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Testing the Purchasing Power Parity (PPP) in West and Central Africa

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ABSTRACT: This paper employs various empirical methods to test the Purchasing Power Parity (PPP) hypothesis in West and Central Africa, considering countries within the WAEMU, CEMAC, CFA, and ECOWAS currency zones and four possible numeraire currencies—U.S. dollar, euro, renmimbi, and the CFA franc. Using panel and single-country unit-root, cointegration, error-correction techniques, our findings indicate that the numeraire currency matters for evidence in favor of PPP. Results show slightly stronger evidence when the euro is used as the reference compared to other numeraire currencies, although results vary across different methods. Evidence for PPP is also stronger across the currency zones after the 1994 devaluation of the CFA franc, when evindence for PPP using the renminbi as reference is also stronger, suggesting an increasing importance of the renminbi for the economies in West and Central Africa. The paper documents significant differences in price dynamics for the CEMAC and the WAEMU, the two components of the CFA zone, with stronger evidence for PPP found for the WAEMU and reversal speed to PPP faster than the 2-3 years found in the literature. Results also indicate that real exchange rates of the currency zones revert to PPP mainly through adjustments of foreign prices expressed in domestic currencies—which may result from changes in nominal exchange rates of the reference currencies or foreign prices—and less so via adjustements in domestic prices.

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WORKING PAPERS

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Contents

Executive Summary

The paper investigates the Purchasing Power Parity (PPP) hypothesis within the CFA currency zone and the Economic Community of West African States (ECOWAS), employing four currencies as numeraire: the euro, the US dollar, the Chinese yuan (i.e., the renminbi), and the CFA franc. It conducts an extensive analysis utilizing various methods to ascertain the validity of both absolute and relative PPP, while also considering the potential impact of the Balassa-Samuelson effect, which may disrupt standard PPP assumptions through long-term trends in real exchange rates.

Key findings include:

1. *Evidence of PPP Variability*: The results suggest that PPP is supported within the CFA and ECOWAS regions, but results change with the numeraire and the country grouping analyzed. Notably, evidence for PPP is slightly stronger for the Euro compared to other currencies, perhaps reflecting the adjustment of price structures of CFA countries (15 out of 21 countries) to the Euro area countries enforced by the longstanding peg.

2. *Regional Analysis*: When examining the country groups, within the CFA zone, the study found stronger support for PPP in the WAEMU sub-region compared to the CEMAC sub-region. This discrepancy maybe attributed to the economic structures of the countries, particularly the significant share of oil-exporting nations in the CEMAC.

3. *Choice of numeraire*: The choice of numeraire is pivotal. The euro produced more consistent evidence for PPP compared to the US dollar and the renminbi. This suggests that the stability and recognition of the Euro may enhance the effectiveness of currency arrangements and price convergence efforts.

4. *The adjustment mechanisms*: Cointegration tests reveal that the reversion to PPP occurs primarily through adjustments in foreign prices measured in domestic currency rather than domestic prices, which might reflect adjustments in of foreign prices or the nominal exchange rates of benchmark currencies that are not pegged (i.e., euro, dollar, renminbi), or also suggest greater degree of price rigidity within these regions.

5. *Post-Devaluation Dynamics*: The study highlights that the evidence for PPP across the studied regions is stronger post-devaluation of the CFA franc in 1994. The results indicate that the response to shocks resulting in deviations from PPP averages between about 2 and 20 months, depending on currency and regional specifics. Moreover, after the CFA franc devaluation, the renminbi is the numeraire currency toward which reversion to PPP is fastest, which reflects the growing importance of China in trade flows with the region.

6. *Policy Recommendations*: The paper suggests that regional monetary policies should consider the implications of currency choice critically, especially as they pertain to fostering economic stability and convergence. Particularly, the possible need for reforms to enhance domestic goods market flexibility and the burgeoning significance of the renminbi presents a viable candidate for future monetary frameworks in the region.

The findings provide valuable insights for policymakers regarding the robustness of PPP in the CFA and ECOWAS regions and underline the importance of currency arrangement and economic policies on achieving favorable price alignment and stability. Further studies could expand on the effects of geoeconomic fragmentation and digital currencies on PPP in these economies.

I. Introduction

The paper investigates the Purchasing Power Parity (PPP) hypothesis in Central and West Africa using different currencies as numeraire[1]. After independence, most of the former French colonies pegged their currency to the French franc to promote economic stability, cooperation, and integration. The resulting CFA monetary arrangement brought to its members fiscal discipline, exchange rate stability, and anti-inflationary credibility (Masson and Pattillo, 2004; Gulde and Tsangarides, 2008).[2] These benefits—along with enhanced integration, and lower transaction costs and exchange rate risk—prompted discussions for a wider West African monetary zone with all the 15 ECOWAS members, who will share the ECO as the common currency.[3] They also supported proponents of an African common currency alongside the African Continental Free Trade Agreement (AfCFTA). However, monetary arrangements have well-known drawbacks (Williamson, 2006) that are subjecting the current and envisioned monetary zones to debates. The arguments revolve around the choice of the exchange rate regime and, in case of a fixed or managed exchange rate regime, the anchor currency to which to peg (i.e., the numeraire), with a view to bring the monetary arrangement closer to an Optimal Currency Area (OCA) (Mundell, R. 1961).

OCA theory suggests, *ceteris paribus*, that it is "optimal" that deviations from the PPP condition (henceforth, just "PPP") are minimized (Liang, 1999). The central notion underlying the absolute version of the PPP hypothesis is an arbitrage condition: abstracting from transaction costs and market segmentation, prices in two different markets should be identical when measured in the same currency. In its weaker version, prices can differ permanently, but their evolution and dynamics should be similar aside from short-term divergence (i.e., they should be cointegrated). Moreover, as deviations from PPP represent arbitrage opportunities, there should exist a self-correcting mechanism: when these opportunities are exploited, the real exchange rate would be forced—via adjustment in prices or (if not in a pegged regime) the nominal exchange rate—to converge towards its PPP-consistent level. Thus, when PPP holds the real exchange rate should be *constant*. In its *absolute* (i.e., stricter) version, PPP implies that the real exchange rate should be constant at 1 (i.e., identical domestic and foreign prices when converted to a common currency). That restriction is relaxed under the *relative* version of PPP, which holds when the nominal depreciation of one currency vis-à-vis another matches the difference in aggregate price inflation between the two countries, keeping any existing relative gap between the *levels* of domestic and foreign prices constant.

Within monetary unions, such as the two in Francophone Africa—the CEMAC and WAEMU common currency areas—and in the envisaged ECOWAS, one obvious trade-off is the loss of *national* monetary and exchange rate policy space. The magnitude of the costs associated with this trade-off depends on how symmetrical the economies' business cycles are, their vulnerability to shocks, and their ability to adjust. The asymmetric

[1] The 21 countries (see Annex I) covered by the paper belong to the CFA zone, or are considering joining the ECO, a prospective currency union for members of the Economic Community of West African States (ECOWAS). For convenience, we will refer to the wider CFA zone, its two currency unions (WAEMU and CEMAC), and the ECOWAS as currency "zones", "unions," or "areas," even though ECOWAS is not yet a formal currency union. That Annex provides a list of member countries for each group and background macroeconomic information on each country.

[2] CFA stands for African Financial Community. It is comprised of two separate sub-zones: WAEMU (8 countries) and CEMAC (6 countries). WAEMU stands for West African (Economic) and Monetary Union, and CEMAC stands for Central African Economic and Monetary Community.

[3] ECOWAS is comprised of the eight WAEMU countries and seven countries with their own currency, of which six belong to the West African Monetary Zone (WAMZ)—i.e., Gambia, Ghana, Guinea, Liberia, Nigeria, Sierra Leone. The remainder (Cabo Verde) pegs to the Euro with Portugal's support.

incidence and propagation of shocks can be a major hindering factor for the efficiency of the common monetary policy (Mundell, 1961), especially in a context of low mobility of factors (capital, labor) and lack of compensatory fiscal transfers across union member countries. The absence of bilateral nominal exchange rates within union countries makes the adjustment to asymmetric shocks more difficult, dependent on the adjustment of domestic prices with potentially different degrees of stickiness. When the union itself relies on a fixed exchange rate regime—the case of the two unions in the CFA zone—yet another (cross-country aggregate) shock absorber mechanism is lost. Therefore, the prevalence of the PPP hypothesis across union countries—implying a similar dynamic of domestic prices relative to foreign prices—indicates that these constraints may be less binding and the derived frictions less costly given that relative prices will tend to converge to fundamentals within a reasonable timeframe, facilitating the propagation of the common monetary policy and the orderly adjustment to potentially asymmetric shocks in the different economies in the union.[4]

A study of PPP in the West African region can, therefore, shed light on that important aspect of the costs associated with both the existing sub-regional currency unions (WAEMU and CEMAC) and the envisioned new currency union (ECOWAS), providing insights for policymakers in (re-)designing them. If the effects of shocks affecting member countries are symmetric, then PPP will more likely hold, indicating that the costs associated with a common monetary policy in a currency union tend to be lower. If not, *ceteris paribus*, persistent deviations from PPP should be more frequent, and any overall response to shocks decided at the union central bank's level could be asymmetrically very costly for some countries in the union (Horváth and Grabowski, 1997). Thus, the prevalence of PPP within and across a group of countries may be one important indicator—albeit not the only one—that the costs of forming a currency union are not prohibitive.

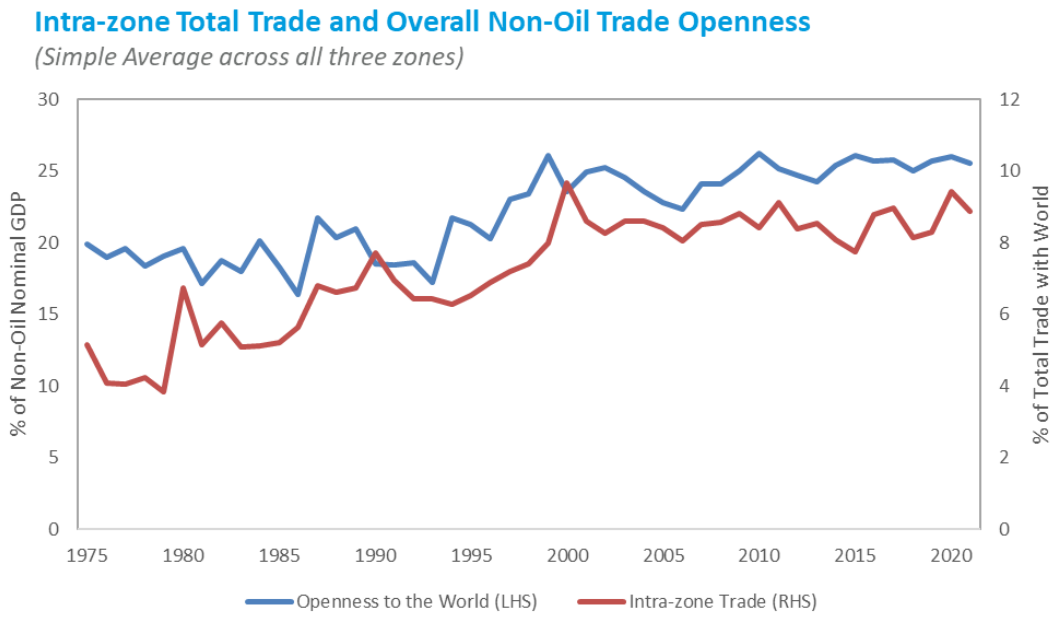
However, one complication to the analysis is that the choice of numeraire or base currency can matter to the evidence of PPP. In a panel test, Papell and Theodoris (2001) showed that evidence of PPP is stronger when the German mark, rather than the US dollar, is used as the base currency. Other authors also report stronger rejections of unit root in exchange rates with the mark as numeraire using consumer price indices (Jorion and Sweeney, 1996; Papell, 1997; and Papell and Theodoris, 1998), as well as tradable goods prices (Wei and Parsley, 1995; Canzoneri, Cumby, and Diba, 1999). These findings have been debated by authors who showed that, under certain conditions, controlling for cross-sectional dependence in panel tests of PPP makes the choice of numeraire irrelevant. However, results on the irrelevance of the choice of the numeraire are only valid if there is no serial correlation or if the serial correlations of each real exchange rate are assumed to be the same (Papell and Theodoris, 2001).

For this paper, which includes two currency unions that peg their exchange rates, the results on numeraire relevance mirror the criticality of the peg. More generally, the choice of numeraire currency matters to tests of PPP due to differences in (i) the degree of price rigidities relative to trading partners, (ii) currency-specific frictions, such as price-setting and currency of invoicing in trade contracts, (iii) overall trade openness and trade restrictions that asymmetrically affect different trade partners, (iv) the proximity to the country (physical and/or from close trade and economic relations) whose exchange rate is used as numeraire, and (v) exchange rate regimes that embed different degrees of exchange rate flexibility (and volatility) depending on the foreign currency, among other factors.

[4] For a survey of the earlier literature on optimum currency areas see, for example, Masson and Taylor (1993). For costs and benefits of currency areas, see also De Grauwe and Vanhaverbeke (1991), Bayoumi and Eichengreen (1994), Mélitz and Weber (1996), Schuberth and Wehinger (1999), Rose (2000), and Persson (2001).

Figure 1 shows that countries in our sample are open, with trade hovering around 30 percent of GDP. Moreover, intra-zone trade has intensified in the CFA and ECOWAS zones, a sign of more favorable conditions for the real exchange rate to revert to PPP from a shock emanating from one of these countries or if the numeraire currency is within the zone. Indeed, for developing countries that chose to use the nominal exchange rate as nominal anchor, one relevant question when considering monetary union membership is "which currency to peg to?" Abstracting from political considerations, and focusing only on economic factors underlining monetary unions, a natural candidate for the currency anchor in case of a peg should be the currency used as numeraire against which evidence of PPP is strongest.

Figure 1. Western and Central Africa: Trade Openness



Source: IMF World Economic Outlook; IMF Direction of Trade Statistics; IMF Staff Calculation

A different but related aspect when analyzing the evolution of real exchange rates—the raw material for PPP tests—is their behavior during the process of "catching up" of an economy which experiences convergence of per capita income towards more developed economies. The Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964; Ito et al, 1997)—which kicks in when the productivity growth in the tradable sectors between the domestic and foreign economies differ—suggests that the real exchange rate in faster growing economies should appreciate, which strictly speaking violates the PPP assumption by introducing a trend in the real exchange rate. Disentangling the Balassa-Samuelson effect from the PPP requires modifications in the standard tests of the PPP hypothesis.

This paper tests PPP in the CFA zone and ECOWAS using four different currencies as numeraire—the euro, the US dollar, the renminbi, and the CFA franc. Tests of both the absolute and relative versions of the PPP hypothesis, with and without reversal to a trend potentially originated by the Balassa-Samuelson effect, and both on a country-by-country or panel regression setup, are conducted. Results from several tests suggest that PPP holds in the CFA and ECOWAS country-groups, but evidence for PPP varies considerably depending on methods used, numeraire currency considered, and country-groups. Evidence for PPP is more common: (i) (slightly) for the euro (15 cases) relative to the other numeraire currencies, which is not surprising given the

history of the CFA zone countries in pegging their currency to the euro (and before that, the French franc); (ii) for the CFA zone taken as a whole (16 cases) relative to the other country groupings, which is also related to its pegging to the euro while non-CFA member-countries in the ECOWAS do not; (iii) within the CFA zone, for the WAEMU rather than the CEMAC, which may reflect the fact that a large share of CEMAC countries are oil exporters; and (iv) when using panel data rather than averaged series of real exchange rate across country groupings. Finally, results from cointegration tests indicate that the convergence to PPP occurs mainly from the adjustment in foreign prices expressed in domestic currency, which may seem surprising given the overall price-taking status of both CFA and ECOWAS countries but may also reflect compensating movements in the nominal exchange rate of benchmark currencies themselves.

The paper contributes to the existing literature in several dimensions. First, it documents evidence for PPP using data from African countries, differently from the bulk of the literature that relies on currencies from major developed economies. To the best of our knowledge, this paper is the first to attempt an assessment of the PPP hypothesis using data from ECOWAS and CFA countries. The paper also relies on a comprehensive suite of tests, both univariate and multivariate, and agnostically accounts for the potential role of the Balassa-Samuelson in causing deviations of the exchange rate from its PPP-consistent level. An important difference from earlier studies is that the paper relies on a constructed measure of the price *level* in the different countries in the sample to account for deviations from PPP at the start and along the sample period. Using price levels rather than price *indices*, typically normalized to an arbitrary reference (or base) date, would not allow for controlling for the initial condition regarding the relative price levels between countries.

The rest of the paper is organized as follows. Section II presents stylized facts on integration and convergence in the zones and reviews the literature on PPP. Section III reports the empirical results on PPP in univariate and panel settings, and Section IV discusses the nature and persistence of shocks affecting countries in the zone. Section V concludes with policy implications.

II. Stylized Facts: Price and Inflation Convergence in the CFA Zone and ECOWAS

Adherence to a fixed exchange rate between members of a currency union should ease the convergence of price levels within the union. If PPP holds, the tendency for prices (or changes in prices) to converge within the currency union should be facilitated by the convergence in the transmission of monetary policy changes implemented by the regional central banks. In the same vein, prices (or changes in prices) will tend to converge toward those of the economy of the currency anchor, given the congruent monetary policy changes. To support the monetary arrangement, union members develop a framework to align economic policies. Within each sub-region of the CFA zone and in the West African Monetary Zone (WAMZ), countries agreed on convergence pacts to promote sound policies, and rein-in fiscal dominance. The pacts call for common accounting methods and judiciary standards and adherence to convergence criteria on key macroeconomic policies and outcomes, including fiscal balances, their financing, and inflation. Convergence would ensure that domestic price levels show a positive and stable relationship and deviations in prices between countries would reflect distance from ports and be temporary, as factor mobility improves and helps absorb differences in transaction costs. Otherwise, divergence would tend to be large and permanent, and keeping the monetary union viable would require adjustments in the nominal exchange rate. Such adjustments are not feasible under the CFA

arrangement (because of the peg to the euro), and the path to equilibrium from asymmetric shocks depends on market forces or the use of other policy instruments.

We first investigate the concept of σ-convergence in prices within a group of countries, defined as a general downward trend in measures of cross-country dispersion in the price level or inflation. Let (p_{it}) and (π_{it}) represent respectively the (natural) logarithm of the price level, and its difference (i.e., the inflation rate) in country *i* =1, ……., N at the time *t* = 1, …., T. We consider two dispersion indices, for the price level and inflation, computed as follow:

$$\sigma_t^p = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(p_{it} - \overline{p_t})^2} \quad \text{and} \quad \sigma_t^\pi = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(\pi_{it} - \overline{\pi_t})^2} \ ,$$

where $\overline{p_t}$ and $\overline{\pi_t}$ are, respectively, the cross-country averages of the log- price level and the inflation rate within a country group at time *t*. The indices computed for all *t*, reflect the path of the second moment of the cross-country distribution of price levels and inflation over time. When prices converge in level, the dispersion around the cross-country average $\overline{p_t}$ should fall over time, reducing σ_t^p. This would constitute preliminary evidence of the absolute version of PPP. In the limit, when $p_{it} - \overline{p_t} = 0$, for all country *i* in the sample, prices are equalized across countries and absolute PPP holds. Similarly, convergence of inflation rates should imply a decreasing path for the σ_t^π overtime *regardless* of the difference in price levels and would be an indicator of the relative version of PPP.

The evolution of the two dispersion indices above, calculated for four different country groupings, is depicted in Figures 2 and 3. They provide insights into whether there is σ-convergence in prices or inflation in the CFA and ECOWAS zones. Prices showed a tendency to be more dispersed from the mid-80's up to the mid 90's, especially in the WAEMU and the ECOWAS. The steady increase in σ_t^p during that period is driven by the interplay of rising prices at different inflation rates, starting from an initial state where prices levels were already different. At the same time, there was a general decline in the trend of σ_t^π, indicating convergence in the inflation rates, likely buttressed by the implementation of some of the convergence policies mentioned above around the end of the 90s. For the WAEMU, the elimination of monetization of deficits and the liberalization of the financial sector could have supported convergence of inflation rates. When the dispersion in the inflation rates in the WAEMU becomes small enough prices stop diverging. The relative flat path for σ_t^p in the WAEMU starting in the mid-90's is a preliminary indication of the relative PPP in that country group. The remaining price dispersion in the WAEMU could reflect physical and structural considerations such as distance from ports, productivity, and preferences. Given the weight of the WAEMU, the measured σ-convergence in the broader CFA zone mimics that observed in the WAEMU. To a lesser extent, the same process is observed in the ECOWAS country grouping, although the convergence in inflation has not fully stopped the increase in the dispersion of prices, only slowing it down.

While the price dispersion in the CEMAC region is, at least, half smaller than in the WAEMU, it is relatively noisier, possibly reflecting the lack of diversity of the oil-dependent economies that increases passthrough of shocks to domestic prices (Balavac and Pugh, 2016). Contrary to the price dynamics in the CFA zone, prices in ECOWAS continue their divergence tendency after the 1990's, albeit at a slowing pace. That reflects divergence of prices in non-CFA ECOWAS members from the average price level in the CFA zone. Inflation has converged in all four zones, although the period around the 1994 CFA franc devaluation was characterized by higher inflation differentials mirroring different expectations before the devaluation, and different domestic adjustment policies after the devaluation (e.g., fiscal policy, including wage policy). In general, σ-convergence

of prices is stronger in the CEMAC than in the WAEMU, but inflation differences are larger in the CEMAC, given the region's exposure to international oil prices, and the presence of one country out of the six that is not an oil exporter.

Figure 2. σ-Convergence of the Price Level (logarithmic scale)

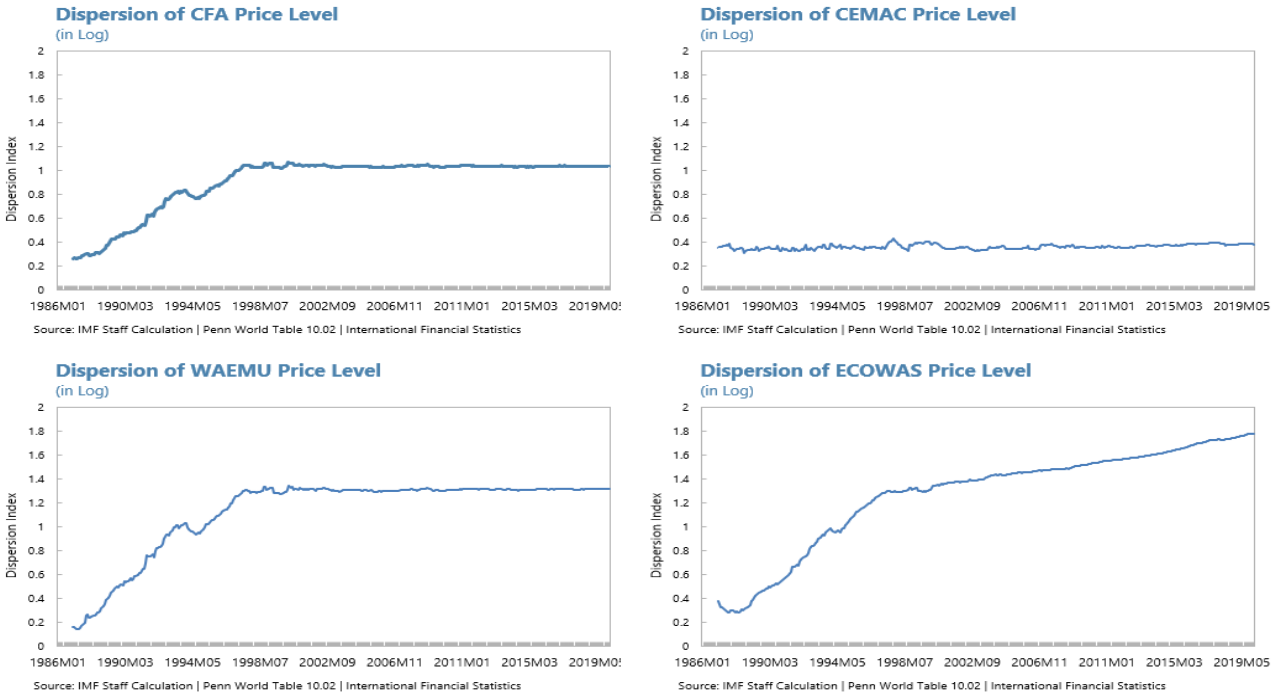
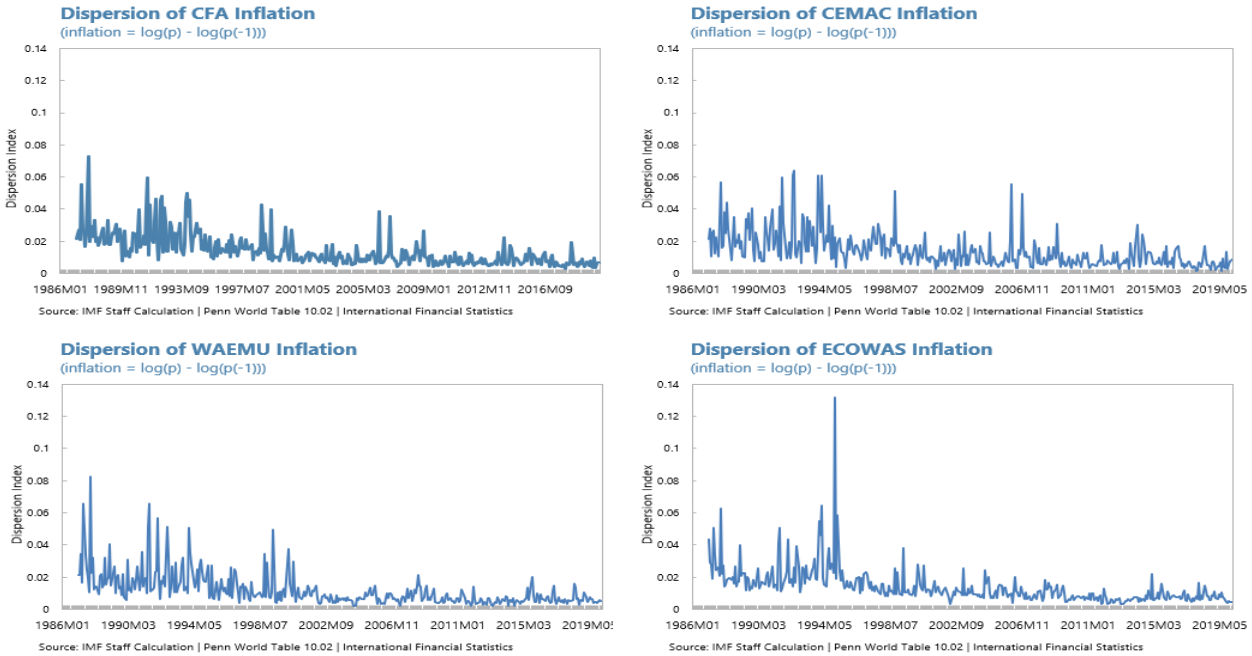


Figure 3. σ-Convergence of Inflation



III. Literature Review

Establishing the empirical validity of any PPP theory has been difficult in practice. There is a consensus in the literature that PPP does not hold in the short run (Taylor, 1988; Abuaf and Jorion, 1990). Recent evidence, at least for the floating rate period of the 1970s and 1980s, suggests that it may not hold even over the long run (Wei and Parsley, 1995). Economists have responded to this divergence between theory and empirical conclusions in several ways. Some argue that this result is an artefact of the period; studies of longer periods give stronger evidence for long-run PPP, especially during the floating rate period of the 1920s (Lothian and Taylor, 1996). Others support the idea that real exchange rates are determined, like other relative prices, by "fundamentals" such as productivity and demand factors; if these are non-stationary, PPP may appear to be violated over short-time periods. Yet others have sought to replace traditional PPP with an ex-ante or "efficient markets" variety of the theory, in which the real exchange rate follows a random walk, arguing that "traditional" tests of PPP that regress domestic price inflation on foreign inflation (expressed in the domestic currency) are inappropriate because they introduce a simultaneity bias (Phylaktis and Kassimatis, 1994).

The traditional way of testing PPP is through a regression of the nominal exchange rate against the ratio of domestic to foreign prices (Nagayasu, 1998). Standard Wald statistics are used to test whether the coefficient estimates are consistent with the restrictions embodied in the PPP hypothesis. This approach usually yields results that reject the PPP hypothesis (e.g., Roll, 1979; Frenkel, 1980; Cumby and Obstfeld, 1984). A major problem with this approach is that it does not take into consideration the time-series properties of nominal exchange rate and prices. If nominal exchange rates and the ratio of domestic to foreign prices are integrated series, and they usually are, then this test could be biased toward rejecting the null hypothesis of PPP. Cointegration tests of PPP are used to overcome this problem. In the spirit of Engle and Granger (1987), if the nominal exchange rate and the ratio of domestic to foreign prices are integrated of order 1 and if there is a long-term cointegrating relationship between them, then PPP is claimed to hold.

Several studies have used the unit root and co-integration tests for PPP by examining the bilateral exchange rates between countries. A general outcome of these studies is that long-term PPP appears not to hold when using tests based on short- or medium-length time-series [e.g., Roll (1979); Mishkin (1984); Piggot and Sweeney (1985)]. However, when longer time samples are used PPP usually holds as showed by Abuaf and Jorion (1990), Froot and Rogoff (1994), and Lothian and Taylor (1996). The inconsistency in results can be attributed to statistical tests becoming less powerful in small samples. Another result is that high frequency data (e.g., monthly data) typically do not support PPP in the long-term (e.g., McNown and Wallace, 1989; Taylor, 1988; Corbae and Ouliaris, 1998). However, when researchers shift to low-frequency data and use cointegration techniques, the evidence usually supports the long-term convergence of real exchange rates toward PPP (e.g., Edison, 1987; Kim, 1990).

The first studies on PPP in developed countries use univariate Augmented Dickey-Fuller (ADF) tests and often do not find evidence for long-run PPP. Lack of evidence for PPP in these studies result mainly from the low power of unit root tests in small samples. To address the small sample problem, researchers use long horizon (up to 200 years) data and show stronger rejections of the unit root hypothesis. However, long horizon data combine fixed and floating exchange rate periods and cannot determine whether PPP would hold over a century (or more) of a stable exchange rate regime. Other researchers used more powerful univariate tests. Cheung and Lai (2000), using the DF-GLS tests of Elliott, Rothenberg and Stock (1996), report more rejections

of the unit root hypothesis, but mostly at a weak (10 percent) significance level. Elliott and Pesavento (2004) and Amara and Papell (2005) find stronger rejections using covariate-augmented tests.

Several studies estimated the speed of convergence between countries' aggregate price indices to the levels predicted by PPP. Rabe and Waddle (2020) offer an overview of the evolution of PPP and finds that half-life deviations from PPP have fallen by approximately 2 years between 1960 and 2015 and estimates an average rate of PPP convergence of 3 years, which is in line with previous studies.

The PPP literature has not been restricted to countries with different currencies. Several empirical works tested the PPP hypothesis at an intranational level. This strand of work lead to a consensus that the PPP hypothesis should be more easily satisfied when nominal exchange rate fluctuations are absent, say within a currency union or a country. This could be explained by higher market integration, lower trade barriers and transport costs, and smaller measurement errors (because of a common data collection methodology). Moreover, sustained deviations from PPP have been explained in the literature by structural or technological differences (Kravis and Lipsey, 1983), or the discovery of natural resources (Buiter and Miller, 1981).

The empirical evidence from panel data studies has been mixed overall. While early studies such as Frankel and Rose (1996) and Jorion and Sweeney (1996) support PPP, work incorporating serial correlation (Papell, 1997) and contemporaneous correlation (O'Connell, 1998) find much weaker evidence. More recently, panel unit root tests that extend post-1973 quarterly exchange rate data with the US dollar as numeraire currency through 1998 tend to provide strong support of PPP for developed countries. Examples of this work include Higgins and Zakrajšek (2000), Wu and Wu (2001) and Papell (2005). Papell and Theodoridis (2001) show stronger rejections of the unit root hypothesis with European rather than non-European numeraire currencies. For less developed countries, panel unit root tests have not provided much support of PPP. Using real exchange rate constructed from price indexes and black-market quotations of nominal exchange rate, Phylaktis and Kassimatis (1994) reject the unit root hypothesis for eight Pacific Basin countries. However, on the other side, Oh (1996) uses data from Summers and Heston's (1991) Penn World Table and fails to reject unit root hypothesis in real exchange rate of less developed countries during the flexible exchange rate period. Both studies use Levin, Lin and Chu (2002) tests. Holmes (2001) uses panel unit root tests, as developed by Im, Pesaran and Shin (2003), and fails to reject the unit root hypothesis in panels of countries with high inflation and of countries located outside Africa. Hence, while panel methods have significantly increased the power of unit root tests, studies using these methods fail to show convincing evidence of PPP.

IV. Data

Series and data transformations

We use monthly data on consumer price indices (CPI), CPI inflation, and nominal exchange rates from the IMF's International Financial Statistics (IFS) database. The sample covers the period of 1986M12-2020M02. Using the monthly CPI *index* and its sequential inflation rate, we obtained monthly interpolated estimates of the annual price *level* of household consumption from Penn World Table 10.01 (PWT) for each country in the sample (see details below). As proxy for economic size, used to produce weighted averages across country groupings, we used both Gross Domestic Product (GDP) in US dollars and in PPP international dollars from IMF's World Economic Outlook (WEO).

Converting price indices into price levels

We calculated the monthly price level for each country using a combination of monthly price index and annual price levels from PWT. Letting $Z = PWT_{t-1,12}$, we used the following approach:

$$PWT_{t,1} = PWT_{t-1,12} \times \frac{P_{t,1}}{P_{t-1,12}} = Z \times \frac{P_{t,1}}{P_{t-1,12}}$$
$$PWT_{t,2} = PWT_{t-1,12} \times \frac{P_{t,1}}{P_{t-1,12}} \times \frac{P_{t,2}}{P_{t,1}} = Z \times \frac{P_{t,2}}{P_{t-1,12}}$$
$$\dots$$
$$PWT_{t,12} = PWT_{t-1,12} \times \frac{P_{t,1}}{P_{t-1,12}} \times \frac{P_{t,2}}{P_{t,1}} \times \dots \times \frac{P_{t,11}}{P_{t,10}} \times \frac{P_{t,12}}{P_{t,11}} = Z \times \frac{P_{t,12}}{P_{t-1,12}}$$

The annual average of $PWT_{t,m}$ becomes:

$$\overline{PWT}_{t,m} = \frac{1}{12} \times \left(Z \times \frac{P_{t,1}}{P_{t-1,12}} + Z \times \frac{P_{t,2}}{P_{t-1,12}} + \dots + Z \times \frac{P_{t,12}}{P_{t-1,12}} \right) = Z \frac{1}{P_{t-1,12}} \times \frac{(P_{t,1}+P_{t,2}+\dots+P_{t,12})}{12} = Z \times \frac{\bar{P}_{t,m}}{P_{t-1,12}} \quad ,$$

where $PWT_{t,m}$ is the interpolated monthly price level from the PWT at year t and month m; $\overline{PWT}_{t,m}$ is the annual average of monthly PWT at year t; $P_{t,m}$ is the monthly price *index* at year t and month m; and $\bar{P}_{t,m}$ is the annual average of the monthly price index.

Note that this approach only requires an interpolated price level (from annual values) at the last month of the year prior to the start of the sample, and ensures that (i) the monthly changes of the *estimated* $PWT_{t,m}$ is equal to the monthly changes in the price index $P_{t,m}$ and (ii) the annual average of $PWT_{t,m}$ is equal to the observed price level at year t. For the rest of the paper, "price level" refers to the result from this procedure.

Weights for cross-country averages

Cross-country average series for the currency zones are calculated using weights that reflect each country's contribution to zones real GDP in 2017 PPP international dollars. For example, for the 14 CFA countries:

$$w_i = \frac{RGDP_{2017\ ppp,i}}{\sum_{m=1}^{14} RGDP_{2017\ ppp,m}},$$

where w_i is the weight in the CFA zone and $RGDP_{2017\ ppp,i}$ is the real GDP of country *i*.

Seasonal adjustment

All monthly data on the price levels, inflation, and exchange rates were seasonally adjusted using U.S. Census Bureau's X-13 seasonal adjustment tools (i.e., X-13 ARIMA-SEATS).

Prices and real exchange rates used in PPP tests

We use the following transformations of the PPP equation involving the domestic (p_{it}) and foreign (p_{it}^*) price levels, the domestic value of foreign price under different numeraire (f_t), the real exchange rate (q_{it}), [5] and the nominal exchange rate (s_{it}):

$$f_t = p_{it}^* + s_{it} \quad (1)$$
$$q_{it} = p_{it} - p_{it}^* - s_{it} \quad (2)$$
$$s_{it} = p_{it} - p_{it}^* - q_{it} \quad (3)$$
$$f_t = p_{it} - q_{it} \quad (4)$$

Summary Statistics of series used

	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
Inflation Rate (in log difference)	0.01	0.00	0.53	-0.22	0.02	5970
Price Level (in Log)	0.18	-0.35	4.65	-2.28	1.50	5985
Real Exchange Rate (CFA franc as Numeraire)	1.32	-0.17	10.27	-1.77	2.76	5985
Real Exchange Rate (euro as Numeraire)	-7.87	-9.37	1.14	-11.00	2.76	5985
Real Exchange Rate (RMB as Numeraire)	-7.56	-8.99	1.45	-10.48	2.76	5985
Real Exchange Rate (USD as Numeraire)	-9.53	-10.95	-0.49	-12.62	2.76	5985
Weighted Real GDP Growth Rate (CEMAC Group)	0.03	0.03	0.10	-0.04	0.03	35
Weighted Real GDP Growth Rate (CFA Group)	0.03	0.04	0.06	-0.01	0.02	35
Weighted Real GDP Growth Rate (ECOWAS Group)	0.04	0.04	0.09	-0.01	0.02	35
Weighted Real GDP Growth Rate (WAEMU Group)	0.04	0.04	0.07	0.00	0.02	35

V. Empirical Results

The PPP hypothesis implies that any deviation of domestic prices from foreign prices, measuring both prices in a common currency, should be transitory, even if persistent. Denoting by s_{it}^j the log of the nominal spot exchange rate in country *i* (domestic currency of country *i* per unit of the foreign base currency *j*), by p_{it} and p_{it}^j the logs of domestic and foreign base prices, respectively, and q_{it} represents the real exchange rate and it should be stationary. The PPP hypothesis suggests that:

$$p_{it} = s_{it}^j + p_{it}^j + q_{it}^j \quad (5)$$

We consider four numeraire currencies:

- The **US dollar (USD)**, given its importance in commodities markets and as a reserve currency.
- The **euro** (or the French franc, until 1998), a reserve currency and current anchor of the CFA zone.
- The **Chinese Yuan (renminbi, RMB)**, given the growing importance of trade with China.
- The **CFA franc**, which could be a potential new anchor for the countries studied.

Equation (5) can only be applied as is to countries outside the CFA zone (i.e., non-CFA ECOWAS countries) and must be adapted for CFA countries. Because CFA countries share the same currency, the effect of the nominal exchange rate s_{it} is not applicable for PPP tests among these countries when using the CFA franc as numeraire currency. Additionally, when considering CFA countries and a non-CFA currency as numeraire the only relevant nominal exchange rate is that between the CFA franc and the numeraire currency. Therefore, we consider the three cases for the PPP test-equation:

[5] The cross-country data used to represent q_{it} under different numeraire currencies is displayed in Annex II.

- Case 1. For countries within the CFA zone, using the CFA as the numeraire (s_{it}^{j} effect disappears):

$$q_{it} = p_{it} - p_{it}^{j}.$$

- Case 2. For countries within the CFA zone, using a non-CFA currency as the numeraire:

$$q_{it} = p_{it} - p_{it}^{j} - s_{i \in CFA,t}^{numeraire}.$$

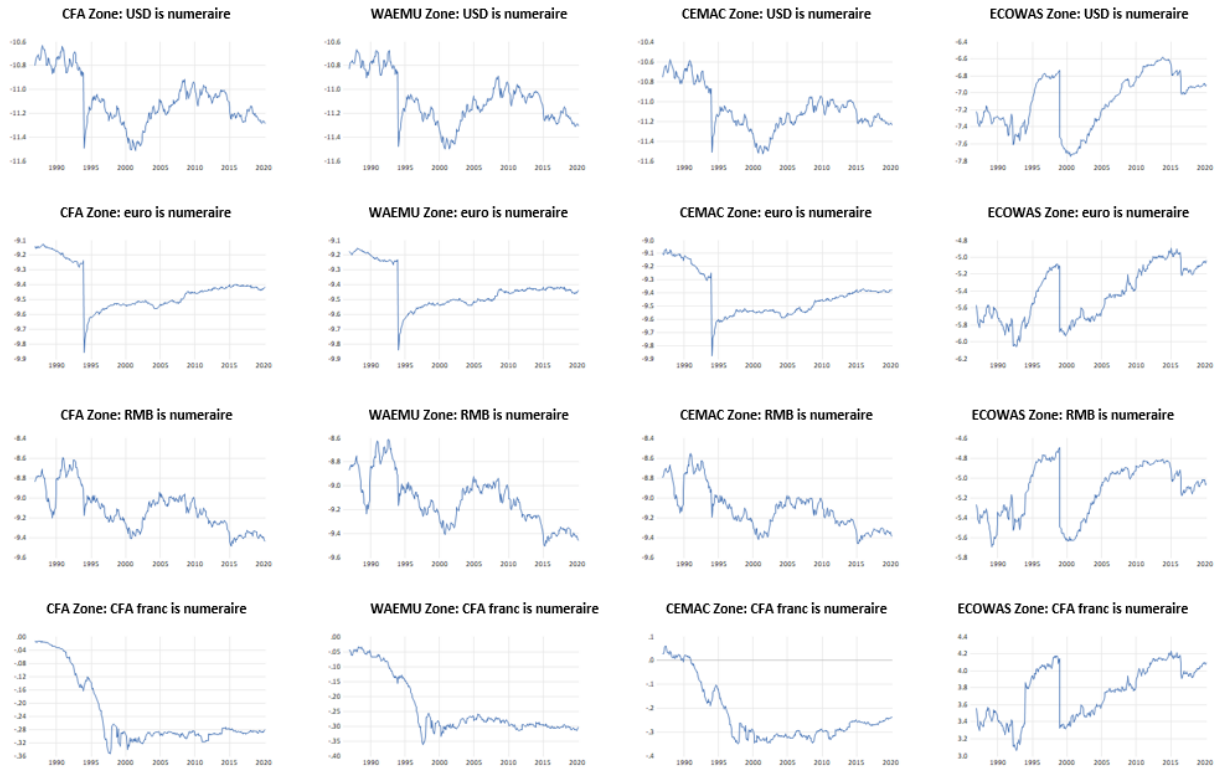
- Case 3. For countries outside the CFA zone, equation (5).

In the several empirical exercises described below, to analyze the impacts of the 1994 CFA Franc devaluation, we split the full sample (1986M01 to 2020M02) in two sub-periods, before (1986M01 to 1994M05) and after (1994M06 to 2020M02) the CFA franc devaluation.

1. Univariate Analysis

If absolute PPP holds, deviations of price levels from the numeraire price level should be temporary when prices are measured in the same currency. For relative PPP, that condition only needs to be valid for inflation rates, not necessarily prices. In both cases, the real exchange rate should converge to a constant (or be trend-stationary if fundamentals are driving real appreciation à la BalassaMB-Samuelson). We first perform univariate PPP tests for all currency unions—ECOWAS, WAEMU, CEMAC, and CFA zones—using successively the US dollar (USD), the euro, the renminbi (RMB), and the CFA franc as numeraire currencies.

Figure 4. GDP-Weighted Average Real Exchange Rate Across Currency Unions



Source: International Monetary Fund, International Financial Statistics (IFS); World Economic Outlooks (WEO).

Figure 4 shows some tendency toward convergence of the real exchange rate for the WAEMU and CFA zones after the 1994 devaluation of the CFA franc using both the euro and the CFA franc as numeraire. This could reflect the interconnections in the monetary policy frameworks of the central banks for the two monetary unions in the broad CFA zone—the BCEAO and the BEAC—and that of the ECB, given the longstanding peg of the two CFA currencies to the euro. It could also be interpreted as a measure of the performance of zone-wide policies to foster integration. When using the renminbi as anchor currency, the dynamics of the real exchange rate for the WAEMU and CEMAC becomes noisier locally, with a long-term tendency toward depreciation.

At first glance, evidence for any form of PPP is more difficult to find for the ECOWAS, regardless of the anchor currency, with a clear upward trend of the average real exchange rate toward its level before the 1998 depreciation of the Naira. Since Nigeria accounts for more than 60% of ECOWAS GDP, ECOWAS's GDP-weighted real exchange rate dynamics largely follows Nigeria's, including the depreciation of the Naïra in 1998, which ended the pegged exchange rate system that kept it overvalued during President Sani Abacha's regime (Feyi, 2015). The different dynamics of exchange rates in the ECOWAS and CFA across currency anchors is reflected in the appreciation of the ECOWAS real exchange rate when the CFA is used as numeraire.[6]

Method 1. Augmented Dicky Fuller Unit Root Test

Results of univariate ADF tests, assuming a deterministic trend, and applied to the weighted cross-country averages of the real exchange rate within each currency zone (Table 1) provides limited support for absolute PPP for the full period. Evidence is found only when using the euro as numeraire for CFA and WAEMU or the CFA as numeraire for the wider CFA zone. For the full period, under any numeraire currency, the real exchange rate for the ECOWAS and for the CEMAC zones display a unit root. In other words, price differentials in the CEMAC and ECOWAS do not tend to die out under any numeraire currency. However, as suggested by Figure 4, the results support the stationarity of the real exchange rate of the CFA and WAEMU zones when the euro or the CFA are used as the numeraire. Thus, PPP for CEMAC and ECOWAS is rejected under any anchor currency, but we cannot reject PPP for the WAEMU and CFA zones when the euro is used. It is also noteworthy that before the devaluation of the CFA franc there was less evidence for PPP, which could only be found for the WAEMU using the US dollar as numeraire. This also reinforces the intuition from Figure 4, where the shift toward stationarity started only after the devaluation.[7]

Table 1. Unit Root Tests: GDP-Weighted Real Exchange Rates within Currency Zones

Group	USD			euro			CFA franc			RMB		
	Full Sample	*Before*	*After*	*Full Sample*	*Before*	*After*	*Full Sample*	*Before*	*After*	*Full Sample*	*Before*	*After*
CFA	0.42	0.18	0.94	0.02	0.99	0.01	0.01	0.90	0.01	0.78	0.99	0.90
WAEMU	0.30	0.01	0.98	0.01	0.99	0.01	0.14	0.99	0.01	0.87	0.99	0.91
CEMAC	0.43	0.99	0.86	0.63	0.99	0.16	0.22	0.83	0.09	0.58	0.99	0.86
ECOWAS	0.90	0.33	0.96	0.79	0.73	0.79	0.72	0.91	0.92	0.84	0.74	0.92

Legend	
p-value	Has Unit Root
p-value	Stationary

Note: Entries in the table are the p-values associated with of the null hypothesis of a unit root. Rejecting the null at the 5% significance level or less is interpreted as evidence of stationarity.

[6] Since Nigeria accounts for a large share of ECOWAS GDP, the (implied, GDP-weighted) real exchange rate for the subregion largely follows Nigeria's Naira and the evidence for any form of PPP becomes more elusive for the ECOWAS, regardless of the anchor currency. When Nigeria is excluded from the ECOWAS country grouping, the results from some of the methods discussed in this section show evidence for PPP (Annex VII).

[7] Additional details of the unit root tests shown at Table 1 are available in Annex III and from the authors upon request.

Using the rejection probability (*p*-values) of unit root tests as a proxy for the distance to PPP, the "best" numeraire currency for the CFA zone is the CFA, followed by the euro, the US dollar, and the RMB. Here again, conclusions for the two blocks (CEMAC and WAEMU) composing the CFA zone differ widely. The rejection of the absolute PPP is stronger for the CEMAC zone using the euro as numeraire while the *p*-value is lowest for the WAEMU zone. This suggests that the two blocks could consider different anchors (CFA franc for CEMAC and euro for WAEMU). It is noteworthy that only the US dollar supported PPP for the WAEMU during the economic and financial instability that preceded the 1994 devaluation. Overall, these results point to shallow evidence of PPP but support the relevance of the numeraire currency for evidence of PPP.

Table 2. Unit Root Tests: Country-Specific Real Exchange Rates

Group	USD			euro			CFA franc			RMB		
	Full Sample	*Before**	*After**	*Full Sample*	*Before**	*After**	*Full Sample*	*Before**	*After**	*Full Sample*	*Before**	*After**
Burkina Faso	0.34	0.32	0.98	0.01	0.99	0.07	0.08	0.97	0.04	0.72	0.99	0.92
Cameroon	0.36	0.72	0.90	0.58	0.99	0.61	0.09	0.94	0.03	0.66	0.99	0.89
Central African Republic	0.82	0.91	0.82	0.76	0.99	0.84	0.55	0.99	0.45	0.21	0.98	0.69
Chad	0.49	0.97	0.77	0.41	0.99	0.28	0.01	0.61	0.01	0.37	0.98	0.97
Congo	0.54	0.89	0.61	0.63	0.97	0.82	0.50	0.98	0.73	0.58	0.96	0.97
Cote d'Ivoire	0.39	0.01	0.88	0.26	0.80	0.52	0.32	0.95	0.36	0.86	0.99	0.93
Gabon	0.20	0.99	0.93	0.01	0.99	0.82	0.01	0.22	0.08	0.54	0.99	0.75
Mali	0.25	0.99	0.99	0.01	0.99	0.01	0.04	0.92	0.01	0.71	0.99	0.93
Niger	0.40	0.99	0.98	0.16	0.99	0.01	0.05	0.82	0.02	0.73	0.98	0.84
Senegal	0.37	0.93	0.98	0.01	0.90	0.10	0.01	0.66	0.01	0.77	0.99	0.81
Togo	0.67	0.44	0.91	0.46	0.99	0.01	0.24	0.93	0.80	0.79	0.99	0.97
Cabo Verde	0.89	0.81	0.99	0.43	0.82	0.58	0.01	0.81	0.01	0.79	0.49	0.71
Benin	0.77	0.01	0.88	0.57	0.43	0.01	0.18	0.29	0.27	0.91	0.94	0.96
Gambia, The	0.29	0.09	0.41	0.01	0.59	0.04	0.03	0.41	0.02	0.76	0.64	0.45
Ghana	0.24	0.03	0.97	0.01	0.01	0.24	0.27	0.01	0.41	0.24	0.30	0.97
Liberia	0.53	0.99	0.16	0.43	0.99	0.03	0.32	0.87	0.01	0.41	0.94	0.01
Nigeria	0.88	0.90	0.03	0.74	0.90	0.07	0.62	0.94	0.01	0.74	0.09	0.01
Sierra Leone	0.01	0.20	0.01	0.01	0.14	0.01	0.01	0.32	0.01	0.08	0.53	0.01
Guinea-Bissau	0.01	0.92	0.02	0.01	0.93	0.01	0.01	0.63	0.01	0.01	0.51	0.11
Guinea	0.69	0.01	0.98	0.95	0.01	0.99	0.87	0.04	0.95	0.07	0.01	0.62
Equatorial Guinea, Rep. of	0.69	0.95	0.05	0.98	0.99	0.53	0.74	0.05	0.87	0.29	0.90	0.14

Legend

p-value	Has Unit Root
p-value	Stationary

Note: Entries in the table are the p-values associated with of the null hypothesis of a unit root. Rejecting the null at the 5% significance level or less is interpreted as evidence of stationarity.

The country-specific results in Table 2 are consistent with the results for the currency zones averages, also showing shallow evidence of PPP and highlighting the importance of the choice of numeraire. They also provide insights on the drivers of the groups' results. When using the US dollar as the numeraire, the PPP hypothesis could not be rejected for only two ECOWAS countries (Sierra Leone and Guinea-Bissau), which is not enough to deliver PPP for the whole ECOWAS zone. Cote d'Ivoire and Benin drive the acceptance of the PPP hypothesis for the WAEMU before the devaluation using the US dollar as numeraire. The CFA and the euro are the numeraire currencies under which the PPP hypothesis cannot be rejected for the largest number of countries. When the euro is the numeraire, PPP seems to hold for four WAEMU countries (Burkina Faso, Mali, Senegal, and Guinea Bissau), three non-WAEMU ECOWAS countries (The Gambia, Ghana, and Guinea), and one CEMAC country (Gabon). The number of CEMAC countries for which the PPP hypothesis cannot be rejected is largest when the CFA franc is the numeraire. Guinea-Bissau is the only country with evidence of PPP under all four currencies as numeraire. There are 10 countries for which no evidence of PPP could be found for the full period. These countries belong to the CEMAC (CAR, Congo, Equatorial Guinea, and Cameroon), to WAEMU (Cote d'Ivoire, Togo, and Benin), and to ECOWAS (Liberia, Nigeria, and Guinea).

Country-specific results can also help distinguish any patterns associated with oil-producing countries. For instance, Gabon and Chad (both CEMAC) are the only oil-exporting countries where deviations of inflation show a tendency to revert to a constant. However, this is only in specific cases using the euro (Gabon) and the CFA franc (Chad) as anchor currencies. Outside of the CFA zone, Nigeria displays stationarity of its inflation series when the CFA and the renminbi are anchor currencies (but only after 1994). Overall, the price dynamics

for oil producers more often display a unit root, which may be reflected in the different PPP test results between the CEMAC—which includes more oil-exporting countries—and the WAEMU currency areas.

Method 2. Cointegration Tests

Cointegration techniques offer an alternative method to check the PPP hypothesis, using equation (1). If PPP holds, the sequences $\{f_{it}\}_{j=1}^{J}$ and $\{p_{it}\}_{j=1}^{J}$ should be cointegrated for currency J (USD, euro, CFA, or RMB).

The results from Philips-Ouliaris residual cointegration tests using cross-country average data for each currency zone, and considering the four possible numeraire currencies, are shown in Table 3. A *p*-value smaller than 0.05 suggests rejection of the null hypothesis of no cointegration. The results are broadly consistent with the unit root approach. For the full period, evidence of cointegration is found for WAEMU under the euro, and for the CFA zone under both the CFA franc and the euro as numeraires. The CEMAC presents stronger evidence of cointegration when the RMB is the numeraire, while evidence is stronger for ECOWAS when the euro is the numeraire. The diverging dynamics for the WAEMU and the CEMAC are also confirmed. The results support cointegration for the WAEMU when the euro is the numeraire, which is also the currency for which the CEMAC is farthest from cointegration after the CFA zone. Country-specific results (Annex III) show that Ghana presents strong evidence of cointegration when the CFA franc or the euro are used as numeraires. This could be related to Ghana's geographic location. All its neighbors belong to the WAEMU and a significant portion of trade by landlocked WAEMU countries such as Mali and Burkina Faso transits through the Ghanaian port of Tema.

Table 3. Philips-Ouliaris Cointegration Tests

Country	USD			euro			CFA franc			RMB		
	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After
CFA	0.12	0.06	0.59	0.05	0.01	0.02	0.00	0.91	0.00	0.30	0.80	0.60
WAEMU	0.13	0.31	0.69	0.02	0.23	0.11	0.93	0.94	0.93	0.51	0.86	0.79
CEMAC	0.36	0.09	0.64	0.47	0.18	0.28	0.73	0.95	0.04	0.11	0.56	0.49
ECOWAS	0.39	0.11	0.63	0.17	0.31	0.45	0.22	0.77	0.51	0.27	0.31	0.47

P-value	Accept H0: no cointegration
P-value	Reject H0

Note: Entries in the table are the p-values associated with the null hypothesis of a unit root. Rejecting the null at the 5% significance level or less is interpreted as evidence of stationarity.

From equation (4), PPP asserts that there exists a linear combination (i.e., the equilibrium regression) of the form:

$$f_t = \beta_0 + \beta_1 * p_{it} + \mu_t \qquad (6)$$

such that μ_t is stationary and the cointegrating vector is such that $\beta_1 = 1$. We estimate the long-run equilibrium relation according to the following criteria:

- Under absolute PPP, $f_t = p_t$, requiring $\beta_0 = 0$ and $\beta_1 = 1$
- Under relative PPP, $\Delta f_t = \Delta p_t$, only requiring $\beta_1 = 1$.

The estimated values of β_0 and β_1 for each numeraire currency and their associated p-values in Wald Coefficient Test are reported in Annex IV. Table 4 presents a summary table of the Wald Coefficient Test on the equilibrium regression.

Table 4. Cointegration Regression: Absolute PPP Test

Country	USD			euro			CFA franc			RMB		
	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After
CFA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WAEMU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CEMAC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
ECOWAS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

P-value	Reject Absolute PPP
P-value	Accept Absolute PPP

Note: Absolute PPP Test: Null Hypothesis (H0) is $\beta_0 = 0 \; and \; \beta_1 = 1$. Acceptance of H0 considers the 5% significance level.

Table 5. Cointegration Regression: Relative PPP Test

Country	USD			euro			CFA franc			RMB		
	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After
CFA	0.00	0.35	0.00	0.59	0.88	0.00				0.00	0.04	0.00
WAEMU	0.49	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.03	0.24
CEMAC	0.00	0.90	0.00	0.00	0.81	0.00	0.00	0.03	0.00	0.00	0.22	0.00
ECOWAS	0.00	0.04	0.00	0.00	0.18	0.00	0.00	0.01	0.00	0.00	0.00	0.00

P-value	Reject Relative PPP
P-value	Accept Relative PPP

Note: Relative PPP Test: Null Hypothesis (H_0) is $\beta_1 = 1$. Acceptance of H_0 considers the 5% significance level.

The full sample results of the equilibrium regression reject the absolute version of PPP for all grou pings (Table 4). This rejection is very strong for all numeraire currencies. However, for the period preceding the devaluation of the CFA franc, the results suggest some weak evidence (at the 10% significance level) of absolute PPP for the CEMAC under the CFA franc as numeraire. The results in Table 5 support relative PPP for some currency zones. For the full period, evidence for relative PPP is strongest for the WAEMU when the RMB is the numeraire, followed by the CFA when the euro is the numeraire and by the WAEMU when the US dollar is the numeraire. Contrary to results from the unit root and Philips-Ouliaris cointegration tests, the weak form of PPP cannot be rejected when the US dollar and the renminbi feature as numeraire currencies. After the 1994 devaluation, relative PPP only holds for the WAEMU using the renminbi as numeraire.[8]

Method 3. Error Correction Model

An error correction analysis for countries or groups of countries can complement the cointegration approach and provide hints about how deviations from the long-term PPP path are reversed—i.e., by adjustments in domestic prices, p_t, or in foreign prices measured in domestic currency, f_t. The results from the error correction models (ECM) for each currency area, under different numeraire currencies, are reported in Figures 5-6. The ECMs for each numeraire currency are estimated as follows:

$$\Delta f_t = a_0 + a_1 \hat{\mu}_{t-1} \qquad (7)$$

$$\Delta p_t = b_0 + b_1 \hat{\mu}_{t-1} \qquad (8)$$

Where the lagged residual from the long-run equilibrium regressions is $\hat{\mu}_{t-1} = y_{t-1} - \beta_0 - \beta_1 x_{t-1}$, for $x = p, f$ and $y = f, p$. Parameters a_0 and b_0 are constant terms, while a_1 and b_1 are the coefficients associated with the error correction terms. Negative and statistically significant values of a_1 and b_1 indicate a reversal to long-term equilibrium, i.e., a cointegrating relationship.

[8] Country-specific counterparts of the cointegration results in Table 3 (displayed in Annex IV and available from the authors upon request) also helps detect possible patterns relating to oil exporting countries in the CFA zone. For instance, the tendency to reject PPP for oil exporters observed in country-specific unit root tests is confirmed in country-specific cointegration tests. The Republic of Congo and Nigeria feature as the only oil-exporting countries for which relative PPP cannot be rejected when using the CFA and the dollar (Republic of Congo) and the renminbi (Nigeria).

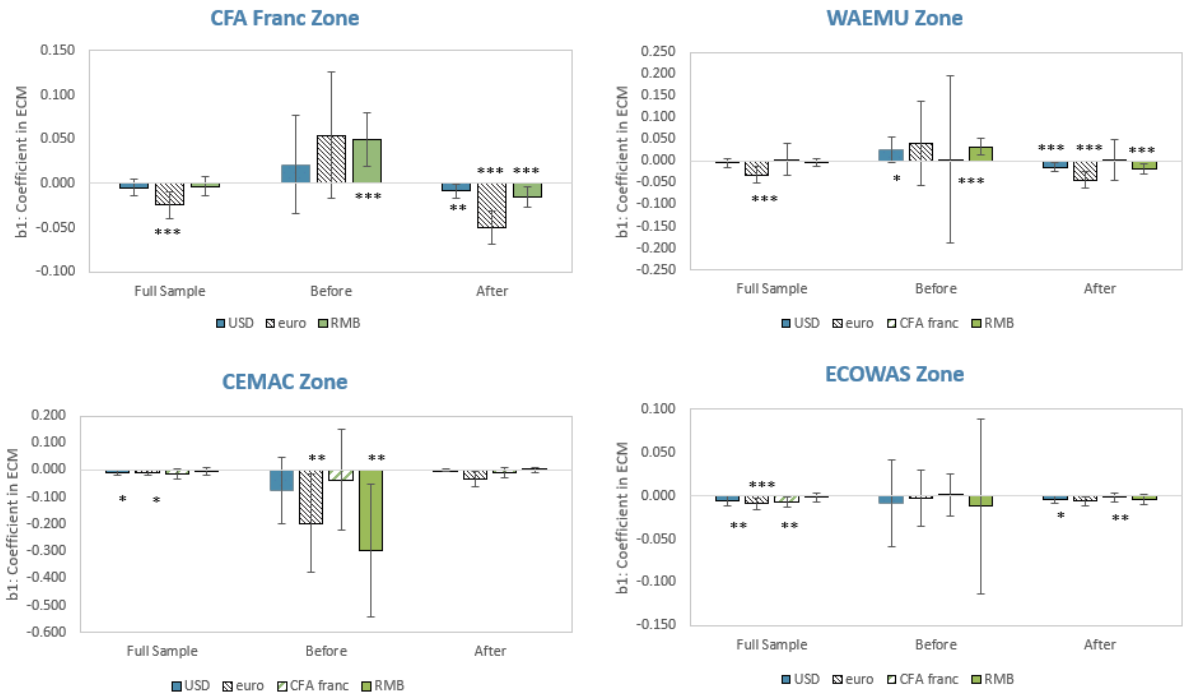
Figure 5. Results from Error Correction Models: Δf_t

Notes: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively. Solid black lines indicate 95 percent confidence intervals.

In the ECM for f_t—i.e., equation (7) and Figure 5—there is evidence of cointegration, suggesting a reversion to PPP through the adjustment in foreign prices measured in domestic currency. Changes in f_t contribute to undo deviations from the long-term PPP equation as indicated by the large negative estimated values for a_1. For countries with a pegged currency (CEMAC, WEAMU), this adjustment excludes changes in the CFA nominal exchange rate against the euro, which means that foreign prices are the main driving factor, including through changes in the nominal exchange rate of the euro against other currencies. Considering the full sample, the reversion to PPP via foreign prices measured in domestic currency is faster for the CFA zone with the euro as numeraire, which is facilitated by the CFA franc's peg to that currency. Within the CFA zone, consistently with evidence previously discussed, signs of cointegration are stronger for the WAEMU than for the CEMAC. While the reversion to equilibrium is faster for the WAEMU than for the CEMAC, it is no longer significant for both sub-regions when the CFA is used as a numeraire. Among numeraire currencies, the euro displays the fastest reversion speed for all sub-groups, except ECOWAS, which has CFA franc as the preferred numeraire according to the speed of adjustment. Comparing the results of the ECMs before and after the 1994 CFA devaluation further illustrates the relevance of the numeraire currency. While before 1994 the US dollar and the euro supported a faster convergence, the picture becomes less clear after the devaluation, with the CFA franc becoming the best options for the CEMAC and ECOWAS and the renminbi supporting a faster return to PPP for the ECOWAS than the US dollar and the euro.[9]

[9] Additional details of the estimated ECMs for each currency area under the four possible numeraire currencies are in Annex V and available from the authors upon request.

Figure 6. Results of Error Correction Models: Δp_t



*Notes: ***, **, and * denote 1%, 5%, and 10% significance levels, respectively. Solid black lines indicate 95 percent confidence* intervals.

From Figure 6, which refers to equation (8), evidence for cointegration is somewhat weaker, which also suggests that the adjustment towards long-run equilibrium does not occur mainly through domestic prices, but rather through foreign prices measured in domestic currency. Note that the negative estimated parameters for the speed of convergence considering the full sample are typically lower in absolute terms compared with those in Figure 5. For the CFA zone as a whole and the WAEMU, the estimated convergence speed coefficients have the wrong sign (i.e., positive) considering the pre-1994 devaluation subsample. Pre-1994, the strongest evidence for convergence to PPP via domestic prices is observed in the CEMAC zone, with about the same speed as in the case displayed in Figure 5. Post-1994, there is evidence of convergence to PPP from domestic prices for all country groupings, except for the CEMAC. Taken together, results in Figures 5-6 indicate that regardless of the choice of the numeraire currency, prices in the CFA zone (both WAEMU and CEMAC), and in the ECOWAS do not change toward eliminating the impact of shocks that create discrepancies from long-run PPP, but most of the adjustment comes from foreign prices measured in domestic currency.

The prevalence of adjustments of foreign prices measured in domestic terms in the explanation of the reversal to PPP—especially for the CFA zone—may suggest that either (i) domestic prices in the CFA zone are less responsive (i.e., stickier), (ii) prices in euros adjust faster than their counterparts in US dollar and renminbi and are passed-through the CFA zone prices with a shorter lag (given the peg), or (iii) the nominal exchange rates of the euro (and therefore the CFA franc) against the US dollar and the renminbi are driving the convergence to PPP in the CFA zone. Further analysis is needed for a more decisive answer.

In the cases displayed in Figure 5-6, estimated coefficients for the sped of convergence range from less than (minus) 0.05 to slightly below (minus) 0.6. These numbers suggest that in response to a shock of 1 percent in foreign prices, the reversal to PPP may take between 1.7 and 20 months.

2. Panel Data Analysis

Panel data analysis offers an alternative to using univariate methods applied to country groupings averages and another approach to address the low power of the univariate unit root tests, by allowing for cross-sectional variation, as developed by Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003).

Method 1: Panel Unit Root Tests

Within an unbalanced panel structure, covering the period of December 1986 to February 2020, we use both tests that assume a common unit root process for all series in the panel (Levin, Lin, and Chu, thereafter LLC) and tests with country-specific unit root processes (Im, Pesaran and Shin (IPS); Fisher-ADF; and Fisher-PP). We begin by classifying our unit root tests based on whether there are restrictions on the autoregressive process across cross-sections or series.

Consider the following AR (1) process for panel data:

$$q_{it} = \rho_i * q_{it-1} + \varepsilon_{it}$$

where $i = 1, 2, 3, \ldots, 21$ series of real exchange rates for each country in the sample over the sample period. Parameter ρ_i is the autoregressive coefficient, and the errors ε_{it} are assumed to be mutually independent idiosyncratic disturbances.

- If $|\rho_i| < 1$, y_{it} is said to be weakly (trend-) stationary.
- On the other hand, if $|\rho_i| = 1$ then y_{it} contains a unit root.

For testing purposes, there are two natural assumptions about ρ_i:

- $\rho_i = \rho$ for all i, which allows a common unit root process, as in the LLC test.
- Alternatively, ρ_i can be allowed to vary across cross-sections, allowing individual unit root processes, as in the IPS, Fisher-ADF, and Fisher-PP tests.

Table 6 shows the results of LLC, IPS, ADF, and PP tests based on an unbalanced panel dataset, organized both by type of null hypothesis and assumptions about the nature of the unit root process. The results of the panel data analysis suggest that the assumptions on the relationship between the unit root processes in the panel structure matter for the conclusions on unit root. Under the CFA franc as anchor, the results suggest strong evidence for PPP, and so more strongly when assuming common unit root processes, except for the CEMAC zone. PPP evidence is mixed for the CEMAC, with weak support for PPP when assuming individual unit root processes. LLC tests support the strong version of PPP for the full sample under any numeraire currency for all sub-groups except for the CEMAC when the renminbi is used as numeraire. The results for the full period dilute the relevance of the numeraire currency, as evidence of PPP is found regardless of the numeraire currency (at the 10 percent significance level, this includes the CEMAC). Evidence of stationarity supporting PPP is also more common after the CFA franc devaluation, except for the renminbi as numeraire.

Table 6. Panel Unit Root Tests

CFA	USD			euro			CFA franc			RMB		
Method	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After
Null: Unit root (assumes common unit root process)												
Levin, Lin & Chu t*	0.00	0.96	0.00	0.00	0.99	0.00	0.00	0.03	0.00	0.00	0.59	0.44
Null: Unit root (assumes individual unit root process)												
Im, Pesaran and Shin W-stat	0.00	0.99	0.00	0.00	1.00	0.00	0.00	0.88	0.00	0.00	0.90	0.26
ADF - Fisher Chi-square	0.00	1.00	0.01	0.00	1.00	0.00	0.00	0.80	0.00	0.01	0.99	0.43
PP - Fisher Chi-square	0.00	0.99	0.00	0.00	1.00	0.00	0.00	0.19	0.00	0.00	0.90	0.34
** Probabilities are computed assuming asympotic normality												

WAEMU	USD			euro			CFA franc			RMB		
Method	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After
Null: Unit root (assumes common unit root process)												
Levin, Lin & Chu t*	0.00	0.62	0.01	0.00	0.74	0.00	0.00	0.02	0.00	0.00	0.34	0.42
Null: Unit root (assumes individual unit root process)												
Im, Pesaran and Shin W-stat	0.00	0.92	0.01	0.00	1.00	0.00	0.00	0.72	0.00	0.03	0.89	0.47
ADF - Fisher Chi-square	0.00	0.97	0.01	0.00	1.00	0.00	0.00	0.47	0.00	0.03	0.98	0.45
PP - Fisher Chi-square	0.00	0.97	0.00	0.00	0.99	0.00	0.00	0.18	0.00	0.00	0.85	0.41
** Probabilities are computed assuming asympotic normality												

CEMAC	USD			euro			CFA franc			RMB		
Method	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After
Null: Unit root (assumes common unit root process)												
Levin, Lin & Chu t*	0.05	1.00	0.08	0.02	1.00	0.00	0.00	0.50	0.20	0.18	0.93	0.50
Null: Unit root (assumes individual unit root process)												
Im, Pesaran and Shin W-stat	0.02	0.97	0.05	0.06	1.00	0.25	0.07	0.87	0.02	0.02	0.69	0.18
ADF - Fisher Chi-square	0.07	1.00	0.15	0.12	1.00	0.24	0.06	0.92	0.00	0.07	0.86	0.39
PP - Fisher Chi-square	0.07	0.94	0.17	0.06	0.99	0.01	0.03	0.35	0.00	0.06	0.72	0.30
** Probabilities are computed assuming asympotic normality												

ECOWAS	USD			euro			CFA franc			RMB		
Method	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After	Full Sample	Before	After
Null: Unit root (assumes common unit root process)												
Levin, Lin & Chu t*	0.00	1.00	0.01	0.00	0.60	0.00	0.00	0.02	0.00	0.00	0.28	0.03
Null: Unit root (assumes individual unit root process)												
Im, Pesaran and Shin W-stat	0.00	0.49	0.01	0.00	0.64	0.00	0.00	0.21	0.00	0.02	0.63	0.12
ADF - Fisher Chi-square	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.03	0.00	0.03	0.71	0.14
PP - Fisher Chi-square	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.37	0.14
** Probabilities are computed assuming asympotic normality												

P-value	Stationary
P-value	Non-stationary

Note: Numbers in the table refer to the p-value associated with the null hypothesis of nonstationarity (H_0). Rejection of H_0 means no evidence of unit root at 5% or less significance level.

Method 2: Deviations from PPP in a Panel Data Framework

The results so far allow rejecting permanent deviations from PPP and accepting PPP, at least in its weak form. We complement the analysis of convergence speed in the univariate framework by using a panel structure. The most popular measure of the persistence of a shock is its half-life, defined as the number of time periods required for a unit impulse to dissipate by one half. There is some consensus in the literature on half-lives of deviations from the PPP of around 3-5 years, using long-horizon data and univariate methods.

We use the procedure proposed by Levin, Lin, and Chu (2002) to estimate the speed of convergence to PPP in a panel data framework. Half-lives are obtained from the estimation of the equation:

$$\Delta q_{it} = c + \beta * y_{it-1} + \sum_{p=1}^{k} \gamma_p * \Delta q_{it-p} + \vartheta_{it} \qquad (9)$$

Given the estimated autoregressive coefficients, the half-life of deviations is defined as:

$$h = \frac{\ln(0.5)}{\ln(1+\beta)}$$

The main reason for neglecting higher order terms in the impulse response is that higher order terms tend to be insignificant. Results from the estimation of the above equation using different currencies as numeraire are displayed in Table 7.

Table 7. Panel Estimates of Reversion Speed to PPP

Half-life (in month)	USD			euro			CFA franc			RMB		
Country Group	**Full Sample**	**Before**	**After**	**Full Sample**	**Before**	**After**	**Full Sample**	**Before**	**After**	**Full Sample**	**Before**	**After**
CFA	2.4	7.8	-13.7	-7.2	-2.9	-1.4***	-0.1***	-0.9***	-2.7	13.6	-3.0	1.9***
WAEMU	0.5**	0.3	-23.1	-2.2	-1.5*	-1.4***	-1.0***	-1.0***	-1.7***	88.6	-2.7	1.8***
CEMAC	-2.8	-3.6	-8.5	-6.6	-3.4	-1.33*	-1.7***	-1.5***	-3.7	4.1	1.8	2.3*
ECOWAS	17.8	2.3	313.9	3.0	569.7	1.7**	0.8***	0.9	0.9***	11.8	-4.9*	2.0**

*** 1% Significance
** 5% Significance
* 10% Significance

Significant at 5% and has negative beta
Not significant or has positive beta or both

For the full period, the results reinforce the conclusion from panel unit root tests of convergence to PPP for the WAEMU zone under the US dollar and for the ECOWAS with the CFA franc as numeraire. The results are also consistent with the ECM results from Figure 5 showing a reversal to PPP through foreign prices in the WAEMU zone and the ECOWAS, using the US dollar and the CFA franc as numeraires, respectively. The estimates of the reversion speed are 0.5 month and 0.8 month, respectively. Looking separately at the sub-periods, the results also confirm the panel unit root conclusion that the currency zones did not revert to PPP under any numeraire before the CFA devaluation. However, the results support a significant convergence to PPP for all zones, except the CEMAC, under the renminbi after the 1994 devaluation. The reversion speeds for the currency zones are comparable with half-lives ranging from 1.8 months to 2.0 months. The results also support reversal to PPP after the devaluation for the ECOWAS using the Euro and CFA franc as anchor, with half-lives of 1.7 month and 0.9 month. These results suggest a faster reversion speed than usually reported in the literature for advanced economies, which could be related to the evidence that reversal towards PPP is mainly related to adjustments of foreign prices measured in domestic currency—which could come from changes in nominal exchange rates of numeraire currencies—rather than to (possibly sticky) domestic prices.

Within the broad CFA zone, our results suggest that evidence of PPP is more consistently present for the WAEMU zone, while the CEMAC zone shows little evidence of PPP. This could be caused by less diversified economy and large exposure to international oil markets in the CEMAC zone, as four out of six CEMAC countries—Chad, the Republic of Congo, Equatorial Guinea, and Gabon—are big oil-producers. While the PPP (at least in the weak form) generally holds at regional level, it may mask opposing trends in individual countries in the zone.

3. Summary of Results

The results from the various empirical methods discussed above to test PPP in the CFA and ECOWAS zones vary across different methods. A summary of the results across the various single-country, grouped-countries, and panel unit-root and cointegration tests is displayed in Table 8 below. Evidence supporting the absolute or relative forms of the PPP hypotheses seem to be:

- Slightly more common for the euro (15 cases) relative to the other numeraire currencies. This is not surprising given the history of the CFA zone countries in pegging to the Euro (and before that, to the French Franc).

- More common for the CFA zone taken as a whole (16 cases) relative to other country groupings, for the same reason.
- More easily found for the WAEMU than the CEMAC when compared across the two separate monetary unions within the CFA zone, which may reflect the fact that a large share of CEMAC countries are oil exporters.
- Stronger when using panel data relative to time series methods with averaged series of real exchange rate across country groupings.
- Indicating that the convergence to PPP occurs mainly from the adjustment in foreign prices, which is somewhat surprising given the overall price-taking status of both CFA and ECOWAS countries but may reflect the fact that CFA countries (and some non-CFA ECOWAS countries) peg their currency and "import" their monetary policy from abroad.

Table 8. Summary of Results (Full Sample): Evidence of PPP across different methods

Table: Summary of Results of Purchasing Power Parity (Full Sample)

	Group\Numeraire	USD	euro	CFA franc	RMB
Method 1: ADF test	CFA		Yes	Yes	
	WAEMU		Yes		
	CEMAC				
	ECOWAS				
Method 2a: Co-Integration test	CFA			Yes	
	WAEMU		Yes		
	CEMAC				
	ECOWAS				
Method 2b: Absolute PPP test using equilibrium regression	CFA				
	WAEMU				
	CEMAC				
	ECOWAS				
Method 2c: Relative PPP test using equilibrium regression	CFA		Yes		
	WAEMU	Yes			Yes
	CEMAC				
	ECOWAS				
Method 3a: Error Correction Model foreign prices adjustment	CFA	Yes	Yes		Yes
	WAEMU	Yes	Yes		Yes
	CEMAC		Yes		Yes
	ECOWAS	Yes	Yes	Yes (faster than Euro)	Yes
Method 3b: Error Correction Model domestic prices adjustment	CFA				
	WAEMU				
	CEMAC				
	ECOWAS				
Method 4a: Unit Root test with panel data (common unit root)	CFA	Yes	Yes	Yes	Yes
	WAEMU	Yes	Yes	Yes	Yes
	CEMAC	Yes	Yes	Yes	
	ECOWAS	Yes	Yes	Yes	Yes
Method 4b: Unit Root test with panel data (individual unit root)	CFA	Yes	Yes	Yes	Yes
	WAEMU	Yes	Yes	Yes	Yes
	CEMAC	Mixed		Mixed	Mixed
	ECOWAS	Yes	Yes	Yes	Yes
Method 5: Half-life	CFA	Yes			
	WAEMU				
	CEMAC				
	ECOWAS			Yes	

Note: "Yes" means evidence for either relative or absolute PPP at 5% significance level or less. "No" means otherwise.

While this study is intended as a fact-finding exercise, with no structural model behind to support a more detailed explanation of results, additional research is needed to rationalize some of the results.

VI. Conclusions and Policy Implications

This study has tested the PPP hypothesis in existing and prospective currency unions using different currencies as numeraire. Its main lessons are that PPP cannot be rejected (at least in its weak form) regardless of the numeraire currency. Overall, the results confirm the relevance of the numeraire currency for PPP, with more evidence of PPP for the full period when the Euro is the numeraire currency. The analysis suggests that evidence of PPP is more consistently present for the WAEMU zone that for other country groupings. Relatedly, prices in the CEMAC and WAEMU zones behave differently, with the CEMAC zone showing little evidence of PPP. This lack of homogeneity between the two sub-groups of the CFA zone puts a question mark on the need, as far as PPP is concerned, to keep them together in a currency union. The ECOWAS and the WAEMU display similar results, especially when the US and the renminbi are used as numeraire. While this can be explained by the fact that WAEMU is a sub-group of ECOWAS, the country-level analysis shows some non-WAEMU ECOWAS (WAMZ) countries have price dynamics close to that of the WAEMU zone. The results indicate that the price dynamics have changed after the CFA devaluation, which increased the evidence of PPP. Importantly, the renminbi appears as the numeraire currency toward which reversion to PPP is fastest after the CFA devaluation. This could reflect the growing importance of China for the region's economies and invites for considering the renminbi among the potential candidates for pegging the region's currencies. The time sensitivity of the numeraire relevance suggests that countries should regularly assess price dynamics to update the design of their currency. Finally, the results on the reversal to PPP through foreign prices call for reforms to liberalize domestic markets to allow prices to adjust faster to shocks.

Annex I. Monetary Unions in Central and Western Africa

1. West African Economic and Monetary Union (WAEMU/UEMOA)

The West African Economic and Monetary Union (also known as UEMOA under French acronym) was established on January 10th, 1994. Since its creation, it follows five main goals:

1) To strengthen the economic and financial competitiveness of the member states.
2) To secure convergence in the economic performances and policies of member states.
3) To create a common market among the member states.
4) To institute the coordination of national sector-based policies.
5) To harmonize all actions taken to ensure the smooth running of the common market, the legislative systems of member states, and particularly the taxation system.

WAEMU's eight member countries are Benin, Burkina Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo.

2. Economic and Monetary Community of Central Africa (CEMAC)

The Economic and Monetary Community of Central Africa was established on March 16th, 1994. Through the establishment of economic and monetary union, it aims to promote peace and harmonious development of its member states.

CEMAC's six member countries are Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, and Gabon.

3. CFA Franc Zone (CFA Franc)

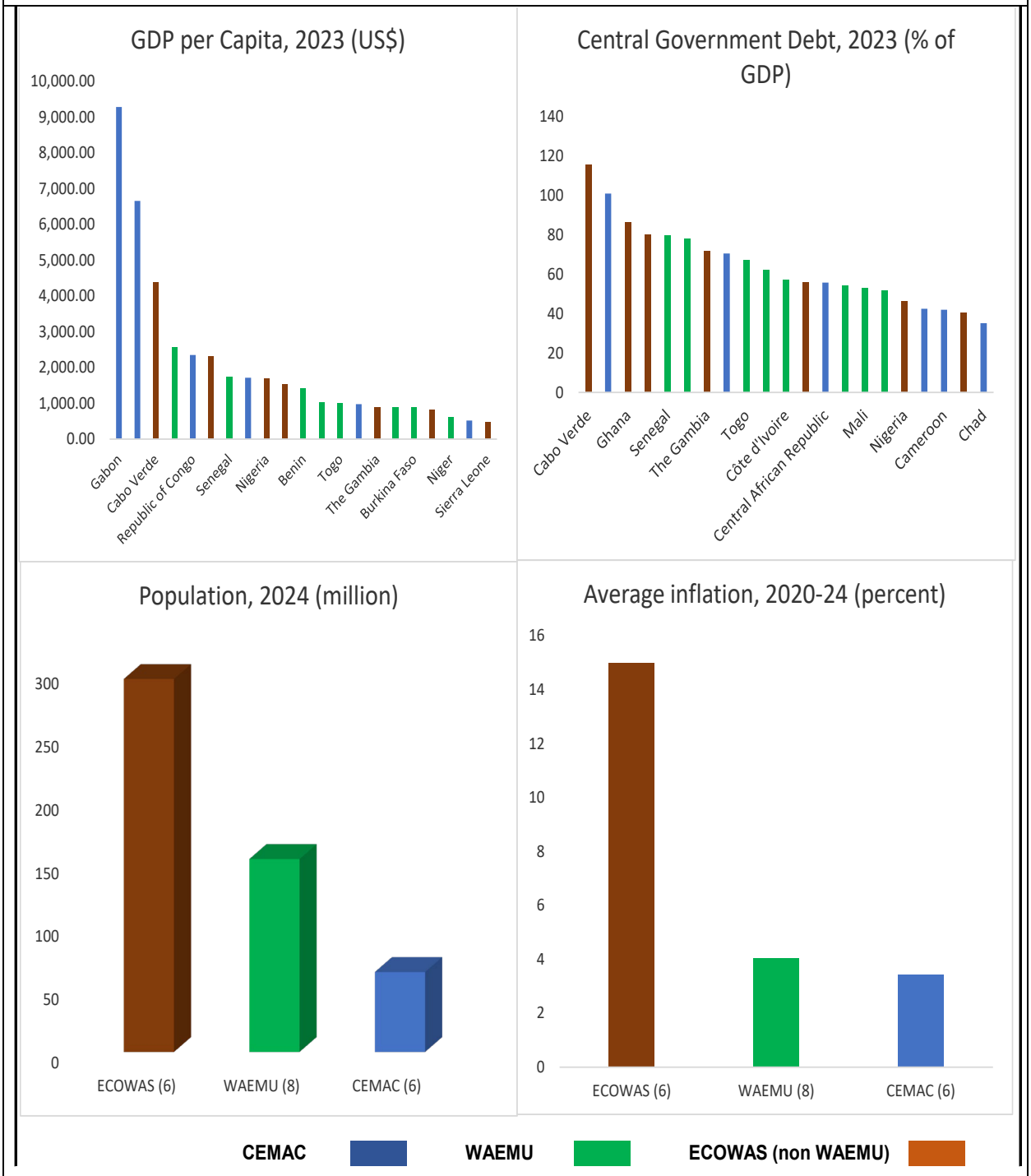
The WAEMU and CEMAC countries maintain the same currency, the CFA franc, and constitute the CFA zone (created in 1945). Most of these fourteen countries were colonies of France and maintain French as its official languages, except Guinea-Bissau (Portuguese) and Equatorial Guinea (Spanish and French). To help maintain the international trade competitiveness, member countries devalued CFA franc in January 1994 from 100 CFA franc per French franc to 50 CFA franc per French franc.

4. Economic Community of West African State (ECOWAS)

The Economic Community of West African State (ECOWAS) was signed on May 28th, 1975, to promote economic integration across the region. As a trading union, it also meant to create a single, large trading bloc through economic cooperation.

ECOWAS's fifteen member countries include all eight WAEMU countries, Cabo Verde, The Gambia, Ghana, Guinea, Liberia, Nigeria, and Sierra Leone.

Panel Chart 1. Selected Macroeconomic Statistics for WAEMU, ECOWAS, and CEMAC Regions



Source: IMF staff and authors' calculations

Annex II. Real Exchange Rate Data

For the charts below, showing country-specific real exchange rate under different numeraire currencies, consider the following country codes:

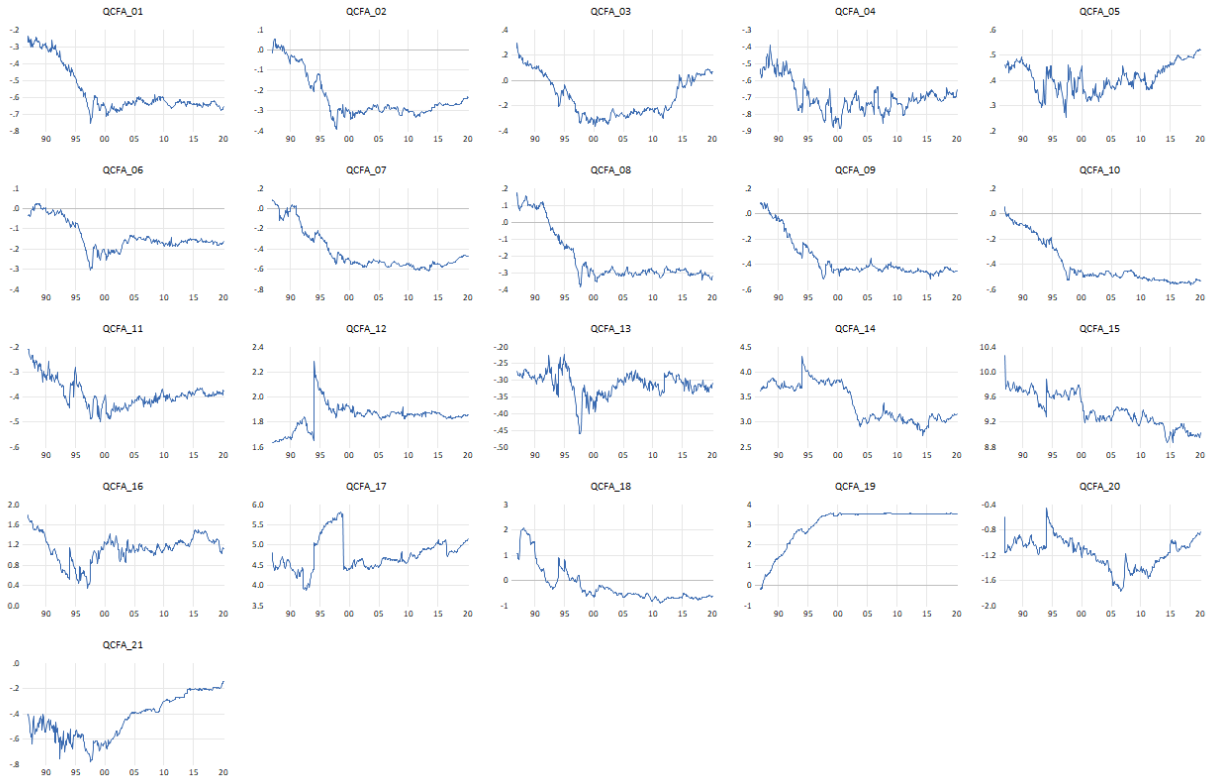
- CFA zone: Burkina Faso (1); Cameroon (2); Central African Republic (3); Chad (4); Congo (5); Cote d'Ivoire (6); Gabon (7); Mali (8); Niger (9); Senegal (10); Togo (11); Benin (13); Guinea-Bissau (19); and Equatorial Guinea (21).

- WAEMU: Burkina Faso (1); Cote d'Ivoire (6); Mali (8); Niger (9); Senegal (10); Togo (11); Benin (13); and Guinea-Bissau (19)

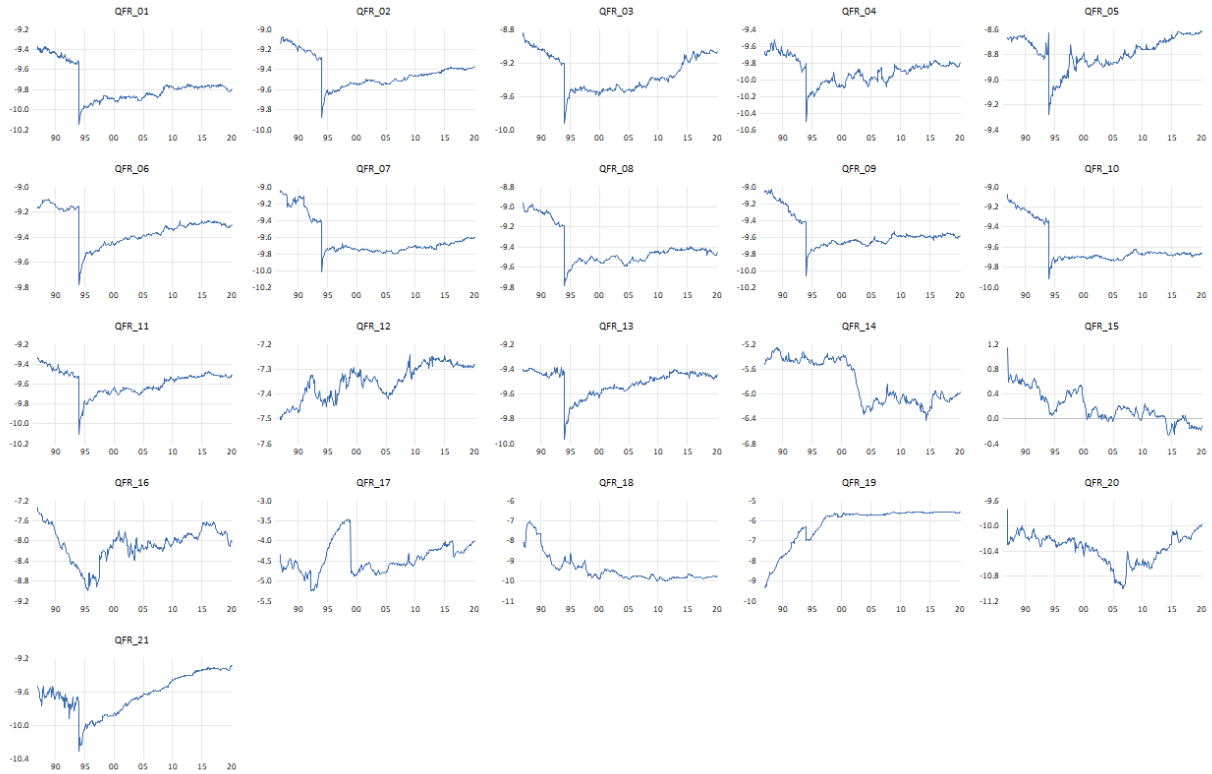
- CEMAC: Cameroon (2); Central African Republic (3); Chad (4); Congo (5); Gabon (7); and Equatorial Guinea (21)

- ECOWAS: Burkina Faso (1); Cote d'Ivoire (6); Mali (8); Niger (9); Senegal (10); Togo (11); Cabo Verde (12); Benin (13); Gambia, The (14); Ghana (15); Liberia (16); Nigeria (17); Sierra Leone (18); Guinea-Bissau (19); Guinea (20)

CFA franc as Numeraire



euro as numeraire



RMB as numeraire

USD as numeraire

Annex III. Unit Root Tests

This Annex provides additional results of unit root tests for the cross-country weighted average of the real exchange rate within each currency zone, considering the four possible numeraire currencies.

Unit Root Tests, Full Sample

	t-statistic	Probability	Unit Root	t-statistic	Probability	Unit Root	Integration Level
	Test with series in level			Test with first differences			
US currency (US$) is the numeraire							
CFA	-3.433102	0.4229	Yes	-31.28542	< 0.01	No	I(1)
WAEMU	-3.663464	0.2999	Yes	-30.76170	< 0.01	No	I(1)
CEMAC	-3.413316	0.4337	Yes	-31.60160	< 0.01	No	I(1)
ECOWAS	-2.502358	0.9024	Yes	-17.98126	< 0.01	No	I(1)
Euro is the numeraire							
CFA	-4.836646	0.0159	No	-126.9638	< 0.01	No	I(0)
WAEMU	-5.572267	0.010000	No	-119.8251	< 0.01	No	I(0)
CEMAC	-3.098450	0.6281	Yes	-93.41098	< 0.01	No	I(1)
ECOWAS	-2.793163	0.7906	Yes	-18.43481	< 0.01	No	I(1)
CFA zone currency is the numeraire							
CFA	-3.978929	0.1631	Yes	-18.37625	< 0.01	No	I(1)
WAEMU	-4.038296	0.1444	Yes	-19.24075	< 0.01	No	I(1)
CEMAC	-3.843692	0.2169	Yes	-18.60722	< 0.01	No	I(1)
ECOWAS	-2.943160	0.7162	Yes	-21.64231	< 0.01	No	I(1)
Chinese RMB is the numeraire							
CFA	-2.811795	0.7820	Yes	-17.65869	< 0.01	No	I(1)
WAEMU	-2.588714	0.8729	Yes	-17.46648	< 0.01	No	I(1)
CEMAC	-3.169931	0.5842	Yes	-18.03431	< 0.01	No	I(1)
ECOWAS	-2.673482	0.8405	Yes	-18.00493	< 0.01	No	I(1)

Unit Root Tests, Subsamples

Before Depreciation

	t-statistic	Probability	Unit Root	t-statistic	Probability	Unit Root	Integration Level
	Test with series in level			Test with first differences			
US currency (US$) is the numeraire							
CFA	-3.927040	0.1824	Yes	-11.11057	< 0.01	No	I(1)
WAEMU	-5.766701	0.010000	No	-10.82715	< 0.01	No	I(0)
CEMAC	-1.777604	0.990000	Yes	-11.53736	< 0.01	No	I(1)
ECOWAS	-3.611031	0.3250	Yes	-11.41838	< 0.01	No	I(1)
Euro is the numeraire							
CFA	-1.054986	0.990000	Yes	-105.6012	< 0.01	No	I(1)
WAEMU	-1.083229	0.990000	Yes	-12.07992	< 0.01	No	I(1)
CEMAC	-1.033238	0.990000	Yes	-59.75642	< 0.01	No	I(1)
ECOWAS	-2.922628	0.7274	Yes	-10.76675	< 0.01	No	I(1)
CFA zone currency is the numeraire							
CFA	-2.507993	0.9010	Yes	-8.111041	< 0.01	No	I(1)
WAEMU	-1.676205	0.990000	Yes	-11.34289	< 0.01	No	I(1)
CEMAC	-2.710639	0.8265	Yes	-8.178575	< 0.01	No	I(1)
ECOWAS	-2.472315	0.9097	Yes	-12.48495	< 0.01	No	I(1)
Chinese RMB is the numeraire							
CFA	-1.679854	0.990000	Yes	-7.548334	< 0.01	No	I(1)
WAEMU	-1.820624	0.990000	Yes	-7.290285	< 0.01	No	I(1)
CEMAC	-1.633219	0.990000	Yes	-8.052242	< 0.01	No	I(1)
ECOWAS	-2.907146	0.7355	Yes	-7.726521	< 0.01	No	I(1)

After Depreciation

	t-statistic	Probability	Unit Root	t-statistic	Probability	Unit Root	Integration Level
	Test with series in level			Test with first differences			
US currency (US$) is the numeraire							
CFA	-3.433102	0.4229	Yes	-31.28542	< 0.01	No	I(1)
WAEMU	-3.663464	0.2999	Yes	-30.76170	< 0.01	No	I(1)
CEMAC	-3.413316	0.4337	Yes	-31.60160	< 0.01	No	I(1)
ECOWAS	-2.502358	0.9024	Yes	-17.98126	< 0.01	No	I(1)
Euro is the numeraire							
CFA	-4.836646	0.0159	No	-126.9638	< 0.01	No	I(0)
WAEMU	-5.572267	0.010000	No	-119.8251	< 0.01	No	I(0)
CEMAC	-3.098450	0.6281	Yes	-93.41098	< 0.01	No	I(1)
ECOWAS	-2.793163	0.7906	Yes	-18.43481	< 0.01	No	I(1)
CFA zone currency is the numeraire							
CFA	-3.978929	0.1631	Yes	-18.37625	< 0.01	No	I(1)
WAEMU	-4.038296	0.1444	Yes	-19.24075	< 0.01	No	I(1)
CEMAC	-3.843692	0.2169	Yes	-18.60722	< 0.01	No	I(1)
ECOWAS	-2.943160	0.7162	Yes	-21.64231	< 0.01	No	I(1)
Chinese RMB is the numeraire							
CFA	-2.811795	0.7820	Yes	-17.65869	< 0.01	No	I(1)
WAEMU	-2.588714	0.8729	Yes	-17.46648	< 0.01	No	I(1)
CEMAC	-3.169931	0.5842	Yes	-18.03431	< 0.01	No	I(1)
ECOWAS	-2.673482	0.8405	Yes	-18.00493	< 0.01	No	I(1)

Annex IV. Country-Specific Cointegration Regressions

This Annex provides additional results from the estimated country-specific cointegration relationships based on equation (6), considering the four possible numeraire currencies. The cointegration vector includes the (logs of) foreign prices expressed in domestic currency and domestic prices.

CFA franc as numeraire

Country-Specific Cointegration Estimations, Full Sample

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	0.886426	0.0000	1.394138	0.0000	None	0.3848
Cameroon	0.365037	0.0000	1.268812	0.0000	None	0.6571
Central African Republic	0.145963	0.0000	1.042603	0.4267	Relative	0.6122
Chad	0.844814	0.0000	1.168265	0.0000	None	0.0571
Congo	-0.412603	0.0000	0.980556	0.1899	Relative	0.1756
Cote d'Ivoire	0.199031	0.0000	1.153638	0.0000	None	0.4956
Gabon	0.901594	0.0000	1.707587	0.0000	None	0.1819
Mali	0.433614	0.0000	1.496266	0.0000	None	0.2469
Niger	0.632034	0.0000	1.474859	0.0000	None	0.1020
Senegal	0.808452	0.0000	1.612040	0.0000	None	0.0076
Togo	0.439637	0.0000	1.083103	0.0000	None	0.0284
Cabo Verde	-1.862397	0.0000	0.859393	0.0000	None	0.0104
Benin	0.325561	0.0000	1.019505	0.0583	Relative	0.0127
Gambia, The	-3.508899	0.0000	1.648370	0.0000	None	0.3235
Ghana	-9.718669	0.0000	1.141326	0.0000	None	0.0001
Liberia	-1.402604	0.0000	0.769310	0.0000	None	0.0380
Nigeria	-4.529398	0.0000	0.911694	0.0038	None	0.2724
Sierra Leone	0.284227	0.0000	1.398142	0.0000	None	0.1543
Guinea-Bissau	-1.073276	0.0000	0.295367	0.0000	None	0.2269
Guinea	0.984704	0.0000	1.079196	0.0003	None	0.2928
Equatorial Guinea, Rep. of	0.263942	0.0000	0.751145	0.0000	None	0.4063
CFA	-2.88E-18	0.0000	N/A	N/A	None	0.0008
WAEMU	-0.117849	0.0000	0.877676	0.0000	None	0.9311
CEMAC	0.291890	0.0000	1.252873	0.0000	None	0.7277
ECOWAS	-3.630984	0.0000	0.714424	0.0000	None	0.2153

Country-Specific Cointegration Estimations, Subsamples

Before CFA Depreciation (1994)

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	2.690721	0.0000	2.847182	0.0001	None	0.4360
Cameroon	0.464231	0.0015	1.426942	0.1134	Relative	0.8847
Central African Republic	-2.905416	0.0000	-2.203979	0.0000	None	1.0000
Chad	-1.007909	0.0000	-0.035389	0.0031	None	0.9969
Congo	-0.601362	0.0000	0.664880	0.2960	Relative	0.7421
Cote d'Ivoire	0.339017	0.0000	1.332213	0.0000	None	0.3096
Gabon	-1.469351	0.0000	-0.494491	0.0000	None	1.0000
Mali	0.227898	0.0000	1.339055	0.3076	Relative	0.9944
Niger	-1.731316	0.0000	-0.751104	0.0000	None	1.0000
Senegal	-3.877869	0.0000	-2.717417	0.0000	None	0.4148
Togo	0.401627	0.0000	1.080044	0.6355	Relative	0.3975
Cabo Verde	-2.111144	0.0000	0.491549	0.0000	None	0.1504
Benin	0.434038	0.0000	1.111295	0.0142	None	0.0196
Gambia, The	-3.711690	0.0000	1.450229	0.0010	None	0.3779
Ghana	-9.666441	0.0000	1.234544	0.0000	None	0.0005
Liberia	-3.123189	0.0000	0.027688	0.0000	None	0.4969
Nigeria	-4.419508	0.0000	1.052634	0.5592	Relative	0.7649
Sierra Leone	0.498410	0.0000	2.356731	0.0000	None	0.4539
Guinea-Bissau	-0.992556	0.0000	0.078660	0.0000	None	0.9999
Guinea	0.928971	0.0000	0.942406	0.4205	Relative	0.0036
Equatorial Guinea, Rep. of	0.172005	0.0000	0.768928	0.1385	Relative	0.6308
CFA	-4.29E-14	0.0000	N/A	N/A	None	0.9077
WAEMU	-0.340903	0.0000	0.638060	0.0000	None	0.9448
CEMAC	-1.157106	0.0812	-0.205381	0.0269	None	0.9457
ECOWAS	-3.562053	0.0000	0.824693	0.0114	None	0.7655

After Depreciation

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	0.638387	0.0000	0.974559	0.2922	Relative	0.0029
Cameroon	0.286660	0.0000	0.929034	0.0036	None	0.0550
Central African Republic	0.129743	0.0000	0.612183	0.0000	None	0.0647
Chad	0.639242	0.0000	0.863477	0.0000	None	0.0006
Congo	-0.312207	0.0000	0.773361	0.0000	None	0.0056
Cote d'Ivoire	0.166723	0.0000	0.865067	0.0000	None	0.0516
Gabon	0.631020	0.0000	1.142633	0.0017	None	0.1304
Mali	0.321806	0.0000	1.037037	0.1407	Relative	0.0383
Niger	0.484864	0.0000	1.072321	0.0011	None	0.0068
Senegal	0.657666	0.0000	1.284082	0.0000	None	0.1253
Togo	0.369000	0.0000	0.875222	0.0000	None	0.0177
Cabo Verde	-1.884799	0.0000	1.207027	0.0000	None	0.0003
Benin	0.288239	0.0000	0.867640	0.0000	None	0.0372
Gambia, The	-3.406945	0.0000	1.702325	0.0000	None	0.7479
Ghana	-10.07438	0.0000	1.227768	0.0000	None	0.0449
Liberia	-1.351558	0.0000	0.770550	0.0000	None	0.1530
Nigeria	-5.077256	0.0000	1.075983	0.2087	Relative	0.5309
Sierra Leone	0.270434	0.0000	1.358181	0.0000	None	0.0870
Guinea-Bissau	-2.452925	0.0000	0.688301	0.0000	None	0.7953
Guinea	0.935571	0.0000	0.988573	0.6115	Relative	0.6251
Equatorial Guinea, Rep. of	0.196017	0.0000	0.452431	0.0000	None	0.0632
CFA	2.19E-17	0.0000	N/A	N/A	None	0.0003
WAEMU	-0.123449	0.0000	0.927594	0.0001	None	0.9276
CEMAC	0.230304	0.0000	0.913708	0.0009	None	0.0373
ECOWAS	-3.810818	0.0000	0.773914	0.0000	None	0.5133

Euro as the numeraire

Country-Specific Cointegration Estimations, Full Sample

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	10.02081	0.0000	1.340309	0.0000	None	0.3958
Cameroon	9.485549	0.0000	1.186707	0.0000	None	0.4944
Central African Republic	9.300636	0.0000	0.970540	0.6657	Relative	0.4412
Chad	9.979859	0.0000	1.096705	0.0403	None	0.2643
Congo	8.765186	0.0000	0.922087	0.0118	None	0.2263
Cote d'Ivoire	9.352841	0.0000	1.154043	0.0000	None	0.2699
Gabon	10.00256	0.0000	1.564038	0.0000	None	0.2781
Mali	9.586041	0.0000	1.418147	0.0000	None	0.3378
Niger	9.758113	0.0000	1.352361	0.0000	None	0.2199
Senegal	9.958948	0.0000	1.573468	0.0000	None	0.1041
Togo	9.587989	0.0000	1.047030	0.1084	Relative	0.1827
Cabo Verde	7.323326	0.0000	0.826907	0.0000	None	0.0570
Benin	9.488508	0.0000	1.022509	0.3528	Relative	0.1577
Gambia, The	5.805444	0.0000	1.554940	0.0000	None	0.5867
Ghana	-0.647993	0.0000	1.149741	0.0000	None	0.0002
Liberia	7.646075	0.0000	0.660443	0.0000	None	0.1268
Nigeria	4.658336	0.0000	0.908052	0.0011	None	0.2320
Sierra Leone	9.482426	0.0000	1.379313	0.0000	None	0.2978
Guinea-Bissau	8.111174	0.0000	0.299099	0.0000	None	0.0336
Guinea	10.23869	0.0000	1.047707	0.0388	None	0.3467
Equatorial Guinea, Rep. of	9.368769	0.0000	0.703648	0.0000	None	0.3287
CFA	9.151099	0.0000	1.011160	0.5886	Relative	0.0530
WAEMU	9.039656	0.0000	0.901775	0.0000	None	0.0218
CEMAC	9.449914	0.0000	1.210622	0.0000	None	0.4702
ECOWAS	5.552611	0.0000	0.709512	0.0000	None	0.1737

Country-Specific Cointegration Estimations, Subsamples

Before CFA Depreciation (1994)

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	12.60366	0.0000	3.440293	0.0000	None	0.0006
Cameroon	11.46439	0.0000	3.269061	0.0000	None	0.1202
Central African Republic	6.398931	0.0000	-2.040316	0.0000	None	0.9931
Chad	9.303035	0.0000	0.731538	0.6252	Relative	0.5985
Congo	9.039391	0.0000	1.598441	0.1250	Relative	0.0004
Cote d'Ivoire	9.929723	0.0000	1.810899	0.0000	None	0.0292
Gabon	7.965903	0.0000	-0.232811	0.0006	None	0.9900
Mali	9.572093	0.0000	1.533136	0.5239	Relative	0.8708
Niger	7.469240	0.0000	-0.699410	0.0000	None	0.9914
Senegal	7.247865	0.0000	-0.871336	0.0163	None	0.0497
Togo	11.47153	0.0000	2.580567	0.0000	None	0.0006
Cabo Verde	7.279695	0.0000	0.757665	0.0000	None	0.8585
Benin	9.749214	0.0000	1.268405	0.0810	Relative	0.0177
Gambia, The	5.502526	0.0000	1.149332	0.0479	None	0.2392
Ghana	-0.549860	0.0000	1.341725	0.0000	None	0.0119
Liberia	5.819332	0.0000	-0.344000	0.0000	None	0.3036
Nigeria	4.758879	0.0000	1.144289	0.0441	None	0.5201
Sierra Leone	9.719229	0.0000	2.419144	0.0000	None	0.3296
Guinea-Bissau	8.152324	0.0000	0.119385	0.0000	None	0.8897
Guinea	10.19517	0.0000	1.015975	0.6997	Relative	0.0000
Equatorial Guinea, Rep. of	11.10661	0.0000	1.946361	0.0077	None	0.0738
CFA	9.132083	0.0000	1.023317	0.8817	Relative	0.0100
WAEMU	8.495690	0.0000	0.411785	0.0006	None	0.2259
CEMAC	9.300054	0.0000	1.164759	0.8145	Relative	0.1785
ECOWAS	5.644227	0.0000	0.934347	0.1791	Relative	0.3146

After CFA Depreciation

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	9.577788	0.0000	0.633708	0.0000	None	0.0493
Cameroon	9.346692	0.0000	0.619233	0.0000	None	0.0051
Central African Republic	9.241886	0.0000	0.376342	0.0000	None	0.7341
Chad	9.565105	0.0000	0.535497	0.0000	None	0.0086
Congo	8.959947	0.0000	0.500336	0.0000	None	0.0383
Cote d'Ivoire	9.276366	0.0000	0.576542	0.0000	None	0.0011
Gabon	9.569665	0.0000	0.728524	0.0000	None	0.6319
Mali	9.373129	0.0000	0.679845	0.0000	None	0.0609
Niger	9.480979	0.0000	0.698910	0.0000	None	0.0076
Senegal	9.597328	0.0000	0.835748	0.0000	None	0.0004
Togo	9.404613	0.0000	0.576264	0.0000	None	0.0007
Cabo Verde	7.329862	0.0000	0.749791	0.0000	None	0.0643
Benin	9.358008	0.0000	0.567620	0.0000	None	0.0004
Gambia, The	5.799184	0.0000	1.546790	0.0000	None	0.8608
Ghana	-0.769212	0.0000	1.177292	0.0000	None	0.0463
Liberia	7.750352	0.0000	0.670749	0.0000	None	0.3073
Nigeria	4.367832	0.0000	0.995683	0.9424	Relative	0.4693
Sierra Leone	9.433644	0.0000	1.248085	0.0000	None	0.0796
Guinea-Bissau	7.673794	0.0000	0.420482	0.0000	None	0.5718
Guinea	10.17132	0.0000	0.906102	0.0000	None	0.8308
Equatorial Guinea, Rep. of	9.291586	0.0000	0.310579	0.0000	None	0.0000
CFA	9.165204	0.0000	0.637039	0.0000	None	0.0180
WAEMU	9.085920	0.0000	0.600545	0.0000	None	0.1060
CEMAC	9.308569	0.0000	0.601728	0.0000	None	0.2808
ECOWAS	5.591213	0.0000	0.699102	0.0000	None	0.4515

RMB as numeraire

Country-Specific Cointegration Estimations, Full Sample

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	9.966358	0.0000	1.634396	0.0000	None	0.3056
Cameroon	9.359375	0.0000	1.501963	0.0000	None	0.1595
Central African Republic	9.113708	0.0000	1.281647	0.0000	None	0.1852
Chad	9.906182	0.0000	1.351825	0.0000	None	0.0501
Congo	8.447273	0.0000	1.151777	0.0000	None	0.0913
Cote d'Ivoire	9.155691	0.0000	1.346757	0.0000	None	0.3117
Gabon	9.966301	0.0000	1.985164	0.0000	None	0.0423
Mali	9.441364	0.0000	1.751503	0.0000	None	0.2011
Niger	9.665400	0.0000	1.700033	0.0000	None	0.1260
Senegal	9.875177	0.0000	1.906293	0.0000	None	0.1811
Togo	9.442940	0.0000	1.270034	0.0000	None	0.1716
Cabo Verde	7.043538	0.0000	1.045783	0.4851	Relative	0.4208
Benin	9.299836	0.0000	1.187435	0.0000	None	0.3599
Gambia, The	5.368266	0.0000	1.764509	0.0000	None	0.1526
Ghana	-0.995491	0.0000	1.189670	0.0000	None	0.2298
Liberia	7.521928	0.0000	0.830599	0.0000	None	0.1142
Nigeria	4.240575	0.0000	0.955495	0.1221	Relative	0.2819
Sierra Leone	9.061309	0.0000	1.484053	0.0000	None	0.0588
Guinea-Bissau	7.718348	0.0000	0.328690	0.0000	None	0.5992
Guinea	9.941641	0.0000	1.134843	0.0000	None	0.1710
Equatorial Guinea, Rep. of	9.238221	0.0000	0.886176	0.0032	None	0.2751
CFA	8.924334	0.0000	1.163764	0.0001	None	0.2971
WAEMU	8.786617	0.0000	1.005987	0.8877	Relative	0.5077
CEMAC	9.277982	0.0000	1.497598	0.0000	None	0.1061
ECOWAS	5.155888	0.0000	0.757947	0.0000	None	0.2691

Country-Specific Cointegration Estimations, Subsamples

Before CFA Depreciation (1994)

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	10.81565	0.0000	2.333909	0.0915	Relative	0.5654
Cameroon	9.728873	0.0000	1.891788	0.2625	Relative	0.5789
Central African Republic	8.796738	0.0000	1.095044	0.9119	Relative	0.8422
Chad	9.479365	0.0000	1.086733	0.8670	Relative	0.6664
Congo	7.739784	0.0000	-0.101855	0.2081	Relative	0.4682
Cote d'Ivoire	8.778761	0.0000	0.990541	0.9864	Relative	0.7378
Gabon	8.671450	0.0000	0.806003	0.5701	Relative	0.8790
Mali	9.669550	0.0000	2.051148	0.2023	Relative	0.7341
Niger	8.836988	0.0000	0.956425	0.9105	Relative	0.7893
Senegal	9.818569	0.0000	1.864037	0.2287	Relative	0.5363
Togo	9.500425	0.0000	1.320045	0.6252	Relative	0.6636
Cabo Verde	6.398566	0.0000	-0.052965	0.0000	None	0.5344
Benin	8.636966	0.0000	0.656884	0.4157	Relative	0.8039
Gambia, The	4.636222	0.0000	0.518724	0.0001	None	0.2869
Ghana	-1.181551	0.0000	1.125796	0.0574	Relative	0.1321
Liberia	6.091438	0.0000	0.069106	0.0000	None	0.4321
Nigeria	4.339729	0.0000	0.976432	0.6780	Relative	0.3452
Sierra Leone	9.286503	0.0000	2.269985	0.0000	None	0.2847
Guinea-Bissau	7.832231	0.0000	0.013759	0.0000	None	0.9293
Guinea	9.499629	0.0000	0.750476	0.0004	None	0.0005
Equatorial Guinea, Rep. of	10.32581	0.0000	1.678116	0.1131	Relative	0.2468
CFA	7.374712	0.0000	-0.414342	0.0352	None	0.7960
WAEMU	8.072657	0.0000	0.272909	0.0344	None	0.8575
CEMAC	9.542680	0.0000	1.803537	0.2195	Relative	0.5564
ECOWAS	5.252617	0.0000	0.759587	0.0000	None	0.3051

After CFA Depreciation

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	9.791609	0.0000	1.357454	0.0018	None	0.7284
Cameroon	9.320592	0.0000	1.357666	0.0002	None	0.6054
Central African Republic	9.076286	0.0000	0.913885	0.1395	Relative	0.2914
Chad	9.783660	0.0000	1.173213	0.0365	None	0.3124
Congo	8.469265	0.0000	1.097838	0.1694	Relative	0.4232
Cote d'Ivoire	9.136910	0.0000	1.217308	0.0407	None	0.7662
Gabon	9.850072	0.0000	1.706073	0.0000	None	0.4054
Mali	9.366542	0.0000	1.487458	0.0000	None	0.6356
Niger	9.584159	0.0000	1.495922	0.0000	None	0.6728
Senegal	9.825041	0.0000	1.791905	0.0000	None	0.6851
Togo	9.432821	0.0000	1.240268	0.0073	None	0.5918
Cabo Verde	7.017142	0.0000	1.534457	0.0000	None	0.6070
Benin	9.308534	0.0000	1.205797	0.0439	None	0.7554
Gambia, The	5.439162	0.0000	1.835810	0.0000	None	0.5253
Ghana	-1.405184	0.0000	1.293324	0.0000	None	0.5580
Liberia	7.646533	0.0000	0.853969	0.0000	None	0.5417
Nigeria	3.594546	0.0000	1.147856	0.0099	None	0.4155
Sierra Leone	8.920703	0.0000	1.398904	0.0000	None	0.1305
Guinea-Bissau	6.882976	0.0000	0.577646	0.0000	None	0.8120
Guinea	9.942839	0.0000	1.072395	0.0005	None	0.2721
Equatorial Guinea, Rep. of	9.163321	0.0000	0.660279	0.0000	None	0.7303
CFA	8.927869	0.0000	1.284223	0.0030	None	0.5961
WAEMU	8.774588	0.0000	1.125873	0.2385	Relative	0.7885
CEMAC	9.277326	0.0000	1.244947	0.0025	None	0.4947
ECOWAS	4.909910	0.0000	0.837765	0.0000	None	0.4711

US dollar as numeraire

Country-Specific Cointegration Estimations, Full Sample

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	11.82155	0.0000	1.503783	0.0000	None	0.4316
Cameroon	11.25865	0.0000	1.390401	0.0000	None	0.3456
Central African Republic	11.01629	0.0000	1.115549	0.1493	Relative	0.4058
Chad	11.77190	0.0000	1.239520	0.0001	None	0.2157
Congo	10.42970	0.0000	1.068203	0.1250	Relative	0.2039
Cote d'Ivoire	11.08135	0.0000	1.275728	0.0000	None	0.2960
Gabon	11.79926	0.0000	1.771963	0.0000	None	0.2576
Mali	11.33491	0.0000	1.592866	0.0000	None	0.3908
Niger	11.53908	0.0000	1.548733	0.0000	None	0.2973
Senegal	11.75207	0.0000	1.769103	0.0000	None	0.2723
Togo	11.35110	0.0000	1.187139	0.0002	None	0.2450
Cabo Verde	9.070686	0.0000	0.808645	0.0009	None	0.3162
Benin	11.23080	0.0000	1.126946	0.0046	None	0.2556
Gambia, The	7.416264	0.0000	1.646851	0.0000	None	0.3158
Ghana	0.972403	0.0000	1.174999	0.0000	None	0.1100
Liberia	9.263857	0.0000	0.660700	0.0000	None	0.2591
Nigeria	6.247044	0.0000	0.938471	0.0407	None	0.3307
Sierra Leone	11.09774	0.0000	1.427618	0.0000	None	0.2737
Guinea-Bissau	9.690388	0.0000	0.330007	0.0000	None	0.0741
Guinea	11.95977	0.0000	1.074855	0.0018	None	0.4006
Equatorial Guinea, Rep. of	11.14394	0.0000	0.802167	0.0000	None	0.3714
CFA	10.87326	0.0000	1.112604	0.0046	None	0.1171
WAEMU	10.74449	0.0000	0.974771	0.4868	Relative	0.1276
CEMAC	11.18521	0.0000	1.372597	0.0000	None	0.3639
ECOWAS	7.152975	0.0000	0.739517	0.0000	None	0.3894

Country-Specific Cointegration Estimations, Subsamples

Before CFA Depreciation (1994)

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	14.30270	0.0000	3.543132	0.0000	None	0.0009
Cameroon	12.59856	0.0000	2.829162	0.0000	None	0.0687
Central African Republic	8.345989	0.0000	-1.614412	0.0001	None	0.9800
Chad	10.91316	0.0000	0.757809	0.6910	Relative	0.5298
Congo	11.05459	0.0000	2.410065	0.0000	None	0.0000
Cote d'Ivoire	11.69827	0.0000	2.000387	0.0004	None	0.0513
Gabon	9.515127	0.0000	-0.253412	0.0005	None	0.9768
Mali	13.02971	0.0000	3.670645	0.0000	None	0.7947
Niger	9.272237	0.0000	-0.477251	0.0000	None	0.9767
Senegal	8.311495	0.0000	-1.340136	0.0009	None	0.0997
Togo	13.06797	0.0000	2.600357	0.0000	None	0.0137
Cabo Verde	8.805420	0.0000	0.677117	0.0025	None	0.4449
Benin	11.91281	0.0000	1.728527	0.0007	None	0.1233
Gambia, The	7.033579	0.0000	1.102471	0.1217	Relative	0.0309
Ghana	0.923344	0.0000	1.317676	0.0000	None	0.1916
Liberia	7.005091	0.0000	-1.019970	0.0000	None	0.9730
Nigeria	6.327366	0.0000	1.140994	0.0150	None	0.4391
Sierra Leone	11.39912	0.0000	2.524181	0.0000	None	0.2550
Guinea-Bissau	9.727853	0.0000	0.112697	0.0000	None	0.8663
Guinea	11.77559	0.0000	0.979654	0.5173	Relative	0.0000
Equatorial Guinea, Rep. of	12.88733	0.0000	2.104906	0.0004	None	0.0276
CFA	10.40264	0.0000	0.727319	0.3450	Relative	0.0584
WAEMU	10.05315	0.0000	0.395400	0.0173	None	0.3060
CEMAC	10.79593	0.0000	1.089851	0.8987	Relative	0.0925
ECOWAS	7.210130	0.0000	0.928466	0.0392	None	0.1098

After CFA Depreciation

Country	Beta 0	Absolute PPP	Beta 1	Relative PPP	Assessment	PO Test
Burkina Faso	11.33367	0.0000	0.727846	0.0112	None	0.7343
Cameroon	11.09438	0.0000	0.767470	0.0124	None	0.6104
Central African Republic	10.95302	0.0000	0.503818	0.0000	None	0.5319
Chad	11.35805	0.0000	0.666427	0.0000	None	0.5191
Congo	10.61245	0.0000	0.622575	0.0000	None	0.5604
Cote d'Ivoire	10.98812	0.0000	0.676100	0.0008	None	0.7056
Gabon	11.36580	0.0000	0.928811	0.5552	Relative	0.5669
Mali	11.10195	0.0000	0.784616	0.0550	Relative	0.7002
Niger	11.23086	0.0000	0.819917	0.1113	Relative	0.6789
Senegal	11.34404	0.0000	0.952409	0.7431	Relative	0.7034
Togo	11.14712	0.0000	0.676512	0.0003	None	0.6457
Cabo Verde	9.032770	0.0000	0.842758	0.1256	Relative	0.6842
Benin	11.08451	0.0000	0.673651	0.0004	None	0.6958
Gambia, The	7.366186	0.0000	1.566484	0.0000	None	0.7857
Ghana	0.945497	0.0000	1.183493	0.0000	None	0.4926
Liberia	9.463637	0.0000	0.708322	0.0000	None	0.4480
Nigeria	5.958142	0.0000	1.026846	0.6839	Relative	0.5361
Sierra Leone	10.96149	0.0000	1.223116	0.0000	None	0.2232
Guinea-Bissau	9.621956	0.0000	0.354965	0.0000	None	0.5218
Guinea	11.92095	0.0000	0.943390	0.0134	None	0.6324
Equatorial Guinea, Rep. of	11.00174	0.0000	0.367373	0.0000	None	0.6874
CFA	10.87502	0.0000	0.718198	0.0017	None	0.5921
WAEMU	10.78734	0.0000	0.638165	0.0001	None	0.6852
CEMAC	11.07301	0.0000	0.567208	0.0000	None	0.6423
ECOWAS	7.209285	0.0000	0.724706	0.0000	None	0.6324

In all tables above, the second and fourth columns present the estimated values of β_0 and β_1, respectively The third and fifth columns ("Absolute PPP") and 5 ("Relative PPP") present p-values associated with Wald tests for the PPP restrictions imposed on the coefficients of the equilibrium regression version of equation (6). The

country-specific assessment regarding evidence for PPP under each numeraire is presented in the second to last column, where “None” means no version of the PPP is detected; “Relative” indicates the existence of relative PPP but not absolute; and “Absolute” indicates the existence of absolute PPP. The last column (“PO test”) presents the *p*-value of the Philips-Ouliaris cointegration test (H_0 is no cointegration).

Annex V. Error Correction Model

This Annex provides additional results of the estimated ECMs based on equations (7)-(8), considering the four possible numeraire currencies.

ECM Estimations, Full Sample

Numeraire	US Dollar		Euro		CFA		Chinese RMB	
Currency Zone	*constant*	*coefficient*	*constant*	*coefficient*	*constant*	*coefficient*	*constant*	*coefficient*
CFA zone								
d(ft)	0.004	-0.037	0.003	-0.106	N/A	N/A	0.004	-0.022
[p-value]	*0.074*	*0.018*	*0.077*	*0.000*	N/A	N/A	*0.013*	*0.056*
d(pt)	0.003	0.008	0.003	0.000	N/A	N/A	0.003	0.001
[p-value]	*0.000*	*0.023*	*0.000*	*1.000*	N/A	N/A	*0.000*	*0.736*
WAEMU								
d(ft)	0.004	-0.034	0.003	-0.081	0.003	-0.028	0.004	-0.019
[p-value]	*0.075*	*0.023*	*0.078*	*0.001*	*0.000*	*0.111*	*0.013*	*0.056*
d(pt)	0.003	0.007	0.003	0.000	0.003	-0.031	0.003	-0.002
[p-value]	*0.000*	*0.087*	*0.000*	*1.000*	*0.000*	*0.156*	*0.000*	*0.531*
CEMAC								
d(ft)	0.004	-0.020	0.003	-0.033	0.003	0.007	0.004	-0.021
[p-value]	*0.072*	*0.122*	*0.077*	*0.023*	*0.000*	*0.307*	*0.013*	*0.102*
d(pt)	0.002	0.006	0.002	0.000	0.003	0.014	0.003	0.009
[p-value]	*0.000*	*0.032*	*0.000*	*1.000*	*0.000*	*0.050*	*0.000*	*0.027*
ECOWAS								
d(ft)	0.010	-0.018	0.010	-0.024	0.010	-0.033	0.011	-0.027
[p-value]	*0.000*	*0.071*	*0.000*	*0.047*	*0.001*	*0.010*	*0.000*	*0.019*
d(pt)	0.013	0.003	0.013	0.006	0.013	0.000	0.013	0.000
[p-value]	*0.000*	*0.380*	*0.000*	*0.114*	*0.000*	*0.890*	*0.000*	*0.932*

ECM Estimations, Subsamples

Before CFA Depreciation (1994M06)

Numeraire	US Dollar		Euro		CFA		Chinese RMB	
Currency Zone	*constant*	*coefficient*	*constant*	*coefficient*	*constant*	*coefficient*	*constant*	*coefficient*
CFA zone								
d(ft)	0.010	-0.342	0.010	-0.557	N/A	N/A	0.007	-0.016
[p-value]	*0.223*	*0.002*	*0.199*	*0.001*	N/A	N/A	*0.237*	*0.659*
d(pt)	0.005	-0.001	0.005	-0.003	N/A	N/A	0.005	0.008
[p-value]	*0.000*	*0.938*	*0.000*	*0.915*	N/A	N/A	*0.000*	*0.319*
WAEMU								
d(ft)	0.010	-0.157	0.010	-0.330	0.005	0.171	0.006	-0.016
[p-value]	*0.245*	*0.085*	*0.214*	*0.008*	*0.000*	*0.222*	*0.255*	*0.624*
d(pt)	0.006	0.000	0.006	0.000	0.006	0.152	0.006	0.002
[p-value]	*0.000*	*0.980*	*0.000*	*0.982*	*0.000*	*0.264*	*0.000*	*0.762*
CEMAC								
d(ft)	0.010	-0.196	0.010	-0.190	0.005	0.014	0.006	-0.034
[p-value]	*0.233*	*0.034*	*0.208*	*0.036*	*0.000*	*0.552*	*0.248*	*0.384*
d(pt)	0.003	-0.003	0.003	-0.004	0.003	-0.007	0.004	0.001
[p-value]	*0.100*	*0.881*	*0.100*	*0.864*	*0.101*	*0.828*	*0.060*	*0.966*
ECOWAS								
d(ft)	0.019	-0.126	0.019	-0.071	0.014	-0.042	0.014	-0.119
[p-value]	*0.001*	*0.042*	*0.000*	*0.116*	*0.060*	*0.362*	*0.018*	*0.076*
d(pt)	0.020	0.027	0.020	0.015	0.020	0.012	0.021	0.001
[p-value]	*0.000*	*0.221*	*0.000*	*0.348*	*0.000*	*0.316*	*0.000*	*0.976*

After CFA Depreciation

Numeraire	US Dollar		Euro		CFA		Chinese RMB	
Currency Zone	*constant*	*coefficient*	*constant*	*coefficient*	*constant*	*coefficient*	*constant*	*coefficient*
CFA zone								
d(ft)	0.002	-0.020	0.001	-0.012	N/A	N/A	0.003	-0.017
[p-value]	*0.104*	*0.063*	*0.000*	*0.148*	N/A	N/A	*0.013*	*0.109*
d(pt)	0.003	-0.005	0.003	0.000	N/A	N/A	0.003	0.002
[p-value]	*0.000*	*0.212*	*0.000*	*1.000*	N/A	N/A	*0.000*	*0.588*
WAEMU								
d(ft)	0.002	-0.017	0.001	-0.011	0.003	0.020	0.003	-0.011
[p-value]	*0.105*	*0.099*	*0.000*	*0.058*	*0.000*	*0.289*	*0.013*	*0.208*
d(pt)	0.003	-0.005	0.003	0.000	0.003	0.028	0.003	0.001
[p-value]	*0.000*	*0.302*	*0.000*	*1.000*	*0.000*	*0.287*	*0.000*	*0.763*
CEMAC								
d(ft)	0.002	-0.028	0.001	0.000	0.003	-0.055	0.003	-0.022
[p-value]	*0.146*	*0.031*	*0.000*	*0.985*	*0.000*	*0.000*	*0.021*	*0.132*
d(pt)	0.002	0.000	0.002	0.000	0.002	0.009	0.002	0.000
[p-value]	*0.000*	*1.000*	*0.000*	*1.000*	*0.000*	*0.423*	*0.000*	*1.000*
ECOWAS								
d(ft)	0.008	-0.017	0.007	-0.025	0.009	-0.030	0.009	-0.025
[p-value]	*0.003*	*0.091*	*0.011*	*0.059*	*0.004*	*0.027*	*0.001*	*0.042*
d(pt)	0.011	0.000	0.011	0.002	0.011	-0.001	0.011	0.000
[p-value]	*0.000*	*0.908*	*0.000*	*0.501*	*0.000*	*0.712*	*0.000*	*0.897*

Annex VI. Reversion to PPP: Half-Life Estimations

Half-Life Estimations, Full Sample

CFA	US Dollar	Euro	CFA	Chinese RMB
beta	-0.25	0.10	1.07	-0.05
t-statistic	-1.03	0.95	5.31	-0.57
half_life, in months	2.40	-7.19	-0.95	13.59
reversion speed, in years	0.20	-0.60	-0.08	1.13

WAEMU	US Dollar	Euro	CFA	Chinese RMB
beta	-0.77	0.38	0.98	-0.01
t-statistic	-2.09	1.56	9.47	-0.09
half_life, in months	0.48	-2.16	-1.01	88.59
reversion speed, in years	0.04	-0.18	-0.08	7.38

CEMAC	US Dollar	Euro	CFA	Chinese RMB
beta	0.28	0.11	0.49	-0.16
t-statistic	1.22	1.05	2.60	-0.66
half_life, in months	-2.79	-6.64	-1.73	4.08
reversion speed, in years	-0.23	-0.55	-0.14	0.34

ECOWAS	US Dollar	Euro	CFA	Chinese RMB
beta	-0.04	-0.21	-0.57	-0.06
t-statistic	-0.32	-1.32	-3.14	-0.74
half_life, in months	17.81	3.00	0.83	11.77
reversion speed, in years	1.48	0.25	0.07	0.98

Half-Life Estimations, Subsamples

Before CFA Depreciation (1994)

CFA	US Dollar	Euro	CFA	Chinese RMB
beta	-0.09	0.27	1.13	0.26
t-statistic	-0.42	1.40	3.63	1.40
half_life, in months	7.76	-2.89	-0.91	-3.02
reversion speed, in years	0.65	-0.24	-0.08	-0.25

WAEMU	US Dollar	Euro	CFA	Chinese RMB
beta	-0.89	0.59	0.96	0.29
t-statistic	-1.52	1.75	6.21	1.86
half_life, in months	0.31	-1.50	-1.03	-2.71
reversion speed, in years	0.03	-0.13	-0.09	-0.23

CEMAC	US Dollar	Euro	CFA	Chinese RMB
beta	0.21	0.22	0.59	-0.32
t-statistic	1.02	1.19	2.61	-0.55
half_life, in months	-3.59	-3.42	-1.49	1.81
reversion speed, in years	-0.30	-0.29	-0.12	0.15

ECOWAS	US Dollar	Euro	CFA	Chinese RMB
beta	-0.26	0.00	-0.53	0.15
t-statistic	-0.70	0.00	-1.04	1.20
half_life, in months	2.26	569.68	0.91	-4.88
reversion speed, in years	0.19	47.47	0.08	-0.41

After CFA Depreciation

CFA	US Dollar	Euro	CFA	Chinese RMB
beta	0.05	0.66	0.30	-0.30
t-statistic	0.75	4.13	1.33	-3.54
half_life, in months	-13.69	-1.37	-2.67	1.95
reversion speed, in years	-1.14	-0.11	-0.22	0.16

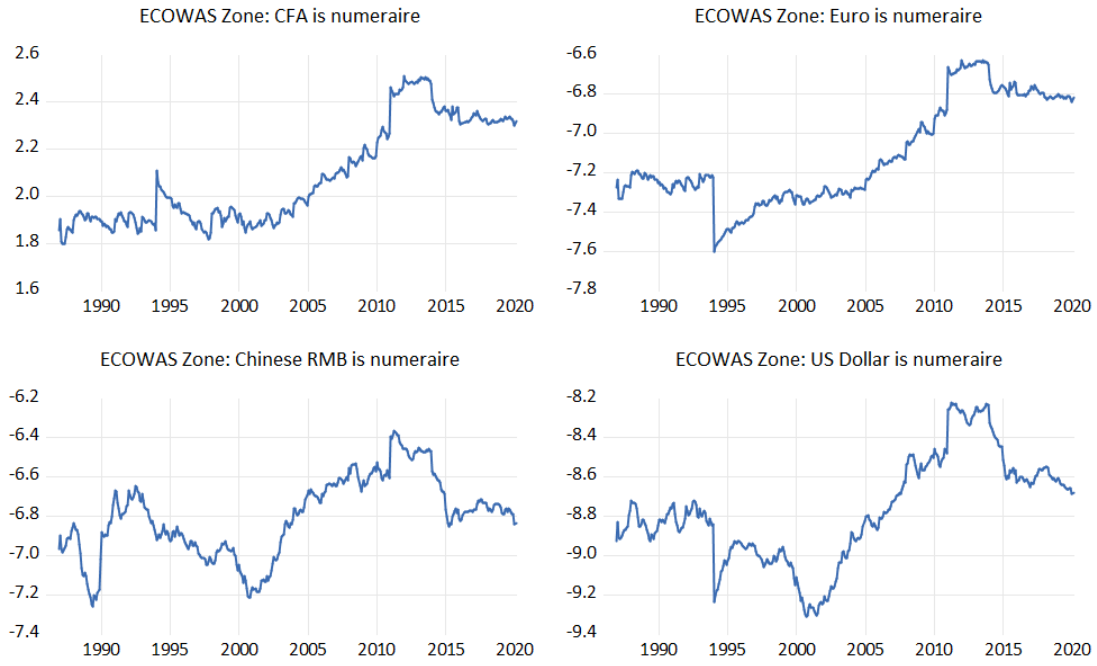
WAEMU	US Dollar	Euro	CFA	Chinese RMB
beta	0.03	0.62	0.49	-0.32
t-statistic	0.36	5.05	2.86	-3.16
half_life, in months	-23.14	-1.43	-1.75	1.80
reversion speed, in years	-1.93	-0.12	-0.15	0.15

CEMAC	US Dollar	Euro	CFA	Chinese RMB
beta	0.09	0.68	0.21	-0.26
t-statistic	0.72	1.86	0.46	-1.77
half_life, in months	-8.49	-1.33	-3.70	2.32
reversion speed, in years	-0.71	-0.11	-0.31	0.19

ECOWAS	US Dollar	Euro	CFA	Chinese RMB
beta	0.00	-0.33	-0.54	-0.29
t-statistic	-0.02	-2.39	-3.47	-2.54
half_life, in months	313.86	1.71	0.88	2.02
reversion speed, in years	26.16	0.14	0.07	0.17

Annex VII. ECOWAS excluding Nigeria

Real Exchange Rate for the ECOWAS zones (excluding Nigeria) using different numeraire currencies



Summary of Results of Purchasing Power Parity (Full Sample for ECOWAS, excluding Nigeria)

	Value Attribute	USD	Euro	CFA Franc	Chinese RMB
Method 1: ADF test	P-value	0.81	0.67	0.71	0.81
Method 2a: Co-Integration test	P-value	0.65	0.43	0.41	0.53
Method 2b: Absolute PPP test using equilibrium regression	F-stat	0.00	0.00	0.00	0.00
Method 2c: Relative PPP test using equilibrium regression	F-stat	0.00	0.00	0.00	0.00
Method 3a: Error Correction Model foreign prices adjustment	Coefficient (P-Value)	-0.01	-0.017*	-0.017*	-0.01
Method 3b: Error Correction Model domestic prices adjustment	Coefficient (P-Value)	0.00	0.00	0.00	0.01***
Method 4a: Unit Root test with panel data (common unit root)	P-value	0.00	0.00	0.00	0.00
Method 4b: Unit Root test with panel data (individual unit root)	Summary Results	Mixed	Yes	Yes	Yes
Method 5: Half-life	Coefficient (P-Value)	-0.03	-0.10	-0.44***	-0.02

**Note: Green highlights indicate evidence of PPP.*

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PUBLICATIONS

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