WP/12/208

IMF Working Paper

Exchange Rate and Foreign Interest Rate Linkages for Sub-Saharan Africa Floaters

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INTERNATIONAL MONETARY FUND

 WP/12/208

IMF Working Paper

African Department

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August 2012

Abstract

The paper considers the determinants of exchange rate movements among sub-Saharan countries that have flexible exchange rate regimes. The determinants are based on the law of one price and interest parity conditions. Results indicate that the exchange rates have responded significantly to changes in the US Treasury bill rate and to the EMBI spread in recent years. The effects are more important for countries with open capital accounts. On the other hand the paper does not provide any support for the interest rate parity theory because domestic interest rates have no bearing on exchange rate movements.

JEL Classification Numbers: F31

Keywords: Exchange Rate, Interest Rate, Interest Parity

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I. INTRODUCTION

Many commentators argue that African countries are becoming more integrated into the world economy with capital and trade flows on the increase. One of the economic variables that is most sensitive to global financial flows is the exchange rate since it has been repeatedly shown that it responds rapidly to movements in financial flows and information. The purpose of this paper is to assess the sensitivity of exchange rates to global interest rate movements among sub-Saharan African countries that follow floating exchange rate regimes. To make this assessment, we use a simplified model of the exchange rate developed by Macdonald (2000) which is based on earlier workhorse models of exchange rate determination Dornbusch (1980) and Frankel (1979).

The literature on nominal exchange rate fluctuations among African countries is fairly limited with most work being conducted on South Africa. Bhundia and Gottschalk (2003) analyze nominal exchange rate fluctuations in South Africa using the Clarida-Gali stochastic two-country version of the Dornbusch model with real demand and supply disturbances and a nominal demand disturbance. They find that nominal disturbances explain most of the changes in the South African rand in 2001–2002 but are unable to identify the source of the disturbances, possibly because they exclude risk premium shocks. Gebreselasie et al. (2007) also develop an econometric model of the rand–US$ nominal exchange rate based on the Dornbusch model and they find a cointegrating vector between the nominal exchange rate, relative money supplies, relative outputs and short-run interest rates. Lacerda et al. (2010) find some support for strict uncovered interest parity and a weaker form of purchasing power parity (with the price coefficients allowed to differ from unity). Finally, Alpanda et al. (2010) develop a DSGE model for the South African economy that includes an interest parity condition with a risk premium and find that shocks to the risk premium have sizeable effects on nominal exchange rate movements.

The paper first considers exchange rate movements in South Africa and then extends the analysis to all sub-Saharan Africa countries that follow floating exchange rate regimes. As in previous research the paper analyzes bilateral exchange rates between the domestic economy and the United States as well as movements in the nominal effective exchange rate. The paper uses interest parity as its basis for understanding short-term movements in the bilateral exchange rate and assumes that long term exchange rate movements are based on the law of one price. Over the long run the paper finds support for the law of one price with cointegrating relationships identified between the domestic exchange rate and foreign price levels. Over the short term, there is no support for the uncovered interest parity condition because of the absence of a relationship between exchange rate movements and the domestic interest rate, although a relationship is identified when the money stock is used as a measure of the attractivenenss of the local currency. In terms of the US interest rate, the South African rand appreciates considerably when the US interest rate rises whereas the exchange rates of countries that have fairly closed capital accounts depreciate significantly. This could be related to the speed at which portfolio flows adjust in various countries to changes in interest rates, consistent with the views of Bacchetta and van Wincoop (2009).

II. EMPIRICAL MODEL AND DATA DESCRIPTION

A. Model

Macdonald (2000) has presented a simple model of exchange rate determination that combines the interest rate and purchasing power parity conditions, assuming no exchange rate intervention.

The model is expressed as follows:

$$ca(t) + ka(t) = 0$$

where ca is the current account and ka is the capital account. The current account is assumed determined by net exports and factor income

$$ca(t) = nx(t) + i * nfa(t)$$

Net exports are determined by the real exchange rate (s+p*-p) and domestic and foreign outputs (y, y*), all defined in log terms; this specification assumes that net exports are demand driven.

$$nx(t) = \alpha 0(s(t) + p*(t) - p(t)) - \alpha 1y(t) + \alpha 2y*(t)$$

The capital account depends on the interest rate differential and a risk premium, corrected for prospective exchange rate movements

$$ka(t) = \mu(i(t) - i^*(t) - rp(t) - Et\Delta s(t+k))$$

where EtΔs(t+k) is the expected change in the nominal exchange rate over the time interval k at time t, i and i* are the domestic and foreign nominal interest rates, and rp is the risk premium.

Under rational expectations, future realizations of the exchange rate equal the value expected at time t plus an error term that is uncorrelated with all information known at t

$$s(t+k) = Et(s(t+k)) + \xi t(t+k)$$

Incorporating this and substituting across equations yields the following expression for the change in the nominal exchange rate

$$\Delta s(t+k) = \theta(i(t) - i*(t) - rp(t), s(t) + p*(t) - p(t), y(t), y*(t), nfa(t)) + \xi t(t+k) \quad (1)$$

where $\xi t(t+k)$ is the rational expectations forecast error.

The above expression is a very general representation of an equilibrium exchange rate in that it satisfies balance of payments equilibrium under floating exchange rates. The general assumption is that the exchange rate depreciates in response to a positive change in the interest rate differential so that the arbitrage condition is maintained. However, many researchers have found that the exchange rate appreciates on impact, possibly because of gradual adjustment of portfolio holdings. This is expecially likely in some countries in sub-Saharan Africa where capital flows are lumpy. With agents only rebalancing their portfolios gradually over time, Bacchetta and van Wincoop (2009) argue that following a decline in the foreign interest rate, the domestic exchange rate only appreciates gradually as investors slowly switch out of foreign bonds. This contrasts with the Dornbusch model assumption that the home currency appreciates immediately on impact, overshooting its long term value, and this movement is followed by a gradual depreciation.

The inclusion of the real exchange rate as a determinant of the movements in the nominal exchange rate captures the law of one price in which the nominal exchange rate adjusts to eliminate any disparity in price levels over time. While the assumptions required for the law of one price to hold are quite stringent, there is considerable empirical support for the phenomenon over long time periods (Taylor and Taylor 2004).

B. Data description

This paper focuses on understanding exchange rate movements among Sub-Saharan African countries that follow money or inflation targeting monetary policy regimes. The sample is based on the definition of the IMF's Annual Report on Exchange Arrangement and Exchange Restrictions (2009). [1]The desire to limit outliers constrains the sample period to 2003–2010 and the analysis is based on monthly data. Moreover, Nigeria is excluded from the empirical analysis because of its strong dependence on oil.

[1] The country list includes The Gambia, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Rwanda, Sierra Leone, South Africa, Tanzania, Uganda, Zambia. Although Malawi is classified as a floating exchange rate country by the IMF AREAER, it's US dollar exchange rate has only experienced a few discrete jumps over the past decade and is therefore excluded from this analysis.

The idea that exchange rates among sub-Saharan African countries respond to interest rates may be surprising given the historically closed nature of these economies. However, over the last decade a number of countries have liberalized their capital accounts considerably and estimates indicate that many of them are now as open as those in industrial countries.

Table 1 presents estimates of the degree of capital account openess in the country sample based on the size of private capital inflows over the 2003–07 period (prior to the global financial crisis) measured in two ways: column (1) presents the flow of private capital from the World Economic Outlook database while column (2) presents the change in portfolio and FDI liabilities from the Lane and Milesi-Ferretti Wealth of Nations database. The two sets of figures are pretty consistent and reveal that Nigeria and South Africa receive the largest inflows, followed by Ghana, Kenya, Tanzania, Uganda and Zambia.

Table 1. Measures of Capital Account Openness

	Private Capital inflows 1/	Change in portfolio and FDI liabilities 2/	
	(in billions of U.S. dollars, average, 2003-07)		% of GDP
Open capital account countries			
South Africa	17.66	39.86	16.86
Nigeria	4.79	11.08	9.57
Ghana	0.56	0.90	8.19
Tanzania	0.50	0.89	6.39
Kenya	0.46	0.51	2.56
Uganda	0.42	0.67	7.38
Zambia	0.38	1.69	21.64
Less open capital account countries			
Mozambique	0.26	0.28	4.38
Madagascar	0.23	0.26	4.73
Rwanda	0.11	0.07	2.61
Gambia, The	0.06	0.06	11.93
Sierra Leone	0.05	0.12	9.38
Open capital accounts (median)	0.5	0.9	7.8
Less open capital acounts (median)	0.1	0.1	4.7

Notes:
The Lane and Milesi-Ferretti data source has been purged of MDRI and HIPC completion point effects
Sources
1/ World Economic Outlook.
2/ Lane and Milesi-Ferretti.

Countries defined as having open capital accounts are those that have sizeable inflows. The other group is defined as countries with less open capital accounts. The major outliers are Gambia and Sierra Leone. These countries have been assigned to the less open capital account category because of their very low private capital inflows even though they are high in relation to GDP. [2] Using these categories, the median estimate for the low private capital mobility group in terms of private capital inflows over 2003–07 is US$0.1 billion, versus US$0.5/0.9 billion for the other group. There are similar large differences in terms of the ratio to GDP.

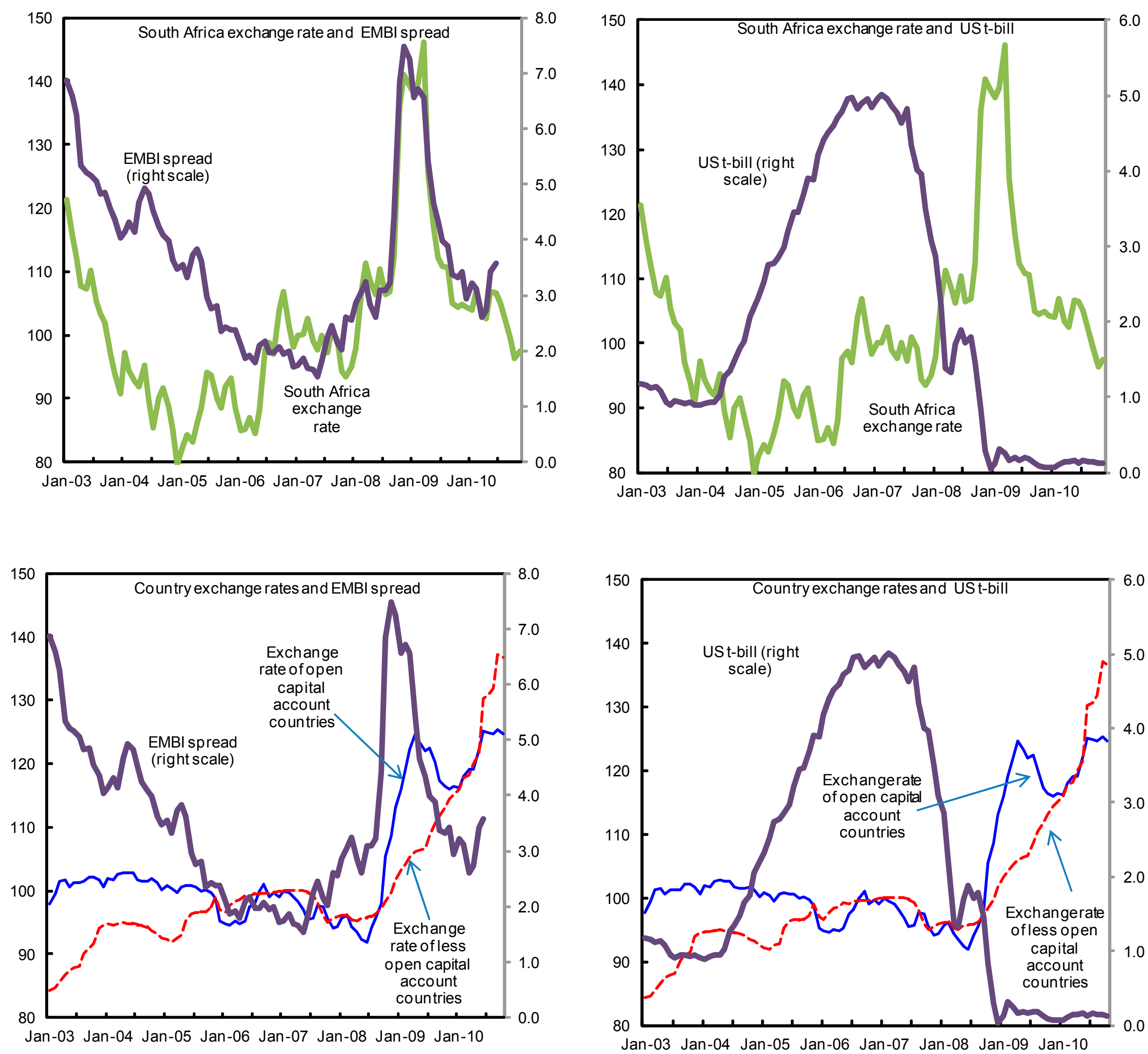
Before turning to an empirical assessment of the strength of the relationship between exchange rates and interest rates for the sample of countries, we first show the graphical relationships. The basic assumption of the interest parity condition is that national bonds are perfect substitutes for each other. To proxy securities that are most similar to each other, Treasury bills are used. The risk premium is assumed to be the Emerging Markets Bond Index spread which is the difference between the total returns of traded debt instruments in emerging markets and the yield on 10 year US Treasury notes. The inclusion of this variable assumes that the riskiness of sub-Saharan African securities is correlated with the riskiness of Emerging Market debt instruments.

Figure 1 plots the Emerging Market Bond Index spread and the U.S. dollar 3-month Treasury bill interest rate against the the bilateral U.S. dollar exchange rates for South Africa, countries with more open capital accounts and countries with less open capital accounts. The interest rate and bond spreads are expressed in percentage terms while the exchange rates are defined as an index of average bilateral exchange rates between the countries in the group and the U.S. dollar, set at January 2006=100. A higher index value represents a more depreciated exchange rate.

The South African rand moves very closely with the EMBI spread during the whole period while there exists a negative relationship between the rand and the US interest rate. In other countries with relatively open capital accounts, the relationship between the EMBI spread and the exchange rate seems to have strengthened since mid 2008 while no relationship is evident between the currencies of the countries that are most closed to foreign financial flows and the EMBI spread. In contrast to the negative relationship between the rand and the US interest rate, the relationship between the US Treasury bill rate and the exchange rate is positive for the countries that are most closed to foreign financial flows, at least before mid-2008.

[2] Chinn and Ito have derived their own capital account indicators based information from the annual IMF publication on capital account restrictions. Their index varies between -2 (least open) to 2.5 (most open) and is fairly closely correlated with the measure used in this paper although exceptions exist. For example, South Africa has a low openness index and reflects the fact that residents face limits on investing in equity and bonds abroad. Non-residents have no restrictions. Nevertheless these restrictions have been relaxed in recent years.

Figure 1. Interest Rates (in percent) and the Nominal Exchange Rate (2007=100)



III. REGRESSION ANALYSIS

A. Stationarity tests

Before estimating relationships, we first assess the order of stationarity of each variable. Since the South African economy is quite different from the other economies in the region, we treat it separately. The augmented Dickey-Fuller test statistics indicate that all variables expressed in first differences are stationary but that interest rates levels, exchange rate and foreign reserves levels and the Emerging Markets Bond Index spread are non-stationary (Table 2).

Table 2. Augmented Dickey-Fuller Test statistics

	South Africa	Panel excluding South Africa 1/
Interest rate differential	-1.83	-0.79
Δ interest rate differential	-6.12 ***	-2.00 **
U.S. treasury bill rate	-1.44	-1.44
Δ U.S. treasury bill rate	-5.69 ***	-5.69 ***
Domestic treasury bill	-1.81	-1.29 *
Δ domestic treasury bill	-6.31 ***	-17.10 ***
EMBI interest rate spread	-1.91	-1.91
Δ EMBI interest rate spread	-9.19 ***	-9.19 ***
Domestic money growth	-9.72 ***	-35.40 ***
CPI	1.55	4.38
Foreign CPI	-1.72	-6.56 ***
Domestic inflation	-7.77 ***	-13.90 ***
Foreign inflation	-15.10 ***	-2.88 ***
Real effective exchange rate (against U.S. dollar)	-1.32	13.02
Real effective exchange rate	-1.82	-1.18
Change in euro-dollar exchange rate	-8.25 ***	-8.25 ***
Nominal effective exchange rate change	-9.33 ***	-26.60 ***
Bilateral U.S. dollar exchange rate change	-8.56 ***	-18.60 ***
Foreign exchange reserves	2.15	3.89
Δ foreign exchange reserves	-4.01 ***	-39.00 ***
Δ Domestic industrial production	-18.20 ***	-18.20 ***
Δ foreign industrial production	-3.72 ***	-3.72 ***

Source: Author's calculations.

Notes: *** indicates rejection of the null hypothesis of a unit root at the 99 percent level.

** indicates rejection of the null hypothesis of a unit root at the 95 percent level.

1/ Levin, Lin, and Chu test statistics

The Johansen trace statistic indicates that one cointegrating vector is identified between the bilateral exchange rate versus the U.S. dollar and the domestic and US CPI indexes (Table 3).

Moreover, the null hypothesis that the coefficient on the domestic CPI is -1 is accepted although the coefficient on the US CPI is considerably above unity. For the other countries, a panel unit root test is used and this reveals a similar pattern of stationary among the variables; the only differences are that the domestic Treasury-bill rate and foreign CPI are stationary. For the panel of countries, the Pedroni PP and ADF statistics indicate a cointegrating vector between the bilateral exchange rate versus the U.S. dollar, the domestic and US CPI indexes, and the EMBI spread and also between the nominal effective exchange rate, the domestic and foreign CPI indexes, and the EMBI spread (Table 3).

Table 3. South Africa: Johansen Cointegration Trace Test Statistics and Cointegrating Vector

Cointegrating variables	Number of cointegrating vectors	Trace statistics	Probability
Local currency-US$ exchange rate index,	None	48.5	0.0001
Domestic CPI, USA CPI	At most 1	15.0	0.06
Restriction: coefficient on domestic CPI =-1			0.55
Cointegrating vector: $\log(s_t)=\log(p_t)-1.66\log(p^*_t)$			
Nominal effective exchange rate,	None	29.9	0.049
Domestic CPI, trade weighted CPI	At most 1	8.9	0.37
Restriction: coefficient on domestic CPI =1, foreign CPI=-1			0.37
Cointegrating vector: $\log(neer_t)=-\log(p_t)+\log(p^*_t)$			

Source: Author's calculations.

Table 4. Pedroni Residual Test Statistics for Panel Data Estimation

Cointegrating variables		Test statistic	Probability
Open capital account panel excluding South Africa			
Local currency-US$ exchange rate index,	PP statistic	-1.63	0.05
domestic CPI, foreign CPI, EMBI spread	ADF statistic	-2.78	0.003
Nominal effective exchange rate,	PP statistic	-0.70	0.23
domestic CPI, trade weighted CPI, EMBI spread	ADF statistic	-1.58	0.06
All countries excluding South Africa			
Local currency-US$ exchange rate index,	PP statistic	-1.90	0.03
domestic CPI, foreign CPI, EMBI spread	ADF statistic	-3.60	0.0002
Nominal effective exchange rate,	PP statistic	-0.58	0.28
Domestic CPI, trade weighted CPI, EMBI spread	ADF statistic	-1.55	0.06

Source: Author's calculations.

Regression analysis

Having identified the degree of stationarity of the data, we start with identifying the determinants of the change in the exchange rate for South Africa. Based on the simplified model presented in section II these determinants comprise short term (interest rate parity condition, risk premium, relative growth rates and foreign asset positions) and long-term considerations (relative prices in a common currency). Since the interest rate differential, EMBI index, and foreign exchange reserves are non stationary in levels, they are introduced into the equation in first differences.

$$\Delta s_t = \alpha + \beta 0(\Delta i_t - \Delta i_t^*) + \beta 1 \Delta EMBIspread_t + \beta 2 \Delta s_{t-1} + \beta 3 \Delta forex_t + \beta 4 \Delta IPdom_t + \beta 5 \Delta IPfor_t + \beta 6(s_{t-1} + \beta 7 p^*_{t-1} - p_{t-1}) + \varepsilon_t$$

Since we are using monthly data, the change in foreign exchange reserves is a proxy for the net asset position that is normally only available on an annual basis. For domestic and foreign output which represent demand determinants of net exports, industrial production (IP) indices are used. The industrial production index for South Africa is a GDP weighted series of the IP indexes for mining, manufacturing, and electricity while the foreign IP index is a weighted average of the IP indexes for the EU, USA, China, Japan and Korea that account for almost 80 percent of South Africa trade. The basic regression is estimated over the period 2003m1 to 2010m5.

Results indicate that the interest rate differential has no explanatory power whereas the EMBI spread is highly significant with a coefficient of 3 implying that a 1 percent increase in the spread would lead to a 3 percent depreciation in the bilateral rate against the U.S. dollar (Table 5While the industrial production indices are insignificant, the change in foreign exchange reserves is strongly significant with a 10 percent rise in international reserves leading to a 4 percent currency appreciation. The euro-dollar rate is also significant with the coefficient less than unity indicating that the South African rand usually strengthens against the euro when the latter depreciates against the U.S. dollar. Finally, the error correction term is significant with a large coefficient showing that half of the adjustment to the long run equilibrium between the nominal exchange rate and relative prices occurs within eight months (eight multiplied by the coefficient is approximately minus one). When the interest rate differential is split between its two components, the estimates reveal that movements in the domestic Treasury-bill rate have no bearing on the exchange rate while the exchange rate is very sensitive to movements in the U.S. dollar rate (column [2]). The negative coefficient implies that the South African rand appreciates in response to an increase in the US Treasury bill. This coefficient sign is consistent with immediate portfolio adjustment with the US currency depreciating to maintain equilibrium in the money market. However, the strength of the effect is surprising since the coefficient should be unity and not larger (equation (1)). In this specification the other coefficients are fairly stable.

Table 5. Determinants of the Change in the Bilateral Exchange Rate Against US dollar

	South Africa		Countries with open capital accounts			All countries			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Δ treasury bill differential	0.50		0.08			0.08			
Δ U.S. treasury bill rate		-4.81 ***		0.18	0.32		0.97 *	0.91 *	2.15 ***
Δ U.S. treasury bill rate for open CA countries									-2.18 ***
Δ Domestic t-bill		-0.21		0.09			0.01		0.08
Δ EMBI interest rate spread	3.00 ***	2.71 **	1.39 ***	1.44 ***	1.21 ***	0.98 ***	1.22 ***	0.95 ***	1.03 ***
Δ EMBI interest rate spread for open CA countries									0.10
Domestic money growth					0.28 ***			0.30 ***	
Domestic inflation					0.13 *			0.15 *	
Δ Bilateral exchange rate (t-1)	0.01	0.07	0.24 ***	0.25 ***	0.27 ***	0.32 ***	0.32 ***	0.31 ***	0.32 ***
Δ Foreign Exchange reserves	-0.37 ***	-0.39 ***	-0.04 ***	-0.04 ***	-0.04 ***	-0.03 **	-0.03 **	-0.04 ***	-0.01
Δ Foreign Exchange reserves for open CA countries									-0.04 ***
Δ Euro-dollar exchange rate	0.57 ***	0.6 ***	0.1 **	0.09 *	0.12 ***	0.15 ***	0.13 ***	0.16 ***	0.13 ***
Δ Domestic Industrial Production	-0.07	-0.02							
Δ Foreign Industrial Production	-0.41	-0.72							
Error correction term (t-1)	-0.13 ***	-0.15 ***							
Real exchange rate against USD (log,t-1)			-0.02	-0.02	-0.02	-0.01	-0.02	-0.02	-0.02
EMBI interest rate spread (t-1)			0.38	0.39	0.38	0.28	0.31	0.31	0.23
R squared	0.66	0.68	0.28	0.28	0.35	0.2	0.22	0.25	0.25
First order serial correlation 1/	4.6	4.43	2.01	2.02	2.09	1.94	1.95	1.95	2.01
Countries	1	1	5	5	5	10	10	10	10

Source: Author's calculations.
Note: ** and *** denote significance at the 5 percent and 1 percent levels, respectively.
1/ LM statistic for the single equation analysis; DW statistic for the panel analysis.

We now turn to the other countries and distinguish between countries with relatively open capital accounts (Ghana, Kenya, Tanzania, Uganda, and Zambia) and those with less open capital accounts. Among the open capital account countries, the change in the interest rate differential has no relation to exchange rate movements but the change in the risk premium is a significant determinant (column 3), consistent with the results for South Africa. The coefficient on the level of the EMBI interest rate spread supports the existence of a positive long run relationship between the exchange rate and the foreign risk premium identified in the Pedroni residual cointegration test. The change in foreign exchange reserves is significantly negative suggesting that a strong foreign asset position puts upward pressure on the exchange rate (appreciation) although the size of the coefficient is considerably less than for South Africa. The euro-dollar rate is only slightly positive so that these currrencies appreciate strongly against the euro when the latter depreciates against the U.S. dollar. Perhaps surprisingly, the extent of appreciation is more than for South Africa. There is considerable persistence in exchange rate movements among these countries and the lagged bilateral real exchange rate term representing relative prices in a single currency is very small indicating that half of the adjustment to purchasing power parity takes over four years. In these countries movement toward PPP takes considerable time. When the domestic and foreign interest rates are separated, no relation is found between the domestic Treasury bill, the US Treasury bill and the exchange rate while the coefficient on the risk premium is fairly stable. The other coefficient estimates are comparable to the previous specification.

An alternative to using the domestic Treasury bill rate as an indication of the attractiveness of domestic assets is to invert the money demand equation and express interest rates as a function of money growth, inflation and real GDP growth. This of course requires the strong assumption that money demand is stable over the period. [3] Moreover, since real GDP is only available on an annual frequency it must be excluded. Notwithstanding these drawbacks, increases in money growth depreciate the bilateral exchange rate through both the interest rate and inflation channels (column 5). A higher money supply elicits a reduction in interest rates to restore equilibrium between money supply and demand and this puts downward pressure on the exchange rate. Similarly, a higher money supply also may lead to domestic price pressures and depreciate the currency through the condition on the law of one price. The domestic inflation rate also depreciates the currency but by less than the money supply so that a real increase in the money stock would also depreciate the currency. Since the contemporaneous money growth and inflation variables are used, there could be issues of endogeneity. When lagged instruments are used for the variables they become insignificant and therefore we cannot be firm about the effects of money growth on the nominal exchange rate. The addition of the money supply variable does not affect the other coefficients except for reducing slightly the estimate of the change in the risk premium.

Columns 6-9 add data for the countries with less open capital accounts. The results are broadly similar for the full sample and the restricted sample of open capital account countries. The coefficients on the change in the US Treasury bill rate and on the EMBI spread provide the major differences. The coefficient on the change in the US Treasury bill rate is positive and insignificantly different from unity at the 10 percent level of confidence suggesting that because of slow movements in portfolio holdings in these countries, the exchange rates depreciate in response to a rise in the US Treasury-bill rate as individuals gradually shift their allocations. This contrasts with the sharp appreciation of the South African rand when the US Treasury bill rate rises, suggesting much slower portfolio adjustment in these economies and providing support for the views of Bacchetta and van Wincoop (see introduction). As expected, the sensitivity of the exchange rate to changes in the EMBI spread in the full sample is considerably less than for South Africa and slightly less than for countries with open capital accounts.

To test whether the difference in the effect of the EMBI spread between countries with closed and open capital accounts is significant, separate coefficients for this variable together

[3] Many analysts have expressed the monetary model of the exchange rate in terms of differences in money stocks, interest rates and output and considerable empirical support has been found for these types of empirical models (see Cerra and Saxena 2010 for a recent example).

with the US interest rate and the change in foreign exchange reserves were allowed for countries with open capital accounts. Column 9 reveals that the coefficient on the US interest rate is now above 2 for the countries that are more closed and it is zero for the other countries. On the other hand the sensitivity of the exchange rate to movements in the EMBI spread is no different between the two groups of countries. Finally, the exchange rate sensitivity to changes in foreign exchange reserves is considerably greater for the countries with open capital accounts.

To assess whether linkages between US interest rates, risk premia and domestic currencies hold more generally, the same analysis was done for the nominal effective exchange rate. Similar stationarity tests were conducted replacing the nominal effective exchange rate for the bilateral rate and the trade weighted CPI index for the USA CPI index. The stationarity test statistics indicate the presence of one cointegrating vector for South Africa between the nominal effective exchange rate and relative prices with unitary coefficients on the price variables (Table 3). The panel cointegrating test statistics indicate stationarity between the nominal effective exchange rate, relative prices and the EMBI spread based on the ADF statistic although not for the PP statistic (Table 4).

Table 6. Determinants of the Change in the Nominal Effective Exchange Rate

	South Africa		Countries with open capital accounts			All countries		
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Δ Treasury bill differential	-0.5		-0.05			-0.04		
Δ U.S. treasury bill rate		5.63 ***		-0.38	-0.5		-1.26 ***	-1.21 ***
Δ Domestic treasury bill		0.71		-0.05			-0.05	
Δ EMBI interest rate spread	-4.26 ***	-2.99 ***	-0.55 *	-0.66 *	-0.47	-0.42	-0.74 **	-0.48 *
Domestic money growth					-0.25 **			-0.25 ***
Domestic inflation					-0.09			-0.1
Nominal effective exchange rate change (t-1)			0.2 ***	0.21 ***	0.22 ***	0.21 ***	0.22 ***	0.26 ***
Δ Foreign Exchange reserves	0.28 ***	0.31 ***	0.04 **	0.04 **	0.04 ***	0.02	0.02	0.03
Δ Euro-dollar exchange rate	0.28 *	0.14	0.37 ***	0.38 ***	0.34 ***	0.37 ***	0.39 ***	0.35 ***
Δ Domestic Industrial Production	-0.1	-0.11						
Δ Foreign Industrial Production	0.99 **	1.11 **						
Error correction term (t-1)	-0.16 ***	-0.2 ***						
Real effective exchange rate (log,t-1)			-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
EMBI interest rate spread (t-1)			-0.36	-0.37	-0.38	-0.31	-0.34	-0.31
R squared	0.6	0.66	0.25	0.25	0.3	0.2	0.2	0.27
First order serial correlation 1/	11.8	8.36	1.96	1.95	2	1.94	1.95	1.95
Countries	1	1	5	5	5	10	10	10

Source: Author's calculations.
Note: ** and *** denote significance at the 5 percent and 1 percent levels respectively.
1/ LM statistic for the single equation analysis; DW statistic for the panel analysis

The results indicate strong similarities with the regressions using the bilateral U.S. dollar exchange rate although the signs of the variables are opposite since the nominal exchange rate index is defined such that a rise implies currency appreciation. For South Africa, the coefficient estimates on the US Treasury bill rate and on the EMBI (Table 6) spread are slightly higher while the change in foreign industrial production is now significantly positive. It indicates that an increase in foreign production raises the demand for South African exports and an exchange rate appreciation is required to restore equilibrium. Movements in the euro dollar rate do not affect South Africa's nominal effective exchange rate because it appreciates against the euro and depreciates against the dollar.

In other countries with open capital accounts, the interest rate differential and both domestic and US interest rates are insignificant. In contrast, the EMBI interest rate spread is consistently negative although the coefficient is considerably less than for South Africa (columns 3–5). The change in foreign exchange reserves is significantly positive suggesting that a strong foreign asset position puts upward pressure on the exchange rate although the size of the coefficient is again considerably less than for South Africa. The change in the euro-dollar exchange rate is significantly positive so that when the euro depreciates against the U.S. dollar, it depreciates considerably against the currencies of the floaters so that the nominal effective exchange rate of these currencies appreciates. The regression in column 5 replaces the domestic interest rate with money growth and the significant negative coefficient indicates that higher money growth leads to a currency depreciation. When countries with less open capital accounts are added to the analysis, the main change is that the coefficient on the US Treasury bill is significantly negative and comparable to minus unity and the EMBI spread is slightly lower.

IV. ROBUSTNESS AND DIAGNOSTIC CHECKS

A. Robustness

One possible explanation for the weak effect of domestic interest rates on the exchange rate is that movements in the domestic risk premium could be overshadowing the effects of movements in the policy rate itself. For example, the government could be running a large deficit at the same time that the central bank is trying to nudge rates upward. To assess whether this might be the case, the change in central bank net credit to government in relation to the broad money stock of the previous period is added to the regressions specified in columns 2 and 4 of table 6 with the hypothesis that an increase in net credit to government should lead to higher inflation and/or sustainability concerns and weaken the currency. In South Africa however, the government has deposited considerable sums at the central bank from terms of trade gains to help sterilize the surge in the domestic currency. This effect would lead to an opposite relationship between net credit to government and the exchange rate. To control for these various effects, country specific estimates are obtained for the net credit to government variable.

The coefficient on the change in net credit is negative for South Africa as suggested by the increase in government deposits at the central bank (Table 7). However, it is positive for three of the five countries with open capital accounts but only significant for Zambia. Moreover, the inclusion of the variable has a negligible effect on the coefficient of the domestic interest rate.

Table 7. Determinants of bilateral U.S. Dollar Exchange Rate Change-Robustness Checks

	South Africa		Countries with open capital accounts	
	Including change in net credit to government	Including change in metals and coal prices	Including change in net credit to government	Including change in metals and coal prices
Δ Domestic treasury bill rate	-0.33	-0.01	0.08	0
Δ U.S. treasury bill rate	-4.6 **	-5.8 ***	0.23	0.22
ΔEMBI interest rate spread	2.5 ***	2.5 ***	1.4 ***	1.16 ***
Domestic real GDP growth(t-1)				
Bilateral exchange rate change (t-1)	0.11	0.04	0.23 ***	0.21 ***
Δ Foreign Exchange reserves (t-1)	-0.36 ***	-0.38 ***	-0.05 ***	-0.04 **
Δ Euro-dollar exchange rate	0.57 ***	0.59 ***	0.09 *	0.03
Δ Domestic Industrial Production	0.02	-0.02		
Δ Foreign Industrial Production	-0.63	-0.58		
Error correction term (t-1)	-0.13 ***	-0.17 ***		
Δ metals prices		0.01		
Δ coal prices		-0.09 **		
Δ net credit to government	-0.58			
Real exchange rate against USD (log,t-1)			-0.11	-0.09
EMBI interest rate spread (t-1)			0.38	0.3
R squared	0.68	0.7	0.3	0.36
First order serial correlation 1/	7.2	7.84	2.02	1.99
Countries	1	1	5	5

Source: Author's calculations.
Note: ** and *** denote significance at the 5 percent and 1 percent levels respectively.
1/ LM statistic for the single equation analysis; DW statistic for the panel analysis

The model in section 2 assumes that net exports depend on demand considerations so that an increase in domestic production reduces net exports because of its effects on import demand. However, for countries that are major commodity exporters, commodity price upswings have traditionally been associated with exchange rate appreciations because of the rise in the value of exports (see Cashin, Cespedes, and Sahay (2002) for a typical example). This is akin to a positive supply shock in prices. To proxy this effect, a monthly indicator of the change in metals and coal prices is added to the specification. Coefficients are allowed to differ between countries to reflect different intensities of metals and coal exports. The exchange rate for South Africa appreciates when coal prices rise while Zambia's exchange rate appreciates when metals prices rise (not shown). While the inclusion of these variables improves the explanatory power considerably, it has no bearing on the significance of the domestic Treasury bill rate.

B. Diagnostic checks

One of the standard yardsticks in assessing whether a particular exchange rate model can capture exchange rate behavior is whether it has any explanatory power over and beyond the standard driftless random walk model. To evaluate this proposition, a root mean squared forecasting error test was conducted. Ever since the Meese and Rogoff (1983) seminal paper, a comparison of any model with the random walk constitutes a basic test of the strength of a model. To conduct the test, the models are estimated over the period 2003m1 to 2008m12 and out of sample forecasts are generated for the period 2009m1 to 2010m5. Table 8 indicates that the root mean squared errors for the models specified in this paper are lower than for the random walk model, although only slightly for the South African nominal exchange rate. Similarly, except for the South African nominal exchange rate equation, all the models represent a significant improvement compared to the random walk based on the test statistic of Clark and West.[4]

Table 8. Out of sample forecasts: One Month Ahead

	Root Mean Squared Errors		
	Random Walk	Model	Theil Statistic
Bilateral exchange rate full sample	2.350	2.130	0.906 ***
Bilateral exchange rate South Africa	4.710	4.100	0.870 ***
Nominal exchange rate full sample	3.390	2.820	0.832 ***
Nominal exchange rate South Africa	2.170	2.160	0.995

Source: Author's calculations.

Notes:*** indicates significant difference in RMSEs at the 1 percent level based on the Clark-West nested test.

[4] Clark and West derive a test based on the difference in the squared residual terms between the random walk and the specified model.

V. CONCLUSION

This paper has shown that all of the exchange rates of sub-Saharan Africa countries with flexible exchange rate regimes have responded significantly to changes in the EMBI spread in recent years and most have responded to changes in the US Treasury bill rate. These results contrast with a widely held view that financial markets in sub-Saharan Africa are closed and do not respond to changes in financial market instruments in developed countries. The South Africa rand appreciates considerably when the US interest rate rises whereas the exchange rates of countries that have fairly closed capital accounts depreciate significantly. This different response is likely related to the speed at which portfolio flows adjust in various countries to changes in foreign interest rates. Finally, the paper provides no support for the interest rate parity theory because domestic interest rates have no bearing on exchange rate movements.

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