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Financial Fragility and Exchange Rate Volatility in Haiti: Evidence from Structural Breaks and VECM Analysis

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Abstract

This study investigates the determinants and dynamics of exchange rate volatility in Haiti over the period 1996 to 2024, within the broader context of financial fragility in small open economies. Using annual macroeconomic data and a multi-stage econometric framework that combines Ordinary Least Squares (OLS), Bai-Perron structural break tests, and a Vector Error Correction Model (VECM), the paper examines how inflation, money supply growth, remittance inflows, GDP growth, and lagged volatility influence currency fluctuations. The Bai-Perron analysis identifies a major structural break in 2002, marking a shift between distinct volatility regimes shaped by institutional change and macroeconomic policy adjustment. The VECM results confirm a stable long-run cointegrating relationship among the variables, while short-run dynamics indicate that inflation, remittances, and past volatility exert significant effects on exchange rate movements. Using this integrated approach, the study highlights how structural fragility amplifies the impact of macroeconomic shocks on currency stability. The findings underscore the need for credible monetary policy, remittance integration strategies, and stronger institutional governance to mitigate exchange rate instability in Haiti and other fragile economies facing persistent external and domestic pressures.

Keywords

Exchange Rate Volatility, Financial Fragility, Haiti, Remittances, Inflation, Monetary Policy, Structural Breaks, VECM

1. Introduction

Haiti's macroeconomic landscape has long been shaped by entrenched structural weaknesses, chronic instability, and recurring shocks that collectively sustain a

fragile financial system. Financial fragility, defined as the economy's limited capacity to absorb shocks without triggering cascading disruptions in key financial and economic sectors, extends beyond transient market risk. It includes systemic vulnerabilities embedded in weak institutions, shallow financial markets, and constrained policy space. In Haiti, these conditions are compounded by protracted political unrest, frequent natural disasters, volatile remittance inflows, and a lack of robust monetary policy instruments, resulting in a macro-financial environment prone to persistent and destabilizing exchange rate fluctuations. To empirically capture this concept, the study adopts common proxies from the literature on small, open economies, including reserve adequacy, inflation volatility, and financial sector depth (Laeven & Valencia, 2018; Kaufmann et al., 2010)

The importance of exchange rate volatility in this context stems from its role as both a signal and an amplifier of economic uncertainty. In fragile economies like Haiti, exchange rate dynamics reflect not only the balance of macroeconomic fundamentals but also the credibility and resilience of institutions. Currency instability often heightens inflation expectations, discourages investment, and distorts resource allocation, thereby deepening financial fragility. The Haitian gourde's pronounced fluctuations, often detached from inflation or output dynamics, indicate a breakdown in monetary transmission and reflect deeper imbalances in the country's external and financial accounts.

Previous empirical work has explored various aspects of exchange rate behavior in Haiti. Jeanniton (2013) applied a remittance-augmented monetary model to demonstrate how domestic money supply and price levels shape nominal exchange rate outcomes. Prophete and Augustin (2022) examined the real exchange rate implications of remittances, suggesting appreciation effects driven by consumption demand. Díaz-Bonilla et al. (2021) and Pierre (2022) emphasized inflation pass-through and competitiveness challenges as key drivers of nominal exchange rate changes. While these studies enrich understanding of price-level movements, they largely overlook the stochastic behavior of exchange rates, particularly volatility, and its implications for macroeconomic stability and financial resilience.

The omission of volatility modeling is particularly significant given the structural evolution of Haiti's economy over the past three decades. Since the adoption of a floating exchange rate regime in 1991, the country has experienced episodes of high inflation, monetary instability, and fluctuating remittance inflows. The choice of 1996 as the start of the estimation period reflects both the availability of consistent data following the implementation of a rolling volatility measure and a new phase of post-liberalization adjustment in Haiti's monetary and financial policy environment. Yet few studies have quantified how these factors interact to influence the time-varying nature of exchange rate volatility or how regime shifts may structurally alter these relationships. This study seeks to bridge this gap by applying an integrated empirical framework that combines rolling-window volatility estimation, Bai Perron structural break tests, and a Vector Error Correction

Model (VECM) to explore both the short-run and long-run dynamics of exchange rate volatility in Haiti.

The paper focuses on key macroeconomic determinants, including GDP growth, inflation, broad money (M2) growth, and remittances, and introduces a regime dummy to account for the 2002 structural break identified through Bai Perron testing. By modeling volatility using squared log returns over a five-year moving average, the study captures both temporary shocks and persistent structural changes in financial behavior.

This paper contributes to the literature by integrating structural fragility, remittances, and exchange rate volatility within a unified empirical framework. It provides new evidence from Haiti, a small remittance-dependent economy, demonstrating how institutional weakness and external shocks jointly shape exchange rate dynamics. The findings extend previous work on fragile states by linking volatility persistence to macro-financial fragility and institutional constraints.

This research further emphasizes the role of coordinated monetary, fiscal, and external sector policies in containing volatility and mitigating systemic risk. For Haiti, where policy credibility is often weak and institutional response capacity limited, understanding volatility drivers is essential for designing resilient macro-financial frameworks.

The remainder of this paper is organized as follows: Section 2 reviews the literature and outlines the study's hypotheses. Section 3 describes the data sources and empirical strategy, including the econometric models employed. Section 4 presents the empirical findings and discusses their implications. Section 5 concludes with key policy recommendations and avenues for future research.

2. Literature Review and Hypothesis Development

2.1. Financial Fragility and Exchange Rate Volatility

Financial fragility refers to the systemic vulnerability of an economy to shocks that can disrupt the stability of its financial system. Unlike transient volatility, financial fragility reflects a deeper structural weakness manifested through limited fiscal space, underdeveloped financial markets, and weak institutional quality. In the context of Haiti, these characteristics are well documented. The country's persistent dependence on foreign aid, high debt ratios, and limited central bank autonomy underscore its susceptibility to both internal and external shocks.

Empirical research on fragile states emphasizes how these institutional and macroeconomic weaknesses heighten exchange rate volatility. For instance, Kaminsky & Reinhart (2000) and Rancière, Tornell, & Westermann (2008) demonstrate that fragile economies lack the institutional buffers necessary to absorb volatility-inducing shocks, leading to amplification rather than absorption of disturbances. Obstfeld & Rogoff (1995) highlight how incomplete markets and imperfect capital mobility in small open economies can intensify the effects of global shocks on domestic exchange rates. Calvo & Reinhart (2002) further show that countries with weak financial institutions often experience "fear of floating",

where exchange rate movements are constrained not by policy rules but by fragility in the financial sector. Similarly, Hausmann, Panizza, & Stein (1999) argue that balance sheet mismatches and limited access to hedging instruments make developing economies highly vulnerable to currency mismatches and capital flow reversals, fueling exchange rate instability.

Ghosh et al. (2002) extend this line of reasoning by demonstrating that macroeconomic fundamentals, particularly inflation and monetary imbalances, are more likely to induce volatility in institutional contexts where policy credibility is low. In Haiti, these dynamics manifest in recurrent exchange rate shocks triggered by inflationary pressures, remittance fluctuations, and monetary overhang, all of which are amplified by weak fiscal and monetary governance.

Comparative evidence from Caribbean and Latin American economies reinforces these findings. For instance, studies on Jamaica and the Dominican Republic (Lena, 2022; Carrière-Swallow et al., 2022) show that limited financial depth and fiscal dependence heighten exchange rate volatility. Similarly, Díaz-Bonilla et al. (2021) find that remittance dependence amplifies volatility in low-governance settings. These regional patterns position Haiti within a broader context of macro-financial fragility, where institutional weakness interacts with external shocks to shape exchange rate outcomes.

Finally, structural change methodologies such as those proposed by Bai and Perron (2003) are valuable for detecting regime shifts that correspond to transitions in macroeconomic fragility. These shifts often mark turning points in the relationship between institutional weakness and exchange rate behavior.

This paper therefore positions Haiti's exchange rate volatility not as an isolated statistical phenomenon but as a manifestation of systemic fragility, requiring a more nuanced macro-financial interpretation.

2.2. GDP Growth and Exchange Rate Volatility

GDP growth plays a dual role in shaping exchange rate dynamics in emerging markets. Sustained economic growth signals macroeconomic health, attracts investment inflows, and reinforces currency stability. According to models such as the Mundell-Fleming framework, economies with stable output are more likely to draw external capital, thereby reducing the likelihood of currency fluctuations. Empirical studies by Hausmann, Panizza, & Stein (1999), Calderón and Schmidt-Hebbel (2008), and Easterly and Kraay (2000) have shown that stronger and more consistent growth performance is associated with reduced macroeconomic and exchange rate volatility, particularly in small and fragile economies. In Haiti's context, where growth has been persistently low and erratic, this lack of consistent expansion undermines the currency's resilience to external shocks.

The volatility of GDP growth itself is an additional source of macro-financial vulnerability. Research by Furceri, Loungani, and Ostry (2019) emphasizes that frequent output swings are more destabilizing than merely low growth averages. Economies subject to "growth busts" are particularly exposed to sudden depreci-

ation episodes. Furthermore, in fragile states such as Haiti, institutional weaknesses may prevent productive sectors from responding effectively to growth momentum, thereby weakening the transmission from real economic performance to currency stability.

H1: Higher and more stable GDP growth reduces exchange rate volatility.

2.3. Inflation and Exchange Rate Volatility

Inflation is one of the most potent sources of exchange rate volatility, particularly in economies with weak monetary anchors. According to the overshooting hypothesis proposed by Dornbusch (1976), unanticipated inflation shocks cause disproportionate changes in exchange rates as investors revise their expectations. This theory remains highly relevant in low-income countries where policy credibility is limited. Ghosh, Levin, Macmanus, & Wolf (2002) and the International Monetary Fund (2016) both find a positive relationship between inflation and currency fluctuations in developing nations.

However, the relationship between inflation and volatility depends critically on how well expectations are anchored and on the credibility of monetary authorities. Countries with formal inflation-targeting frameworks, such as Chile and South Africa, have demonstrated that even moderate inflation rates can coexist with exchange rate stability when policy credibility is high. Roger (2010) reviews two decades of inflation-targeting experiences worldwide and concludes that credible inflation-targeting regimes reduce both price volatility and exchange rate instability by strengthening expectations management. In contrast, Haiti's monetary framework, which lacks an explicit inflation target and operates under fiscal dominance, allows inflation shocks to amplify volatility. The nature of monetary institutions therefore plays a decisive role in moderating this relationship.

H2: Higher inflation is associated with greater exchange rate volatility.

2.4. Broad Money Growth and Exchange Rate Volatility

Monetary expansion, particularly unsterilized growth in M2, can introduce excess liquidity that destabilizes foreign exchange markets. According to monetarist theory (Friedman, 1953), rapid money growth not aligned with output can create inflationary pressure, depreciate the currency, and increase volatility. In fragile economies with underdeveloped financial markets, this effect is even more pronounced. Hnatkovska and Loayza (2019) note that excess liquidity in low-income countries often spills into currency markets due to limited domestic absorption capacity.

However, the institutional context matters. Ito and Mishkin (2006) show that the effects of monetary growth depend on the strength of financial supervision and sterilization capacity. In countries where central banks are autonomous and operate under inflation-targeting regimes, money growth can be managed without destabilizing exchange rates. For Haiti, where monetary growth may be driven by fiscal monetization and external imbalances, the risk of volatility increases significantly.

H3: Accelerated growth in broad money (M2) increases exchange rate volatility, especially in low-capacity monetary regimes.

2.5. Remittances and Exchange Rate Volatility

Remittances are a double-edged sword. While they offer a stable source of external financing and reduce current account deficits, their effects on exchange rate volatility depend on their cyclicality and concentration. Ratha (2003) posits that remittances help smooth consumption and support currency stability. Empirical work by Bugamelli and Paterno (2009) finds that countries with higher remittance-to-GDP ratios exhibit lower exchange rate volatility during external shocks.

Nevertheless, if remittance inflows are highly procyclical or concentrated in a few source countries, they may become a transmission channel for foreign volatility. Combes and Ebeke (2021) show that in fragile states, remittances can exacerbate volatility when global or diaspora economic conditions change abruptly. For Haiti, the reliance on the U.S. and Canada for remittances creates exposure to labor market conditions in those economies. Additionally, speculative remittance-driven consumption can fuel monetary expansion and exchange market pressure.

H4: Greater and stable remittance inflows reduce exchange rate volatility, but volatile remittance patterns may amplify risk.

2.6. Lagged Volatility and Exchange Rate Volatility

Volatility clustering is a well-documented empirical regularity in financial markets. According to Engle (1982) and Bollerslev (1986), periods of high exchange rate volatility are likely to be followed by further high volatility due to inertia in investor behavior and information dissemination. This persistence has been observed in both developed and developing economies, indicating that lagged volatility is a robust predictor of current volatility.

In Haiti's context, where political uncertainty, external shocks, and speculative behaviors are recurrent, volatility persistence may be particularly strong. Incorporating lagged volatility in the model captures this inertia and provides a more accurate representation of real-world dynamics. The inclusion of this term also aligns with GARCH-based modeling, enhancing the credibility of linear estimation approaches.

H5: Past volatility significantly predicts current exchange rate volatility due to persistence and clustering effects.

Table 1 shows the description of the variables included in this study and their expected effect.

Table 1. Description of variables and expected relationship.

Variable	Corresponding Determinant	Measure	Expected Relationship
Exchange Rate Volatility (VOL)	Market Risk	5-year moving average of squared log returns	(*Dependent variable*)

Continued

GDP Growth (GDP)	Economic Activity	Annual % change in real GDP	Negative (↑ GDP ⇒ ↓ volatility)
Inflation (INF)	Price Stability	Annual % change in CPI	Positive (↑ INF ⇒ ↑ volatility)
Broad Money Growth (M2)	Monetary Conditions	Annual % change in M2	Positive (↑ M2 ⇒ ↑ volatility)
Log Remittances (log_REM)	External Financial Inflows	Natural log of remittance inflows (US$)	Negative (↑ log_REM ⇒ ↓ volatility)
Lagged Volatility (VOL_{t-1})	Persistence in Risk	One-period lag of exchange rate volatility	Positive (↑ VOL_LAG ⇒ ↑ volatility)

3. Data and Methodology

3.1. Data Description

This study employs annual data for Haiti covering the period 1990-2024. The starting point is motivated by the country's exchange rate regime history: in January 1990, Haiti shifted from a fixed or heavily managed system to a floating regime, and by September 1991, all foreign exchange transactions were conducted at the interbank market rate (IMF, 1992). Under a floating system, the exchange rate is determined primarily by market forces, making volatility both endogenous and economically significant. Beginning the dataset in 1990 allows the study to capture the full liberalization episode and its macroeconomic implications, while extending to 2024 incorporates the most recent developments and potential structural breaks.

The data are drawn from reputable international sources, including the World Bank's World Development Indicators, the International Monetary Fund (IMF), and the Bank of the Republic of Haiti (BRH). The analysis focuses on modeling exchange rate volatility in relation to key macroeconomic determinants, with all estimations conducted using R software. The variables are defined as follows:

- Exchange Rate Volatility (VOL): Measured as the five-year rolling average of the squared logarithmic returns of the nominal exchange rate (HTG/USD).
- GDP Growth (GDP): The annual percentage change in real gross domestic product, reflecting the level of economic activity.
- Inflation (INF): Measured as the annual percentage change in the Consumer Price Index (CPI), capturing price stability.
- Broad Money Growth (M2): The annual growth rate of the M2 monetary aggregate, used as a proxy for monetary policy stance and liquidity.
- Personal Remittances (log_REM): The natural logarithm of remittance inflows in U.S. dollars, a transformation used to correct skewness and heteroscedasticity.
- Lagged Exchange Rate Volatility (VOL_{t-1}): A one-period lag of VOL, included

to capture the persistence of volatility over time.

Due to the construction of the rolling volatility measure and the inclusion of a lagged volatility term, the first complete set of observations is available from 1996. Consequently, the effective estimation sample spans 1996-2024, providing 29 annual observations. This period encompasses Haiti's experience under a liberalized exchange rate regime, including major macroeconomic shocks, episodes of policy adjustment, and structural transitions in the economy.

Note on Data Frequency

The use of annual data provides a stable view of long-run structural trends and minimizes noise from short-term fluctuations. Although higher-frequency data (e.g., quarterly) might offer more detailed insights into short-term dynamics, such datasets are either incomplete or inconsistently reported for Haiti. Thus, the reliance on annual data is both methodologically justified and pragmatically necessary for a study of this scope.

3.2. Construction of the Dependent Variable: Exchange Rate Volatility

To proxy for exchange rate volatility, the study computes:

$$R_t = \log\left(\frac{EX_t}{EX_{t-1}}\right)$$

$$VOL_t = \frac{1}{5}\sum_{i=0}^{4} R_{t-i}^2$$

where R_t is the logarithmic return of the exchange rate, and VOL_t is the 5-year rolling average of the squared returns. This smoothed volatility measure reduces short-term noise and better reflects sustained patterns in market risk.

3.3. Empirical Methodology

This section outlines the econometric strategies adopted to evaluate the relationship between macroeconomic fundamentals and exchange rate volatility in Haiti, a proxy for financial fragility in small open economies. While most prior studies on Haiti have concentrated on modeling the level of the exchange rate, this research extends the inquiry by focusing on volatility, capturing the time-varying risks embedded in a fragile macro-financial environment.

The empirical framework is conceptually inspired by Jeanniton (2013), who employed a structural macroeconomic approach to analyze nominal exchange rate movements. Although Jeanniton's model was not designed to capture exchange rate volatility, its inclusion of key macroeconomic variables such as money supply, inflation, and external inflows provides a foundational structure relevant to this study's focus. Here, we adapt and expand this approach by incorporating volatility measures, persistence dynamics, and structural break analysis, thereby transforming a static price-level model into a dynamic volatility-based framework that is more suitable for evaluating systemic fragility.

To uncover both short- and long-term drivers of exchange rate volatility, we employ a multi-stage methodology combining static and dynamic models. Ordinary Least Squares (OLS) regression provides a baseline estimation, while structural break tests detect regime-dependent shifts in volatility behavior. We further assess the data's time-series properties through unit-root and cointegration tests, and apply a Vector Error Correction Model (VECM) to examine both equilibrium relationships and adjustment processes over time.

This approach allows us to capture the persistence of volatility, the structural heterogeneity of macroeconomic impacts, and the adjustment speeds with which Haiti's economy responds to shocks, elements that are critical in assessing exchange rate behavior under conditions of financial fragility.

3.3.1. Conceptual Framework Overview

The empirical strategy is guided by the conceptual framework illustrated in Figure 1, which outlines the hypothesized relationships between exchange rate volatility and its macroeconomic determinants: GDP growth, inflation, broad money growth (M2), remittance inflows, and lagged volatility.

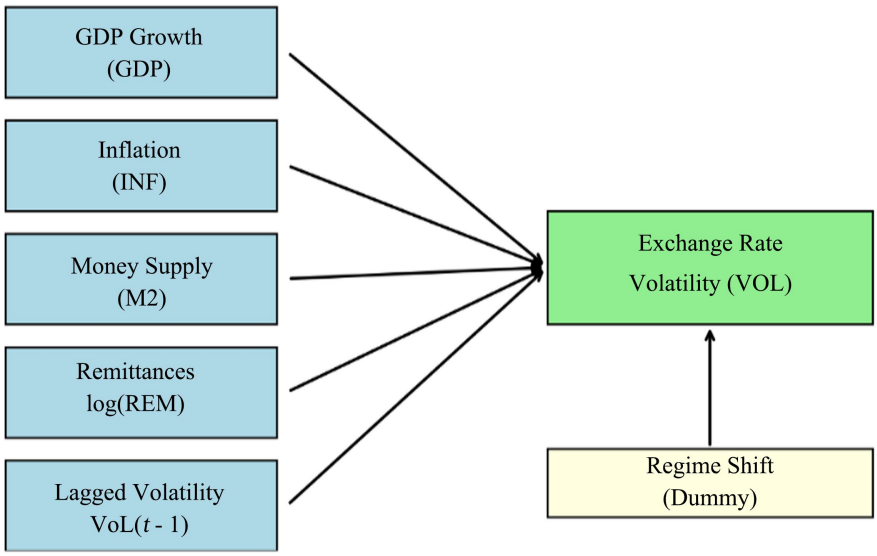

Figure 1. Conceptual framework of macroeconomic determinants of exchange rate volatility.

We begin with OLS estimation to establish baseline relationships between volatility and its covariates. To address the possibility of regime shifts, we apply the Bai-Perron structural break test to the volatility series, which enables us to identify structural changes and partition the sample into sub-periods for more context-sensitive analysis.

Next, we investigate the time-series characteristics of the variables using the Augmented Dickey-Fuller (ADF) test. If variables are integrated of the same order, we proceed with the Johansen cointegration test to determine the existence of long-run equilibrium relationships. Where cointegration is present, we esti-

mate a Vector Error Correction Model (VECM) to jointly model the short-run dynamics and long-run equilibrium adjustments between exchange rate volatility and macroeconomic fundamentals.

This comprehensive empirical framework provides a robust and theoretically grounded approach to examining the structural roots and dynamic behavior of exchange rate volatility in fragile states like Haiti.

3.3.2. Ordinary Least Squares (OLS) Model

The OLS model serves as the baseline estimation technique to examine the relationship between exchange rate volatility and its macroeconomic determinants. The model is specified as follows:

$$VOL_t = \beta_0 + \beta_1 GDP_t + \beta_2 M2_t + \beta_3 \log\_REM_t + \beta_4 INF_t + \beta_5 VOL_{t-1} + \varepsilon_t \quad (1)$$

Let VOL_t denote the exchange rate volatility at time t, which serves as the dependent variable. The explanatory variables are: GDP_t, the GDP growth rate; $M2_t$, the growth rate of broad money supply; $\log\_REM_t$, the natural logarithm of remittance inflows; and INF_t, the inflation rate, and VOL_{t-1}, the lagged exchange rate volatility at time $t-1$, which captures the persistence of volatility over time. The term ε_t represents the stochastic error at time t.

For the OLS estimators to yield unbiased and consistent results, several classical assumptions must be satisfied: 1) linearity in parameters, 2) homoscedasticity of residuals (constant variance), 3) no perfect multicollinearity among regressors, and 4) normally distributed errors with zero mean and constant variance. Diagnostic tests, including variance inflation factor (VIF) analysis, the Breusch-Pagan test, and residual plots, are applied to evaluate the validity of these assumptions in the estimated models.

3.3.3. Structural Break Analysis (Bai-Perron Test)

To account for potential regime shifts in volatility patterns, a Bai-Perron multiple breakpoint test was applied:

$$VOL_t = \mu_j + \varepsilon_t \quad \text{for} \quad t \in T_j \quad (2)$$

This test identifies significant changes in the mean level of volatility, signaling structural breaks in the exchange rate regime or macro-financial environment. Based on the results, a regime dummy variable was created:

$$\text{Regime}_t = \begin{cases} 0 & \text{if } t \le t^* \\ 1 & \text{if } t > t^* \end{cases} \quad (3)$$

where t^* represents the identified break year.

An extended OLS model was estimated including the regime dummy:

$$\begin{aligned} VOL_t = {} & \beta_0 + \beta_1 GDP_t + \beta_2 M2_t + \beta_3 \log\_REM_t + \beta_4 INF_t \\ & + \beta_5 VOL_{t-1} + \beta_6 Regime_t + \varepsilon_t \end{aligned} \quad (4)$$

3.3.4. Sub-Sample Analysis

To capture regime-specific dynamics, the dataset is divided into two sub-periods based on the break year t^*. Separate OLS regressions are estimated for each sub-

period to allow for structural heterogeneity in the impact of macroeconomic variables on exchange rate volatility. The models are specified as:

$$VOL_t^{(pre)} = \beta_0^{(pre)} + \sum_{i=1}^{5} \beta_i^{(pre)} X_{it} + \varepsilon_t^{(pre)} \quad (5)$$

$$VOL_t^{(post)} = \beta_0^{(post)} + \sum_{i=1}^{5} \beta_i^{(post)} X_{it} + \varepsilon_t^{(post)} \quad (6)$$

where X_{it} denotes the vector of explanatory variables, including GDP growth, inflation, money supply growth, remittances, and lagged volatility, and the parameters $\beta_0^{(pre)}$, $\beta_0^{(post)}$ capture their respective influences before and after the structural break. This specification enables comparison of macroeconomic drivers across different macro-financial regimes.

3.3.5. Unit Root Testing and Cointegration

Prior to estimating dynamic models, all series are subjected to unit root testing using the Augmented Dickey-Fuller (ADF) procedure to determine their order of integration. If the variables are found to be integrated of the same order, commonly I(1), the Johansen cointegration test is employed to assess the existence of long-run relationships among them. The long-run equilibrium condition is expressed as:

$$\beta_1 GDP_t + \beta_2 M2_t + \beta_3 \log\_REM_t + \beta_4 INF_t = \zeta_t \quad (7)$$

In this formulation, ζ_t represents the stationary error correction term capturing long-run deviations from equilibrium. Detection of at least one cointegrating vector validates the application of a Vector Error Correction Model (VECM).

3.3.6. Vector Error Correction Model (VECM)

Once cointegration is confirmed, a VECM is estimated to capture both the long-run relationships and short-run dynamics among the variables. The VECM takes the general form:

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \mu + \varepsilon_t \quad (8)$$

where $\Pi = \alpha\beta'$ is the matrix capturing cointegration, with β representing the long-run cointegrating vectors and α the adjustment speeds at which disequilibria are corrected. The differenced terms ΔX_t represent the short-run dynamics, while ε_t is a white noise error term. This structure allows the model to simultaneously address short-term volatility behavior and the underlying long-term economic linkages driving it.

Before estimating the VECM, an appropriate lag length k is selected using standard information criteria such as the Akaike Information Criterion (AIC) or Schwarz Bayesian Criterion (SBC). This ensures the model adequately captures temporal dependencies without overfitting.

It is also essential that the variables included in the cointegration analysis are integrated of the same order, typically I(1), a condition verified through unit root testing. Once these prerequisites are satisfied, the VECM is estimated, enabling the simultaneous analysis of how deviations from long-run equilibrium are corrected and how short-run shocks influence the system.

The short-run coefficients (in the Γ_i matrices) are interpreted as immediate effects of past changes in the explanatory variables on current changes in exchange rate volatility, while the coefficients α indicate the speed at which the system adjusts to restore equilibrium following a disturbance.

3.3.7. Robustness and Endogeneity Considerations

Remittance inflows are included in the model in logarithmic form to account for scale effects and reduce variance instability. This transformation improves the normality of the series and mitigates potential bias from extreme remittance fluctuations. While remittances are treated as an external determinant of exchange rate volatility, it is acknowledged that feedback effects may exist, as periods of currency depreciation can influence the behavior of remittance senders. Addressing these potential two-way interactions remains an area for future empirical investigation.

4. Results and Discussion

4.1. Descriptive Statistics and Stylized Facts

Table 2 presents the summary statistics of key macroeconomic indicators and exchange rate volatility in Haiti from 1996 to 2024. The average level of exchange rate volatility (VOL) is 0.02, with a standard deviation also of 0.02, suggesting moderate but noteworthy dispersion across the sample. Its positive skewness (0.88) indicates that although lower volatility values are more prevalent, occasional high-volatility spikes have occurred. These spikes are typically associated with episodes of political unrest, external financial disruptions, and monetary instability.

Table 2. Descriptive statistics of key variables (1996-2024).

Variable	Observation	Mean	SD	Min	Max	Skew	Kurtosis
VOL	29	0.02	0.02	0.00	0.07	0.88	0.01
GDP	29	1.16	2.87	−5.65	5.89	−0.53	−0.53
INF	29	13.73	9.55	0.39	36.81	0.76	−0.36
M2	29	14.56	10.83	−9.64	38.90	0.27	−0.24
log_REM	29	21.01	0.80	19.46	22.13	−0.41	−0.93
VOL_{t-1}	29	0.02	0.02	0.00	0.07	1.00	0.15

Source: Author's own calculation.

GDP growth (GDP) averaged 1.16% over the sample period, with a standard deviation of 2.87%. The negative skewness (−0.53) indicates that periods of economic contraction are more extreme than periods of high growth, which is consistent with Haiti's historical record of economic shocks and slow structural transformation. The relatively low average growth reflects persistent bottlenecks in infrastructure, weak institutional capacity, and political instability, all of which contribute indirectly to exchange rate fragility by weakening investor confidence and

reducing productive capacity.

Inflation (INF) demonstrates substantial variability, averaging 13.73% with a standard deviation of 9.55%. This volatility is consistent with episodes of acute economic dislocation, such as the 2003-2004 political crisis and the COVID-19 period, during which supply-side disruptions and fiscal pressures often triggered inflationary episodes. The positively skewed distribution (0.76) further implies the occurrence of outlier inflation spikes.

Broad money supply growth (M2) displays even greater variability, averaging 14.56% and reaching a maximum of nearly 39%. These oscillations suggest a reactive monetary environment, potentially driven by fiscal deficits, central bank interventions, or external inflows, typical of developing economies with shallow financial markets.

The variable for personal remittances, expressed as log_REM, exhibits a steady upward trend with minimal dispersion (standard deviation = 0.80). This reflects the consistent role of remittances in cushioning Haiti's economic vulnerabilities, particularly in the wake of natural disasters and prolonged development stagnation. Its slightly negative skewness (−0.41) suggests infrequent declines, reinforcing its relative resilience.

Lagged exchange rate volatility (VOL_{t-1}) mirrors the observed patterns in current volatility, confirming the persistence and clustering behavior often found in exchange rate dynamics. The higher skewness (1.00) here again highlights recurrent episodes of pronounced instability, underscoring the need for autoregressive modeling approaches.

These patterns are visually corroborated in **Figure 2**, which plots the time series of the main variables: Exchange Rate Volatility (VOL), GDP Growth (GDP), Inflation (INF), Broad Money Growth (M2), Log Remittances (log_REM), and Lagged Volatility (VOL_{t-1}). VOL is high and erratic in the late 1990s, surges again in the early 2000s, and then declines to a relatively stable phase before rising once more after 2015 and particularly after 2020.

GDP remains highly volatile, with repeated fluctuations throughout the sample and marked contractions after 2018, reflecting persistent structural weaknesses. INF shows pronounced peaks coinciding with major crisis periods, most notably in the early 2000s, late 2000s, and after 2019. M2 displays large and frequent swings, suggesting inconsistent liquidity management and reactive monetary policy.

log_REM, in contrast, follows a steady upward trend with minimal interruptions, acting as a stabilizing inflow to the economy. VOL_{t-1} closely mirrors current volatility patterns, underlining persistence and clustering in exchange rate movements.

Overall, the descriptive evidence confirms stylized facts common to small, open, low-income economies, namely macroeconomic fragility, vulnerability to inflationary shocks, and a strong reliance on remittances. These dynamics are consistent with the crisis framework of Kaminsky & Reinhart (2000), where exchange rate instability emerges from a mix of weak fundamentals, policy inconsistency, and external shocks.

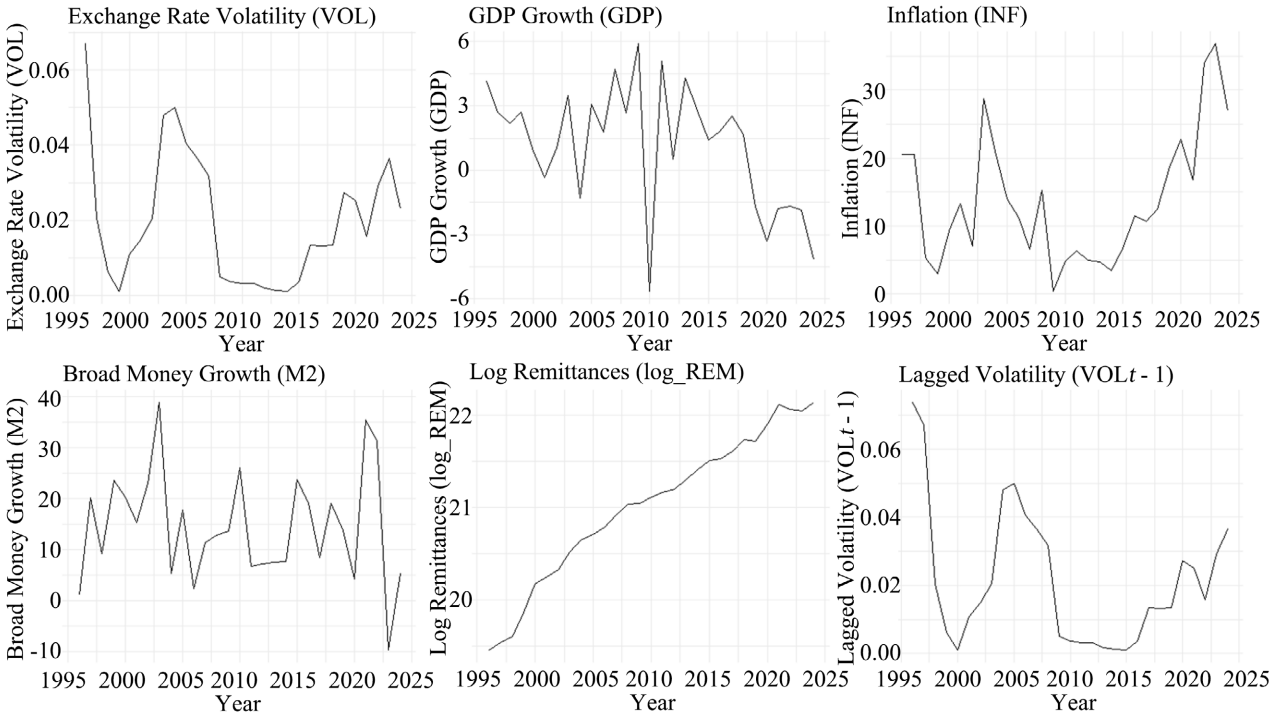

Figure 2. Time series of exchange rate volatility and key macroeconomic determinants (1996-2024).

4.2. Baseline OLS Estimation and Regression Diagnostics

The baseline Ordinary Least Squares (OLS) model was estimated to examine the relationship between exchange rate volatility and its core macroeconomic determinants in Haiti over the period 1996-2024. The dependent variable is exchange rate volatility (VOL), and the explanatory variables include GDP growth (GDP), broad money supply growth (M2), inflation rate (INF), personal remittances in logarithmic form (log_REM), and the lagged volatility term (VOL_{t-1}).

The model exhibits a relatively strong explanatory power, with an R-squared of 0.699, indicating that approximately 70% of the variation in exchange rate volatility is explained by the included macroeconomic variables. The adjusted R-squared of 0.634 suggests that the explanatory capacity remains substantial even after accounting for the number of predictors, which is notable for annual macroeconomic data in a small open economy.

Among the explanatory variables, inflation (INF) emerges as a statistically significant determinant at the 5% level, with a positive coefficient (0.001). This indicates that a one percentage point increase in inflation is associated with a 0.001 rise in exchange rate volatility, supporting the view that price instability heightens currency market fluctuations. The coefficient for log_REM is negative but statistically insignificant, suggesting a potential stabilizing role of remittances, although the effect is not robust in the baseline model. Similarly, GDP and M2 display coefficients close to zero and are statistically insignificant, indicating that short-term changes in real economic activity or money supply may have a limited direct effect on volatility in Haiti's context.

The lagged volatility term (VOL_{t-1}) is positive (0.415) and statistically significant at the 5% level, indicating persistence in volatility over time, consistent with volatility clustering often observed in exchange rate series.

To assess the robustness of these estimates, several diagnostic tests were conducted. Multicollinearity was examined using the Variance Inflation Factor (VIF), with all values below the conventional threshold of 4, indicating no serious collinearity issues. Heteroscedasticity was tested via the Breusch-Pagan test (p-value = 0.0415) and the Non-Constant Variance (NCV) test (p-value = 0.0006), both suggesting mild evidence of heteroscedasticity. To address this, robust standard errors were computed in subsequent estimations.

The Shapiro-Wilk normality test returned a W statistic of 0.9123 (p-value = 0.0195), indicating some deviation from normality, mainly in the tails of the residual distribution. However, visual inspection via Q-Q plots suggested that these deviations were relatively minor. Serial correlation was examined using the Durbin-Watson test, which produced a statistic of 1.8547 (p-value = 0.1712), indicating no significant first-order autocorrelation.

In summary, while the model exhibits mild heteroscedasticity and some departure from residual normality, there is no evidence of problematic multicollinearity or autocorrelation. The use of robust standard errors ensures valid inference, and the results highlight the significant role of inflationary pressures and volatility persistence in shaping Haiti's exchange rate dynamics.

The overall goodness-of-fit of the baseline OLS model is visually confirmed in Figure 3, which compares actual and fitted values of exchange rate volatility. The fitted trajectory (red dashed line) follows observed fluctuations (blue solid line) closely, particularly during periods of heightened volatility in the early 2000s and post-2019. The structural break in 2002, marked by the vertical dotted line, underscores the shift in volatility dynamics across regimes and aligns with the statistical evidence from the break tests, supporting the model's explanatory power.

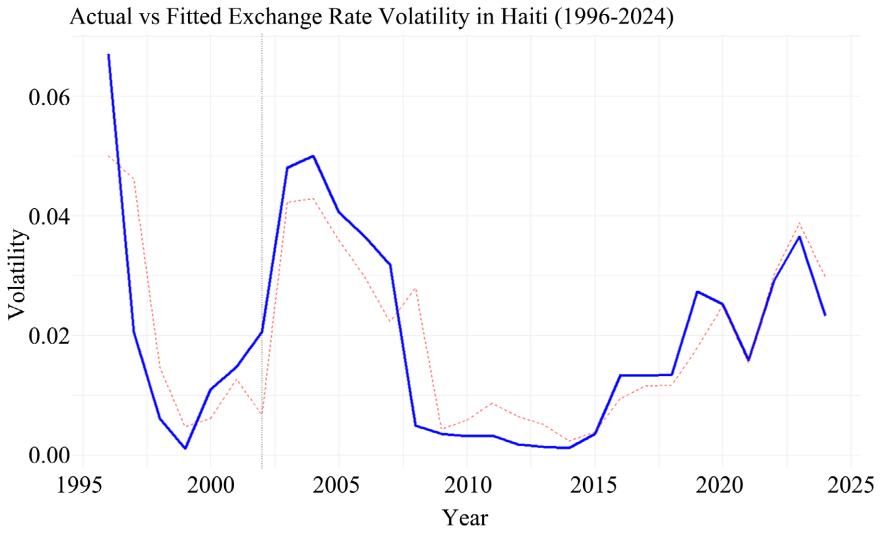

Figure 3. Actual vs fitted exchange rate volatility in Haiti (1996-2024).

4.3. Structural Break and Regime Effects

The Bai-Perron structural break test identifies a significant breakpoint in the early 2000s, dividing the sample into two regimes. This division aligns with pivotal macroeconomic events in Haiti, notably the fallout from the 2003-2004 political crisis and subsequent institutional reforms. Economically, this marks a transition from a period of elevated macro-financial volatility and policy fragility to a post-crisis environment shaped by increased international aid flows and stabilization efforts.

The structural break identified in 2002 coincides with a major shift in Haiti's macroeconomic and institutional landscape. This period marked intensified political instability, fiscal imbalances, and episodes of monetary expansion that collectively undermined exchange rate management. The 2002 breakpoint therefore reflects a transition between relatively stable post-liberalization dynamics and a more fragile macroeconomic regime characterized by recurrent depreciation and heightened volatility. To account for these dynamics, this study introduces a regime dummy variable into the empirical model. This dummy acts as a proxy for the unobserved institutional and political disruptions associated with the break, as no direct governance indicators are included in the estimation.

To capture the shift in volatility dynamics, the extended OLS model incorporates a regime dummy variable. As shown in Table 3, the regime dummy is positive (0.014) but statistically insignificant ($p = 0.126$), suggesting a possible post-break increase in exchange rate volatility, though the evidence is not conclusive. This implies that regime-dependent dynamics may be driven more by other evolving macroeconomic or policy-specific factors than by the break itself.

Table 3. OLS estimation with regime dummy (Dependent variable: Exchange rate volatility).

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
Intercept	0.200	0.121	1.648	0.114
GDP	0.000	0.001	0.143	0.888
M2	0.000	0.000	−0.175	0.862
INF	0.001	0.000	3.283	0.003**
log_REM	−0.010	0.006	−1.684	0.106
VOL_{t-1}	0.335	0.152	2.202	0.039**
Regime Dummy	0.014	0.009	1.592	0.126
R-squared	0.730			
Adjusted R^2	0.657			
F-statistic	9.917			
Prob (F-statistic)	0.000			

Note: *** significant at 0.01, ** significant at 0.05, * significant at 0.1. Source: Author's own calculation from R Software.

The inclusion of the regime dummy leaves the main relationships broadly intact. Inflation (INF) remains positive and statistically significant at the 5% level (coefficient = 0.001), confirming its role as a key driver of volatility. The lagged volatility term (VOL_{t-1}) also remains significant at the 5% level, with a coefficient of 0.335, indicating persistence and clustering in exchange rate fluctuations. Remittances (log_REM) continue to show a negative sign, hinting at a stabilizing effect, though the coefficient remains statistically insignificant at conventional levels.

Overall, the evidence suggests that while the structural break reflects an important historical and policy turning point, its direct statistical effect on exchange rate volatility appears limited when macroeconomic fundamentals are controlled for. However, the regime dummy adds value by capturing unobservable institutional fragility and allowing the model to reflect regime-dependent behavior.

4.4. Sub-Sample Analysis

Table 4 presents the OLS estimation results for Haiti's exchange rate volatility model across two distinct macroeconomic regimes, before and after the structural break identified earlier. The comparison reveals marked differences in both the magnitude and significance of macroeconomic influences, reflecting a changing economic structure and institutional environment.

Table 4. OLS estimation results for pre- and post-break subsamples (Dependent variable: Exchange rate volatility).

Variable	Coefficient (Pre)	Std. Error	t-Statistic	*p*-value	Coefficient (Post)	Std. Error	t-Statistic	*p*-value
Intercept	−0.001	0.014	−0.042	0.968	0.248	0.101	2.453	0.026*
GDP	-	-	-	-	0.000	0.001	0.132	0.896
M2	-	-	-	-	0.000	0.000	0.387	0.704
INF	0.001	0.002	0.487	0.652	0.001	0.000	4.221	0.001***
log_REM	-	-	-	-	−0.012	0.005	−2.515	0.023**
VOL_{t-1}	0.383	0.438	0.874	0.432	0.416	0.143	2.899	0.010**
R-squared	0.616				0.831			
Adjusted R^2	0.423				0.778			
F-statistic	3.202			0.148	15.710			0.000
Prob (F-statistic)	0.148				0.000			

Note: *** significant at 0.01, ** significant at 0.05, * significant at 0.1. Source: Author's own calculation from R Software.

In the pre-break subsample, the model specification is deliberately restricted to only two explanatory variables, Inflation Rate and Lagged Volatility, rather than the full set of macroeconomic indicators used in the post-break estimation. This restriction reflects the small number of observations available for the early regime, which makes estimating a larger model statistically unreliable and prone to overfitting. Beyond sample size constraints, the variable choice is also grounded in economic rationale: in the early years of the sample, inflation was the most imme-

diate policy concern, and volatility the clearest signal of macro-financial instability. Other potential stabilizers, such as remittances, had not yet emerged as prominent macroeconomic buffers. To preserve degrees of freedom and ensure robust inference, only the two variables that were consistently significant in both the baseline (Table 5) and regime-augmented (Table 3) models were retained. This ensures that the pre-break regression focuses on the most stable and theoretically relevant determinants of exchange rate volatility while maintaining model reliability given the sample size constraint.

Table 5. Baseline OLS estimation results (Dependent variable: Exchange rate volatility).

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
Intercept	0.041	0.072	0.580	0.568
GDP	0.001	0.001	0.730	0.473
M2	0.000	0.000	−0.048	0.962
INF	0.001	0.000	2.905	0.008**
log_REM	−0.002	0.003	−0.619	0.542
VOL_{t-1}	0.415	0.148	2.801	0.010**
R-squared	0.699			
Adjusted R^2	0.634			
F-statistic	10.680			
Prob (F-statistic)	0.000			

Note: *** significant at 0.01, ** significant at 0.05, * significant at 0.1. Source: Author's own calculation from R Software.

Model diagnostics demonstrate a better overall fit in the post-break period. The R-squared improves from 0.616 in the pre-break subsample to 0.831 post-break, indicating that the model explains a greater proportion of volatility in the latter period. The adjusted R-squared also increases from 0.423 to 0.778, suggesting the improved fit is not merely due to overfitting. Similarly, the F-statistic rises from 3.202 to 15.710, with a highly significant *p*-value in the post-break period, confirming overall statistical significance.

In the pre-break period, neither inflation nor lagged volatility reaches statistical significance, although both retain their expected signs: inflation has a small positive coefficient, and lagged volatility is also positive, indicating persistence. In contrast, the post-break model shows a stronger and more statistically robust structure. Inflation remains a key determinant and is significant at the 1% level, while lagged volatility is significant at the 5% level, indicating continued persistence in exchange rate fluctuations. Remittances (log_REM) are significant at the 5% level post-break, with a negative sign, confirming their stabilizing role in the latter regime. GDP growth and M2 growth remain statistically insignificant in the post-break period, suggesting a diminished role for real activity and monetary expansion in explaining exchange rate volatility.

Altogether, the subsample comparison confirms that Haiti's exchange rate volatility dynamics exhibit structural heterogeneity. Inflation and past volatility remain central, while the stabilizing effect of remittances becomes more visible post-break. The diminished roles of GDP growth and monetary expansion point to weakening macroeconomic transmission channels, consistent with the heightened fragility and policy constraints of the post-2000s period.

4.5. Cointegration and VECM Dynamics

The time-series analysis begins with unit root testing using the Augmented Dickey-Fuller (ADF) test. Results confirm that all key variables, exchange rate volatility (VOL), GDP growth (GDP), inflation rate (INF), broad money supply growth (M2), and the log of remittances (log_REM), are non-stationary at levels but become stationary after first differencing. This means the series are integrated of order one, I(1), fulfilling the necessary condition for cointegration testing.

Johansen's cointegration test (trace statistic) identifies at least one cointegrating relationship among the variables, with both the trace and maximum eigenvalue statistics exceeding their 5% critical values. This finding suggests that macroeconomic fundamentals and exchange rate volatility share a stable long-run equilibrium, even though they may experience short-run deviations.

Given this result, a Vector Error Correction Model (VECM) is estimated to capture both short-term dynamics and long-term adjustment. Table 6 reports the short-run volatility equation. The error correction term (ECT) is negative and statistically significant at the 5% level (−0.371, $p = 0.019$), validating the existence of a long-run relationship and indicating that approximately 37% of any disequilibrium is corrected within one period. This reflects a moderate speed of adjustment toward the long-run equilibrium.

Table 6. VECM estimation results (Dependent variable: ΔVolatility).

Variable	Coefficient	Std. Error	t-Statistic	*p*-value
Intercept	0.005	0.005	1.000	0.327
GDP	−0.001	0.001	−1.211	0.239
M2	0.000	0.000	1.502	0.146
INF	0.001	0.000	2.532	0.022**
log_REM	−0.003	0.001	−2.741	0.015**
VOL_{t-1}	0.422	0.169	2.497	0.023**
ECT(−1)	−0.371	0.141	−2.633	0.019**
R-squared	0.612			
Adjusted R^2	0.529			
F-statistic	7.293			
Prob (F-statistic)	0.001			

Note: *** significant at 0.01, ** significant at 0.05, * significant at 0.1. Source: Author's own calculation from R Software.

In the short run, inflation (INF) has a positive and significant impact (0.001, p = 0.022), confirming that inflationary pressures amplify volatility. Conversely, remittances (log_REM) have a negative and significant coefficient (−0.003, p = 0.015), underscoring their stabilizing role by buffering the economy against shocks. Lagged volatility (VOL_{t-1}) is also significant at the 5% level (0.422, p = 0.023), indicating persistent volatility clustering in Haiti's exchange rate. GDP growth (GDP) and broad money supply growth (M2) appear with theoretically consistent signs but are not statistically significant in the short run, implying that their influence may be more relevant in long-term dynamics.

Overall, the VECM results reveal that Haiti's exchange rate volatility is shaped by a combination of persistent short-run factors, especially inflationary shocks and remittance inflows, and a gradual correction process toward a stable long-run path. This supports the policy view that sustaining price stability and strengthening external financial buffers are critical to dampening volatility in small, shock-prone economies.

4.6. Discussion and Comparative Insights

The results across empirical methodologies, ranging from baseline OLS estimation to structural break tests and VECM modeling, reveal a coherent narrative about the determinants and behavior of exchange rate volatility in Haiti. The evidence underscores that both structural and transitory macroeconomic factors jointly influence volatility, while also revealing regime-dependent sensitivities that shift in response to political and external shocks.

Inflation consistently emerges as a statistically significant driver across all model specifications, confirming its central role in amplifying exchange rate volatility. This aligns with the monetary approach to exchange rates, where high and unstable inflation weakens confidence and increases currency market turbulence. Remittances, on the other hand, display a persistent stabilizing effect, with their impact becoming statistically significant in the post-break period, particularly in the VECM framework where they dampen short-run volatility. Their increased importance in later years suggests a growing role of diaspora inflows as an informal stabilizer amid weak institutional capacity.

Lagged volatility remains significant across most models, highlighting strong persistence and volatility clustering in Haiti's exchange rate market, a feature common in fragile economies. GDP growth and broad Money Growth (M2), while theoretically relevant, show limited statistical significance, suggesting that real sector activity and money supply changes have weaker short-term transmission effects on currency markets in Haiti's context.

The subsample analysis reinforces the idea of structural heterogeneity. In the pre-break period, constrained by fewer observations, only inflation and lagged volatility were retained, both maintaining expected signs but lacking statistical significance. In the post-break period, the model improves markedly in explanatory power, with inflation, lagged volatility, and remittances emerging as key de-

terminants. This regime shift corresponds with heightened macroeconomic openness, deeper reliance on remittances, and persistent political instability.

When compared to similar contexts, such as Caribbean economies (Jeanniton, 2013) and broader emerging markets (Kaminsky & Reinhart, 2000), Haiti shares the same vulnerability to political disruptions and external shocks but stands out for the magnitude of its reliance on remittances as a stabilizing force. The structural break identified around 2002 reflects both political regime change and institutional weakening, reinforcing the notion that exchange rate volatility in Haiti is as much a political and institutional phenomenon as it is an economic one.

From a policy standpoint, the findings stress that addressing inflationary pressures, integrating remittance flows into the formal financial system, and reducing volatility persistence should be key priorities. Strengthening institutional resilience and policy credibility will be critical to breaking the cycle of instability and achieving a more predictable exchange rate environment.

5. Conclusion

This study provides a comprehensive and methodologically rigorous analysis of the determinants and dynamics of exchange rate volatility in Haiti over the period 1996-2024. Employing an integrated empirical framework that combines descriptive analysis, Ordinary Least Squares (OLS) estimation, Bai-Perron structural break detection, and Vector Error Correction Model (VECM) estimation, the research captures the complex macro-financial interactions shaping volatility in a structurally fragile, small open economy. The findings reveal that inflation, monetary expansion (M2 growth), remittance inflows, and lagged volatility are key determinants of exchange rate fluctuations, each exerting amplifying or dampening effects across distinct periods. A structural break identified around 2002 marks a regime shift in volatility behavior, coinciding with a deterioration in institutional stability and macroeconomic management.

The VECM results confirm a long-run cointegrating relationship among the main macroeconomic variables, suggesting that despite recurrent shocks and policy inconsistencies, the exchange rate system tends to revert to equilibrium over time. The negative and statistically significant error correction term indicates a moderate speed of adjustment toward long-run equilibrium. In the short run, exchange rate volatility is most responsive to inflationary pressures, remittance inflows, and lagged volatility, highlighting how domestic fragility and external exposure jointly shape Haiti's exchange rate dynamics. Overall, the results underscore that volatility in Haiti is not episodic but structurally embedded within the country's macroeconomic and institutional framework.

From a policy perspective, the evidence points to the limitations of discretionary interventions and underscores the need for a coherent, rules-based monetary framework. Adopting a flexible inflation-targeting regime, supported by enhanced central bank transparency and autonomy, could strengthen monetary credibility and anchor inflation expectations. However, for such a regime to be

effective in a fragile context like Haiti, several institutional preconditions must be met, including central bank independence, credible policy signaling, and robust data systems for inflation forecasting and communication. Closer coordination between fiscal and monetary authorities is also essential to improving policy transmission and sustaining macro-financial stability.

Remittances should be strategically integrated into broader development and financial policies. Expanding financial inclusion for remittance-receiving households, reducing transaction costs, and channeling flows into productive investment instruments, such as diaspora bonds, cooperative lending schemes, and infrastructure funds, would help transform remittances from short-term consumption buffers into long-term stabilizers of external balance and currency value.

Improved liquidity management is another critical requirement. The results indicate that unchecked monetary expansion exacerbates volatility and inflationary pressures. Strengthening the central bank's sterilization capacity through open market operations, adaptive reserve requirements, and short-term instruments could help maintain monetary discipline and exchange rate stability.

The policy implications extend beyond Haiti. For small and fragile economies, strengthening monetary credibility, improving fiscal transparency, and deepening financial markets are vital to moderating volatility transmission. Regional monetary cooperation and coordinated remittance management frameworks could further buffer external shocks and enhance macroeconomic resilience.

Ultimately, mitigating exchange rate volatility in Haiti requires more than short-term macroeconomic adjustments. It demands institutional resilience, political stability, and credible policy frameworks capable of absorbing both domestic and external disturbances. Future research should integrate political instability indicators, differentiate remittance flows by origin, and employ high-frequency data to capture immediate volatility responses. Comparative studies with other Caribbean and fragile-state economies could extend the relevance of these findings and inform regional policy dialogue.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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