Measuring persistence in nominal exchange rate: Implications for Angola's entrepreneurship and business development

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Abstract **- The purpose of this paper is to measure the degree of persistence in the Kwanza to US Dollar exchange rate. First, our results indicate that nominal exchange rates both in levels and in first differences are I(0), thus implying that the relative purchasing power parity hypothesis for Angola is not rejected. Secondly, we find a significant degree of persistence in both the formal and informal nominal exchange rates. Thirdly, the degree of persistence in the official market is significantly lower than in the formal market, while In first differences, persistence in the official exchange rate is substantially higher than in the informal exchange rate. Lastly, we could not find strong evidence that persistence has changed in levels throughout the sample period. By contrast, there is significant evidence that persistence in first differences has consistently increased after September 2003.**

These results have important policy implications as the National Bank of Angola is preparing to change its monetary and exchange-rate policy focus to a more inflation-targeting regime and to a more a flexible (or low-managed) exchange-rate regime.

Keywords *- Nominal exchange rate, persistence, entrepreneurship, business development, Angola*

1. Introduction and motivation

The purpose of this paper is to measure the degree of persistence in the Kwanza nominal exchange rate *vis-a-vis* the US Dollar and to identify the implications for the decision-making process of the Angolan monetary authorities.

Understanding the degree of persistence of the nominal exchange rate is a crucial issue for policy purposes because it may have important implications for the design, implementation and effectiveness of the exchange rate policy, especially when under a *managed floating* exchange rate regime as is the case of Angola. The issue is even more critical since Angola is expected to move towards an inflation-targeting regime and thus to a flexible (or low-managed) exchange-rate regime.

Assessing the degree of persistence in the nominal exchange rate is crucial for policy purposes because the appropriate response to a random shock depends on the degree to which its effects on the exchange rate will persist. If the nominal exchange rate is highly (weakly) persistent, then bringing the exchange rate back to a desired target after a shock would require a more(less) vigorous policy action than if persistence is low(high). This property is particularly relevant for the Angolan monetary authorities given the existence of an informal exchange rate market where the exchange rate is clearly endogenous, unlike the formal market. Secondly, if the exchange rate is low persistent then it is clearly mean reverting. Accordingly, past behavior can fairly be used to predict future values of the bilateral exchange rate. Third, because of the so-called hump-shaped response, policy-makers need to know how long before their policy actions take effect: with high (low) persistence, the exchange rate will be stabilized in a longer (shorter) time following a shock. Finally, persistence may be seen as an important factor determining the medium-term orientation of exchange rate policy to achieve exchange rate stability. Furthermore, given the high pass-through of the nominal exchange rate to prices, assessing the degree of persistence of the nominal exchange rate is also important for price stability and competitiveness.

Persistence is a well-known concept in the macroeconomic literature. It has been an important subject of investigation in many macroeconomic issues such as aggregate output deviations, inflation, staggered prices and wage setting or deviations from purchasing power parity (PPP) condition.

Bouakez and Kano (2006) suggest that persistence mechanisms are inherent to the propagation of the causal effects of temporary shocks, such as policy measures and, therefore, capable of explaining the (strong) persistence of output.

The papers by Dixon and Kara (2006), Pivetta and Reis (2007), Fuhrer (2009), Dias and Marques (2010) or Belbute (2013) are a few examples of the many contributions to the literature on inflation persistence. Moreover, the papers by Huang and Liu (2002) and Wang and Wen (2006) find evidence that staggered price and staggered wage-setting may be causes of persistence in the major macroeconomic aggregates. Belbute and Caleiro (2009) find evidence of a strong level of persistence in aggregate and disaggregate private consumption.

In addition, the degree of exchange rate persistence has also been an intensively investigated subject over at least the past two to three decades, mainly in the context of the well-known PPP puzzle. Topics such as whether the exchange rate is weakly (highly) persistent and its implications for the effectiveness of monetary policy, whether it has changed over time or may vary according to the monetary regime, are just examples of the crucial issues that have been addressed. The articles by Mussa (1986), Meese and K. Rogoff (1988), Rogoff (1996), Frankel and Rose (1996), Taylor and Sarno (1998), Cheung and Lai (2000), Obstfeld and Rogoff (2000), Murray and Papell (2002), Crucini et al. (2005), Lopez et al (2005), Elliott and Pesavento (2006), Crucini and Shintani (2008) and Bergin et al. (2012) are examples of measurements of the persistence (and volatility) of PPP deviations from equilibrium, while the papers by Guender (2006) and Giugale and Korobow (2000), are examples of contributions to the literature that relate persistence of output and the exchange rate with the degree of openness of the economy and the exchange-rate regime.

Persistence can be thought of as a measure of the speed at which a variable returns to its equilibrium levels after a shock [see, for example, Dias and Marques (2010)]. In this sense, when the degree of persistence is low, a shock tends to have more temporary effects and conversely when the degree of persistence is high, a shock tends to have more long-lasting effects. In other words, persistence refers to the tendency of the exchange rate to converge (slowly or quickly) towards its long run value in response to these shocks.

In this paper we use the sum of the autoregressive coefficient approach to measure the degree of persistence of Angola's nominal exchange rate assuming a time varying mean. The sum of the autoregressive coefficients approach is the most popular scalar indicator of persistence in the literature. It has the advantage of concentrating in a scalar the information contained in the impulse response functions of the estimated data generating process. In particular, a scalar is useful in comparing the degree of persistence across series. Of course there are other scalar measures of persistence, namely the largest autoregressive root, the spectrum at zero frequency, or the half-life decay [see Marques (2010) for a discussion on the relative virtues of these different measures].

In this paper we measure we measure persistence for both the level and the growth rate of the exchange rate. Both indicators are crucial for the monetary authorities. Indeed, Persistence in levels is crucial regarding international trade flows, competitiveness and international payments. But if one care about inflation or about the risk premium of holding foreign-currency assets, then persistence in first differences (growth rates) might be important. In both cases, high persistence means that deviations from the equilibrium will tend to last longer than when persistence is low.

Our approach is in line with the literature on exchange rate persistence and aims to contribute to the nominal exchange rate debate, and in particular to the debate about the design and effectiveness of the exchange-rate policy in Angola. Indeed, from a policy point of view, the challenge for the exchange-rate authorities is how to reconcile the enormous short-term volatility with the high level of persistence in both the nominal and real exchange rate. Moreover, it is well known in the literature that volatility and persistence in real as well as in nominal exchange rates increase after a switch from a fixed to a flexible exchange-rate regime. In addition, there is enough empirical evidence that after moving to a floating exchange-rate the real exchange rate takes a much longer time to return to its long run value (see, among others, Mussa, 1986 or Chari et al, 2002).

The absence of evidence about persistence in the exchange rates focusing on less advanced and, in particular, on oil producer economies is an important void

in the literature. This is a void that we begin to fill with this paper by concentrating on both the formal and informal exchange rate for Angola - a country for which no evidence on this matter is available at all. Furthermore, given its prevailing exchange rate regime and its economic vulnerabilities, understanding persistence in Kuanza to US Dollar is also crucial for Angola in order to sustain the take-off in the non-oil component of the tradable goods and services sector. Finally, the issue is also crucial for entrepreneurship and business development environment in Angola.

The paper is organized as follows: section 2 presents the data and our results of the unit root analysis. Section 3 briefly presents the concept of persistence and discusses how it might be measured. In section 4 we compute the degree of persistence for the nominal exchange rates both in levels and in growth rates. In section 5 we test whether or not the degree of persistence has changed throughout the sample period and section 6 concludes the paper and suggests extensions for future research.

2. Data and stationary analysis

This section describes the basic data set and presents the results of the unit root analysis.

2.1 Data: sources and description

We use monthly average data for the nominal Kwanza/UD Dollar exchange rate from January 2002 through July 2014. Data was obtained from the Banco Nacional de Angola (Angola's National Bank, BNA hereafter) and refers to two of the three active nominal exchange rates in Angola: the formal (or secondary) market and the informal market exchange rates.

Angola has three nominal (bilateral) exchange rates; primary exchange rate which is set by the BNA, the secondary market exchange rate - also labeled as the formal exchange rate, which is set by commercial banks which have to respect a maximum 3% spread over the primary market exchange rate, and the informal exchange market, which is set by the "street." Allegedly, the informal market exists because there is not a fully floating exchange rate regime, but rather a *managed floating* exchange rate regime. Furthermore, the country still has some restriction measures for foreign exchange transaction related with its Balance of Payments, but since 2012 monetary authorities have been easing some of these foreign controls. The monetary authorities do not take any actions to prevent arbitrages between the formal and the informal markets.

The upper part of Figure 1 shows the exchange rates of the two markets and the lower part shows the informal market spread as a percentage of the secondary market exchange rate. Table 1 summarizes some basic statistics for these two exchange rates, their corresponding growth rates and the informal market spread.

The nominal exchange rate in the secondary market has dramatically devaluated in the last fifteen years, from its highest value in January 2000 (5.89 Kwanzas to the dollar) to its lowest value in May 2014 (97.66 Kwz/USD). This corresponds to an overall nominal devaluation of 1,558.07%, or equivalently to an average monthly devaluation rate of around 1.7%. For the whole-period sample the average monthly exchange rate in the secondary market was 73.40 Kwz/USD. In the informal market the exchange rate has followed a similar pattern and has remained above the formal exchange rate for almost the entire time horizon (77.512 Kwz/USD). Furthermore, the monthly average spread of the informal market was nearly 6 % throughout the sample period, which corresponds to nearly 4.1 percentage points (pp. hereafter) above the formal exchange rate.

Nonetheless, this aggregate result hides a great disparity of disaggregate effects. In particular, we can identify three sub-periods - common to both foreign exchange markets - where the average exchange rate as well as its corresponding growth rates are statistically different and follow a different path. Indeed, the monthly average formal exchange rate consistently increased from 5.89 in January 2000 to a peak of 84.69 in August 2003. The informal exchange rate was continually above the formal rate and ranged from its lowest level of 5.90 in January 2000, to its peak of 89.89 in August 2003. For both exchange rates the average nominal devaluation was nearly 6.50% per month, corresponding to an overall nominal devaluation of 1,337.86 % and 1,423.56%, respectively.

The second sub-period goes from September 2003 to September 2005, and represents a transition to a more stable pathway for both exchange rates. The average monthly formal exchange rate throughout this sub-sample period was 84.61 (86.43 for the informal exchange rate) and ranged from 78.05 to 89.21 Kwanza per US Dollar (81.09 - 91.00 for the informal exchange rate). Accordingly, the average rate of depreciation fell sharply

to just 0.221% per month in this sub-period. Moreover, the spread in the informal market dropped to an average value of 2.19 pp, which is the lowest value compared with the monthly average spread throughout the overall sample.

The third sub-period is characterized by three flat levels in both monthly average exchange rates (80.40, 75.60 and 77.81, respectively for the formal market and 81.94, 75.60 and 90.17 respectively for the informal market), while the monthly average spread was 3.12 % for the sub-sample period.

This is also the sole sub-period where the Kwanza appreciated vis-à-vis the US Dollar by a monthly average value of 0.27%, in the secondary market. Note that after March 2009 the informal market clearly anticipated the strong depreciation of about 17% in the secondary market in the following three months.

In the last sub-period average depreciation was about 0.39% per month in the secondary market, very close to the depreciation occurring in the informal market (0.33%). Not surprisingly, the informal exchange rate remained, on average, 7.7pp above the secondary market, the highest spread of the overall sample. In addition, both exchange rates reached their highest value (117.50 Kz/USDollar) in the sample. Note that for both markets this last sub-period was the least volatile in both level and growth rate.

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Naturally, during the sample period of 2000:01-2014:07 many changes occurred in Angola and in the domestic markets, which may lead to structural breaks. First, this sample period includes years before and after the end of the civil war in April 2002. Accordingly, we will consider the possibility of a structural break around this date throughout the empirical analysis.

Second, the sample period also includes important structural disturbances in crude oil and its refined product between late 2004 and late 2009, as well as the international economic and financial crisis in late 2009. Therefore, the possibility of a structural break in this period will also be considered in the empirical analysis.

2.2 Unit root analysis

In this sub-section we test the unit roots hypothesis for the two exchange rates using the modified Dickey–Fuller test (ADF, hereafter) proposed by Elliott et al. (1996). The unit root literature shows that the existence of structural breaks can dramatically affect estimates' credibility as well as statistical inference. Indeed, in the presence of structural breaks results may be biased towards the non-stationary hypothesis and the erroneous non-rejection region (see, for example, Perron (1989)) or even to the erroneous conclusion that the series has a stochastic trend. Accordingly, we may incorrectly conclude that any shock affecting the series will have permanent effects. Therefore, we consider the possibility of structural breaks in the times series under analysis affecting their deterministic components.

We begin by using the Chow test to confirm the dates of the expected structural breaks. The Chow test does not confirm the existence of a structural break consistent with the end of the civil war in April 2002. Instead, it was possible to identify two break dates located around August 2003 and September 2009 for both exchange rate markets in levels. In addition, the Chow test has also pointed one break point around August 2003 in the rate of change in both exchange rates.

Figure 1. The formal (secondary) and informal monthly average exchange rate

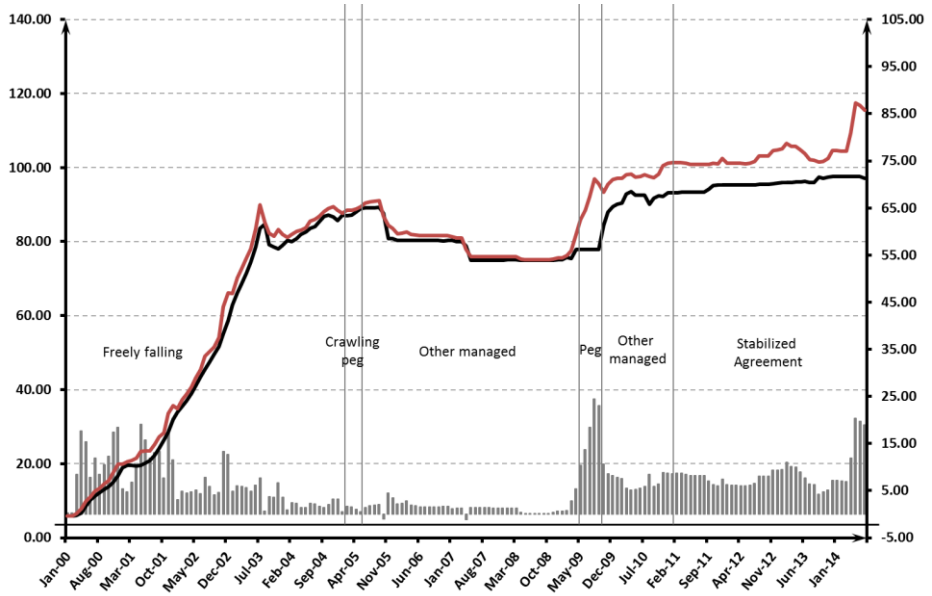

Table 1. Summary statistics for the exchange rates

sub-samples	Exchange rates (in levels)						Average monthly rate of change								
	Official market			Infomal market			Official market			Infomal market			Difference (%)		
	m	s	s/m	m	s	s/m	m	s	s/m	m	s	s/m	m	s	s/m
Jan:00 - Aug:03	34.669	3.544	0.102	37.236	3.705	0.099	6.506	0.774	0.119	6.569	0.923	0.140	8.700	0.769	0.088
Sep:03 - Sep:05	84.605	0.771	0.009	86.433	0.682	0.008	0.221	0.327	1.479	0.268	0.249	0.927	2.194	0.261	0.119
Out:05 - Sep:09	77.623	0.410	0.005	80.024	0.770	0.010	-0.274	0.208	-0.758	0.122	0.273	2.235	3.080	0.801	0.260
Out:09 - Jul:14	94.446	0.349	0.004	102.144	0.592	0.006	0.392	0.183	0.468	0.335	0.187	0.559	8.137	0.416	0.051
Overall sample	73.396	1.990	0.027	77.512	2.126	0.027	1.695	0.299	0.176	1.807	0.324	0.179	6.043	0.386	0.064

Note: μ stands for the mean, σ stands for the standard deviation and σ/μ stands for the coefficient of variation. The coefficient of variation shows the extent of variability in relation to the mean. Source: Banco Nacional de Angola. Author's calculations.

Since the timing of the structural breaks is known, the use of the ADF t-test to test the null hypothesis of a unit root is appropriate [see, for example, Maddala and Kim, 1998]. The optimal lag structure is chosen using the Schwartz Bayesian Information Criterion (BIC), while the deterministic components and the corresponding dummies were included if statistically significant.

We start by applying the ADF t-tests to each of the two exchange rates in levels without considering possible break points, and consistently find that we can reject the null hypothesis of non-stationarity at the 5% level of significance only for the formal market exchange rate (see upper part of table 2). On the contrary, we cannot reject the null hypothesis of a unit root in the informal exchange rate at the 5% significance level. We then tested for stationarity of these two variables in growth rates (see also Table 2). The ADF t-tests suggest that the null hypothesis of a unit root in the growth rates can be rejected for all variables at the 1% significance level.

We then tested the existence of a unit root conditional to the identified break points, and consistently find that both the level and the growth rate of the two exchanges rates are stationary (see lower part of table 2). Moreover, we also tested stationarity within the three sub-periods for the two exchange rates. Ignoring the possible presence of one (or more) break dates within each sub-periods, our results suggest that both exchange rate indicators are non-stationary. In particular, in the first sub-periods of both exchange rates in levels the ADF-t statistic is big and positive, implying explosive behavior, which is clear from figure 1.

For the second and the third sub-periods the ADF-t statistics are slightly positive. Given these results, we then tested stationarity accommodating for the breakpoints within each sub-periods. Our results suggest that conditional to one (or more) breaks, we could reject the null hypothesis of a unit root for the two exchange rates. In other words, we reject the hypothesis that both exchange rates (in levels) follow a random walk, which implies that they are mean-reverting (i.e. they revert toward some fundamental equilibrium exchange rate indicator.

Summing up, we find strong evidence that under a process without a break, the level of the official exchange rate is I(1) whereas the informal exchange rate is clearly I(0). However, under the assumption of a process with a time varying deterministic component defined by the detected structural breaks, our results suggests that both the official and the informal exchanges rates are is I(0), for both the overall and the three sub-sample periods. In these cases, quantifying persistence by estimating univariate auto-regressive models is feasible because, by definition, these are mean reverting processes; in response to an exogenous random shock, these processes tend to move away from and return to their baseline level. For this reason, these shocks will tend to be temporary.

3. Persistence: concept and measurement

In this section we briefly present the concept of persistence, discuss how it might be measured and present some methodological notes regarding the tests of a change in the level of persistence between two periods.

Table 2. ADF unit roots tests

Sub-periods	Break dates	Det	$\hat{\rho}$	ADF-*t*	Lag	BIC
Levels						
Formal market		Constant	0.988	-3.274 **	1	566.513
Informal market		Constant	0.989	-2.355	3	650.410
Growth rates						
Formal market		Constant and trend	0.616	-6.513 ***	1	801.519
Informal market		Constant and trend	0.531	-6.447 ***	1	897.863
Conditional to break points						
Levels						
Formal market	2001:04, 2002:10, 2003:08, 2005:10, 2006:02, 2007:03, 2008:03, 2009:01, 2009:09, 2010:02, 2010:11, 2011:08 and 2013:09	Constant and trend	0.493	-26.543 ***	0	901.978
Informal market		Constant and trend	0.663	-7.530 ***	0	823.630
Growth rates						
Formal market	2003:08	Constant and trend	0.527	-7.296 ***	10	639.126
Informal market	2003:08	Constant and trend	0.196	-10.516 ***	10	760.347

Critical values for unit root test:
Constant: 3.58 for1%, -2.93 for 5%, and -2.60 for 1%.
Constant and trend: 4.15 for 1%: -3.50 for 5% and -3.18 for 1%.
***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Furthermore, since there is clear evidence of the existence of structural breaks, we will address the issue of whether the degree of persistence may have changed over the sample period.

There are several definitions of persistence in the literature, not all entirely coincident and some even contradictory [see, for example Fuhrer (2009) who makes the analogy to the concept of inertia in physics and for whom a variable is persistent if it shows a tendency to stay where it has been recently. At the extreme, a series reaches its highest degree of persistence when it does not depart from its trend after a shock]. But the majority share the idea that persistence is related to the speed of a variable's response to a shock [see, for example, Dias &Marques (2010)].

In this paper, we adopt the definition proposed by Dias and Marques (2010) and define persistence as the speed with which a variable converges to its equilibrium after a shock. Accordingly, a variable is said to be more (less) inertial the slower (faster) it converges (or returns) to its equilibrium after the occurrence of a stimulus. In other words, when the value is small, a variable responds quickly to a shock, tending to deviate from its trend briefly. Therefore, deviations from the trend tend to be temporary. Conversely, when the value is high, the speed of adjustment is low and the shock tends to have long-lasting effects. In extreme cases, the series does not revert to its initial trend.

The usual way to capture the degree of persistence is by estimation of the *sum of the autoregressive coefficient.* A univariate AR(k) process may be simply written as

$$y_t = \alpha + \sum_{j=1}^{k} \beta_j y_{t-j} + \varepsilon_t \qquad (1)$$

Where y_t denotes either the level or the growth rate of the exchange rate at moment t, which is explained by a constant α, by past values up to lag k, and by a number of other factors captured by the random term ε_t.

Alternatively, the process presented by Eq. (2) can be re-parameterized and written as

$$(y_t - \mu) = \sum_{j=1}^{p-1} \delta_j \Delta(y_{t-j} - \mu) + \rho(y_{t-1} - \mu) + \varepsilon_t \qquad (2)$$

Where $\mu = \frac{\alpha}{1-\rho}$ is the "unconditional mean" of the y_t series, which can also be seen as representing the equilibrium level of the series. The parameter ρ is the "sum of the auto-regressive coefficients", and can be written as

$$\rho = \sum_{j=1}^{k} \beta_j \quad \text{and} \quad \delta_j = -\sum_{i=j+1}^{k} \beta_i \qquad (3)$$

In the parametric representation of the $AR(k)$ process, model 1 (or equivalently, model 2) is considered highly (weakly) persistent if variable y_t converges slowly (quickly) to its mean, after a shock to the disturbance term ε_t. Accordingly, persistence is linked to the impulse-response function of the $AR(k)$ process. Andrews and Chen (1994) propose the "sum of the autoregressive coefficients" parameter ρ to be a measure of persistence, while other authors have proposed alternative measures of persistence, such as the largest autoregressive root, the spectrum at zero frequency, or "half-life." The rationale for this measure comes from the fact that for $|\rho| < 1$, the cumulative effect of a shock on y_j is given by $\frac{1}{1-\rho}$. The larger the value of ρ, the greater the cumulative impact of the shock will be [for a technical appraisal of these other measures, see, for instance, Dias and Marques (2010)].

This formulation has the advantage of highlighting the relationship between persistence and mean reversion present in Eq. (2) by the term $(\rho - 1)(y_{t-1} - \mu)$. Again, the sum of the autoregressive coefficients (the degree of persistence) can be obtained directly by estimating the model for the time series of deviation from the mean. If the time series is stationary (that is, $0 < \hat{\rho} < 1$), then any unit deviation from the mean in period *t* - 1, [that is, $(y_{t-1} - \mu) \neq 0$], will force the series in the next period to display a (positive or negative) change in the amount $(\hat{\rho} - 1)$ thus bringing it close to the mean. Accordingly, the mean reversion effect is stronger the larger the coefficient $(\hat{\rho} - 1)$. Given that persistence is measured by the coefficient $\hat{\rho}$, it is clear that mean reversion and persistence are inversely related: a high degree of persistence implies weak mean reversion effects. Ultimately, a non-stationary time series (that is $\hat{\rho} = 1$) shows a high degree of persistence and does not revert to its mean after a shock. On the contrary, a stationary process (that is, with $\hat{\rho} < 1$) is mean reverting and therefore, any shock has transitory effects.

In the context of this work, the equilibrium (or trend) around which the exchange rate tends to gravitate may be the PPP, the fundamental equilibrium exchange rate (FEER) or some other sustainable current-account balance indicator. For the growth rate there seems to be no clear indicator since in the secondary market it is allowed a maximum spread of 3% on the primary market exchange rate. Of course, the most obvious candidate for such equilibrium would be a zero risk premium.

The usual methodology to test the possibility of changes in the level of persistence between periods is to use the residuals of the unit root tests [see, for, instance, Dias and Marques (2010)]. However, given the strong influence of the various structural breaks found in our data, we will adopt a more flexible strategy based on a simple independent two-sample t-test. This allows us to establish, precisely, rankings for the degree of persistence among our exchange rate indicators, among the different sub-periods.

4. Assessment of the degree of persistence of the exchange rate

The results in Table 3 suggest that the nominal exchange rate of the Kwanza to US Dollar is persistent and equal to 0.493 and 0.663 in the official and informal market, respectively. As regards the growth rate of the Kwanza to USD exchange rate, the degree of persistence in the official market (0.527) is aligned with the values for the exchange rate in levels, but it is considerably small (0.196) in the informal market.

Using a simple independent two-sample t-test (not shown but available upon request to the authors) we were unable to reject the null hypothesis of equal persistence between the two nominal exchange rates in levels, with a 5% significance level test. In particular, persistence in the official exchange rate is substantially lower than in the informal exchange rate. This suggests that after a policy shock, the official exchange rate will tend to move from and return to its equilibrium more quickly than the informal exchange rate. Indeed, it will take 0.98 months for the impulse response to a unit shock to the formal exchange rate to dissipate by half, while

the same shock will have a half-life of 1.70 months in the informal. Accordingly, the cumulative response (CR) to a shock will be smaller in the official market (1.97) than in the informal market (1.97).

This result seems to be inconsistent with the general belief that the informal exchange rate reflects the balance of payment imbalances more accurately than the official exchange rate [Gelbard and Nagayasu (2004)], and particularly the transition dynamics following an official realignment. Indeed, throughout the sample period there were several official devaluations but at the same time the Angolan average monthly rate of inflation (1.74 percent) has consistently remained above the USA inflation rate (0.20 percent). If we consider the period of greater price and exchange rate stability (2009:09-2014:07), the monthly average differential between the Angolan and the USA inflation rate was 69 base points (bp), while the average monthly rate of depreciation of the Kwanza against the USD was 38 bp in the official market (and 39 bp in the informal market). This suggests a clear and steady loss of real competitiveness signaling that Angola has failed to offset the impact of its higher inflation on its competiveness. Despite the time pattern of the nominal depreciation in both markets has closely followed the time path of the inflations differential, the two nominal exchange rates did not depreciate fast enough to prevent real appreciation. Therefore, the informal market seems to be anticipating that gains in competitiveness caused by official devaluations are temporary and useless. Accordingly, new devaluations are reasonably expected.

Table 3. Persistence in the exchange rate in both levels and in growth rate, in each sub-period samples

Sub-periods	Break dates	Det	$\widehat{\rho}$	ADF-*t*
Levels				
Formal market				
Overall sample	all breacks	Constant and trend	0.493	-26.543 ***
2001:01 - 2003:08	2001:04, 2002:10	Constant and trend	0.522	-4.538 ***
2003:09 - 2009:09	2005:10, 2006:02, 2007:03, 2008:03 and 2009:01	Constant and trend	0.496	-3.981 **
2009:10 - 2014:07	2010:02, 2010:11, 2011:08 and 2013:09	Constant and trend	0.534	-7.311 ***
Informal market				
Overall sample	all breacks	Constant and trend	0.663	-7.53 ***
2001:01 - 2003:08	2001:04, 2002:10	Constant and trend	0.509	-3.693 **
2003:09 - 2009:09	2005:10, 2006:02, 2007:03, 2008:03 and 2009:01	Constant and trend	0.434	-8.082 ***
2009:10 - 2014:07	2010:02, 2010:11, 2011:08 and 2013:09	Constant and trend	0.416	-4.703 ***
Growth rates				
Formal market				
Overall sample	2003:08	Constant and trend	0.527	-7.296 ***
2001:01 - 2003:08	None	Constant and trend	0.400	-3.759 **
2003:09 - 2014:07	None	Constant and trend	0.447	-7.481 ***
Informal market				
Overall sample	2003:08	Trend	0.196	-10.516 ***
2001:01 - 2003:08	None	Constant and trend	0.227	-5.071 ***
2003:09 - 2014:07	None	None	0.463	-6.341 ***

Note: "Det" stands for the "Deterministic component." Critical values for unit root test with constant and trend: 1%: −4.15; 5%:−3.50; and 10%: −3.18. ∗∗∗p < 0.01, ∗∗p < 0.05, ∗p < 0.10

The PPP hypothesis also suggests that exchange rate fluctuations are tied to movements in relative prices. If domestic prices rise faster than international prices, the country's competiveness declines and one should expect depreciation in the nominal exchange rate. In a pure floating exchange rate regime, market forces would prevent the exchange rate from moving too far or even remaining away from the PPP indefinitely. In other words, the nominal exchange rate will tend to be stationary, thus reverting to its equilibrium value. Under a managed floating exchange rate regime the relative PPP is still active, so that the competitiveness benefit from the initial devaluation will be entirely offset by the inflation differential with the country to whose domestic currency is pegged. In other words, devaluations only have temporary effects. It should be noted that more than 95 percent of the country's total exports are concentrated in a single commodity while consumption goods account for more than 50 percent of the country's total imports. Moreover, as recent events clearly show, the managed floating exchange rate regime is not entirely immune to crisis of the first (competitiveness), the second (macroeconomic vulnerabilities) and the third (fiscal vulnerabilities) generations.

When we look for the growth rates we find that the devaluation rate in the informal market is statistically less persistent (0.196) than in the formal market (0.527). Assuming that the depreciation rate of the Kwanza against the US Dollar can be viewed as proxy of the premium risk, this result suggests that the deviations from the uncovered interest rate parity (UIRP) in the official market last longer than in the informal market. Indeed, it will take 1.08 months for the impulse response to a unit shock to the formal risk to dissipate by half, while the same shock will have a half-life of nearly 15 days in the informal. Accordingly, the cumulative response (CR) to a shock will be higher in the official market (2.11) than in the informal market (1.24).

This is a quite interesting result for the official market since Angola still imposes some capital mobility controls which do not allow for potential opportunities to earn risk(less) profits from uncovered/covered interest arbitrage. For the informal market our results suggests that the uncovered interest rate parity holds almost permanently, so that investors are indifferent between Kwanza versus Dollar based assets in that some shortfall in return on Dollar assets must be offset by some expected gain from depreciation of the Kwanza against the Dollar. Conversely, any excess return on Dollar based assets must be offset by some expected loss from appreciation of the Kwanza against the Dollar. Intuitively, this conjecture seems to be consistent with the condition of the real interest rate parity (RIRP) for which both the UIRP (particularly in its approximation form) and the PPP must hold. However, the appropriate conditions for the international Fisher equation are far from to being verified in Angola - including efficient markets, in country risk premia, zero change in the expected real exchange rate, and high degree of financial integration with the USA. But such an investigation is outside the scope of the present paper.

5. Are there changes in the levels of persistence over time?

Since there is clear evidence for the existence of structural breaks, we now address the issue of whether or not the degree of persistence may have changed over the sample period.

Table 4 and table 5 report the tests of differences in persistence between two sub-periods and between the two exchange rates (both in level and in rate of change), using a simple independent two-sample t-test. This allows us to establish, precisely, rankings for the degree of persistence among the different sub-periods.

Table 4 shows that at the 5% level we cannot reject the null hypothesis of equal persistence in the official exchange rate between the first and the second sub-period, whereas the degree of persistence in the second sub-period (0.496) is slightly smaller than in the first-period (0.522). However, we reject the null hypothesis of equal degree of persistence between de second (0.496) and the third sub-period (0.534) at the 5% significance level.

In contrast, we find a clear reduction in the degree of persistence in the informal exchange rate throughout the sample period (from 0.509 in the first sub-period to 0.416 in the third sub-period). Furthermore, the degree of persistence in the informal exchange rate has decreased along with the devaluation of the Kwanza against the US Dollar, signaling that informal exchange market reflects the imbalances in the country current account more accurately than the official exchange market.

Table 4. Testing differences in persistence between sub-periods: nominal exchange rate levels

	Formal market			Informal market		
	Sub-period #1	**Sub-period #2**	**Sub-period #3**	**Sub-period #1**	**Sub-period #2**	**Sub-period #3**
Formal market						
2000:01 - 2003:08						
2003:09 - 2009:09	1.208					
2009:10 - 2014:07	-0.618	-2.199 (**)				
Informal market						
2000:01 - 2003:08	0.514	0.523	-1.116			
2003:09 - 2009:09	4.914 (***)	3.649 (***)	-8.471 (***)	3.444 (***)		
2009:10 - 2014:07	4.615 (***)	3.583 (***)	6.3488 (***)	3.553 (***)	0.941	

Notes: Critical values for a two-sided t-test: 1%: 2.576; 5%: 1.960; and 10%: 1.645.

***, ** and * denote rejection of the null hypothesis of equal degree of persistence at 1%, 5% and 10% significance level, respectively.

Regarding the rate of change in the two nominal exchange rates we could reject the null hypothesis of equal degree in persistence at 5 % significant level, between the two sub-periods in both markets (see table 5).

In particular, our results suggest a slight, though significant, increase in the degree of persistence in the formal market (from 0.400 to 0.472) and a substantial rise in the informal market (from 0.227 to 0.463). This indicates that deviations from their corresponding average equilibrium levels became more permanent, thereby shocks will tend to last longer. This rise in persistence is consistent with the country's effort to reduce and stabilize inflation, which has sharply fallen from a peak in December 2002 (8.62%) until a more stable and flat monthly average value of 0.81% in September 2009.

Table 5. Testing differences in persistence between sub-periods: growth rate

	Formal market		Informal market	
	Sub-period #1	**Sub-period #2**	**Sub-period #1**	**Sub-period #2**
Formal market				
2000:01 - 2003:08				
2003:09 - 2014:07	-2.538 (**)			
Informal market				
2000:01 - 2003:08	5.148 (***)	-9.781 (***)		
2003:09 - 2014:07	-2.482 (**)	0.099	-9.671 (***)	

Notes: Critical values for a two-sided t-test: 1%: 2.576; 5%: 1.960; and 10%: 1.645.

***, ** and * denote rejection of the null hypothesis of equal degree of persistence at 1%, 5% and 10% significance level, respectively.

Moreover, our results also suggest that persistence has increased with the average level of the two nominal exchange rates indicators. In addition, the increase in persistence in the two indicators was followed by a decrease of volatility, which confirms the assumption that a volatile series is not a persistent series, and vice versa.

6. Conclusions

This paper assesses the degree of persistence in the Kwanza/US Dollar nominal exchange rate. The main conclusions can be summarized as follows.

First, we found that under the assumption of a

process with a time varying deterministic component the official and the informal exchanges rates (both in levels and in first differences) are stationary, thus implying that the two nominal exchange rates are mean-reverting. In other words, the two nominal exchange rates in Angola follow a random walk, which implies the non-rejection of the PPP hypothesis for Angola.

Secondly, we found a significant degree of persistence in the two exchange rates both in levels and in first differences. The degree of persistence in the official exchange rate is statistically lower than in the informal exchange rate, signaling that the official currency exchange market adjusts more quickly than the informal market after a shock. This is not a surprising result since the Angolan official market is highly regulated and distorted by a managed floating exchange rate. In addition, this result seems to be inconsistent with the general belief that the informal exchange rate reflects the balance of payment imbalances more accurately than the official exchange rate [Gelbard and Nagayasu (2004)]. However, persistence in the rate of change of the official exchange rate is substantially higher than in the informal exchange rate. This suggests that contrary to what happens to the nominal exchange rate, the informal market will tend to move from and return to its equilibrium more quickly than the informal exchange rate, after a policy shock.

Third, when we look for changes in persistence we could not find strong evidence that persistence has changed in levels throughout the sample period, whereas there is significant evidence that persistence in first differences consistently increased after September 2003, along with a steady slowdown of both the domestic currency devaluation rate and inflation rate.

These results have important implications for the effectiveness of both exchange policy and monetary policy, especially when under a fixed (or managed) exchange rate regime. First, since the Angolan monthly exchange rate (both in levels and in growth rates) is a stationary process, shocks will tend to temporary deviate it from its trend values, thereby requiring a permanent policy stance. This effect is stronger in the informal markets since shocks tend to last longer than in the official market. Secondly, our results are also relevant for prediction and modeling purposes since in these circumstances past behavior can fairly be used to predict the future value of the exchange rate. Indeed, for the overall sample period and conditional to breaks, it will take 0.98 months for the impulse response to a unit shock to the official exchange rate to dissipate by half, while the same shock will have a half-life of 1.7 months in the informal exchange rate. Accordingly, the cumulative response (CR) to a shock will be smaller in the official market (1.97) than in the informal market (1.97).

The evidence of a significant degree or even an increase of persistence is good news. A high degree of persistence reflects long-lasting and greater shock effects. Ultimately, a monetary/exchange policy aiming for exchange rate stability can be implemented in a favorable setting in which their effects will tend to promote positive feedback and be long-lasting. The nominal exchange rate's speed of adjustment in response to shocks is of crucial importance for a central bank committed to price stability. Given that the degree of persistence has become lower in growth rates than in levels, the effects of a (policy) shock will rapidly move the exchange rate to a different level and stay there longer until a new shock occurs.

Furthermore, given the strong connection of the exchange rate (both formal and informal) to the rest of the economy, the effects of exchange rate policies may be transmitted to other variables such as real exchange rate, inflation, interest rates, monetary aggregates or national reserves. In particular, it is well known that real exchange rates tend to be more persistent and volatile than most models can account for. Accordingly, given the strong connection between nominal and real exchange rates, it is not unlikely that some sort of persistence (as well as volatility) of the former may pass to the latter. Therefore, investigating volatility in both real and nominal exchange rates, as well as their possible connection, are natural extensions of this paper.

Finally, the issue is also crucial for the environment entrepreneurship and business development in Angola. Indeed, nominal exchange rates variability can have serious impact on operational exposure which is often a large cause on operational profit. Moreover, knowing how persistent the nominal exchange rate is will allow companies to adjust their operational flexibility, thus allowing for downside risks control as the nominal exchange rate becomes more volatile.

Recent research [see, for example, Bergin et all. (2012)] suggests that long-run dynamics rather than

just short-run volatility and persistence can play an important role in reconciliation of the PPP puzzle. Therefore, assessing the presence of long memory in both the nominal and real exchange rate would be a second research avenue for this paper.

Finally, despite finding no significant differences in persistence between secondary and informal nominal exchange rates, the existence of a binary exchange rate market in Angola raises the question of which one is an attractor and which is leading. Therefore, given its obvious implications for the exchange rate policy, this issue is also a candidate for an extension of our paper.

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