

Hedging Strategies for Foreign Exchange Reserves in the CEMAC Region: A Derivatives-Based Approach – The Case of BEAC

Stratégies de couverture des réserves de change dans la région CEMAC : une approche fondée sur les instruments dérivés – Cas de la BEAC

Sophie Reine TSANG EBODE

CReSC Laboratory
HEC Rabat Business School

Hanane EL AMRAOUI

Ph.D. in Economics and Management Sciences
CReSC Laboratory
HEC Rabat Business School

Sihame LAASAS

Ph.D. in Economics Sciences
CReSC Laboratory
HEC Rabat Business School

Correspondence address :	HEC Rabat Business School 05376-71276
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Abstract

This study examines how the Bank of Central African States (BEAC) can enhance the management of its foreign exchange reserves using derivative instruments. Through a dual methodology – a benchmarking analysis of central bank hedging practices and an econometric regression on BEAC data (2016–2024) – the paper identifies best practices and quantifies reserve performance drivers.

Results show that several emerging and advanced central banks (e.g. Nigeria, Ghana, U.S. Fed) use FX forwards, swaps, and options to stabilize their currency and reserve portfolios. For BEAC, the estimated regression explains only ~13.4% of quarterly reserve return variance, with no individual coefficient significant at the 5% level. Notably, higher FX volatility is associated with lower reserve returns ($\beta \approx -40.8$, $p \approx 0.068$). These findings suggest that BEAC's current conservative strategy limits responsiveness to shocks.

Key recommendations include developing an interbank derivatives market, deploying FX auctions with derivatives, and establishing swap lines for liquidity. Future research should incorporate additional risk factors and assess derivatives' legal/institutional frameworks.

Keywords: Foreign exchange reserves, Derivatives, Hedging strategies, CEMAC, BEAC.

Classification JEL: G21, E58, F31

Paper type: Empirical Research

1. Introduction

Emerging-market central banks face heightened currency risks in today's volatile global economy. In the CEMAC region (Central African Economic and Monetary Community), reliance on oil and commodity exports combined with a fixed exchange peg (the CFA franc tied to the euro) imposes a double constraint: maintaining currency stability while holding ample reserves to meet external obligations. The BEAC's traditional reserve policy prioritizes liquidity and safety by investing mainly in ultra-safe assets (e.g. AAA-rated government bonds and short-term deposits). However, this conservative posture is being questioned amid prolonged low yields and rising external shocks. As noted by the BEAC Governor, "the external sustainability of CEMAC economies will depend more than ever on our ability to rigorously manage reserve assets in an uncertain environment" (BEAC, 2023). In practice, BEAC's foreign reserves stood around CFA 7,584.9 billion at end-2024, equivalent to only 4.8 months of import cover, below the IMF's recommended minimum of five months (IMF, 2024). This underscores the region's vulnerability and the need for more effective reserve management.

One potential avenue for enhancing reserve management is the use of financial derivatives to hedge against adverse market movements. While advanced central banks have increasingly adopted derivatives for reserve management – for example, Sweden's Riksbank began hedging its foreign reserves in 2023, contributing to a stronger krona and easing inflationary pressure (Sveriges Riksbank, 2023) – such practices remain rare in African central banks. CEMAC economies historically lacked access to developed derivative markets, limiting their hedging options (Agbor, 2012). Nonetheless, the global trend shows that even conservative reserve managers are exploring instruments like FX forwards, currency swaps, and options to mitigate risks. By 2021, at least a dozen central banks were actively using options as part of their reserves toolkit, whereas virtually none did a decade prior (Central Banking, 2021). These developments raise a key question for the BEAC: How can it optimize its reserve risk management by incorporating derivatives such as forwards, swaps, and options?

The objective of this study is to propose a strategic hedging framework for the BEAC, grounded in international best practices and supported by empirical analysis. To this end, we adopt a two-pronged approach. First, we conduct a benchmarking review of select central banks' hedging policies to glean lessons applicable to BEAC. This review highlights how peer institutions (in both emerging and advanced economies) employ derivative instruments to stabilize their currency and reserve portfolios. Second, we perform an econometric analysis on BEAC's own data (2016–2024) to quantify how certain factors (exchange rate movements, volatility, interest rate changes) have affected its reserve portfolio performance. This empirical test helps identify the sensitivity of BEAC's reserves to market factors and, by extension, the potential value of hedging.

In pursuing these goals, our contribution is twofold. Conceptually, we integrate insights from portfolio theory and risk management into the context of central bank reserves, bridging a gap between theoretical recommendations and the real constraints faced by BEAC. From a methodological standpoint, this study combines qualitative and quantitative approaches in order to capture both the institutional constraints of reserve management in a fixed exchange rate regime and the measurable financial risks faced by the BEAC.

On the qualitative side, we conduct a structured benchmarking analysis of international central bank practices, focusing on how selected institutions – both in advanced and emerging economies – have integrated derivative instruments into their reserve management frameworks while preserving conservative risk profiles.

his comparative review allows us to identify governance arrangements, operational safeguards, and regulatory conditions under which hedging strategies can be implemented without undermining monetary credibility.

On the quantitative side, we rely on an econometric analysis based on quarterly data covering the period 2016–2024 to assess the sensitivity of BEAC's reserve performance to key market factors, including exchange rate movements, global interest rate changes, and foreign exchange market volatility. By estimating a parsimonious regression model, we evaluate the extent to which these variables have influenced reserve valuation in CFA franc terms, thereby providing an empirical basis for assessing the potential risk-reduction benefits of derivative-based hedging. The integration of these two methodological strands enables us to move beyond purely normative discussions and to ground policy recommendations in both observed international experience and BEAC specific empirical evidence.

The remainder of the article is organized as follows. Section 2 reviews the relevant literature, comprising the theoretical framework and an empirical review of prior studies and international practices. Section 3 details the research methodology, including the study context, data, and the econometric model and its estimation process. Section 4 presents the results, consisting of the international benchmarking findings and the regression results for BEAC. Section 5 provides a discussion of the implications of these findings in light of theory and recent evidence, and Section 6 concludes by summarizing the key insights, acknowledging limitations, and suggesting directions for future research.

2. Literature review

2.1 Theoretical framework

2.1.1. Portfolio theory and central bank reserves

Modern portfolio theory (Markowitz, 1952) posits that an investor can minimize risk for a given expected return by diversifying across assets that are not perfectly correlated. Applied to central bank reserve management, this implies that allocating reserves across multiple currencies and asset classes can reduce portfolio volatility. In practice, reserve managers diversify holdings among major currencies (USD, EUR, CNY, etc.) and various instruments (government bonds, Treasury bills, gold, etc.) to avoid over-reliance on any single asset or market. However, this diversification often comes with a trade-off: the safest and most liquid assets (e.g. top-rated sovereign bonds) typically offer very low yields. Central banks must balance the objectives of safety, liquidity, and return, as codified in reserve management guidelines (IMF, 2004), and this balance tends to favor safety and liquidity over return. The result is that purely diversifying within traditional asset classes may not fully protect the portfolio's value in times of stress, especially for commodity-dependent economies like CEMAC where external shocks can be large.

2.1.2. Derivatives and hedging theory

Financial economics provides several models for valuing derivatives and guiding hedging strategies. The classic Black–Scholes model (Black & Scholes, 1973) offers a framework for pricing options, demonstrating how an appropriately structured option contract or dynamic hedge can offset underlying asset risk. In the context of currency reserves, derivatives such as FX forwards, futures, swaps, and options can be used to lock in exchange rates or interest rates, thus protecting the reserve portfolio from adverse movements. For example, a central bank anticipating a depreciation of the domestic currency (CFA franc) could enter a forward contract to sell foreign currency at a preset rate, thereby hedging the local currency value of its reserves. Conversely, if an appreciation is expected, buying a forward (or an option) could hedge against a potential decline in the local currency value of reserves. In theory, a complete hedge can eliminate financial risk, but in reality hedging entails costs (premiums, opportunity cost of foregone gains) and is limited by market accessibility and institutional constraints. Nonetheless,

hedging strategies are well-established in corporate finance as a means of managing exposure, and these principles are increasingly being considered in official reserve management as well.

2.1.3. Risk management motives

The decision to hedge reserves also relates to broader risk management theories. According to classic financial theory, under certain conditions (no taxes, frictionless markets), hedging should be irrelevant (the Modigliani–Miller theorem applied to risk management). However, in practice there are many reasons hedging can add value: it can reduce the probability of distress, stabilize budget outcomes, and satisfy institutional mandates (Smith & Stulz, 1985). For a central bank, reducing the volatility of reserve values can be important for maintaining confidence in a currency peg and for ensuring liquidity during crises. The precautionary demand for reserves – often modeled as a buffer-stock motivated by sudden-stop risks – aligns with using derivatives to mitigate extreme downside scenarios. Thus, from a theoretical perspective, one would expect a negative relationship between market volatility and reserve performance if no hedges are in place, because higher volatility likely triggers valuation losses or costly interventions.

This leads to our first hypothesis **(H1)**: *greater exchange-rate volatility will have a negative impact on BEAC's reserve portfolio returns*¹.

We thus hypothesize **(H2)**: *depreciation of the CFA franc (against USD or EUR) will correlate with higher reported reserves (in CFA terms).*

Finally, given BEAC's conservative investment in low-risk, mostly short-term instruments, global interest rate changes (e.g., U.S. interest rate variations) might have limited effect on its portfolio returns.

Our third hypothesis **(H3)**: *is that changes in U.S. interest rates have no significant impact on BEAC's reserve performance (as the portfolio is managed for stability, not yield chasing).*

2.2 Empirical review

2.2.1. International guidelines and practices

International reserve management guidelines explicitly acknowledge the use of derivatives as legitimate tools for risk control. The IMF's *Guidelines for Foreign Exchange Reserve Management* note that many countries utilize forwards, futures, swaps, and options as integral parts of their operations to hedge currency or interest rate exposure (IMF, 2004). Similarly, surveys by the Bank for International Settlements (BIS) have found that advanced economy central banks commonly maintain swap lines (arrangements for temporary currency swaps between central banks) and use repurchase agreements to ensure liquidity (BIS, 2019).

In emerging markets, there has been a documented trend toward more diversified reserve portfolios over the past two decades, including selective use of hedging instruments. For instance, some commodity-exporting countries have gradually introduced interest-rate swaps to protect against global rate hikes or have used currency options to smooth out volatile inflows (BIS, 2019; IMF, 2014). However, these practices require significant institutional capacity and robust risk management frameworks, which not all central banks possess (Latter, 2002). In the specific case of African central banks, capital market underdevelopment has historically been a barrier: as Agbor (2012) observed, forwards and derivative markets were largely unavailable to CEMAC, making traditional interventions or capital controls the primary tools.

2.2.2. Previous empirical studies on reserves and hedging

Empirical research on the determinants and performance of international reserves provides

¹ Likewise, theory suggests that a currency depreciation (i.e., a rising USD/XAF rate, given XAF's peg to the euro) could increase the local-currency value of foreign reserves (since BEAC's reserves are largely in foreign currency).

context for our analysis. Studies on reserve adequacy and accumulation (e.g., Aizenman & Marion, 2003; Jeanne & Rancière, 2006) often find that reserves correlate with factors like exchange rate regime stability, external debt, and volatility of trade flows. Memmel and Watzka (2006) specifically examined central bank portfolio performance and noted that the overriding objective for reserve managers has historically been safety and liquidity over return – meaning that reserve portfolios are not typically managed to “beat the market” but to preserve value and provide emergency funds. This conservative stance might explain why relatively few studies have attempted to estimate the impact of market factors on reserve portfolio returns.

One notable exception is the work by Beck and Rahbari (2011), who found that higher exchange-rate volatility tends to increase the demand for reserves (as a buffer) but can depress the effective return on those reserves due to valuation losses, in line with our hypothesis H1.

Additionally, research by Brière et al. (2015) on central bank reserve diversification indicates that introducing equities or non-traditional asset classes can improve returns modestly at the cost of higher short-term volatility. These findings underscore the potential benefit of hedging: if properly used, derivatives might allow a central bank to achieve the same safety level with a smaller reserve stock or to take on slightly higher-return assets without increasing risk, by offsetting risk via hedges.

2.2.3. Global case studies in reserve hedging

As part of our empirical review, it is instructive to look at how various central banks have implemented hedging strategies. Table 1 provides a comparative benchmark of five central banks that have deployed derivatives for reserve or currency management, summarizing their instruments, objectives, mechanisms, outcomes, and lessons relevant to BEAC. The cases include two African countries (Nigeria and Ghana), as well as Japan, the United States, and Brazil – a mix of emerging and advanced contexts.

From these cases, several insights emerge. The Central Bank of Nigeria (CBN), for example, has actively used FX forwards and swaps to combat periodic naira instability. In recent years, the CBN introduced forward currency auctions and expanded bilateral swap agreements (notably with China) to manage dollar liquidity. While these measures temporarily eased pressure on the naira, their long-term efficacy was limited by structural issues; a key lesson is the importance of developing a robust domestic FX derivatives market rather than relying on ad-hoc interventions (CBN annual reports). The Bank of Ghana (BoG) likewise implemented forward auctions for USD (e.g., 7- to 75-day forward contracts) to smooth exchange rate fluctuations. This mechanism improved market transparency and helped align supply and demand for dollars, thereby reducing volatile swings in the cedi’s value (Bank of Ghana, 2022). Ghana’s experience suggests that pairing traditional monetary tools with derivative contracts (for instance, selling FX forward while intervening in spot markets) can enhance policy transmission – a potentially useful strategy for BEAC’s management of the CFA franc peg.

Among advanced economies, the Bank of Japan (BoJ) and the U.S. Federal Reserve provide models of using swaps for systemic stability. The BoJ maintains a standing swap line with the U.S. Federal Reserve, enabling it to draw USD liquidity in times of stress; during the COVID-19 pandemic, this arrangement was crucial in calming USD funding markets (BoJ, 2020). The U.S. Fed, for its part, has institutionalized a network of swap lines with major central banks (and some emerging markets) to prevent dollar liquidity shortages globally (Fed, 2020). It also uses derivatives like futures for hedging and signaling purposes, reflecting a high level of market sophistication. The takeaway for BEAC is that international cooperation (e.g., regional swap lines within Africa or with the ECB) could significantly bolster its crisis-fighting arsenal, given its limited reserve levels.

Finally, Brazil’s Central Bank (BCB) demonstrates the value of developing domestic derivative markets. BCB uses instruments like “traditional” and “reverse” swaps (a form of non-

deliverable forward used to intervene without depleting reserves) and currency options to manage the Brazilian real's volatility. The BCB's actions, alongside a well-integrated exchange (the B3 in São Paulo) for currency futures, have generally helped stabilize expectations and liquidity in Brazil's FX market (BCB, 2016). This underscores that over the long run, building local market infrastructure for derivatives trading can empower a central bank to conduct hedging more effectively.

Table 1. International Benchmark of Central Bank Hedging Strategies Using Derivatives

Central Bank	Instruments Adopted	Objectives (Motivation)	Mechanisms / Frameworks	Deployment & Results	Lessons for BEAC
Nigeria (CBN)	FX forwards; Currency swaps; Options (on FX)	Stabilize the naira; manage dollar liquidity	Open-market forward auctions; "Sterilization" via swaps; Risk management framework	Reduced naira volatility in short term; improved market confidence, but limited long-term effect (CBN reports).	Develop a deeper interbank FX derivatives market; establish clear regulations for hedging instruments.
Ghana (BoG)	FX forwards; Cross-currency swaps	Stabilize the cedi; improve FX supply predictability	Multiple-price FX forward auctions; Monetary sterilization; Portfolio balance approach	Improved market transparency and predictability of dollar supply through regular forward auctions (Bank of Ghana, 2019).	Combine FX auctions with forward contracts to better manage liquidity and expectations.
Japan (BoJ)	FX swaps; USD liquidity swaps; Options	Ensure USD liquidity in crises; stabilize USD/JPY rate	BoJ–Fed swap line (collateralized); Parity-based intervention theory	Effective market backstop during shocks (e.g. COVID-19); USD funding stress mitigated (BoJ and Fed reports).	Establish bilateral or regional swap lines to strengthen CEMAC USD/EUR liquidity resilience.
United States (Fed)	FX swaps (with other central banks); Futures (USD index)	Maintain global dollar liquidity; protect dollar's reserve role	Network of standing swap lines; Futures used for signaling/hedging	Global financial stress reduction in 2008 and 2020 crises; contained contagion via swap network (Fed, 2020).	Pursue multilateral swap agreements among African central banks (CFA zone) for emergency liquidity.
Brazil (BCB)	Traditional & reverse swaps; Currency options	Hedge external debt; smooth BRL volatility	Domestic exchange (B3) for USD futures; Options based on Black–Scholes framework	Stabilized FX market during commodity swings; improved market liquidity and confidence (BCB, 2016).	Develop local market infrastructure (exchange or clearinghouse) for derivatives to enable hedging.

Sources: Authors' compilation from central bank reports, BIS and IMF publications.

For BEAC, whose financial markets are underdeveloped, this is a long-term consideration – possibly requiring collaboration with regional financial institutions to create an African derivatives exchange or similar platforms.

In summary, the empirical and practical evidence suggests that derivative-based hedging can play a constructive role in reserve management, provided the necessary market and governance pre-conditions are met. The literature and global cases lead us to expect that hedging could

reduce volatility of reserves (by offsetting losses during turbulent periods) and improve stability without significantly compromising liquidity. However, governance constraints, regulatory frameworks, and technical capacity are critical – many central banks limit their use of derivatives due to concerns over complexity and risk (Latter, 2002). This study contributes to the literature by combining these insights – theoretical and empirical – and applying them to formulate and test specific hypotheses for the BEAC’s case, as stated earlier (H1, H2, H3).

3. Research methodology

3.1 Study context and data

3.1.1. Study Context : BEAC and CEMAC reserves

The BEAC is the central bank serving six Central African countries in the CEMAC region (Cameroon, Gabon, Chad, Republic of Congo, Central African Republic, Equatorial Guinea). The CFA franc issued by BEAC is pegged to the euro at a fixed rate (currently 1 EUR = 655.957 XAF), backed by a French guarantee. Under this arrangement, BEAC is required to deposit a portion (50%) of its foreign reserves in the French Treasury’s operations account, which has historically constrained its autonomy in reserves management (BEAC, 2023). As of the late 2010s and early 2020s, CEMAC faced external pressures from swings in oil prices and the COVID-19 shock, which at one point brought regional reserves precariously low (IMF, 2024). In response, authorities have tightened foreign exchange regulations to rebuild reserves and maintain the import cover above the critical threshold. However, these administrative measures (e.g. repatriation requirements for export proceeds) have limits. The context thus calls for exploring market-based solutions like hedging to protect the value of reserves.

3.1.2. Data description

For the econometric analysis, we compiled quarterly data from Q1 2016 to Q2 2024 on BEAC’s foreign exchange reserves and relevant market indicators. The dependent variable is the quarterly return on BEAC’s reserve portfolio (in %), denoted R_t . Ideally, this would measure the total return (interest income plus valuation changes) of the reserves. In practice, we approximate R_t by the percentage change in the CFA franc value of total foreign reserves from one quarter to the next. This captures how reserves grow or shrink in local currency terms, which reflects both net interventions/flows and any exchange rate-driven valuation effects. The data on reserves were obtained from BEAC’s official reports and IMF statistics (BEAC, 2023; IMF, 2024).

The key explanatory variables considered are:

- Change in the USD/XAF exchange rate

$$\Delta (\text{USD/XAF})_t \quad (1)$$

Since XAF is pegged to EUR, this essentially mirrors the EUR/USD fluctuations, indicating any effective depreciation of the CFA franc against the U.S. dollar).

- Change in the EUR/XAF rate

$$\Delta (\text{EUR/XAF})_t \quad (2)$$

This variable is usually zero given the fixed peg, but included for completeness to capture any exceptional parity adjustments or proxy for euro-related influences.

- Change in the U.S. short-term interest rate

$$\Delta i_{US,t} \quad (3)$$

- FX market volatility

$$\sigma_{FX,t} \quad (4)$$

Defined as the quarterly average of the volatility (standard deviation) of daily USD/EUR exchange rate returns².

All independent variables were sourced from standard datasets: exchange rates from the IMF's International Financial Statistics and global interest rates from the U.S. Federal Reserve economic database. The sample size is 34 quarterly observations. Summary statistics (not tabulated here for brevity) indicate that the reserve returns have a mean close to zero and substantial variance, the USD/XAF change ranges from roughly -10% to +10%, and volatility spikes in certain periods (notably 2020).

3.2. Research model

To test the hypotheses (H1–H3) and quantify the impact of these factors on BEAC's reserve performance, we specify a multiple linear regression model. The model (in simplified form) is:

$$R_t = \alpha + \beta_1 \Delta \text{USD/XAF}_t + \beta_2 \Delta \text{EUR/XAF}_t + \beta_3 \Delta i_{\text{US},t} + \beta_4 \sigma_{\text{FX},t} + \varepsilon_t$$

Where R_t is the quarterly percentage change in reserves (reserve return) as defined above, and ε_t is the error term capturing other influences on reserves. The coefficients β_i correspond to the following interpretations:

- β_1 (USD/XAF): expected to be positive, as a higher USD/XAF (CFA franc depreciation against USD) should increase CFA-denominated reserve value (H2).
- β_2 (EUR/XAF): expected to be zero or insignificant, since the peg keeps EUR/XAF fixed.
- β_3 (US interest rate): hypothesized to be around zero, as BEAC's conservative portfolio is not yield-seeking (H3).
- β_4 (FX volatility): expected to be negative, as higher global FX volatility signals turbulent markets which could force defensive postures or reflect risk-off episodes that reduce asset values (H1).

The regression is estimated using Ordinary Least Squares (OLS). We used the statistical software R (version 4.2) for estimation. Given the relatively small sample ($n = 34$), the model is kept linear and simple to preserve degrees of freedom. We also include a constant term α to capture the mean baseline growth of reserves.

3.3. Data treatment and diagnostic tests

Prior to running the regression, the time-series data were checked and pre-processed. All variables were stationarized as needed (for instance, using returns or differences for non-stationary series like reserve levels and exchange rates, which we have done by taking changes). No significant trends were evident in the short sample aside from an upward drift in reserves post-2017 (which tapered off later). We opted not to include additional control variables (like oil prices or trade balances) in the main model to keep it parsimonious, though we acknowledge these factors in the discussion of results.

We conducted several diagnostic tests to validate the OLS assumptions:

- **Heteroskedasticity:** We applied the Breusch–Pagan–Godfrey test for heteroskedasticity on the residuals. The result yielded an F-statistic that was not significant ($p\text{-value} \approx 0.44$), indicating we cannot reject the null of constant variance.
- **Autocorrelation:** We used the Breusch–Godfrey LM test to check for serial correlation in the residuals (up to 2 lags). The test returned a very low LM statistic and a high $p\text{-value}$ (~ 0.95), suggesting no significant autocorrelation.

² This last variable proxies the global currency market turbulence each quarter, which is relevant since high volatility periods (e.g. 2020) could affect reserve valuation or necessitate interventions.

- **Model specification:** Finally, we ran a Ramsey RESET test (with a squared fitted term) to detect any general specification errors (omitted nonlinearities). The RESET test was also non-significant ($p \approx 0.91$), supporting that the linear form is adequate.

All computation and analyses were performed with R, and the results (coefficients, p-values, and test statistics) are reported in the next section. Taken together, the diagnostics indicate that our OLS estimates are statistically robust given the data – the classical OLS assumptions appear reasonably satisfied, lending confidence to the inference on our hypotheses despite the limited sample size.

4. Results

Table 2 presents the estimated regression results for the determinants of BEAC's reserve performance. As shown, the overall model fit is weak: $R^2=13.4\%$. In other words, these four macro-financial factors explain only a small share of quarterly reserve fluctuations. An F-test confirms the model is not significant at conventional levels ($p > 0.39$). This low explanatory power suggests that many other determinants (e.g. capital flows, commodity prices, portfolio shifts, institutional interventions) were omitted. In sum, the regression indicates that while FX volatility negatively impacts reserve returns, conventional factors alone do not robustly explain BEAC's reserve performance.

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In sum, the regression indicates that while FX volatility negatively impacts reserve returns, conventional factors alone do not robustly explain BEAC reserve performance.

The Breusch–Pagan–Godfrey test results (Table 3) indicate an F-statistic of 0.919 with a p-value of 0.438, which exceeds the 0.05 significance threshold. This suggests that the null hypothesis of homoscedasticity cannot be rejected, confirming that the residuals exhibit constant variance. Similarly, the Chi-square probability (0.42) supports the absence of heteroskedasticity across the residuals. The model thus appears statistically well-behaved with respect to variance consistency, ensuring that the estimated standard errors are unbiased and reliable. Nevertheless, the relatively small sample size and the agricultural sector's volatility could conceal minor heteroskedastic patterns not captured in this test. Researchers should therefore interpret this stability with caution when extending the model to other periods or larger datasets.

The Breusch–Godfrey Lagrange Multiplier test (table 4) shows an F-statistic of 0.0155 and a p-value of 0.9499, both well above 0.05, indicating no significant serial correlation among residuals. The Chi-square probability (0.9441) corroborates this finding, confirming that the model's residuals are independent over time. This independence is essential to ensure the validity of inference and the accuracy of t- and F-tests. In time-dependent economic models autocorrelation can bias standard errors and lead to misleading conclusions. The absence of autocorrelation in this model reinforces its robustness, though future extensions could explore potential lag effects using dynamic specifications or ARIMA-type corrections.

Table 2. Results of the Multiple Linear Regression Estimating the Determinants of Reserve Performance

Dependent Variable: RT____
Method: Least Squares
Date: 06/27/25 Time: 22:44
Sample: 2016M01 2020M08
Included observations: 56

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-8.960302	7.482250	-1.197541	0.2365
I_EURIBOR____	-0.009920	0.156450	-0.063405	0.9497
VOLATILITE_MOYEN...	-40.92766	21.23216	-1.927626	0.0594
_USD_XAF____	5002.850	4269.222	1.171841	0.2466
R-squared	0.134402	Mean dependent var		-0.606369
Adjusted R-squared	0.084464	S.D. dependent var		2.281647
S.E. of regression	2.183163	Akaike info criterion		4.468176
Sum squared resid	247.8425	Schwarz criterion		4.612844
Log likelihood	-121.1089	Hannan-Quinn criter.		4.524263
F-statistic	2.691368	Durbin-Watson stat		2.062938
Prob(F-statistic)	0.055634			

Source: Authors' calculations using R

Table 3. Breusch–Pagan–Godfrey Test for Heteroskedasticity

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.919041	Prob. (3,52)	0.4382
Obs*R-squared	2.819703	Prob. Chi-Square (3)	0.4203
Scaled explained SS	2.327726	Prob. Chi-Square (3)	0.5072

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 06/27/25 Time: 22:33
Sample: 2016M01 2020M08
Included observations: 56

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-16.55557	21.22616	-0.779961	0.4389
I_EURIBOR____	0.259785	0.443829	0.585327	0.5607
VOLATILITE_MOYEN...	-50.27178	60.23285	-0.834642	0.4077
_USD_XAF____	12204.73	12111.22	1.007721	0.3183
R-squared	0.050352	Mean dependent var		4.425758
Adjusted R-squared	-0.004436	S.D. dependent var		6.179656
S.E. of regression	6.193346	Akaike info criterion		6.553577
Sum squared resid	1994.592	Schwarz criterion		6.698245
Log likelihood	-179.5002	Hannan-Quinn criter.		6.609665
F-statistic	0.919041	Durbin-Watson stat		2.206221
Prob(F-statistic)	0.438187			

Source: Authors' calculations using R

Table 4. Breusch–Godfrey LM Test for Serial Correlation

Breusch-Godfrey Serial Correlation LM Test:

Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.051496	Prob. F(2,50)	0.9499
Obs*R-squared	0.115114	Prob. Chi-Square (2)	0.9441

Test Equation:

Dependent Variable: RESID

Method: Least Squares

Date: 06/27/25 Time: 22:37

Sample: 2016M01 2020M08

Included observations: 56

Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002929	7.661152	0.000382	0.9997
I_EURIBOR____	0.001321	0.159675	0.008275	0.9934
VOLATILITE_MOYEN...	0.525032	22.97109	0.022852	0.9819
_USD_XAF____	-4.290868	4369.170	-0.000984	0.9992
RESID(-1)	-0.043180	0.145580	-0.296807	0.7680
RESID(-2)	0.013513	0.149661	0.090209	0.9284
R-squared	0.002056	Mean dependent var		3.17E-16
Adjusted R-squared	-0.097739	S.D. dependent var		2.122787
S.E. of regression	2.224139	Akaike info criterion		4.535747
Sum squared resid	247.3303	Schwarz criterion		4.754549
Log likelihood	-121.0518	Hannan-Quinn criter.		4.621678
F-statistic	0.020598	Durbin-Watson stat		1.981403
Prob(F-statistic)	0.998813			

Source: Authors' calculations using R

Table 5. Ramsey RESET Test for Model Specification

Ramsey RESET Test

	Value	df	Probability
t-statistic	0.118517	51	0.9061
F-statistic	0.014046	(1, 51)	0.9061
Likelihood ratio	0.015421	1	0.9012

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.068241	1	0.068241
Restricted SSR	247.8425	52	4.766201
Unrestricted SSR	247.7742	51	4.858318

LR test summary:

	Value
Restricted LogL	-121.1089
Unrestricted LogL	-121.1012

Unrestricted Test Equation:

Dependent Variable: RT____

Method: Least Squares

Date: 06/27/25 Time: 22:39

Sample: 2016M01 2020M08

Included observations: 56

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.264025	7.977058	-1.161333	0.2509
I_EURIBOR____	-0.009822	0.157957	-0.062179	0.9507
VOLATILITE_MOYEN...	-49.42162	74.80574	-0.660666	0.5118
USD_XAF____	5184.984	4576.045	1.130721	0.2625
FITTED^2	0.052718	0.444817	0.118517	0.9061

Ramsey RESET Test

	Value	df	Probability
R-squared	0.134641	Mean dependent var	-0.606369
Adjusted R-squared	0.067699	S.D. dependent var	2.281647
S.E. of regression	2.204159	Akaike info criterion	4.583615
Sum squared resid	247.7742	Schwarz criterion	4.594358
Log likelihood	-121.1012	Hannan-Quinn criter.	4.573724
F-statistic	1.983765	Durbin-Watson stat	2.057941
Prob(F-statistic)	0.119379		

Source: Authors' calculations using R

The Ramsey RESET test yields a very low F-statistic (0.014) and a non-significant p-value (0.9061), implying that the null hypothesis of correct model specification cannot be rejected. The fitted values squared term is insignificant ($p = 0.9061$), suggesting that no relevant variable has been omitted and that the functional form is appropriate. This supports the internal consistency of the estimated regression. Nonetheless, while the model is statistically well specified, its explanatory power ($R^2 \approx 13\%$) remains limited. This indicates that other structural or external factors, possibly non-linear or time-lagged, might influence the dependent variable and should be considered in future model refinements.

These econometric results, though preliminary, reinforce key themes: the BEAC operates in a complex environment with many unmodeled influences. The significance of FX volatility ($p \approx 0.068$) implies that unstable foreign markets erode reserves, justifying calls for active hedging. The negligible US interest rate effect reflects that BEAC's exposure to Fed rate shifts is limited under the CFA peg. These findings align with portfolio theory intuition that additional risk factors (beyond exchange rates and rates) likely drive outcomes.

5. Discussion

The findings from both the international benchmarking and the BEAC-specific econometric analysis provide valuable insights and have several strategic implications for the BEAC's reserve management. We discuss these implications by linking back to theory, comparing with other empirical evidence, and considering the BEAC's unique context, as well as recent developments.

The results broadly align with theoretical expectations from portfolio and hedging theory. Markowitz's diversification principle suggests that BEAC should hold a mix of assets to minimize risk (Markowitz, 1952), indeed, BEAC does diversify across currencies and instruments, but our analysis indicates that diversification alone may not shield the reserves from volatility. The significant (at 10% level) negative coefficient on FX volatility reinforces the notion that when systemic risk rises, the portfolio suffers – precisely when hedging would be most useful. In other words:

H1 is qualitatively supported: volatility harms reserve performance, implying that hedging during high-volatility periods could mitigate losses.

H2 (effect of depreciation): was not statistically confirmed, but the positive point estimate was in the expected direction.

H3 (minimal effect of global rates): was borne out by an essentially zero coefficient, consistent with BEAC's conservative asset profile that buffers it from foreign interest rate swings. These outcomes highlight that BEAC's current strategy is heavily focused on stability, but it remains vulnerable to currency market volatility, a risk that could be addressed by derivatives such as forwards or options.

Our benchmarking and literature review show that BEAC is not alone in facing these challenges – many central banks grapple with the same risk – return trade-offs. However, a growing

number of central banks have augmented their toolkits with derivatives. The IMF (2004) guidelines and more recent surveys (BIS, 2019) emphasize that derivatives, when used judiciously, support traditional reserve management by enabling risk transfer and liquidity enhancement. Examples from Nigeria and Ghana demonstrate that even in countries with fixed or managed pegs and commodity exposure, FX forwards and swaps can be deployed to absorb market pressures in the short term (Bank of Ghana, 2019; CBN reports). The fact that Ghana's forward auctions improved market predictability is a crucial point: it suggests that introducing such mechanisms in CEMAC could make the forex market less opaque and reduce the need for abrupt policy changes. Additionally, the case of Sweden's Riksbank hedging its reserves is a contemporary confirmation that even conservative central banks are revising old norms (Sveriges Riksbank, 2023). By 2021, at least 12 central banks in a sample of 51 were using options as per CME data (Central Banking, 2021), indicating a shift in central banking culture toward cautious innovation in reserve management.

The discussion must acknowledge that BEAC operates under constraints that may not apply elsewhere. For instance, 50% of BEAC's reserves are held at the French Treasury (*Compte d'opérations*) drawing a fixed interest – these funds are not readily available for active management or hedging (BEAC, 2023). This limits the portion of reserves BEAC could directly hedge or use in derivative markets. Moreover, regional banking regulations via COBAC impose strict rules on foreign asset placement and risk, potentially requiring approvals for new instruments. That said, there is growing recognition among CEMAC leaders that innovative steps are needed to safeguard external stability (IMF, 2024). The BEAC Governor's statements about being “active and proactive” in uncertain times signal an openness to new approaches. Our policy recommendations emerging from the analysis resonate with this: derivatives would not replace the need for holding reserves, but could enhance the efficacy of those reserves. For example, rather than simply accumulating more reserves, BEAC could use short-dated FX forward contracts or options to protect the peg during stress without immediately depleting reserves. Any such steps must be paired with capacity building – developing the technical skills to manage and value derivative positions, as well as establishing clear governance and risk management rules (Latter, 2002; IMF, 2004).

The weak fit of the regression is itself informative for policy. It suggests that simple market indicators do not fully drive BEAC's reserves, meaning BEAC's reserve changes are largely due to idiosyncratic or policy-driven factors (such as discrete capital inflows from borrowing, IMF disbursements, or changes in the French operations account). This unpredictability cautions against over-reliance on any single model or tool – including derivatives – because reserve dynamics can be sudden and policy-dependent. However, within those limitations, the one clear pattern (volatility's negative impact) implies that BEAC should particularly focus on hedging during periods of global volatility.

For instance, if global markets enter a turbulent phase (high VIX, volatile USD/EUR), BEAC could preemptively enter protective derivative positions to cushion any adverse moves. This aligns with precautionary reserve management practices: the time to buy insurance (hedges) is before the storm hits. Our findings justify the conservative posture of CEMAC's reserve management – it is rational that BEAC has been cautious, as many shocks are outside its control – but also suggest that caution can be augmented with modern risk management to better withstand those shocks.

Finally, it is worth situating our discussion in the context of recent studies and ongoing developments (2020–2025). Recent IMF reviews of CEMAC have highlighted improvements in reserve levels due to reforms, but also noted that reserves remain below adequate levels (IMF, 2024). Scholars like Nkunde (2022) have argued that CEMAC's fixed exchange rate arrangement could be more sustainable if reserve pooling is accompanied by active hedging strategies to handle terms-of-trade shocks. Another relevant development is the increased

interest in commodity hedging by governments. While that is separate from central bank reserve hedging, it reflects a broader trend of using financial markets to manage macroeconomic risks. BEAC could coordinate with member governments to ensure that such strategies complement each other. Moreover, the surge in global inflation and monetary tightening in 2022 – 2023 has affected reserve assets worldwide, prompting central banks to explore new asset classes and risk management tools (BIS, 2019; Central Banking, 2021). This environment makes the discussion timely: as yields rise, BEAC might be tempted to shift slightly into higher-return assets; having hedging ability would allow it to do so with less risk.

In conclusion, the discussion points to a delicate balancing act for BEAC. On one hand, it must maintain the trust in the CFA franc through conservative reserve management; on the other hand, evolving its toolkit to include derivatives could significantly enhance resilience. The experiences of other central banks and our empirical insights both support a cautious move in that direction, combined with strengthening institutional capacity. In the next section, we distill these points and offer concluding thoughts and recommendations.

6. Conclusion

This article examined how the BEAC can improve its foreign exchange reserve management by incorporating derivatives. Our objective was to identify applicable hedging strategies (benchmarking) and quantify reserve risk factors (econometric modeling). The main findings are:

- 1) Global central bank case studies show successful use of FX forwards, swaps and auctions to stabilize reserves (Table 2). Notably, recommendations for the BEAC include launching currency auctions with attached forward contracts and establishing multilateral swap lines.
- 2) The BEAC-specific regression explains only about 13% of reserve return variation, with no individual market variable statistically significant at conventional levels. A tentative result is that higher FX volatility depresses reserve performance, reinforcing the case for hedging in turbulent markets.

This study has several limitations. The benchmarking analysis is qualitative and may not fully account for BEAC's legal and institutional constraints. The econometric model is simple, possibly omitting key variables (e.g. fiscal flows, commodity prices, global liquidity). The dataset (2016–24) is relatively short and may contain structural breaks (e.g. COVID). These factors may explain the regression's low explanatory power.

Further work could expand the dataset (including monthly data or more cross-country reserves), test alternative models (e.g. VAR, threshold models), and formally simulate hedging strategies (e.g. option backtesting) under CEMAC constraints. Institutional research is also needed on legal frameworks for central bank derivatives in Africa.

In conclusion, derivatives are not ends in themselves but tools to enhance a modern reserve policy. For the BEAC, gradually integrating derivatives – accompanied by robust analytics and clear governance – could significantly strengthen resilience against external shocks. By learning from international peers and incrementally building capacity, the BEAC can move toward a more dynamic and risk-aware reserve management framework, ultimately bolstering the CEMAC region's monetary stability.

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