small Open Economy	Hanif et al. (2016)	Pass-through of 3.5% in 30 months of 1% shock to change in exchange rate[20]	Time series data for Pakistan monthly data 1992:07 till 2014:06	Factor Augmented Bayesian Structural Vector Auto Regressive Model (FABSVAR)
Exchange Rate pass-through to domestic prices in Pakistan	Hyder and Shah (2005)	Short Run pass-through of 0.2 after 3 months for CPI	Time series data starting 1988:01 till 09:2003	Recursive VAR model with following ordering for IRFs: oil price inflation, QIM Index, M2 Growth, change in Nominal Exchange Rate, WPI and CPI
The Impact of Changes in Exchange Rate on Prices: A Case Study of Pakistan	Siddiqui and Akhtar (1999)	The coefficients of log of real exchange rate ranged from a low of -3.342 to a high of -0.291 for a variety of specifications.	Time series data of Pakistan for the period 1972-98.	First Order Auto Regressive Model (Error Correction Model). CPI as dependent variable, real exchange rate, ratio of domestic money supply to foreign money supply, difference between domestic and foreign interest rate, ratio of domestic to foreign GDP, difference between domestic and foreign inflation expectations.

[20] This only includes estimate for overall inflation which is highest among very others shocks which includes variety of dependent variables of inflation.

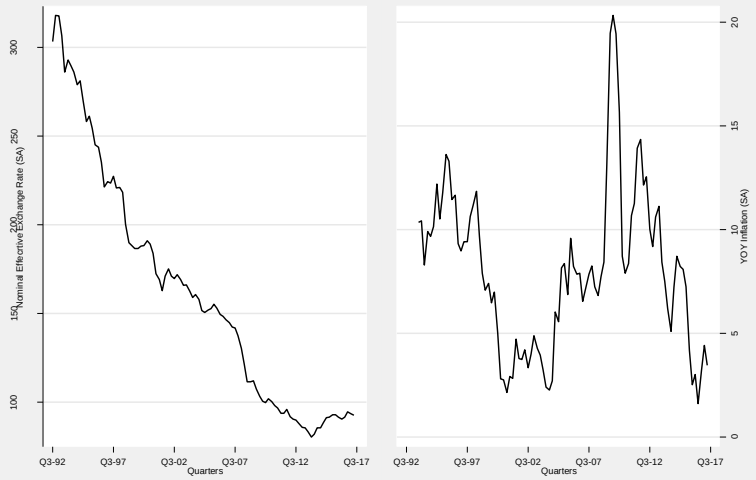
TABLE A2

Panel Data Studies on Exchange Rate Pass-Through whose Sample Includes Pakistan

Title	Reference	ERPT Elasticity	Data Type	Model and Other Variables
Exchange rate pass-through to domestic prices: Does inflationary environment matter?	Choudhary and Hakura (2006)	Short Run pass-through of -0.05 for 1-month horizon and -0.07 for 20-month horizon for Pakistan. For total sample, the numbers were 0.24 and 2.6 respectively.	Panel data consisting of a sample of 71 countries for the period starting 1979 till 2000.	OLS estimates based on a simple Linear model. Consisting of CPI as a dependent variable and nominal exchange rate (variable of interest), foreign price, average inflation rate, variance of inflation rate, variance of proportional exchange rate and import-to-GDP ratio as proxy for openness as control variables
Time-varying nature and macroeconomic determinants of exchange rate pass-through	Ozkan and Erden (2015)	ERPT for developing countries 0.316 and 0.076 for less developing countries.	Panel data consisting of a sample of 88 countries over the periods of 1980–2013 (monthly)	Dynamic Conditional Correlation-Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) and panel threshold regression analyses. ERPT, inflation rate, inflation volatility, exchange rate volatility, openness, GDP gap, inflation targeting.
The Pass-through from Depreciation to Inflation: A Panel Study	Goldfajan and Werlang (2000)	ERPT of 0.17 up to 3 months, 0.42 up to 6 months and 0.73 up to 12 months. 0.72 up to 12 months compared to 0.69 for Americas, 0.643 for Africa and 0.360 for Europe. Country coefficients not available	Panel data consisting of a sample of 71 countries over the periods of 1980–2013 (monthly)	Fixed effect model. Accumulated exchange rate as dependent variable, accumulated exchange rate depreciation, initial inflation, GDP deviation, openness, exchange rate overvaluation.

APPENDIX B

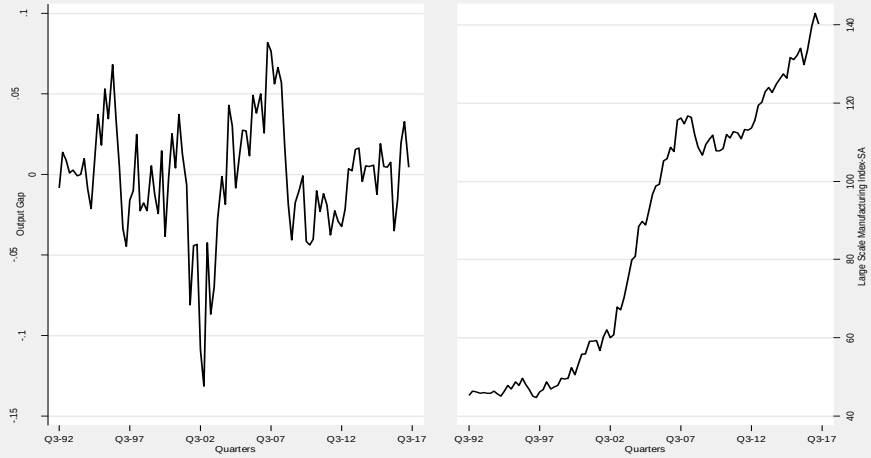
Fig.1 Panel-A



Source : State Bank of Pakistan

Source : State Bank of Pakistan

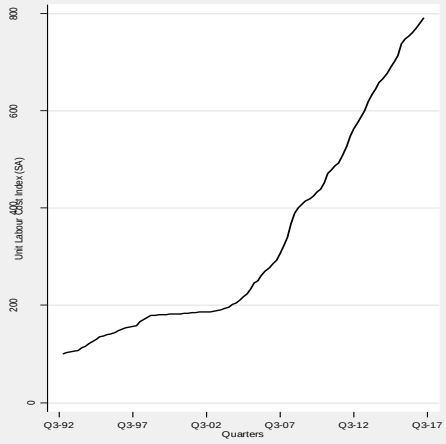
Fig.1 Panel-B



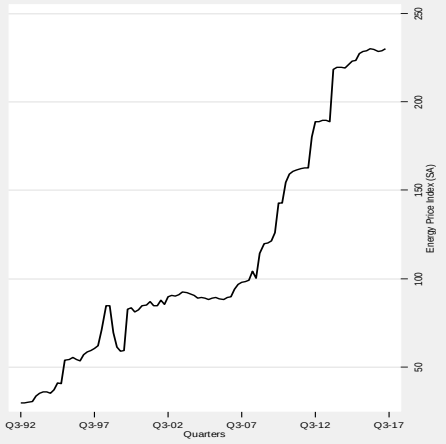
Source : Authors ' Calculations

Source : State Bank of Pakistan

Fig.1 Panel-C

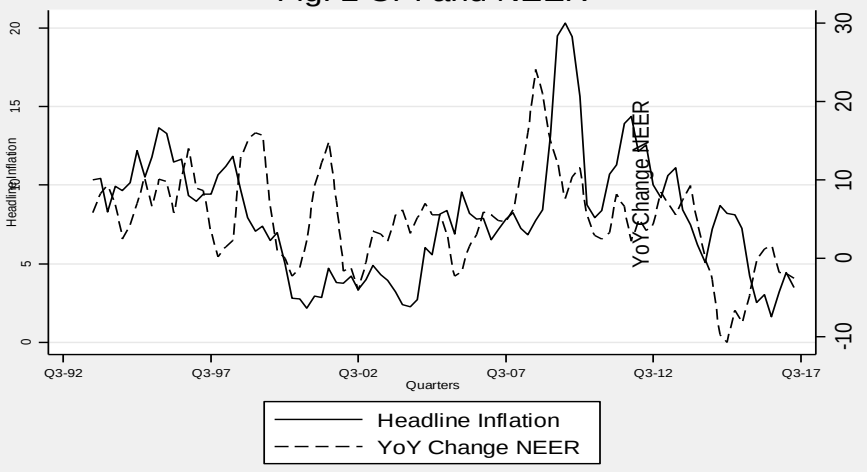


Source : Authors ' Calculation based on CPI Index



Source : Authors ' Calculations based on CPI Index

Fig. 2 CPI and NEER



Source : State Bank of Pakistan

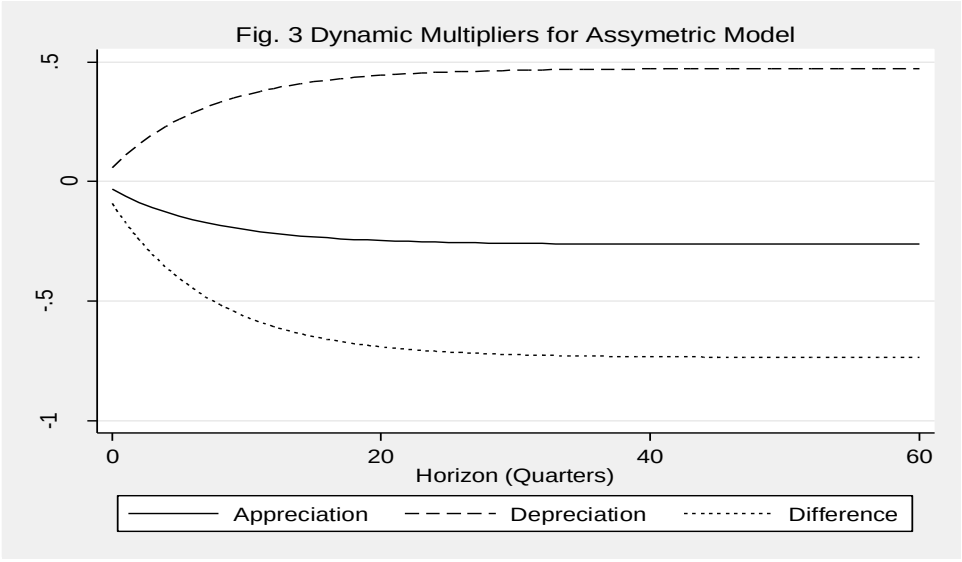


Fig. 3 Dynamic Multipliers for Assymetric Model
.5
0
-.5
-1
0
20
40
60
Horizon (Quarters)
Appreciation
Depreciation
Difference

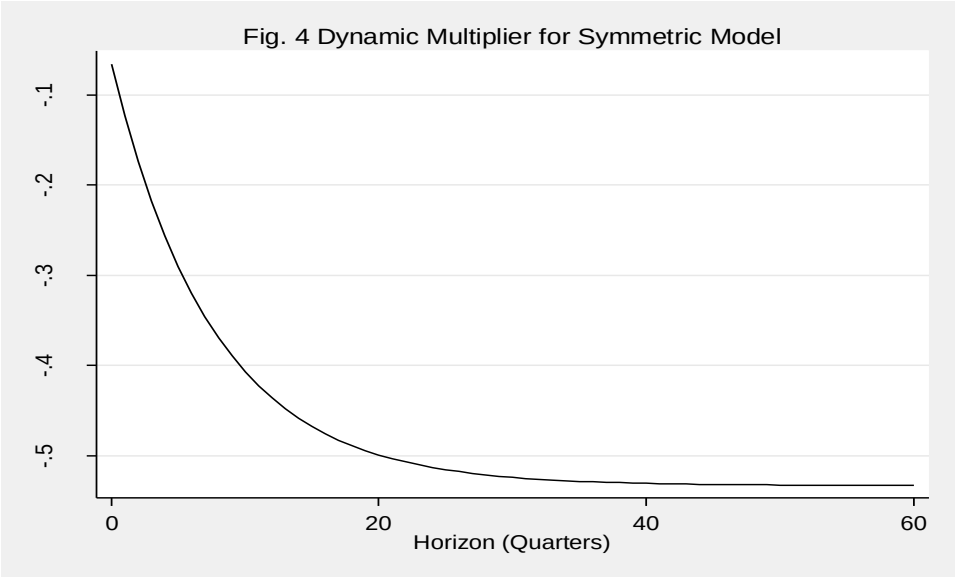


Fig. 4 Dynamic Multiplier for Symmetric Model
-.1
-.2
-.3
-.4
-.5
0
20
40
60
Horizon (Quarters)

APPENDIX C

TABLE C1

Basic Statistics on and CPI inflation and Changes in NEER

	Inflation (QoQ) %	Appreciation % (QoQ)	Depreciation (QoQ) %
Count	99	32	67
Average	2.01	1.60	2.53
Standard Deviation	1.33	1.35	2.01
Minimum	-0.29	0.02	0.039
25th Percentile	1.14	0.64	1.03
50th Percentile	1.86	1.32	1.97
75th Percentile	2.84	2.28	3.68
Maximum	8.10	4.80	8.69
Skewness	1.26	0.91	1.26
Kurtosis	6.63	3.05	4.23
	-	-	-

TABLE C2

Long/Short Run Estimates from the Symmetric Model (Equation 2)

	Coefficient	test-statistics
Short Run		
$\emptyset$	0.10	2.44*
Long Run		
β_1	-0.53	6.72*
F_{PSS}	7.85*	
R^2	0.88	
$Adj\ R^2$	0.87	
χ^2_{sc}	8.33*	

Note: β_1 is the long-run coefficient associated with the change in exchange rate.

F_{PSS} is F-Statistics (see Table CI (iii) in Pesaran, Shin and Smith (2001). Its critical value at 5% for K=4 is 4.01

χ^2_{SC} is Breusch-Godfrey LM test of serial correlation.

*indicates statistical significance at 5%.

TABLE C3

Hybrid Model-1 (SR Symmetric/LR Asymmetric)

	Coefficient	test-statistics
Short Run		
$\emptyset$	0.10	2.32*
Long Run		
β_1^+	0.42	0.70
β_1^-	0.82	6.54*
F_{PSS}	7.85*	
R^2	0.89	
$\chi^2_{serial\ correlation}$/DW	8.33[0.00]/1.50	

Hybrid refers to long run asymmetric and short run symmetric model.

β_1^+ is the long-run coefficient associated with the appreciation in exchange rate while β_1^- is associated with the depreciation.

F_{PSS} is F-Statistics (see Table CI(iii) in Pesaran, Shin and Smith (2001). Its critical value at 5% for K=4 is 4.01

χ^2_{SC} is Breusch-Godfrey LM test of serial correlation.

* indicates statistical significance at 5%.

TABLE C4

Hybrid Model-2 (SR Asymmetric/LR Symmetric)

	Coefficient	test-statistics
Short Run		
$\emptyset_{t-2}^+$	0.05	0.53
$\emptyset_{t-1}^-$	-0.10	-1.74
Long Run		
β_1	-50	5.11*
F_{PSS}	7.85*	
R^2	0.88	
$\chi^2_{serial\ correlation}$/DW	8.33[0.00]/1.50	
β_1		-50

Hybrid refers to long run asymmetric and short run symmetric model.

β_1^+ is the long-run coefficient associated with the appreciation in exchange rate while β_1^- is associated with the depreciation.

F_{PSS} is F-Statistics (see Table CI(iii) in Pesaran, Shin and Smith (2001). Its critical value at 5% for K=4 is 4.01

χ^2_{SC} is Breusch-Godfrey LM test of serial correlation.

* indicates statistical significance at 5%.

TABLE C5

Base Line Specification

	Plausible Spec-1	Spec-2	Spec-3	Spec-4	Spec-5	Spec-6	Spec-7
S	-0.12**	-0.53***	-0.33***	-0.045***	-0.11***	-0.10*	-0.13
ulc	0.55***	0.67***	0.78***	0.440***	0.57***	0.57***	0.55***
Elec	0.33***	-		0.319***	0.28**	0.30**	0.33
Global Oil Price	-	-.14***	-	-	-	-	-
Global Food Price	-	-	-0.22***	-	-	-	-
M2	-	-	-	0.110***	-	-	-
Discount Rate	-	-	-	-	-0.00***	-	-
Lending Rate	-	-	-	-	-	-0.01***	-
Wheat Price	-	-	-	-	-	-	0.00
Constant	0.42	3.84***	2.74***	-2.57**	0.53	0.38	0.44**
N	99	99	99	99	99	99	99
R2	0.996	0.994	0.994	0.997	0.997	0.997	0.996
R2_Adj.	0.996	0.994	0.994	0.997	0.997	0.996	0.996
F	8189.74	5203.75	5291.13	7295.86	9017.58	6210.22	6077.79

TABLE C6

Bootstrap Results of the Asymmetric ARDL model for Pakistan

	Coefficient	z-statistics	P-Value
p_{t-1}	-12.53	-1.80	0.073
s^{+}_{t-1}	-3.29	-0.58	0.563
s^{-}_{t-1}	5.92	1.98	0.048
eng_{t-1}	2.26	1.03	0.301
ulc_{t-1}	4.63	1.12	0.264
Δp_{t-1}	0.717	10.65	0.000
Δp_{t-2}	-	-	
Δp_{t-3}	-	-	-
Δp_{t-4}	-	-	-
Δs^{+}_{t-1}	-	-	-
Δs^{+}_{t-2}	0.030	0.39	0.698
Δs^{+}_{t-3}	-	-	-
Δs^{+}_{t-4}	-	-	-
Δs^{-}_{t-1}	-0.098	-1.78	0.075
Δs^{-}_{t-2}	-	-	-
Δs^{-}_{t-3}	-	-	-
Δs^{-}_{t-4}	-	-	-
Δeng_{t-1}	-	-	-
Δeng_{t-2}	-	-	-
Δeng_{t-3}	-	-	-
Δeng_{t-4}	0.032	2.53	0.011
Δulc_{t-1}	-	-	-
Δulc_{t-2}	0.251	2.89	0.004
Δulc_{t-3}	-	-	-
Δulc_{t-4}	-	-	-
gap_{t-1}	-	-	-
gap_{t-2}	-0.666	-2.79	0.005
gap_{t-3}	-	-	-
gap_{t-4}	-	-	-
_constant	14.192	1.79	0.073

Note: (a) Replications=500, (b) Lags in ARDL model are chosen according to a general-to-specific approach with lags initially set at max lag length of 4. (c) All the variables are defined in equation (2) in the methodology section. R^2=0.883 Adjusted R^2=0.866, N=92