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Stylized Facts of Informal FX Markets

Alejandro García-Figal[1] Carla Coburger[2] Alejandro Lage-Castellanos[1] Niklas Hohman[3]

[1]University of Havana, Group of Complex Systems
[2]University of Duisburg-Essen
[3]HAWK University

Abstract

This paper addresses the empirical breakdown of the standard welfare-economics premise that the official exchange rate is the price coordinating private agents' saving, investment, and currency-holding decisions in countries with binding capital controls, where an informal parallel rate instead becomes the operative signal. We propose a unified cross-country empirical framework - combining Wald–Wolfowitz runs tests, Lo–MacKinlay variance-ratio tests, Empirical Mode Decomposition, and Gaussian Hidden Markov Models - applied to a newly constructed, text-mined dataset of daily and intraday parallel exchange rates for Cuba, Argentina, and Nigeria (2021–2025, 1,593 daily observations per market), demonstrating its effectiveness through the robust rejection of weak-form efficiency at every time scale and market regime, evidenced by persistent return autocorrelation (5–15 day decay), heavy point-mass at zero returns, and dual-regime (low-/high-volatility) dynamics with asymmetric responses to political shocks. The findings contribute to the political economy and market-microstructure literatures on capital controls and informal financial systems, providing a candidate set of cross-country stylized facts showing that parallel exchange rates are systematically biased, backward-looking signals - with direct implications for how researchers, policymakers, and international financial institutions should interpret and weight parallel-market data in welfare and policy analysis.

1 Extended Abstract

The welfare economics of capital controls rests on a fundamental premise: that the official exchange rate is the price that coordinates private agents' decisions about saving, investment, and currency holding (Farhi2014, Jeanne2019, Cavallino2019). Under this premise, the design of optimal controls reduces to a problem of correcting externalities in a single, unified foreign exchange market. This paper documents that the premise is empirically violated in a systematic and economically significant way. In countries with binding capital controls, a parallel market price - the black-market or informal exchange rate - emerges as the operative signal for private agents, often diverging substantially from the official rate and displaying statistical properties inconsistent with efficient information aggregation.

The existence of parallel markets has been recognized in the literature since at least (Pinto 1991) and (Kiguel and O'Connell 1995). What has not been established is the

microstructure of price formation in these markets and, critically, whether the parallel rate functions as a reliable signal of the true cost of capital controls for private agents. If the parallel rate is informationally efficient - in the sense that it correctly prices the scarcity of foreign exchange given available information - then it can serve as the relevant price in welfare analyses of capital control regimes, and the standard framework requires only minor modification. If, on the other hand, the parallel rate is systematically inefficient - exhibiting predictable dynamics, regime-dependent behaviour, and sensitivity to political rather than economic shocks - then the welfare analysis of capital controls is fundamentally misspecified, because the price that agents respond to does not correctly aggregate information about fundamentals.

We resolve this question using a new cross-country dataset of parallel exchange rates and text-mined trading volume proxies for Cuba, Argentina, and Nigeria. We find that parallel markets are robustly and pervasively inefficient across all three countries, at all time scales, and in all identified market regimes. This inefficiency is not random noise: it exhibits a specific structure - persistent autocorrelation, dual-regime volatility dynamics, and asymmetric responses to policy shocks - that is consistent with price formation through backward-looking social learning rather than forward-looking information aggregation. The implication is that the parallel rate systematically overweights recent price changes and political signals relative to economic fundamentals, introducing a predictable bias into the signal that private agents use to make real decisions. We show that this bias is quantitatively large and has first-order implications for the welfare cost of capital controls.

The coexistence of official and unofficial exchange rates is one of the most persistent phenomena in the political economy of developing and transition economies. Whenever a government fixes or constrains the official price of foreign currency below its market-clearing level, a parallel market emerges to accommodate excess demand. The premia that appear on such markets—sometimes modest, sometimes exceeding several hundred per cent of the official rate - are simultaneously barometers of macroeconomic distress, signals of policy credibility, and objects of speculative activity in their own right (Agénor 1990; Kiguel and O'Connell 1995; Pinto 1991). Yet despite this economic importance, the microstructure and statistical properties of parallel exchange markets remain far less studied than their formal counterparts. This paper asks a deceptively simple question: across institutionally distinct parallel markets, is there a set of *stylized facts* - empirical regularities that hold robustly regardless of country context - comparable to those long documented for formal foreign exchange markets (Baillie and Bollerslev 1989; Cont 2001; Goodhart and Figliuoli 1991)?

The concept of stylized facts, introduced into economics by (Kaldor 1961) and subsequently codified for financial markets by (Cont 2001), refers to statistical properties that are sufficiently general and robust to serve as benchmarks for theory and policy. For formal foreign exchange and asset markets, these include heavy tails in return distributions, volatility clustering, near-unit-root behaviour in price levels, and the approximate validity of the Efficient Market Hypothesis (EMH) in its weak form (Baillie and Bollerslev 1989; Fama 1970; Lo and MacKinlay 1988). The degree to which these regularities extend to informal, unregulated, and politically constrained currency markets is an open question. Answering it requires both appropriate data—historically scarce for informal markets - and a comparative analytical framework capable of spanning heterogeneous institutional environments.

We contribute to this agenda along three dimensions. First, we introduce a new,

machine-generated dataset covering daily parallel exchange rates and text-mined proxies for trading volumes across three countries - Cuba, Argentina, and Nigeria - spanning the period 2020–2024. The Cuban data are scraped from *ElToque*, a non-governmental online news source that aggregates user-reported buy and sell prices from social networks and chat rooms (García-Figal et al. 2025b). In each case, we supplement spot-rate data with a text-mining layer that recovers daily proxies for trading volume and market sentiment from the same underlying message streams, producing what we believe to be the most comprehensive cross-country parallel market dataset yet assembled.

Second, we apply a unified empirical framework - combining the Wald-Wolfowitz runs test, Lo-MacKinlay variance-ratio tests, Empirical Mode Decomposition (EMD), and Gaussian Hidden Markov Models (HMMs) - to each series and to their high- and low-frequency components. This framework, applied to the Cuban market by (García-Figal et al. 2025a,b), allows us not only to test the EMH in the conventional sense but also to identify whether inefficiency is pervasive across time scales and market regimes or whether it is concentrated in specific episodes. The cross-country comparative design enables us to separate country-specific idiosyncrasies from structural regularities that reflect the common political economy of parallel markets.

Third, and most importantly, we use these results to propose a set of stylized facts for parallel exchange rate markets. We find that, in contrast to the formal markets to which they are compared - the USD/EUR, USD/MXN, and related series that pass standard efficiency tests (Azad 2009; Diamandis 2003), all three parallel markets exhibit: (i) systematic departures from random-walk behaviour at multiple time scales; (ii) significant return autocorrelation decaying over windows of five to fifteen days; (iii) return distributions with pronounced deltaic mass at zero, reflecting the discrete and intermittent nature of price updating in thin, socially mediated markets; (iv) dual-regime dynamics identifiable via HMMs, with one regime characterised by low volatility and one by high-volatility drift; and (v) sharp, asymmetric responses to political and policy events that produce persistent mean shifts rather than transitory deviations. These findings constitute, we argue, a coherent set of stylized facts specific to parallel markets, with direct implications for how policymakers, researchers, and international financial institutions should interpret and use parallel rate data.

Our work connects several strands of the literature. The political economy of parallel exchange markets has been studied extensively since the 1970s and 1980s (Agénor 1990; Culbertson 1975; Kiguel and O'Connell 1995; Pinto 1991), with a focus on the determinants of the black-market premium and its relationship to macroeconomic fundamentals such as inflation, money growth, and official reserves. More recently, this literature has intersected with work on currency substitution and dollarization (Lévy-Yeyati 2006), on the political costs of illicit currency markets (Schiumerini and Steinberg 2020), and on the role of informal financial systems in development (Asongu 2014). A second and largely separate strand examines the microstructure of foreign exchange markets, emphasising the role of order flow, heterogeneous agents, and information asymmetries in price formation (Evans and Lyons 2002; King et al. 2013; Osler et al. 2011). We bring these strands together by treating the parallel market as a microstructure problem embedded in a political-economy context: prices are formed by heterogeneous, informationally constrained agents operating under legal risk and without the infrastructure—market makers, electronic trading systems, central clearing - that underpins efficiency in formal markets.

The use of digital trace data and text mining to study informal financial markets is it-

self an emerging area. Foley et al. (2019) exploit blockchain data to study cryptocurrency use in illicit activity; Cavallo (2016) use online price data to measure inflation in countries with unreliable official statistics; and Arslan et al. (2015) demonstrate that social-media sentiment can predict short-run exchange rate movements in formal markets. Our contribution extends this tradition to the parallel market context, where digital trace data are often the *only* source of systematic price and volume information. The methodological challenges are significant: message volumes on informal chat platforms are noisy, selection-biased, and do not correspond to executed transactions in any verifiable sense. We address these challenges explicitly and argue that, properly handled, such data yield reliable proxies for market activity.

1.1 The Data and first Results

This study utilizes a comprehensive dataset combining daily and high-frequency observations from the informal foreign exchange markets of Argentina, Cuba, and Nigeria. Because these parallel markets operate outside formal financial systems, the data were assembled via tailored web scraping pipelines and API integrations rather than institutional repositories. The resulting database features a dual macro- and micro-structural design, enabling the simultaneous analysis of long-term statistical regularities and short-term intraday dynamics.

The data collection strategies reflect the unique architecture of each localized market. For Cuba, daily exchange rate benchmarks were obtained by web scraping *El Toque*, while underlying liquidity conditions and short-term price dispersion were captured by scraping decentralized peer-to-peer transaction intentions across social networks, including WhatsApp, Telegram, and Facebook groups (García-Figal et al. 2025b). For Argentina, the daily *Dólar Blue* benchmark was scraped from the financial platform *Ámbito*, whereas high-frequency microstructural dynamics were extracted via the Binance Peer-to-Peer (P2P) marketplace API, which functions as a highly liquid proxy for parallel currency demand and implicit price discovery. For Nigeria, data from multiple parallel-market monitoring platforms—including *NGN Rates* and *AbokiFX*—were aggregated and cross-validated to harmonize regional fragmentation and eliminate observational gaps.

All datasets were synchronized, standardized, and statistically filtered to remove duplicate entries or scraping anomalies. For the macroscopic analysis, Figure 1 illustrates the daily informal exchange rates (expressed as local currency per U.S. dollar) across a uniform horizon from July 24, 2021, to December 2, 2025, comprising 1,593 daily observations per market. These series serve as the foundation for computing aggregate statistical indicators, including logarithmic returns and volatility measures.

Figure 1: Daily informal exchange rate time series for Argentina, Cuba, and Nigeria over the period from July 24, 2021 to December 2, 2025, comprising a total of 1593 daily observations for each market. The first panel (blue) corresponds to the Argentine informal exchange market (*Dólar Blue*), the second panel (green) to the Cuban informal FX market, and the third panel (red) to the Nigerian parallel exchange market. Exchange rates are expressed in units of local currency per U.S. dollar (USD).

At the microscopic level, intraday quotations and peer-to-peer orders are mapped into a simulated limit order book (LOB) framework to evaluate high-frequency price formation. Each order x is defined by four attributes: the sign ϵ_x ($+1$ for buy orders, -1 for sell orders), the quoted price p_x in local currency per USD, the traded volume $v_x > 0$ denominated in USD, and the posting timestamp t_x. Formally, each order is represented as

$$x := (\epsilon_x, p_x, v_x, t_x).$$

This standardized microstructural representation allows for the synthetic reconstruction of order books to consistently analyze volume and order distributions across all three economies.

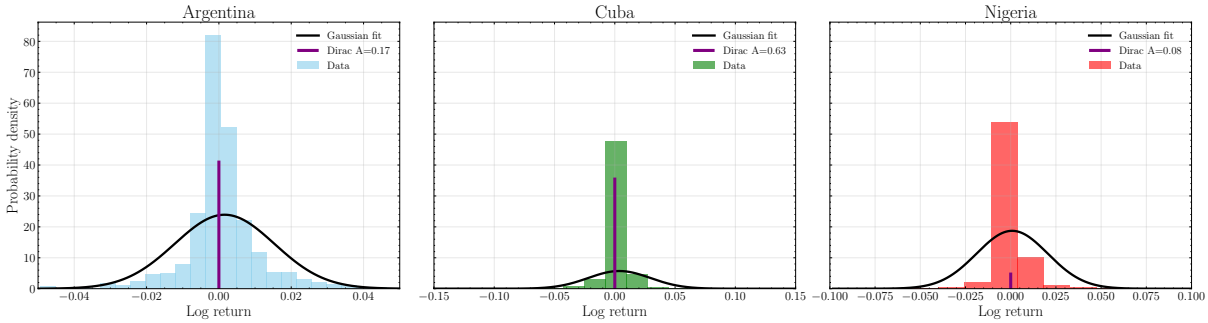

Figure 2: Empirical distributions of log-returns for Argentina, Cuba, and Nigeria informal markets. Each histogram is decomposed into a mixed model $P(r) = A\delta(r) + (1 - A)\mathcal{N}(\mu, \sigma^2)$, where the black curve shows the Gaussian fit to non-zero returns and the vertical line at $r = 0$ represents the empirical probability mass A of zero returns.

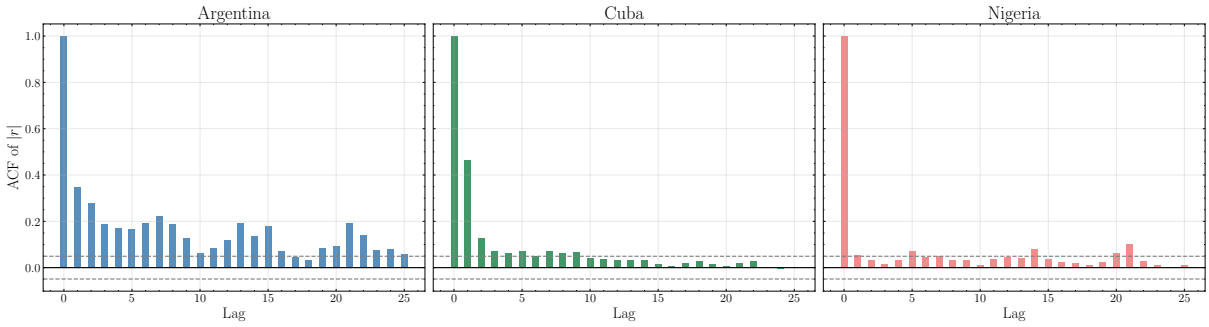

Figure 3: Autocorrelation functions (ACF) of absolute log-returns for the informal markets of Argentina, Cuba, and Nigeria. Bars show empirical autocorrelations up to 25 lags, while dashed lines indicate 95% confidence bounds under the null hypothesis of no serial correlation.

Relative to formal benchmark series (USD/EUR, USD/MXN) that pass standard efficiency tests, all three parallel markets reject the random walk hypothesis at multiple time scales and in every identified regime. Return distributions exhibit a two-component mixture

$$P(r) = A\,\delta(r) + (1 - A)\,\mathcal{N}(\mu, \sigma^2),$$

with an empirical point mass at zero ranging from $A = 0.08$ (Nigeria) to $A = 0.63$ (Cuba), reflecting discrete, intermittent price updating in thin, socially mediated markets. Autocorrelation of absolute returns is significant and decays over five-to-fifteen-day windows in all three countries, evidence of volatility clustering inconsistent with weak-form efficiency. Hidden Markov Model classification identifies a consistent two-state (low-volatility/high-volatility) regime structure across all markets, with Nigeria additionally showing abrupt structural breaks coinciding with documented policy shocks (the June 2023 and December 2023–January 2024 devaluations). Empirical Mode Decomposition confirms that inefficiency is not confined to high-frequency noise but is present across intermediate intrinsic mode functions, indicating multi-scale, rather than merely short-horizon, mispricing.

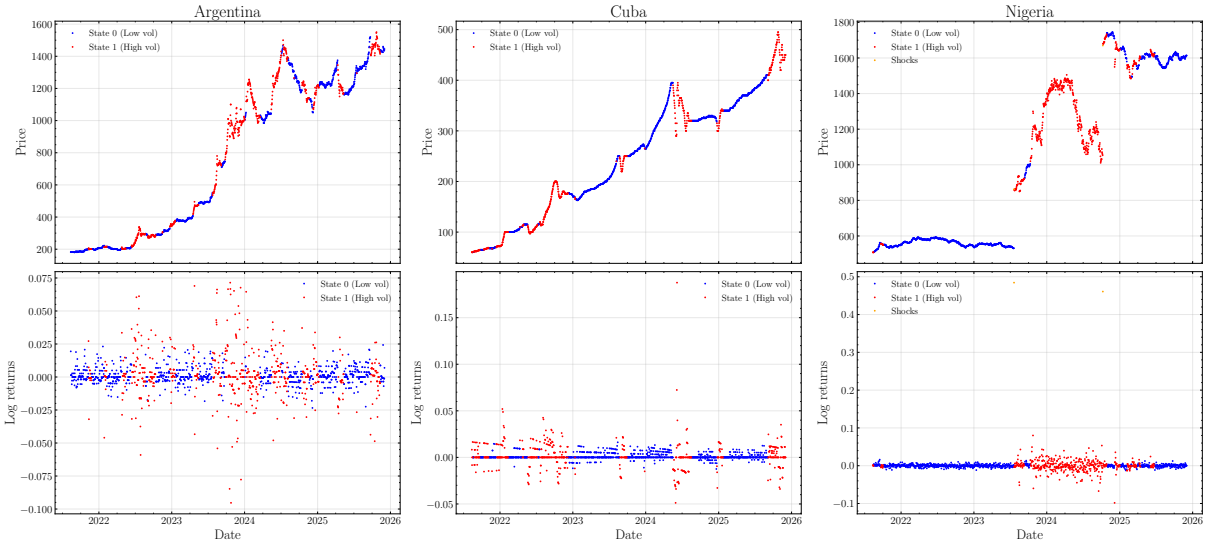

Figure 4: Hidden Markov Model (HMM) regime classification of informal exchange rate dynamics. Each panel shows the inferred two-state structure: a low-volatility regime (blue) and a high-volatility regime (red). For Nigeria, structural breaks corresponding to abrupt exchange rate level shifts are highlighted in orange. The results show that all three markets can be consistently described by a two-state regime-switching process, capturing alternating periods of stability and volatility clustering across heterogeneous institutional environments.

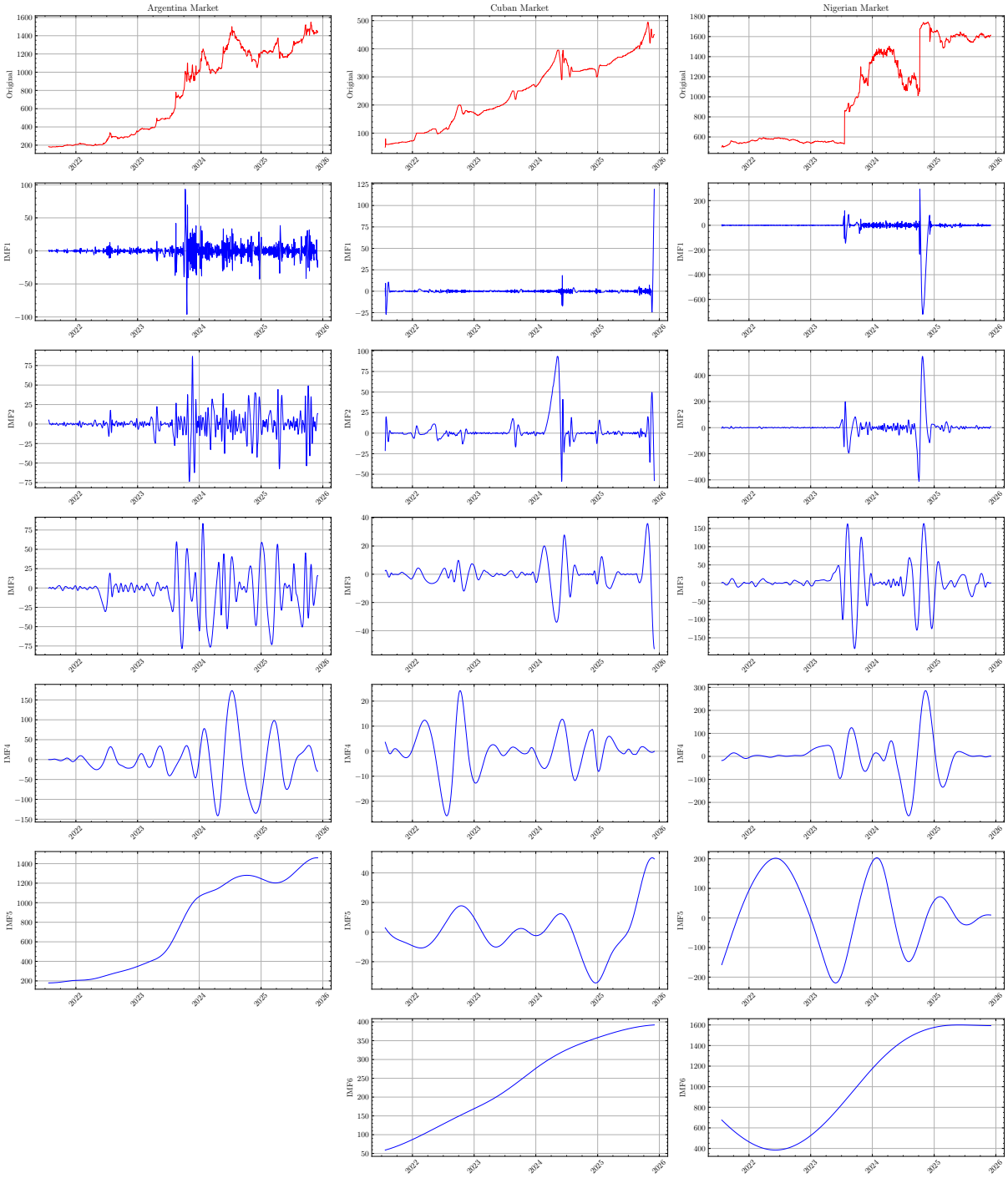

Figure 5: Empirical Mode Decomposition (EMD) of informal exchange rate series for Argentina, Cuba, and Nigeria, with each column corresponding to a different country over the full sample period. The top row shows the original exchange rate signal, while the subsequent rows display the intrinsic mode functions (IMFs) ordered from high- to low-frequency components, and the bottom row shows the residual trend. The decomposition separates each non-stationary series into adaptive oscillatory modes and a long-term trend component, enabling a multi-scale characterization of volatility, cyclical behavior, and structural dynamics across heterogeneous informal FX markets.

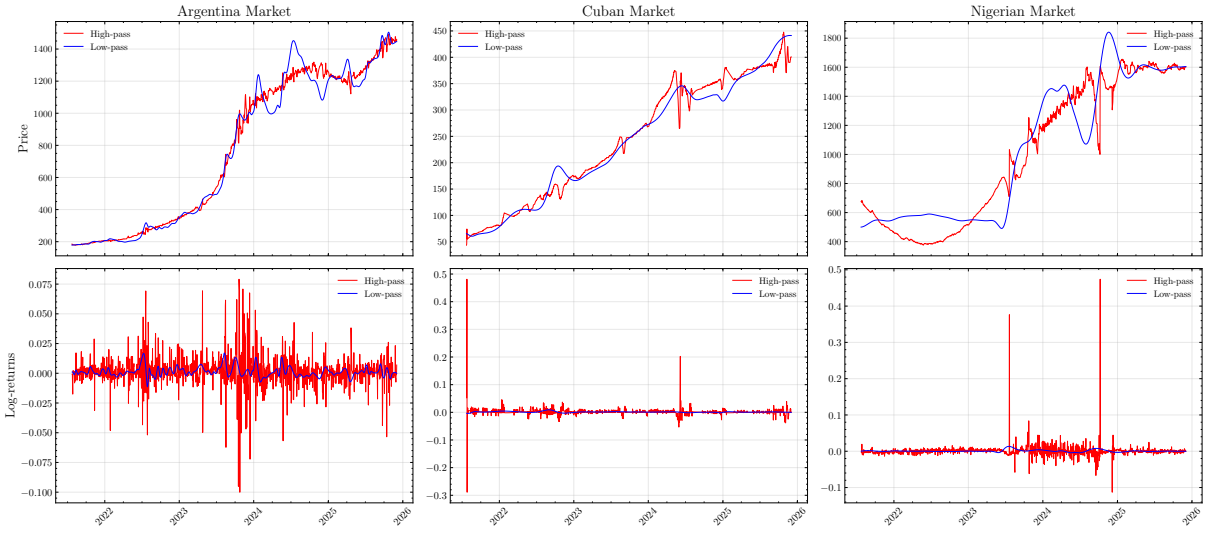

Figure 6: High-pass and low-pass filtered components and corresponding log returns of informal exchange rate series for Argentina, Cuba, and Nigeria, with each column representing one country. For each market, the top row shows the filtered exchange rate series, where the low-frequency (low-pass) component is displayed in blue and the high-frequency (high-pass) component in red, capturing long-term trends and short-term fluctuations respectively. The bottom row shows the corresponding log returns of both components.

These regularities constitute a candidate set of cross-country stylized facts for informal foreign exchange markets, distinct from, and less benign than, those established for formal FX markets, pointing to price formation via backward-looking social learning rather than forward-looking fundamentals aggregation. This has direct consequences for the welfare analysis of capital controls, for the interpretation of parallel rates as macroeconomic distress indicators by researchers and international financial institutions, and for modeling currency substitution and dollarization dynamics in politically constrained economies.

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