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Exchange Rate Volatility and Pass-Through to Inflation in South Africa

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Abstract

Does the South African rand's relatively large volatility affect inflation? To shed some light on this question, a standard estimation technique of exchange rate pass-through to inflation is extended to incorporate exchange rate volatility. Estimated results suggest that higher exchange rate volatility tends to increase core inflation but to a relatively limited extent in South Africa. The finding lends support to the policy of allowing the rand to float freely and work as a shock absorber, consistent with the nation's successful inflation targeting regime.

JEL Classification Numbers: E31, E58, F31

Keywords: Exchange rate pass-through, exchange rate volatility, inflation

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I. INTRODUCTION

The South African rand has been relatively volatile because it has been subject to domestic and external disturbances given its role as a shock absorber based on the South African Reserve Bank (SARB)'s free-floating exchange rate policy. Domestic shocks have been relatively large in recent years, elevating rand volatility to above the VIX, or US stock price volatility, a commonly-used indicator of global uncertainty. External shocks also have important transmission channels—the rand is traded globally in large volumes, sometimes as a currency that proxies emerging market (EM) risks, and nonresident investors hold large shares of local assets.

The relatively high rand volatility may have an implication for inflation. While the pass-through of exchange rate appreciation and depreciation to inflation has declined due partly to increased central bank credibility, exchange rate volatility—often considered as an indicator of uncertainty—could still increase risk premia and inflation.[2] Across major EMs, higher exchange rate volatility increases risk premia and local currency sovereign bond yields (Gadanecz et al, 2018). In South Africa, global uncertainty shocks could depreciate the rand and increase inflation (Mumtaz and Theodoridis, 2015). Uncertainty shocks could be inflationary due also to precautionary increases in prices by firms (Redl, 2015).

This paper assesses the impact of rand volatility on inflation in South Africa. The analysis focuses on core inflation, which comprises ¾ of the items covered in the headline consumer price index (CPI). In other words, core inflation excludes electricity and fuel prices, which are administered, and food prices, which have exhibited large swings particularly in the past few years due to domestic harvest conditions. A standard empirical model of the pass-through of exchange rate appreciation and depreciation to inflation is extended by adding exchange rate volatility to assess the extent to which the latter affects inflation, both directly and indirectly. Given that exchange rate variables show strong comovements, the robustness of key findings is checked with efforts to attenuate potential endogeneity between exchange rate volatility and depreciation.

The rest of the paper is structured as follows. Section II discusses stylized facts about rand volatility. Section III provides a brief overview of the literature. Sections IV and V discuss the empirical technique and data. Section VI presents the estimated results and Section VII checks the robustness of the baseline results. Section VIII concludes.

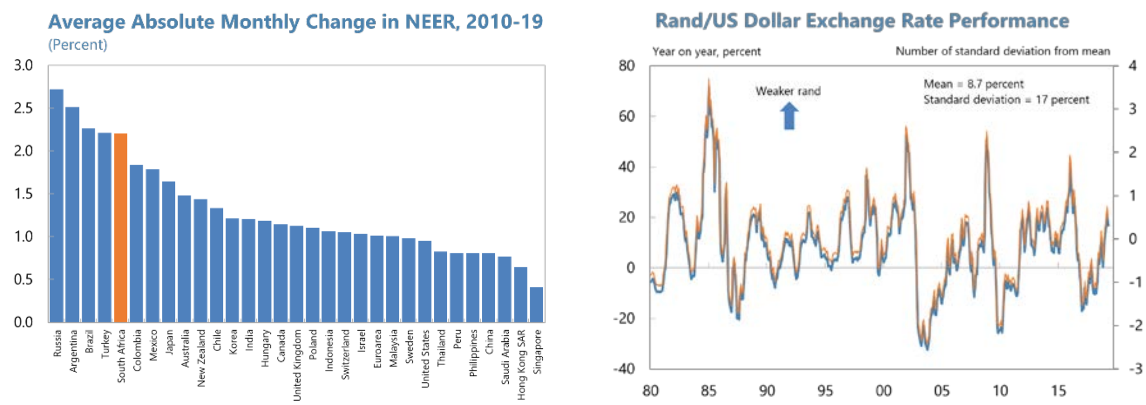
II. STYLIZED FACTS—RAND VOLATILITY

The rand has been relatively volatile. In nominal effective terms and in terms of the absolute size of monthly movements, the rand is one of the most volatile currencies within the group of advanced economies (AE) and EMs (Figure 1, left panel). Its performance is comparable

[2] See, for instance, Kabundi and Mbelu (2018). The SARB has become more credible since the adoption of the inflation targeting regime through improved communication, transparency, and independence (Kabundi and Mlachila, 2019) similar to other EMs in the aftermath of the adoption of an inflation targeting regime (Aleem and Lahiani, 2014).

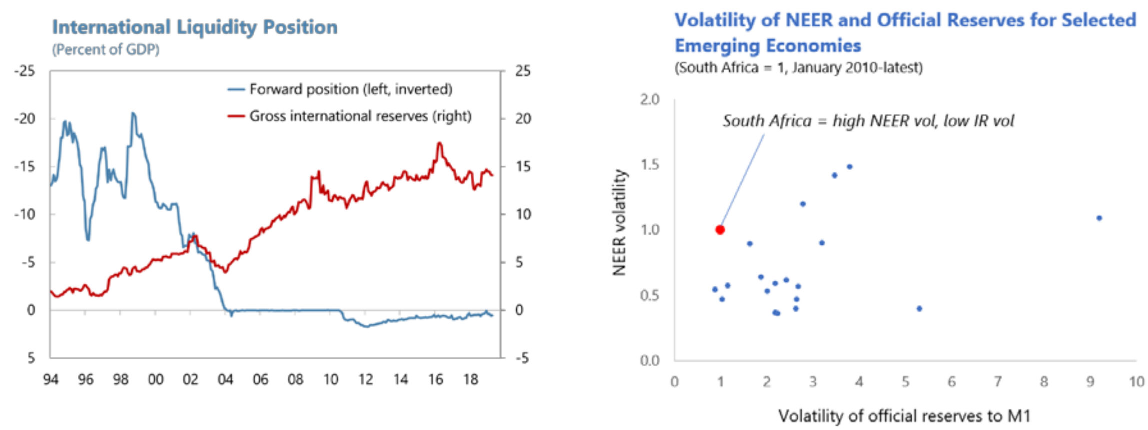
to that of the Brazilian *real* and Turkish lira. The Russian ruble and Argentine peso registered even larger degrees of movement. Central banks in some of the countries mentioned intervened in foreign exchange (FX) markets, in the absence of which volatility of their currencies would have been even higher. Historically, the rand weakened more than 70 percent year on year against the dollar in the mid-1980s related to a debt standstill.[3] In the 2000s, the currency pair weakened around 40–50 percent year on year in 2001, 2008 and 2015 (right panel).[4]

Figure 1. Indicators of Rand Performance



Sources: Haver and IMF staff calculations.

Figure 2. Indicators of SARB's Foreign Exchange Policy



Sources: Haver and IMF staff calculations.

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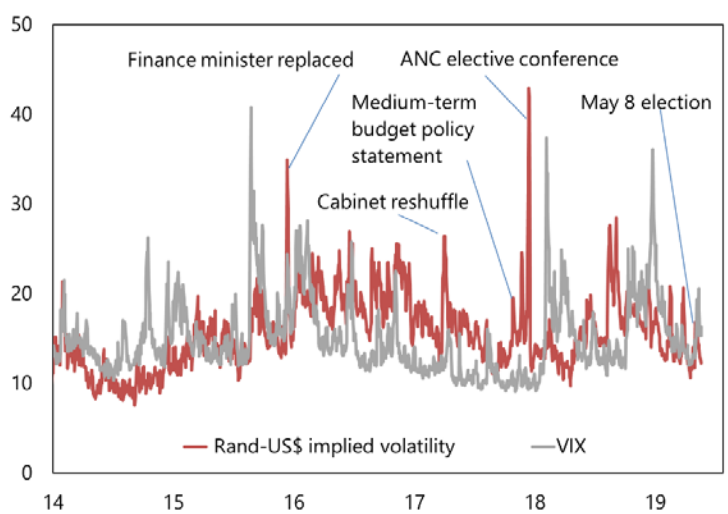
[3] Debt standstill is a mechanism by which a country agrees to cease payments on its debts until a restructuring agreement has been negotiated with its creditors.

[4] South Africa witnessed several bouts of large currency depreciation and capital outflows in the past: the mid-1980s (a debt standstill; Harris, 1986), 1998, 2001 (Bhundia and Ricci, 2005), the global financial crisis (GFC) in 2008, and the removal of the finance minister in 2015. Capital flight is estimated to have been worth 15–20 percent of GDP in the early-1980s and up to 15 percent of GDP in the late-1990s (Mohamed and Finnoff, 2004).

Rand volatility is relatively high for several reasons. Rand performance has been subject to domestic and external disturbances as a shock absorber reflecting the SARB's policy to let the rand float freely. The left panel of Figure 2 illustrates the evolution of the SARB's foreign exchange policy. The blue line represents the SARB's forward position as a share of GDP, inverted, and plotted on the left scale. The forward position was short until 2003, indicating that the SARB sold dollars to support the rand, and swapped the short dollar positions into forwards. The stock of short positions used to be sizable, up to 20 percent of GDP through the late-1990. After the adoption of inflation targeting, much of the short forward positions declined, as foreign exchange intervention was scaled down or ended. Gross official reserves (red line) increased gradually, likely as the SARB bought foreign inflows opportunistically. The right panel illustrates that South Africa has been using the rand, rather than official reserves, to absorb shocks—volatility of the rand is relatively high, while that of official reserves relative to M1 is one of the lowest among EMs.

Domestically, policy and political uncertainty have tended to increase rand volatility at least in the past several years.[5] In Figure 3, the red and gray lines show the volatility of the rand against the US dollar implied by the pricing of option contracts, and the VIX, a similar index for US stock prices, often used as an indicator of global investors' risk appetite. Rand volatility remained below the VIX until the early-2015. Following an increase in policy and political uncertainty since the late-2015, rand volatility rose and stayed above the VIX much of 2016 and 2017. Since then, the two lines have been changing positions relative to each other.

Figure 3. Implied Volatility of Rand-US Dollar Currency Pair and US Stocks
(Percent)



Sources: Bloomberg and IMF staff calculations.

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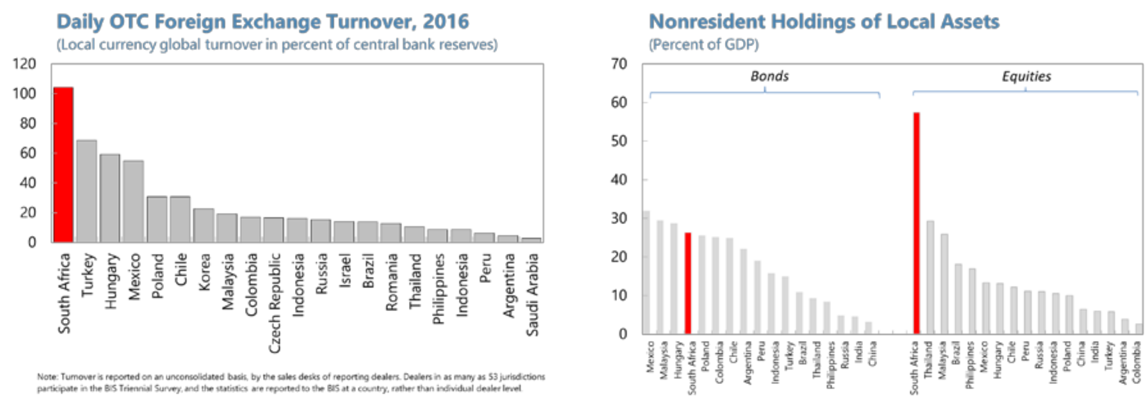
[5] Relatively high exchange rate volatility could be due to a high inflation differential (Du Plessis and Reid, 2015).

The rand is also subject to external shocks, at least through two important channels. First, the rand trades in large volumes globally. Compared to major EMs, South Africa's daily currency turnover in global markets scaled by official reserves is by far the highest partly as the rand is traded as EM proxy (Figure 4, left panel). Second, nonresident holdings of local assets are large in South Africa (right panel). This could increase the impact of a given external shock—discussions with market participants suggested that some nonresident investors tend to trade South Africa's local bonds based mainly on changes in global conditions.[6]

Figure 4. Key Transmission Channels of External Shocks

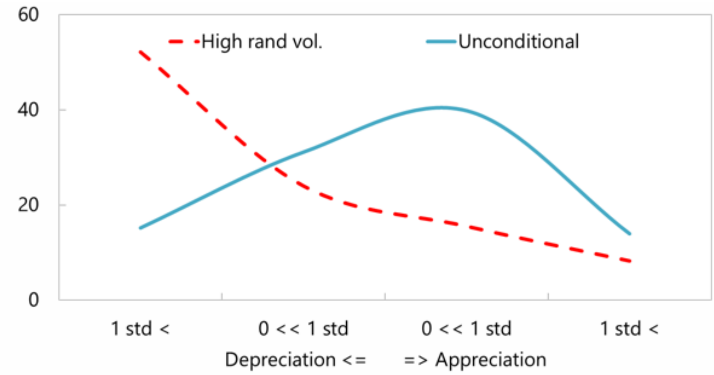


Sources: BIS, Haver, and IMF staff calculations.

Historically, high rand volatility has been accompanied by rand depreciation. Generally, asset prices tend to fall abruptly and increase uncertainty and risk premia. This linkage is present in the rand exchange rate against the US dollar (Figure 5). The x-axis represents rand performance—from large rand depreciation on the extreme left to mild depreciation as one moves to the right, and large appreciation on the extreme right. The y-axis represents the percent share of total observations. The blue line, which shows the distribution of rand performance without conditioning on rand volatility, is broadly bell-shaped, that is, moderate appreciation and depreciation take place more often than more extreme appreciation and depreciation. The red line plots the distribution of rand performance by sampling the data only when rand volatility is relatively high (one standard deviation or more away from the historical average). The red line is upward slowing to the left, suggesting that, relatively high rand volatility tends to be accompanied by relatively large rand depreciation.

[6] Bloomberg data on nonresident holdings of local currency sovereign bonds in South Africa suggest that the importance of cross-over investors may have increased. More generally, the impact of foreign participation on domestic asset prices appears to be country-and event-specific, gauging from the rather inconclusive views coming out of the literature. For instance, one view in the literature is that high foreign investor penetration into local currency EM bond markets can raise domestic currency yields due to a greater chance of sudden withdrawals (Calvo and Talvi, 2005; Ebeke and Kyobe, 2015). Another view is that greater capital account openness would entail lower domestic interest rates (Eichengreen and Rose, 2014). Yet another view is that foreign investors compress local currency sovereign yields by pushing up bond prices through their purchases (Gadanecz, Miyajima and Urban, 2015). Warnock and Warnock (2009) argue that official sector investment into US bond tends to lower the yields on those bonds.

Figure 5. Distribution of Rand Performance
(Percent, daily rand-US dollar data, January 2000–February 2019)



Sources: Bloomberg and IMF staff calculations.

Note: High rand volatility refers to three-month rand-dollar volatility implied by option pricing being one standard deviation (std) or more above the mean. Daily rand performance relative to HP trend.

III. Literature Review

Exchange rate pass-through (ERPT) to inflation has been studied widely. For instance, Jašová et al (2016) study the evolution of ERPT to headline CPI inflation since the GFC for a large number of AEs and EMs. The authors apply GMM to data in quarter-on-quarter changes and control for non-linearities. They find that ERPT in EMs decreased after the GFC, while that in AEs remained relatively low and stable over time. In particular, an updated result in Carstens (2019) shows that ERPT in EMs moderated from around 0.3 in the early-2000s to 0.1 in the late-2000s and first half of the 2010s, and edged up to around 0.2 by the end of 2018.

ERPT in South Africa could be affected by several key factors. A low degree of product market competition (IMF, 2018) could reduce the extent of ERPT (Krugman, 1986; and Dornbusch, 1987). Forbes et al (2017, 2018) argue that ERPT depends on the nature of the shock to the exchange rate, and that the inflation response is significantly larger when exchange rate movements are caused by monetary policy shocks compared to demand shocks. To the extent that the rand tends to be subject to changes in global financing conditions, such shocks would make ERPT in South Africa relatively large.

Several studies estimate EPRT for South Africa. Kabundi and Mbelu (2018) find ERPT to headline inflation at around 0.2–0.25 in the mid-2010s. They model ERPT for 1994–2014 using ECM and, instead of directly estimating the overall pass-through, implement a two-stage ERPT framework, distinguising a first-stage PT (the impact of exchange rate movement on import prices) from a second-stage PT (the effects of import prices on overall consumer prices). They find that the behavior of ERPT over the business cycle is asymmetric in that ERPT tends to rise during business cycle upturns relative to downturns. ERPT is complete in the first stage but incomplete in the second stage, implying that retailers do not pass all price changes to consumers. The first-stage ERPT declined slightly since the GFC while the second-stage ERPT fell considerably since the adoption of the inflationtargeting regime. The authors also attribute the reduction in ERPT to weak domestic demand and possibly the concentration of firms in the manufacturing sector. Forbes et al (2017) obtain smaller estimates for South Africa using a distributed lag regression approach—around 0.15 for 1990–2015 and 2001–09, but 0.06 for 2010–15.

Kabundi and Mlachila (2019) attribute the decline in ERPT in South Africa over the past two decades documented in Kabundi and Mbelu (2018) largely to improved monetary policy credibility. The SARB has become more credible since the adoption of the inflation targeting regime through improved communication, transparency, and independence. As standard in the literatue, the authors use forecastors' disagreement as a proxy for central bank credibility.

Some studies find that ERPT to inflation increases with currency volatility. One important channel for South Africa, which is small, open, and highly integrated in the global capital markets, is the impact of higher uncertainty (or volatility) in the rest of the world. In this respect, Mumtaz and Theodoridis (2015) find that higher volatility in the rest of the world would weaken the local curency and increase inflation, using both empirical (SVAR) and strucutural (DSGE) approaches.

Another channel is the choice of the currecy of pricing. For a sample of 27 OECD countries, Ben Cheikh (2011) employs both FM-OLS and DOLS approaches to estimate long-run ERPT (LRERPT) and find that countries with higher inflation and exchange rate volatility would experience higher pass-through. Currencies with relatively low variability are preferred for transaction invoicing and local-currency pricing would reduce ERPT. The author also argues that the literature on ERPT generally finds that lower currency volatility tends to be accompanied by lower ERPT.

Currency volatility could also affect the degree of precautionary pricing and EPRT. Redl (2015) studies the impact of unanticipated increases in macroeconomic uncertainty using a SVAR and shows that higher uncertainty weakens economic activity but increases inflation. In his New Keynesian model, higher uncertainty (volatility of technology) leads to lower output and higher inflation—the latter is driven by precautionary increases in prices by firms. Firms face asymmetric costs in choosing their prices, that is, pricing too low is much more costly than pricing too high. With nominal rigidities, as an insurance policy they raise prices today. This is broadly consistent with Gadanecz et al (2018) who argue that exchange rate volatility increases risk premia and local currency sovereign bond yields in EMs.

IV. Emprical Strategy

Following Jašová et al (2016), ERPT to inflation in South Africa is modelled using the dynamic approach as follows:

$$\pi_t = \alpha + \beta\pi_{t-1} + \sum_{i=1}^{4} \gamma_i\, e_{t-i} + \sum_j \delta_t^j + \varepsilon_t \quad (1)$$

$\pi_t$is the quarterly log difference of the seasonally-adjusted consumer price index in quarter t. e_{t-i} is the quarterly log difference of the exchange rate. A total of four terms are used to capture delayed ERPT, similar to Jašová et al (2016) to capture ERPT over the period of one year. δ_j is a set of control variables including domestic and external factors.

As a second step, the baseline model is extended to capture the effect of exchange rate volatility as follows:

$$\pi_t = \alpha + \beta\pi_{t-1} + \sum_{i=1}^{4}\gamma_i\, e_{t-i} + \theta\ \ v_{t-l} + \sum_{i=1}^{4}\mu_i\, e_{t-i}v_{t-5} + \sum_{j}\delta_t^j + \varepsilon_t \quad (2)$$

v_{t-l} is an indicator of exchange rate volatility at lag l. Exchange volatility in $t-5$ is interacted with the exchange rate in up to $t-i$ where i = 1, ..., 4 to capture nonlinear effects of ERPT, similar to how Jašová et al (2016) use inflation with a fixed lag to interact with NEER depreciation with different lags.

Based on estimated results, yearly and long-run ERPT (LRERPT) can be obtained. Yearly ERPT is the sum of the coefficients on log changes in the exchange rate over four quarters. LRERPT is yearly pass through divided by one minus the coefficient on lagged inflation.

V. DATA

The dependent variable is core inflation, that is, headline inflation excluding electricity, fuel, and food price inflation (Table 1 and Figure 6). Core inflation represents ¾ of the overall inflation basket. Food items represent 17 percent while fuel and electricity 4–5 percent, respectively. Core inflation (average 4.3 percent year on year) is lower and less volatile than electricity, fuel, and food price inflation. Core inflation became less volatile particularly after 2011. Electricity prices are administered and their inflation (10.7 percent) is the highest among the four components. It rose to around 30 percent year on year in the late-2000s and gradually declined. Fuel price inflation is the most volatile component (standard deviation of 13.7 and coefficient of variation of 1.5), strongly affected by global oil prices and rand performance. It exhibited large up and down swings, reflecting volatility in global commodity prices, around the GFC. It fell deep into negative territory again after oil prices collapsed in the summer of 2014. Food price inflation has been affected by global food prices and domestic harvest conditions. The large volatility around the GFC reflected global commodity price developments, while the surge in 2017 and the following persistent disinflation reflected the impact of a severe drought and recovery from it.

Several explanatory variables are used (Figure 7). Exchange rate performance, the variable of interest, is captured by NEER. It is computed by accounting for changes in the composition of import origin countries on an annual basis. Positive values represent depreciation in year on year terms. Inflation in import origin countries is controlled for by an index of producer price inflation in these economies. As South Africa's position on its business cycle would affect demand pressures and inflation, a measure of the output gap estimated from HP filters is also included. Wage pressure is controlled for by unit labor cost inflation. Realized exchange rate volatility is represented by the 3-month rolling standard deviation of the daily percent change in the dollar-rand exchange rate.[7]

Table 1. Core and Other Components of Headline Inflation

	Electricity	Fuel	Food	Core
CPI basket weight	3.8	4.6	17.2	74.4
Inflation performance, 2003-19				
a. Mean	10.7	9.0	6.7	4.3
b. Standard deviation	7.5	13.7	4.1	2.7
c. Coefficient of variation (b/a)	0.7	1.5	0.6	0.6

Sources: Haver and IMF staff calculations.

Quarterly data for March 2005–June 2018 are used. Core inflation data go back to 2002 but the data during the initial years are very volatile and thus removed. Some explanatory variables are available through June 2018.

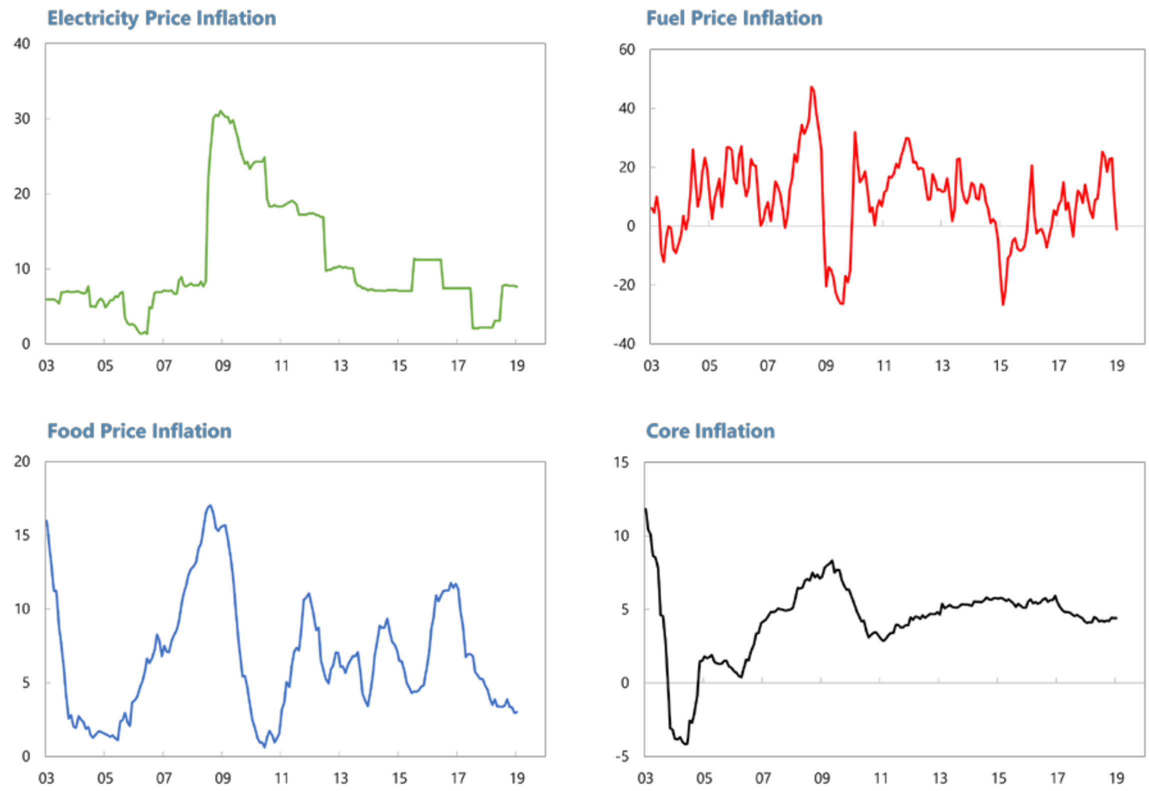
An initial data analysis suggests that the estimated "Granger-causality" with core inflation is highly heterogenous among the explanatory variables. Table A1 shows results from Granger causality Wald tests implemented for up to 4 lags. These tests do not identify causation and rather indicate if a variable can improve the prediction of the explanatory variable. With this caveat in mind, NEER depreciation and the output gap strongly impact (statistically, at the 1 percent level) core inflation at all lags. Other variables either exert statistically weaker influence on core inflation, or they do so with some lag. Looking at the other direction of Granger-causality, core inflation generally does not have a strong impact on the explanatory variables. This suggests issues of reverse causality could be small. Exchange rate variables (depreciation and volatility) tend to respond more quickly and strongly to core inflation, consistent with the notion that exchange rates are an asset price which tends to quickly incorporate information. To help reduce potential reverse causality in estimating the empirical model, recognizing this would not fully solve the problem, explanatory variables are lagged, except for foreign PPI which is exogenous to South Africa.

Looking at the Granger-causality between the two exchange rate variables, exchange rate volatility strongly impacts NEER depreciation, likely as NEER depreciation is affected by the domestic and external shocks captured by exchange rate volatility. NEER depreciation has only some causal impact on exchange rate volatility.[8]

[7] Using NEER data yields a similar volatility measure.

[8] The estimated result that core inflation granger causes foreign PPI needs to be interpreted with caution as core inflation in South Africa should be exogenous to foreign PPI.

Figure 6. Core and Other Components of Headline Inflation
(Percent)



Sources: Haver and IMF staff calculations.

Figure 7. Determinants of Core Inflation
(Percent)

Sources: Haver and IMF staff calculations.

VI. RESULTS

This section discusses the baseline results and those from an extended model that includes exchange rate volatility.

A. Core vs. Headline Inflation

Before delving into the analysis of core inflation, we start from comparing ERPT to core and headline inflation.[9] While the literature suggests headline inflation tends to show greater ERPT than core inflation, this may not be as clear for South Africa. Domestic electricity and food price inflation is uncorrelated with exchange rate movements.[10] Domestic fuel price inflation exhibits some positive correlation with exchange rate depreciation, but its share in the CPI basket is small. Thus, when all three components–electricity, fuel, and food–are put together, it is not clear whether ERPT would increase as suggested in the literature.

In the empirical estimation, explanatory variables are introduced with lags to help attenuate potential reverse causality issues, except for foreign PPI (for which a contemporaneous value is used as the variable is exogenous to South Africa). Variables are in quarter-on-quarter log difference, except for the output gap, which is in percent deviations from trend.

Table 2 shows that the impact of NEER depreciation on headline inflation is moderately larger than that on core inflation initially but does not persist as much. The yearly ERPT (9 percent) for headline inflation is moderately larger than that for core inflation (8 percent). Headline inflation has a much smaller persistence (autoregressive coefficient) consistent with the fact that the series includes more volatile components. The small autoregressive term dampens the LREPRT to 12 percent, below 19 percent for core inflation (see Table A2 for more results). Foreign PPI is an important determinant of headline inflation, likely through energy and food prices. Unit labor costs and the output gap do not show a very strong impact on either.[11]

[9] Core inflation data are extended backwards to the late 1990s chaining discontinued data because results for headline inflation are otherwise statistically weak. However, the rest of the paper analyzing core inflation in detail relies on the period starting from 2005.

[10] Using quarterly data for 2003-18, all in log differences, the correlation between NEER changes and domestic electricity price inflation is -0.04, domestic fuel price inflation is 0.33, and domestic food price inflation is 0.06.

[11] The impact of the output gap on core inflation becomes statistically significant when data from 2005 are used in the next section.

Table 2. Determinants of Core and Headline Inflation

Dept. var		Core	Headline
AR1.		0.581***	0.289***
NEER			
	L1.	0.040***	0.036***
	L2.	-0.002	0.017
	L3.	0.023*	0.023**
	L4.	0.017	0.012
Foreign PPI	L0.	0.015	0.187***
ULC	L1.	0.083	0.084*
Output gap	L1.	0.002	0.049*
Constant		0.122*	0.281***
N		78	78
Adj. r^2		0.587	0.551
Yearly ERPT			
Coef.		0.078**	0.088***
F-stat		3.13	5.15
Long-run ERPT			
Coef.		0.186***	0.124***
F-stat		18.66	8.40

Source: Author's calculations.
Note: "***", "**", and "*" signify statistical significance at the 1, 5, and 10 percent levels. See Table A2 for more results.

B. Baseline Results for Core Inflation

Now we turn to the analysis of core inflation. The baseline model is re-estimated with data starting from 2005 to focus on the period during which core inflation does not display structural breaks. Core inflation is influenced by NEER depreciation and the output gap. However, ERPT declined over time, consistent with what Kabundi and Mlachila (2019) argue. The yearly ERPT is between 2 and 4 percent, down from close to 8 percent in the previous sub-section where data for earlier quarters were included. LRERPT of 6 to 10 percent is also below the 19 percent in the previous sub-section. The output gap coefficient is significant but at the 10 percent level. The one-standard-deviation variation in the output gap is around 1, suggesting that the extent of its pass-through to core inflation is relatively limited.

LRERPT to core inflation gradually rose in recent years but remains relatively small (Figure 8). The time-series estimates on a 10-year rolling basis, using the last model in Table 3, show a gradual increase from 4 percent in 2014 to 7 percent in 2018. The rising trend is similar to estimates in Carstens (2019), where LRERPT for a set of EMs rose from 10 percent in 2014 to 20 percent in 2018.

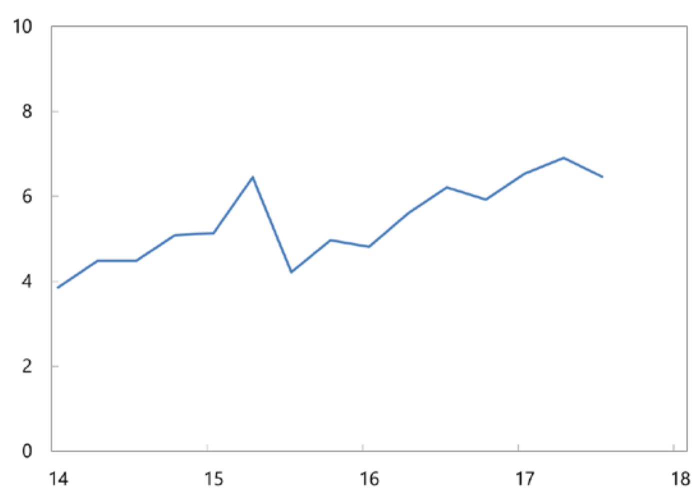
Table 3. Yearly and Long-Run ERPT to Core Inflation

Dept. var		Core inflation					
AR1.		0.756***	0.579***	0.599***	0.611***	0.586***	0.588***
NEER							
	L1.	...	0.020***	0.021***	0.021***	0.015**	0.015**
	L2.	...	0.005	0.005	0.005	0.002	0.002
	L3.	...	-0.001	0.000	0.000	-0.004	-0.004
	L4.	...	0.011	0.011	0.011	0.010	0.010
Foreign PPI	L0.	...	...	0.022	0.020	0.014	0.014
ULC	L1.	...	...	...	-0.006	...	-0.001
Output gap	L1.	...	...	...	...	0.029*	0.029*
Constant		0.127**	0.209***	0.192***	0.190***	0.202***	0.202***
N		53	50	50	50	50	50
Adj. r^2		0.58	0.56	0.56	0.55	0.59	0.58
Yearly ERPT							
coef.		...	0.035**	0.037**	0.037**	0.023^	0.023^
F-stat		...	3.27	3.40	3.29	1.86	1.81
Long-run ERPT							
coef.		...	0.083***	0.092***	0.095***	0.056***	0.056***
F-stat		...	13.65	13.02	11.86	9.64	8.13

Source: Author’s calculations.

Note: “***”, “**”, “*”, and “^” signify statistical significance at the 1, 5, 10 and 15 percent levels.

Figure 8. Long-Run ERPT to Core Inflation
(Percent)



Sources: Author’s estimation.

C. Adding Exchange Rate Volatility

The baseline model is extended to include exchange rate volatility and its interaction with NEER depreciation. The interaction term is introduced up to four lag depths. Exchange rate volatility is introduced with one lag depth. Different models with different lag depths are estimated to check coefficient stability (Table A3). As extended models involve estimation of a large number of parameters relative to the number of observations, a parsimonious model is also estimated by dropping insignificant terms.

Table 4. Determinants of Core Inflation–Extension

Dept. var		Core inflation		
AR1		0.588***	0.404***	0.421***
NEER				
	L1.	0.015**	0.017**	0.017***
	L2.	0.002	0.000	-0.003
	L3.	-0.004	-0.001	…
	L4.	0.010	0.007	…
ER vol	L2.	…	0.034#	0.040***
NEER*L5.ER vol				
	L1.	…	0.014	0.013
	L2.	…	-0.002	-0.002
	L3.	…	-0.001	…
	L4.	…	0.003	…
Foreign PPI	L0.	0.014	0.000	…
ULC	L1.	-0.001	0.002	…
Output gap,	L1.	0.029*	0.038**	0.040***
Constant		0.202***	0.303***	0.298***
N		50	49	49
Adj. r^2		0.580	0.550	0.598

Source: Author’s calculations.

Note: “***”, “**”, “*”, and “#” signify statistical significance at the 1, 5, 10, and 20 percent levels.

Selected results in Table 4 show that a rise in exchange rate volatility leads to higher core inflation. The second lag of exchange rate volatility is significant when introduced without the interaction term (Table A3). It remains significant with all interaction terms only at the 20 percent level. However, in a parsimonious model, its statistical significance improves to the 1 percent level. As for the size of the impact, it appears relatively small, with up to 4 percent of exchange rate volatility being passed through to core inflation. A one unit change in the exchange rate volatility data, which represents one standard deviation movement (as the data is normalized to so-called Z-score), or a “normal” variation, affects core inflation by 0.04 percent. The interaction terms are insignificant, suggesting the extent of ERPT is not systematically affected in a nonlinear way by the level of exchange rate volatility. Meanwhile, the coefficients on ERPT and the output gap remain similar to those of the baseline model.

VII. Robustness Checks

Several additional models are estimated to check the robustness of the findings. First, exchange rate volatility may reflect NEER depreciation and bias the results. Indeed, Table 5 shows that NEER depreciation and volatility affect each other. Thus, the realized exchange rate volatility is replaced by the residual after controlling for own lag and NEER depreciation (using the contemporaneous value and the first lag). Second, the results may be sensitive to the kinds of currency volatility measure used. Thus, the realized exchange rate volatility is replaced by the volatility implied by option pricing (of rand-dollar currency pair, three-month tenor). In doing so, similarly estimated residuals are used (from a regression of implied volatility on own lag and NEER depreciation, both using contemporaneous value and the first lag). Third, the exchange rate volatility is replaced by the VIX, a commonly-used indicator of global uncertainty, as another effort to attenuate potential endogeneity between the exchange rate and its volatility.

Table 5. Determinants of NEER Depreciation and ER Volatility

		NEER deprecaiton	Exchagen rate volatility
AR1		0.294**	0.525***
NEER deprecaiton			
	L0.	...	0.171***
	L1.	...	-0.089*
Exchagen rate volatility			
	L0.	-1.098***	...
	L1.	1.283***	...
N		53	53
r2_a		0.225	0.309

Source: Author’s calculations.

Note: “***”, “**”, and “*” signify statistical significance at the 1, 5, and 10 percent levels.

Selected results summarized in Table 6 suggest that higher exchange rate volatility leads to higher core inflation, even though with a small impact in size. When the residual of realized exchange volatility is used, exchange rate volatility remains a statistically important determinant, at the 5–10 percent levels (See Table A4 for more results). The interaction terms do not have statistically significant impact. The coefficient on the implied volatility is statistically significant at the 1 percent level, but the pass-through is smaller. In some models reported in Table A5 the implied volatility appears to somewhat increase ERPT. As for the other coefficients, straight ERPT terms are generally stable, with coefficients being positive and statistically significant. The coefficient on the output gap remains statistically significant.

Our findings remain robust to additional checks using VIX instead of exchange rate volatility (Table A6).

Table 6. Determinants of Core Inflation–Extension

		Baseline	With alternative ER vol measures			
			Realized volatility, residual		Implied volatility, residual	
AR1		0.588***	0.364**	0.398***	0.398***	0.368***
NEER						
	L1.	0.015**	0.014**	0.014**	0.005	0.008
	L2.	0.002	0.005	...	0.003	...
	L3.	-0.004	-0.003	...	-0.004	...
	L4.	0.010	0.01	0.009	0.013*	0.013**
ER vol	L2.	...	0.044*	0.039**	0.013***	0.012***
NEER*L5.ER vol						
	L1.	...	0.017	0.015	0.004	0.003
	L2.	...	0.007	...	0.002	...
	L3.	...	-0.011	...	0.002	...
	L4.	...	-0.002	-0.007	-0.001	-0.001
Foreign PPI	L0.	0.014	-0.004	...	-0.007	...
ULC	L1.	-0.001	-0.001	...	0.005	...
Output gap,	L1.	0.029*	0.045***	0.037***	0.036***	0.039***
Constant		0.202***	0.326***	0.314***	0.333***	0.333***
N		50	48	48	49	49
Adj. r^2		0.580	0.553	0.592	0.552	0.596

Source: Author's calculations.

Note: "***", "**", and "*" signify statistical significance at the 1, 5, and 10 percent levels. ER vol is residual of either realized or implied volatility on NEER depreciation (first and second lags).

VIII. Conclusion

This paper analyzed the impact of exchange rate volatility on core inflation in South Africa. While exchange rate pass-through (ERPT) to inflation has declined like in other EMs, a related question is how the relatively large exchange rate volatility has affected inflation. A standard empirical model of ERPT was extended to incorporate exchange rate volatility, and main findings from the baseline specification were subjected to a number of robustness checks.

Estimated results suggest that higher exchange rate volatility would lift core inflation in a statistically significant way, but with a relatively small impact in size. The finding was robust after controlling for potential endogeneity among exchange rate variables (depreciation and volatility). Meanwhile, the estimated ERPT to core inflation was broadly stable and the output gap remained an important determinant across different models.

The finding lends support to the policy of allowing the rand to float freely and work as a shock absorber, consistent with the successful inflation targeting regime. At least from an inflation targeting point of view, this paper did not find evidence that relatively large rand volatility has had negative effects. The rand has worked as an important shock absorber while the consequent large rand volatility has had limited inflationary impact.

A possible extension of this work is to assess the potential impact of rand volatility on other sectors. For instance, while one view is that domestic corporates have become accustomed to large rand volatility, SMEs with limited natural hedges (e.g., foreign currency revenue) or insufficeint resources and/or expertise to put on financial hedges could be less insulated. Also, given the importance of capital inflows, particularly portfolio investment in South Africa, the impact of exchange rate volatility on cross-border bond and equity inflows could be another fruitful topic to analyze.

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X. ANNEX TABLES

Table A1. Granger Causality Wald Test Results

chi^2	df	Probability > chi^2		chi^2	df	Probability > chi^2	
H0 = X does not cause core inflation				H0 = Core inflation does not cause X			
X = NEER depreciation							
8.0774	1	0.004	***	0.0287	1	0.866	
9.9400	2	0.007	***	5.2575	2	0.072	*
16.0200	3	0.001	***	5.7763	3	0.123	
18.2370	4	0.001	***	10.4130	4	0.034	**
X = Realized 3-month NEER volatility							
0.7712	1	0.380		3.8467	1	0.050	*
1.6264	2	0.443		7.2473	2	0.027	**
12.5920	3	0.006	***	7.2588	3	0.064	*
12.7770	4	0.012	**	6.1979	4	0.185	
X = Output gap							
10.5370	1	0.001	***	5.9976	1	0.014	**
12.7660	2	0.002	***	4.4408	2	0.109	
20.7180	3	0.000	***	3.7756	3	0.287	
22.7700	4	0.000	***	7.0355	4	0.134	
X = Unit labor cost							
2.1434	1	0.143		1.3118	1	0.252	
4.3209	2	0.115		3.7642	2	0.152	
5.3612	3	0.147		3.3264	3	0.344	
8.0441	4	0.090	*	3.3174	4	0.506	
X = Import origin PPI							
0.8312	1	0.362		4.4521	1	0.035	**
5.0416	2	0.080	*	4.1886	2	0.123	
0.2506	3	0.100		5.6112	3	0.132	
7.3698	4	0.118		6.2289	4	0.183	
H0 = NEER vol. does not cause NEER depreciation				H0 = NEER depreciation does not cause NEER vol.			
2.2109	1	0.137		0.9334	1	0.334	
10.6530	2	0.005	***	5.5169	2	0.063	*
10.3200	3	0.016	**	6.0521	3	0.109	
10.3030	4	0.036	**	5.4573	4	0.244	

Source: Author's calculations.

Note: NEER vol. is 3-month rolling standard deviation of daily change.

Table A2. Determinants of Core and Headline Inflation

Dept. var		Core inflation					
		1	2	3	4	5	6
AR1.		0.727***	0.594***	0.594***	0.581***	0.594***	0.581***
NEER							
	L1.	...	0.040***	0.041***	0.040***	0.041***	0.040***
	L2.	...	0	0	-0.002	0	-0.002
	L3.	...	0.020*	0.021	0.024*	0.021	0.023*
	L4.	...	0.018	0.019	0.017	0.019	0.017
Foreign PPI	L0.	...	...	0.009	0.015	0.009	0.015
ULC	L1.	...	...	...	0.083	...	0.083
Output gap	L1.	...	...	...	...	0	0.002
Constant		0.138***	0.174***	0.171***	0.122*	0.171***	0.122*
N		82	79	79	78	79	78
Adj. r^2		0.53	0.593	0.587	0.593	0.581	0.587

Dept. var		Headline inflation					
		5	6	7	8	9	10
AR1.		0.545***	0.446***	0.392***	0.355***	0.340***	0.289***
NEER							
	L1.	...	0.035***	0.041***	0.041***	0.037***	0.036***
	L2.	...	0.013	0.019*	0.019*	0.017	0.017
	L3.	...	0.015	0.022**	0.025**	0.020*	0.023**
	L4.	...	0.01	0.013	0.013	0.013	0.012
Foreign PPI	L0.	...	...	0.182***	0.190***	0.178***	0.187***
ULC	L1.	...	...	...	0.071	...	0.084*
Output gap	L1.	...	...	...	...	0.043	0.049*
Constant		0.274***	0.298***	0.273***	0.246***	0.308***	0.281***
N		82	79	79	78	79	78
Adj. r^2		0.288	0.439	0.53	0.537	0.539	0.551

Source: Author's calculations.

Note: "***", "**", and "*" signify statistical significance at the 1, 5, and 10 percent levels.

Table A3. Determinants of Core Inflation—Extention : Realized Volatility

Dept. var		Core inflation													
AR1		0.588***	0.564***	0.535***	0.614***	0.618***	0.464***	0.454***	0.441***	0.444***	0.442***	0.404***	0.456***	0.477***	0.421***
NEER															
	L1.	0.015**	0.012	0.016**	0.014*	0.014*	0.016**	0.016**	0.016**	0.016**	0.015*	0.017**	0.016**	0.016**	0.017***
	L2.	0.002	0.002	-0.003	0.001	-0.002	0.004	0.005	0.004	0.004	0.004	0.000	0.004	0.001	-0.003
	L3.	-0.004	-0.005	-0.003	-0.002	-0.004	-0.003	-0.003	-0.001	-0.001	-0.002	-0.001	0.000	-0.002	...
	L4.	0.010	0.008	0.007	0.009	0.013	0.010	0.010	0.010	0.009	0.008	0.007	0.009	0.012	...
ER vol															
	L1.	...	0.021	...	...	...	...	...	...	...	0.007	...	...	...	...
	L2.	...	...	0.036*	...	...	...	...	...	...	...	0.034#	...	...	0.041**
	L3.	...	...	...	-0.011	...	...	...	...	...	...	...	-0.005	...	...
	L4.	...	...	...	...	-0.021	...	...	...	...	...	...	...	-0.018	...
NEER*L5.ER vol															
	L1.	...	...	...	...	...	0.013	0.014	0.013	0.013	0.012	0.014	0.013	0.015	0.013
	L2.	...	...	...	...	...	...	-0.003	0.002	0.002	0.002	-0.002	0.001	0.001	-0.002
	L3.	...	...	...	...	...	...	...	-0.004	-0.004	-0.004	-0.001	-0.004	-0.004	...
	L4.	...	...	...	...	...	...	...	...	0.002	0.003	0.003	0.003	0.002	...
Foreign PPI	L0.	0.014	0.012	0.005	0.014	0.013	0.009	0.009	0.010	0.010	0.009	0.000	0.010	0.009	...
ULC	L1.	-0.001	-0.007	-0.009	-0.001	-0.006	0.008	0.012	0.012	0.011	0.007	0.002	0.010	0.005	...
Output gap,	L1.	0.029*	0.033**	0.039**	0.027	0.025	0.028*	0.028*	0.031*	0.031*	0.032*	0.038**	0.029*	0.026	0.040***
Constant		0.202***	0.218***	0.233***	0.191***	0.195***	0.270***	0.272***	0.274***	0.275***	0.278***	0.303***	0.270***	0.267***	0.298***
N		50	50	50	50	50	49	49	49	49	49	49	49	49	49
Adj. r^2		0.580	0.580	0.599	0.572	0.578	0.558	0.549	0.541	0.529	0.517	0.550	0.516	0.524	0.598

Source: Author's calculations.

Note: "***", "**", "*", and "#" signify statistical significance at the 1, 5, 10, and 20 percent levels

Table A4. Determinants of Core Inflation—Extention: Residuals of Realized Exchange Rate Volatility

AR1		0.588***	0.587***	0.575***	0.589***	0.494***	0.389***	0.359**	0.341**	0.340**	0.336**	0.364**	0.351**	0.337**	0.398***
NEER															
	L1.	0.015**	0.015**	0.013*	0.015*	0.015**	0.014**	0.014**	0.015**	0.016**	0.016**	0.014**	0.015**	0.016**	0.014**
	L2.	0.002	0.002	0.001	0.002	0.001	0.005	0.005	0.006	0.005	0.005	0.005	0.005	0.006	...
	L3.	-0.004	-0.004	-0.003	-0.004	0.000	-0.004	-0.004	-0.003	-0.002	0.000	-0.003	-0.002	-0.002	...
	L4.	0.01	0.01	0.006	0.01	0.01	0.012*	0.011*	0.013*	0.013*	0.014*	0.01	0.013*	0.013*	0.009
ER vol															
	L1.	...	0.003	...	...	...	...	...	...	...	-0.018	...	...	...	...
	L2.	...	...	0.048**	...	...	...	...	...	...	...	0.044*	...	...	0.039**
	L3.	...	...	...	-0.001	...	...	...	...	...	...	...	-0.008	...	...
	L4.	...	...	...	...	-0.019	...	...	...	...	...	...	...	0.001	...
NEER*L5.ER vol															
	L1.	...	...	...	...	...	0.019	0.021	0.018	0.017	0.020	0.017	0.018	0.017	0.015
	L2.	...	...	...	...	...	...	-0.006	0.001	0.000	-0.002	0.007	-0.001	0.000	...
	L3.	...	...	...	...	...	...	...	-0.008	-0.008	-0.008	-0.011	-0.008	-0.008	...
	L4.	...	...	...	...	...	...	...	...	-0.006	-0.007	-0.002	-0.006	-0.006	-0.007
Foreign PPI	L0.	0.014	0.014	0.004	0.014	0.014	0.005	0.006	0.004	0.007	0.006	-0.004	0.007	0.007	...
ULC	L1.	-0.001	-0.001	-0.014	-0.001	0.006	0.004	0.009	0.012	0.016	0.020	-0.001	0.017	0.016	...
Output gap,	L1.	0.029*	0.029*	0.036**	0.029*	0.026*	0.034**	0.036**	0.039**	0.038**	0.038**	0.045***	0.037**	0.038**	0.037***
Constant		0.202***	0.203***	0.221***	0.201***	0.251***	0.314***	0.324***	0.326***	0.323***	0.321***	0.326***	0.316***	0.324***	0.314***
N		50	50	50	50	49	48	48	48	48	48	48	48	48	48
Adj. r^2		0.580	0.569	0.615	0.569	0.555	0.53	0.523	0.524	0.514	0.509	0.553	0.502	0.5	0.592

Source: Author's calculations.

Note: "***", "**", and "*" signify statistical significance at the 1, 5, and 10 percent levels.

Table A5. Determinants of Core Inflation—Extention: Residuals of Implied Exchange Rate Volatility

Dept. var		Core inflation													
AR1		0.588***	0.577***	0.548***	0.653***	0.426***	0.380***	0.407***	0.435***	0.433***	0.424***	0.398***	0.479***	0.423***	0.368***
NEER															
	L1.	0.015***	0.015***	0.009	0.012*	0.016***	0.012**	0.012*	0.010*	0.011*	0.011*	0.005	0.008	0.011*	0.008
	L2.	0.002	0.002	0.002	0.004	0.007	0.005	0.003	0.004	0.003	0.003	0.003	0.007	0.006	...
	L3.	-0.004	-0.003	-0.005	-0.005	-0.003	-0.001	-0.001	-0.003	-0.003	-0.003	-0.004	-0.005	-0.005	...
	L4.	0.010*	0.009*	0.009*	0.010*	0.010*	0.011*	0.011*	0.009*	0.013*	0.013*	0.013*	0.012*	0.013*	0.013**
ER vol															
	L1.	...	0.004	...	...	...	...	...	...	...	0.002	...	...	...	...
	L2.	...	...	0.014***	...	...	...	...	...	...	...	0.013***	...	...	0.012***
	L3.	...	...	...	-0.010*	...	...	...	...	...	...	...	-0.009	...	...
	L4.	...	...	...	...	0.007	...	...	...	...	...	...	...	0.007	...
NEER*L5.ER vol															
	L1.	...	...	...	...	...	0.004	0.004	0.004*	0.004*	0.004*	0.004	0.004*	0.004	0.003
	L2.	...	...	...	...	...	...	0.002	0.002	0.002	0.002	0.002	0.000	0.002	...
	L3.	...	...	...	...	...	...	...	0.003	0.003	0.003	0.002	0.003	0.003	...
	L4.	...	...	...	...	...	...	...	...	-0.002	-0.002	-0.001	-0.001	-0.002	-0.001
Foreign PPI	L0.	0.014	0.015	-0.006	0.016	0.019	0.013	0.011	0.011	0.013	0.014	-0.007	0.018	0.017	...
ULC	L1.	-0.001	-0.002	-0.013	-0.001	0.020	0.009	0.005	0.001	0.003	0.003	-0.009	0.005	0.009	...
Output gap,	L1.	0.029**	0.029**	0.038***	0.023*	0.034***	0.032***	0.031***	0.029**	0.028**	0.028**	0.036***	0.023*	0.031***	0.039***
Constant		0.202***	0.207***	0.236***	0.169***	0.273***	0.315***	0.306***	0.304***	0.303***	0.307***	0.333***	0.277***	0.302***	0.333***
N		50	50	50	50	49	48	48	48	48	48	48	48	48	48
Adj. r^2		0.580	0.573	0.613	0.59	0.562	0.522	0.515	0.516	0.511	0.498	0.552	0.514	0.51	0.596

Source: Author’s calculations.

Note: “***”, “**”, and “*” signify statistical significance at the 1, 5, and 10 percent levels