

From Blackouts to Battered Markets: Energy Deficits and Exchange Rate Dynamics in Cuba

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Abstract

This paper investigates the relationship between energy deficits and exchange rate volatility in Cuba's informal foreign exchange market. Using high-frequency data compiled by DevTech Systems, Inc. through an AI/ML-enabled scraping of public digital sources, the study analyzes daily electricity shortages and informal exchange rate movements between November 2022 and September 2025. Descriptive analysis, structural variance tests (Standard Deviation tests and F-tests), and statistical models (ARCH, GARCH (1,1)) reveal a clear structural break in volatility following major nationwide blackouts in early 2025, particularly after the March 17 crisis. The results show an observable increase in variance and strong volatility persistence, suggesting that power shortages could be a contributing factor in the lasting shift toward a high-volatility regime in Cuba's informal foreign exchange market. The paper contributes to the literature by applying financial volatility modeling to a data-constrained, state-controlled economy, providing new evidence that energy insecurity can act as a macro-critical source of financial instability even in informal or non-liberalized markets.



DEVTECH

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1. Introduction

Cuba's economy is characterized by a tightly controlled exchange rate regime, a largely state-owned energy sector, and long-standing challenges in meeting electricity demand. The country operates with an official exchange rate of 24 Cuban Pesos (CUP) per U.S. Dollar (USD) for the state sector under exchange rate controls that lead to an informal foreign exchange (FX) market. The informal market fills the gaps in dollar access for private transactions, a system that imposes distortions and incentives for arbitrage (Mesa-Lago 2021). Simultaneously, Cuba's electricity infrastructure is under severe stress, with frequent blackouts, fuel shortages, aging thermal plants, and a reported deficit of over 1,600–1,700 megawatts during peak hours, at times exceeding 2,000 MW in recent months (CiberCuba 2025; Torres 2025). A nationwide electricity deficit of approximately 2,000 megawatts (MW) in Cuba represents a critical collapse of the island's power system, with direct implications for widespread, long-duration blackouts. At peak hours, Cuba's electricity demand is estimated at roughly 3,300 MW. This gap means that more than half of national demand goes unmet, forcing grid operators to implement massive load shedding that interrupts power supply across most of the country. In practice, this translates into unpredictable and prolonged outages, with reports of communities enduring over twenty hours without electricity in a single day (Cibercuba 2025). Notably, electricity interruptions are not evenly distributed across the country. Havana, as the administrative and economic center, is often prioritized in the allocation of limited generation capacity, resulting in fewer blackouts compared to other provinces. In contrast, municipalities in the interior experience more frequent and prolonged outages, reflecting geographic inequities in energy access and state resource management (France 24 2025; OnCuba News 2023). Such persistent energy deficits impose real economic costs, affecting households, commerce, and basic supply chains.

This research emerged from the observation of two unique, high-frequency datasets collected by DevTech Systems, Inc. (DevTech): daily records of Cuba's informal exchange rate and national energy deficits. Observation of records revealed that major blackouts appeared to coincide with sharp peso fluctuations, leading to the question: could disruptions in the power grid be influencing exchange rate volatility?

On the night of Friday, March 14, 2025, at around 8:15 p.m. (Cuba Daylight Time), Cuba's national grid began to fail. Streetlights along Havana's Malecón flickered and went dark before the entire capital plunged into blackout. Within the hour, reports under *#ApagónGeneral* described outages across nearly every province. The Cuban Electric Union (UNE) later confirmed a cascading failure at the Diezmero substation that triggered a collapse of the western transmission network. Officials described it as “a chain reaction of voltage instability,” while independent analysts cited years of underinvestment, deferred maintenance, and fuel shortages as the system's root weaknesses (AP News, 2025; Reuters, 2025). The blackout lasted over 36 hours; the fourth nationwide outage in six months (Mercopress, 2025). With multiple thermal plants offline and

seventy-three distributed units idle for lack of diesel, the grid had no reserve capacity to recover (CiberCuba, 2025). Daily life came to a standstill: water pumps failed, food spoiled, and mobile networks faltered. *“There isn’t a drop of water, and the food is starting to spoil,”* one Havana resident wrote (CiberCuba, 2025). Another warned, *“At any moment the people themselves will light up the streets,”* expressing frustration (CiberCuba, 2025). Images of dark neighborhoods contrasted sharply with the bright tourist hotels powered by private generators. *“Those who have money or relatives abroad have generators,”* another post complained, highlighting widening inequality (CiberCuba, 2025). Official communication was minimal; President Miguel Díaz-Canel later thanked citizens “for their understanding during these uncertain and troubling times” (Cuba Headlines, 2025). Power gradually returned by March 16, though western regions remained offline for another day (Reuters, 2025). The blackout hit during Cuba’s high tourist season, disrupting hotels, transport, and digital payment systems. Economists reported volatility in the Cuban peso following the outage, describing it as a “national stress test” that exposed the convergence of fuel scarcity, grid fragility, and monetary instability in an already strained economy. (Mercopress, 2025).

This paper investigates whether peaks in energy deficits contribute meaningfully to volatility in Cuba’s informal exchange rate. In other words, when electricity blackouts intensify, does the peso become more volatile? This is more than anecdotal conjecture: energy disruptions may curtail tradable-sector activity, reduce export earnings, and force reliance on FX-priced emergency measures, each of which can exert pressure on an already fragile currency regime.

We hypothesize that significant peaks in the energy deficit act as a key driver of exchange rate volatility in Cuba’s informal FX market. To test this, we leverage DevTech’s proprietary high-frequency data, which continuously harvests public posts and news reports across Cuba’s provinces to construct daily indicators of the national energy deficit and parallel market exchange rates. This novel dataset enables us to empirically evaluate a relationship that to date has remained largely anecdotal in the Cuban context.

This paper makes several key contributions to the literature on macroeconomic instability and energy-driven shocks in severely constrained economies. First, it provides one of the first empirical analyses of volatility transmission in Cuba’s informal exchange rate, using high-frequency, real-time data derived from digital market signals, an innovative approach given the scarcity of official statistics. Second, by integrating energy deficit indicators with econometric models of conditional volatility (GARCH), the study extends existing frameworks on macro-financial linkages to a context characterized by information scarcity and state-controlled markets. Third, the paper documents structural breaks and regime shift in exchange rate behavior following major power outages, offering new evidence that energy insecurity can act as a sustained driver of financial instability even outside formal market systems. Together, these

contributions advance understanding of how infrastructure shocks propagate through informal financial channels, providing a methodological template for volatility analysis in similarly data-limited economies.

The structure of the paper is as follows. In Section 2, we present relevant theoretical and empirical literature, outlining the mechanisms linking energy shortages and FX volatility. Section 3 offers comparative case studies, and frames lessons for Cuba. Section 4 describes the Cuban evidence and key data patterns. In Section 5, we detail the econometric strategy and methods. Section 6 presents the results, and Section 7 discusses implications and limitations as well as concluding the paper with broader reflections and directions for further research.

2. Literature Review

2.1 Broader Macroeconomic Background

Macroeconomic literature identifies energy shocks and supply constraints as critical drivers of currency instability in developing economies. Energy deficits weaken external balances through two channels: by reducing export earnings from tradable sectors and by increasing foreign exchange outflows as governments and firms rely on imported fuels for emergency generation (IMF 2015; Foster and Steinbuks 2009). These pressures tighten current-account conditions and heighten exchange rate volatility, particularly in economies with limited reserve buffers and structural rigidities (IMF 2022). Empirical studies reinforce this link between energy insecurity and financial fragility. Persistent electricity shortages lower productivity and an economy's ability to earn foreign currency, thereby amplifying vulnerability to depreciation shocks (Fried and Lagakos 2023). Firm-level evidence across developing economies shows that unreliable power supply directly reduces export participation and competitiveness (Sen Gupta and Singh 2021; Allcott, Collard-Wexler, and O'Connell 2016).

In Cuba's case, these dynamics unfold within a closed, state-dominated economy where official exchange rates remain administratively fixed, and market pressures are expressed through informal channels. Power shortages strain fiscal resources and fuel imports, but their most significant macroeconomic impact operates through expectations and liquidity constraints in the informal FX market. Recurrent blackouts signal systemic stress, undermining confidence in both economic management and the value of the peso. Thus, in Cuba, energy insecurity functions not only as a production constraint but also as a macroeconomic signal that amplifies volatility in informal exchange rate dynamics.

2.2 Mechanisms Linking Power Failures and FX Volatility

Recent empirical research and policy analyses have documented the multiple ways in which electricity shortages can influence both formal and informal foreign exchange (FX) dynamics. Beyond their direct economic costs, power failures affect a country's external position by

constraining tradable output, raising reliance on FX-priced fuel imports, and weakening investor confidence. They can also pressure balance-of-payments reserves, erode public trust in institutions, and intensify the preference for holding foreign currency as a store of value. The following subsections review four main mechanisms emphasized in the literature.

Confidence & Currency Substitution

A possible pathway through which electricity shortages affect informal exchange rate dynamics runs through household confidence and currency substitution: prolonged blackouts signal institutional fragility, corroding trust in macroeconomic management and pushing residents to store value in foreign currencies (a classic response under uncertainty) rather than in domestic money. In theory and evidence on dollarization, perceived policy risk and weak institutions accelerate the shift into hard currency balances (Calvo and Végh 1992; Savastano 1992).

In Cuba, repeated nationwide outages in 2024–2025, widely reported alongside protests and administrative shutdowns, have reinforced public perceptions of systemic stress (The Guardian 2025; France 24 2025). Concurrently, independent monitoring and reporting point to growing dollarization in everyday transactions (movement toward USD/MLC pricing and away from CUP), as households and firms insure against institutional risk by demanding foreign currency (El Toque 2025; CiberCuba 2025; Havana Times 2025; Inter-American Dialogue 2024). These dynamics dovetail with the investor-confidence mechanism emphasized in the macro literature, where unreliable power depresses productivity and heightens perceived sovereign risk (Fried and Lagakos 2023), but operate at the household level, amplifying informal exchange-rate pressures through expectation-driven currency substitution even before formal balance-of-payments strains or trade effects fully materialize.

Investor Confidence Channel

A further mechanism linking energy shortages to exchange rate volatility operates through investor confidence. Persistent power unreliability undermines productivity and long-term growth expectations, discouraging investment and raising sovereign risk premiums. These dynamics not only weaken the domestic investment climate but also erode external perceptions of macroeconomic stability, contributing to heightened currency risk. Fried and Lagakos (2023), using a calibrated general equilibrium model, demonstrate that chronic electricity unreliability depresses productivity and reduces the economy's long-run capacity to generate foreign exchange earnings. The result is greater vulnerability of the domestic currency to depreciation shocks, as investors anticipate both lower growth and higher financing risks. This evidence highlights how energy insecurity reverberates through expectations and risk assessments, amplifying exchange rate pressures beyond the immediate effects of reduced exports or higher fuel imports.

Repeated nationwide blackouts in Cuba during 2024–2025 have intensified public discontent and laid bare the fragility of Cuba’s electricity infrastructure. The stark visibility of disruptions such as cars idle, water pumps failing, hospitals reliant on backup generators, amplifies perceptions of institutional weakness and macroeconomic vulnerability. In such a setting, capital providers may demand higher risk premiums and shift toward holding hard currency as a self-insurance mechanism. This could result in feedback pressure on informal exchange rate expectations, where confidence losses stemming from infrastructure instability help destabilize currency markets beyond direct fiscal or trade shocks.

Import Channel

A third pathway through which electricity shortages affect exchange rate dynamics is via the import channel. When grid failures occur, households and firms are compelled to rely on costly self-generation using imported fuels such as diesel or liquefied natural gas (LNG). This reliance not only raises production costs but also increases FX outflows when export earnings are already under strain. Evidence from enterprise surveys in Sub-Saharan Africa shows that firms frequently resort to self-generation at costs two to three times higher than grid-supplied electricity, with most of this generation dependent on FX-priced inputs like diesel and gas (Foster and Steinbuks 2009). These coping strategies, while essential to sustain operations, create a structural dependence on volatile international fuel markets, amplifying balance-of-payments vulnerabilities and heightening exchange rate volatility in economies already experiencing constrained foreign exchange inflows.

In Cuba, the import channel functions differently than in more open economies. When blackouts intensify, some households and small private businesses turn to self-generation using imported generators and fuel, raising demand for foreign currency. Cuba has authorized the noncommercial importation of electric generators exceeding 900 watts, and reports indicate that sales have increased as blackouts persist (Cuba Headlines 2024; CiberCuba 2024; Havana Times 2022; Translating Cuba 2021). However, these purchases are limited by the small size of the private sector and import licensing restrictions. As electricity production fell, the government sought to stabilize the grid by importing more fuel, reflecting Cuba’s persistent reliance on external energy sources (OnCuba News 2023; EDF 2024).

Balance-of-Payments Stress

Large-scale electricity shortages often translate directly into stress on a country’s balance of payments, as governments resort to costly emergency measures to stabilize supply. Extended outages frequently necessitate ad-hoc electricity imports or urgent fuel swaps, generating sudden drains on foreign exchange reserves. The International Monetary Fund (2015) explicitly connected Ghana’s 2014–2016 “Dumsor” energy crisis to a deterioration of the balance of payments, noting that the increased reliance on emergency imports compounded fiscal pressures

and contributed to depreciation of the cedi. A similar pattern unfolded in Lebanon during its 2019–2022 grid collapse, when reliance on imported diesel became the only means of sustaining basic electricity supply. This dependence quickly depleted foreign reserves, accelerating the country’s broader macroeconomic crisis and fueling sharp depreciation of the Lebanese pound (World Bank 2021). These cases underscore how power shortages can rapidly destabilize external accounts, intensifying exchange rate pressures in fragile economies.

In the Cuban context, this mechanism operates within a far more closed economic structure. Consequently, energy-related balance-of-payments stress manifests not through market-driven capital flows but through state-mediated reserve depletion, as the government allocates scarce foreign currency to purchase imported fuel and spare parts to sustain the grid (OnCuba News 2023; EDF 2024). These dynamics can influence informal FX markets indirectly. As the state’s foreign currency position weakens, public expectations of scarcity intensify, increasing informal demand for hard currency and feeding exchange rate volatility outside formal channels. Thus, balance-of-payments stress operates as a confidence and liquidity mechanism, a signal of macroeconomic fragility that resonates through the informal market (Aenert 2024; Cambridge University Press 2018).

Export Channel

Electricity shortages also generate significant foreign exchange pressures through the export channel. Power outages undermine the productive capacity of tradable sectors, reducing both the quantity and quality of goods available for export. Evidence from a cross-country firm-level study covering 137 developing economies demonstrates that unreliable electricity significantly lowers the likelihood of firms initiating export activities while also diminishing the export intensity of existing exporters (Sen Gupta and Singh 2021). This finding highlights how unreliable infrastructure can create structural barriers to entry into international markets, thereby curtailing FX inflows that are critical for balance-of-payments stability. Supporting evidence from India shows that electricity shortages impose substantial revenue losses on manufacturing plants, with outages reducing plant revenues by 5–10% (Allcott, Collard-Wexler, and O’Connell 2016). The cumulative effect is a contraction of export capacity precisely at the moment when economies most need foreign exchange, reinforcing the link between energy insecurity and exchange rate volatility.

In the Cuban context, however, this mechanism is highly constrained by structural characteristics of the economy. Cuba’s external trade is limited, with a small, state-controlled export sector dominated by nickel, medical services, and tourism rather than manufacturing (Cambridge University Press 2018; World Bank 2023). The private sector, though expanding, remains largely concentrated in domestic commerce and services, with limited direct exposure to export markets (U.S.–Cuba Trade and Economic Council, Inc. 2025). Consequently, while power shortages may

indirectly affect export logistics or service delivery, their impact on overall export earnings and official FX inflows is modest. Nevertheless, the informal FX market could be responding more sensitively to perceived economic stress. Even when outages do not substantially reduce exports, they can erode confidence in Cuba's productive and fiscal capacity, prompting households and small firms to seek protection through foreign currency holdings. In this way, the export channel operates indirectly by shaping expectations of scarcity and depreciation that amplify volatility in the informal market.

Additional Considerations of the Cuban Context

More recently, the growing use of the Mexican peso (MXN) in informal transactions has added an additional layer of volatility. The peso's adoption reflects deepening financial ties between Cuban migrants and remittance networks in Mexico, as well as the operational choices of exchange platforms that price currencies relative to each other rather than to the official CUP (El Toque 2024; Inter-American Dialogue 2024). As a result, fluctuations in the MXN, driven by Mexico's own monetary and macroeconomic conditions, can transmit exogenous shocks into Cuba's informal FX market. The peso's rise as a transactional and remittance currency thus suggests that part of recent volatility may reflect external financial linkages and shifting settlement practices rather than purely domestic macroeconomic stress. Understanding this interaction between domestic energy instability and the evolving structure of Cuba's informal currency system is therefore central to interpreting the observed volatility in unofficial exchange rates.

This paper contributes to the literature by extending existing models of macro-financial volatility to contexts where informal markets and infrastructure fragility interact to shape exchange rate dynamics. Building on frameworks that link supply shocks and financial instability, the study demonstrates that energy deficits can function as systemic volatility shocks in economies with limited market depth and constrained institutional capacity. By formally modeling how power shortages generate persistent changes in conditional variance through a GARCH-based framework, the paper bridges the gap between theories of energy-induced macroeconomic stress and the micro-level mechanisms of expectation formation in informal FX markets. This contribution highlights that volatility in such markets is not merely a financial phenomenon but a reflection of deeper structural and infrastructural vulnerabilities, thereby expanding the conceptual boundaries of exchange rate theory beyond formal monetary and trade determinants.

3. Case Studies Section

3.1 Case Studies from Other Countries

To contextualize Cuba's experience, this section examines a set of comparative case studies from economies that exhibit similar structural vulnerabilities, high energy import dependence, limited foreign exchange buffers, and strong state involvement in the energy sector. These cases illustrate how power shortages can evolve into broader macro-financial disturbances, transmitted through

production losses, fiscal pressures, and shifts in market confidence. The selected countries, Sri Lanka, Jamaica, the Dominican Republic, and Venezuela, represent diverse but instructive examples of how energy crises have interacted with exchange rate instability in small or mid-sized developing economies.¹ Collectively, these comparisons provide a foundation for understanding the mechanisms through which Cuba's 2025 energy crisis translated into volatility in its informal foreign exchange market.

Sri Lanka: Energy Shortages, Blackouts, and Rupee Volatility

Sri Lanka's energy crisis from 2019-2023 provides a compelling parallel to Cuba's 2025 blackout, illustrating how electricity shortages in import-dependent, service-oriented economies can trigger exchange rate instability. Beginning in March 2019, drought conditions reduced water levels in key hydroelectric reservoirs, forcing the government to implement daily three- to five-hour rolling blackouts nationwide (EIU 2022). The crisis deepened again in 2022, when rising global oil prices and fuel import shortages precipitated a complete collapse in power reliability, with entire districts going dark for up to ten hours per day (Caldera et al. 2023).

Tourism, remittances, and services, the primary sources of foreign exchange, were heavily disrupted, while dwindling reserves left the government unable to secure sufficient energy imports. The Sri Lankan rupee (LKR) depreciated rapidly as confidence in the country's ability to meet fuel demand collapsed, losing over 80% of its value between March and August 2022 (Reuters 2022) (Hsu 2025). The International Monetary Fund later identified the energy import crisis as one of the leading drivers of the external and currency collapse that year (IMF 2024).

Sri Lanka's experience illustrates how, in small tourism-dependent economies with limited reserves, energy supply shocks act as powerful external triggers for currency depreciation. The combination of fuel scarcity, grid failures, and a narrow foreign exchange base makes Sri Lanka a structural analog to Cuba's current vulnerabilities. In both countries, energy insecurity in import-dependent, service-oriented economies transforms power shortages into macroeconomic shocks, amplifying uncertainty, depleting reserves, and destabilizing exchange rates. The Sri Lankan rupee's collapse during prolonged blackouts mirrors the Cuban peso's volatility following major grid failures, highlighting how energy crises in low-reserve contexts erode market confidence. The key difference lies in regime structure: while Sri Lanka's liberalized FX system transmits shocks directly through market depreciation, Cuba's state-controlled regime suppresses official movement, pushing volatility into the informal market as a proxy for broader instability.

¹ Additional cases explored during the research, including Ghana, Zambia, Pakistan, and Zimbabwe, further inform the analytical framework and are summarized in the Appendix.

Jamaica: Power Outages, Energy Dependence, and Dollar Instability

Jamaica's chronic exposure to imported fuel and electricity unreliability offers another service-based comparison to Cuba's energy–FX linkage. The country imports nearly 90% of its energy and rising global oil prices in 2022–2023 strained both households and the national grid (ETI 2015). During this period, the Jamaica Public Service Company (JPS) reported a 168% increase in forced outages compared with pre-pandemic levels, while blackouts lasting several hours affected business districts and tourism zones (Jamaica Gleaner 2024).

Tourism operators and small manufacturers, key foreign exchange earners, reported significant production losses due to unstable electricity and higher diesel-generator costs (World Bank 2017). As power reliability worsened, Jamaica's import bill for oil and refined fuels surged, contributing to depreciation pressure on the Jamaican dollar (JMD). Between mid-2022 and early 2023, the JMD weakened from J\$149 to J\$156 per USD, a period coinciding with both high oil import payments and the rise in power outages.

Although no formal econometric study isolates blackouts as the single cause of JMD volatility, the temporal coincidence of energy disruptions and exchange rate weakening suggests a causal relationship through trade and expectations channels. Jamaica's dependence on imported energy and service-sector FX inflows positions it closely alongside Cuba as an example of how energy instability amplifies currency risk in small, open, tourism-driven economies.

Jamaica's experience reinforces the mechanisms observed in Cuba, where energy dependence and service-sector vulnerability jointly magnify exchange rate pressures. Both economies rely heavily on imported fuel to sustain electricity generation and on tourism as a primary source of foreign exchange, making them particularly susceptible to global energy price shocks. As in Cuba, blackouts and rising generator costs in Jamaica disrupted tourism and small-scale manufacturing, reducing FX inflows precisely as fuel import costs increased. The resulting depreciation of the Jamaican dollar parallels Cuba's informal peso volatility following energy crises, reflecting the same trade and expectation channels through which power unreliability undermines currency stability. However, while Jamaica operates under a market-based exchange rate regime, Cuba's dual and state-controlled system internalizes these pressures, shifting their expression to the informal market rather than the official rate, yet the underlying macroeconomic dynamics remain strikingly similar.

Dominican Republic: Fuel Import Pressures, Power Shortages, and Peso Volatility

The Dominican Republic's experience during the global energy price spikes of 2022–2023 mirrors Cuba's vulnerability to external shocks in electricity generation and their spillover into the foreign exchange market. Despite steady tourism recovery after the pandemic, the country's dependence on imported oil and gas for electricity production, covering more than 85% of generation capacity, exposed it to global price volatility and fuel-supply disruptions. As oil prices

surged above \$100 per barrel in early 2022, the government struggled to maintain electricity subsidies, leading to rolling blackouts and tariff adjustments across the grid.

Businesses in Santiago and Santo Domingo reported several-hour power outages through mid-2022, prompting factories and hotels to operate on diesel generators. These additional fuel imports widened the current account deficit, while higher energy costs pushed inflation and fiscal spending upward. The Dominican peso (DOP), which had appreciated modestly in early 2022 due to tourism inflows, began to weaken by mid-year, reflecting increased foreign currency demand to pay for oil imports and backup generation fuel (IMF 2023).

According to the Central Bank of the Dominican Republic, exchange rate volatility rose by nearly 20% between May and September 2022, coinciding with the highest energy import bills on record. The *Diario Libre* described this as “energy pressure on the peso,” noting that sustained blackouts and public frustration led to heightened speculative activity in the FX market. The Dominican case illustrates how energy shocks can undermine monetary stability in tourism-based economies even when fundamental indicators, like tourism receipts and remittances, remain strong.

The Dominican Republic’s experience during the 2022–2023 energy price surge parallels Cuba’s exposure to fuel-import dependency and energy-driven exchange rate volatility. In both cases, heavy reliance on imported oil for power generation transformed global price shocks into immediate domestic pressures on the energy system and foreign reserves. As in Cuba, blackouts and generator reliance in the Dominican Republic increased FX outflows for emergency fuel imports, widened current account deficits, and eroded market confidence. The weakening of the Dominican peso amid rising electricity costs and public discontent reflects the same expectation-driven mechanisms that characterize volatility in Cuba’s informal FX market. However, while the Dominican Republic’s more open economy allows depreciation to manifest through market rates, Cuba’s state-controlled monetary structure channels these pressures through informal exchange rate dynamics, producing volatility that signals broader macroeconomic strain despite the absence of formal market adjustment.

Venezuela: National Blackouts, Oil Sector Collapse, and the Bolívar’s increasing Volatility and Collapse

Venezuela’s 2019 electricity crisis demonstrates how an energy sector collapse can intensify exchange rate volatility, even within a pre-existing macroeconomic crisis. On March 7, 2019, a catastrophic failure at the Simón Bolívar Hydroelectric Plant (also known as the Guri Dam) triggered a nationwide blackout that lasted for more than a week, cutting power to over 90% of the country (Popik 2019). The outage paralyzed oil refineries, transport, and communications, halting exports, and production for days (Viscidi and Graham 2019).

The blackout struck at a moment when the Venezuelan economy was already crippled by sanctions and hyperinflation. Yet analysts noted a distinct spike in exchange rate volatility during and after the outage, as citizens rushed to convert cash into dollars amid the collapse of

electronic payment systems (Laya 2019). Businesses unable to process digital transactions temporarily resorted to bartering or U.S.-dollar pricing (Rendón 2019).

Following the outage, the government instituted rolling rationing schedules and declared national holidays to reduce demand, signaling the deep interdependence between electricity supply and monetary stability (Popik 2019). In this context, energy failure became both a symptom and a multiplier of economic distress. The Venezuelan case reinforces the core proposition that energy disruptions can amplify currency crises through production, confidence, and liquidity channels, a dynamic also visible, though less extreme, in Cuba's 2025 blackout (Huertas 2019).

Venezuela's 2019 blackout offers an extreme version of the dynamics observed in Cuba, illustrating how energy system failure and monetary instability can reinforce one another. Both countries exhibit state-dominated energy sectors, limited access to foreign capital, and restricted exchange rate mechanisms, conditions under which electricity disruptions rapidly evolve into confidence and liquidity crises (Viscidi and Graham 2019). In Venezuela, the nationwide blackout paralyzed oil production, the country's main source of FX earnings, and triggered an immediate surge in dollar demand as citizens and firms lost access to electronic payment systems. Similarly, Cuba's 2025 blackout occurred in a setting of constrained reserves and policy rigidity, where the loss of power eroded confidence in institutional capacity and drove informal peso volatility (Laya 2019; Oliveros 2019). While Venezuela's collapse unfolded on a larger scale and within a hyperinflationary environment, both cases demonstrate that when energy reliability deteriorates under state monopoly control, the resulting shocks magnify currency fragility and accelerate the transition to parallel-market behavior.

3.2 Lessons for Cuba

The comparative experiences of Sri Lanka, Jamaica, the Dominican Republic, and Venezuela underscore that energy insecurity in import-dependent, service-oriented economies can act as a major driver of exchange rate instability. In each case, electricity shortages and fuel import constraints triggered or amplified currency volatility through confidence, trade, and liquidity channels.

Sri Lanka's 2022 collapse demonstrates how fuel scarcity and blackouts can erode reserves and market confidence, leading to rapid depreciation (Reuters 2022). Similarly, Jamaica's surge in generator use and import costs during frequent blackouts weakened the Jamaican dollar, revealing how energy shocks propagate through expectations and balance-of-payments pressures (World Bank 2017). The Dominican Republic's 2022–2023 experience confirms that even amid tourism recovery, fuel import exposure can destabilize the currency by raising import bills and inflation (IMF 2023). Venezuela's 2019 national blackout offers the most extreme parallel,

showing how energy collapse under state monopoly control can trigger broader monetary disorder and parallel-market dependence.

For Cuba, these cases collectively illustrate that energy deficits are not only infrastructure problems but macro-financial shocks that magnify existing fragilities in a closed, state-controlled economy. Strengthening energy reliability and reducing import dependence are therefore essential to stabilizing both the power grid and the peso's volatility dynamics.

4. Data

The study's use of high-frequency, AI-scraped indicators enables the testing of short-run causal mechanisms within a single-country setting, something rarely possible with official macroeconomic data in Cuba. By leveraging informal digital signals, the dataset captures behavioral and expectation-driven responses to power shortages that traditional national accounts overlook. Despite limitations in coverage and precision, this dataset provides the first systematic evidence linking Cuba's energy deficit peaks with volatility in informal exchange rates, consistent with anecdotal evidence and theoretical mechanisms identified in the literature.

4.1 Sources and data collection

This study uses proprietary, high-frequency data generated by DevTech's Artificial Intelligence/Machine Learning (AI/ML)-enabled scraping platform, which systematically collects and processes public social-media posts related to energy deficits and informal exchange rates across Cuban provinces. The study focuses on the period November 2022 – September 2025 (referenced as “Whole Sample” in the analysis), with consistent energy deficit data available from September 2024 – September 2025 (referenced as “Short Sample” in the analysis). The scraping algorithm employs ChatGPT-5-nano to classify unstructured, Spanish-language text from informal digital channels into structured records of currency exchange offers and reports of electricity shortages. The model determines whether each post references the U.S. dollar (USD), euro (EUR), or Mexican peso (MXN), extracts the quoted exchange rate, and records the geographic location and timestamp.

For energy-related posts, the same pipeline identifies mentions of power deficits (in megawatts, MW), aggregates them across users, and computes daily averages. DevTech uses a python script built for semantic analysis to read public posts which report energy updates in Cuba. The script identifies the location and amount of a reported deficit and calculates daily averages for instances when multiple outages were reported. This analysis targets only messages where explicit energy shortages are reported and ignores other energy updates. A simple moving average is calculated to smooth the results from the data scraping.

Both data series, informal FX rates and energy deficits, thus reflect real-time conditions in Cuba's informal economy. They are particularly valuable in this context because official statistics on

electricity reliability and exchange rates are scarce, delayed, or administratively constrained. DevTech's data therefore provides an independent, high-frequency window into the intersection of energy insecurity and currency volatility on the island.

4.2 Variables

The analysis relies on four primary variables constructed from DevTech's dataset:

CUP_Avg: Daily average of the informal Cuban exchange rate (CUP/USD, CUP/EUR, and CUP/MXN). Derived from the aggregation of thousands of informal exchange offers, this indicator reflects the de facto market price of foreign currencies and serves as a proxy for public confidence in the peso.

Deficit_Avg: Daily average of the energy deficit in megawatts (MW), calculated from scraped posts reporting power shortages and outages. This serves as a real-time indicator of energy system stress and grid instability.

CUP_5Day: Five-day moving average of the informal exchange rate (CUP/USD, CUP/EUR, CUP/MXN). This smoothed metric reduces noise and highlights medium-term currency trends while sacrificing some temporal granularity.

Deficit_5Day: Five-day moving average of the energy deficit in MW, smoothing short-term fluctuations in reported power shortages to better capture sustained energy stress.

These variables together allow for dynamic testing of the hypothesis that energy shortages (Deficit_Avg) contribute to informal exchange rate volatility (CUP_Avg) within a unified high-frequency framework.

4.3 Data Limitations

Several limitations qualify the analysis. Reporting of energy deficits is inconsistent across time, with significant gaps in some periods, particularly for the Energy Deficit data before September 2024. The sample window is also relatively short, as consistent reporting began only in recent years, leaving earlier observations sparse and irregular. In addition, informal exchange rate quotes often lack decimal precision, limiting observed variability and potentially dampening volatility estimates. The use of five-day moving averages for both CUP_5Day and Deficit_5Day helps smooth random fluctuations but also reduces the number of independent observations, slightly constraining the statistical degrees of freedom. Finally, both electricity shortages and informal FX activity tend to occur in event-driven bursts, generating clusters of high volatility followed by extended periods of relative stability. Together, these limitations reflect the realities of Cuba's information-constrained environment and the methodological challenges of relying on crowd-sourced, real-time digital signals to approximate underlying economic behavior.

5. Empirical Strategy

To evaluate whether energy deficits contribute to volatility in Cuba's informal exchange rate, this study employs an empirical strategy that integrates time-series econometric techniques with volatility modeling traditionally used in financial economics. The approach focuses on identifying structural breaks, persistence, and clustering in exchange rate fluctuations surrounding major blackout episodes. This strategy allows for both descriptive and formal testing of volatility dynamics, combining classical statistical tools, such as variance comparison and ARCH diagnostics, with a GARCH framework capable of capturing time-varying behavior. By applying this hybrid methodology, the analysis isolates how shocks in electricity supply translate into sustained changes in market uncertainty and exchange rate instability.

5.1 Methodology

The methodological strategy integrates descriptive statistics, variance comparison tests, and conditional volatility modeling to evaluate whether energy deficits influence exchange rate volatility in Cuba's informal market. The analysis proceeds in three stages.

First, a visual and descriptive assessment examines the co-movement between daily energy deficits (DEF01) and the growth rate of the informal exchange rate (DLCUP01). By inspecting trends and spikes across both series, this stage identifies candidate breakpoints (specifically February 7 and March 17, 2025), when Cuba experienced major nationwide blackouts. These observations guide the statistical tests for structural change.

Second, formal statistical tests are applied to assess the stability of the exchange rate variance before and after the March 17, 2025 blackout. According to anecdotal reports, the nationwide blackout occurred between March 14 and March 17, with the event's impact becoming visible in the dataset on March 17 (CBS News 2025; France 24. 2025). The F-test for equality of variances compares the dispersion of daily exchange rate growth across pre- and post-event subperiods, while complementary ARCH tests evaluate whether the variance is constant over time (homoscedastic) or evolves conditionally based on past shocks (heteroscedastic).

Third, the analysis estimates GARCH (1,1) models to quantify volatility persistence and detect structural breaks without imposing specific dates a priori. The GARCH specification allows for the decomposition of conditional variance into short-run (ARCH) and long-run (GARCH) components, capturing how shocks to volatility propagate through time. This framework identifies whether volatility clustering, periods of sustained turbulence, emerges around energy deficit peaks. In addition, Andrews–Quandt and Andrews–Ploberger tests are used to detect endogenous breakpoints in the variance process, revealing when and how volatility regimes may have shifted.

Overall, this methodology combines traditional econometric tools with volatility modeling techniques commonly used in financial time series analysis, adapted here to the unique constraints of Cuba’s informal FX data environment.

5.2 Analytical Approach

The analytical approach is grounded in the hypothesis that major electricity deficits act as volatility shocks in the informal currency market. To test this, the exchange rate is expressed as the first log-difference of daily informal CUP quotations (DLCUP01), while its volatility proxy (DLCUPVARIABILITY) is computed as the squared, demeaned second difference of the log exchange rate. This transformation isolates high-frequency fluctuations and facilitates the estimation of conditional variance models.

The analysis proceeds across two samples:

- Whole sample: November 8, 2022–September 12, 2025 (1,040 usable observations)
- Short sample: September 28, 2024–September 12, 2025 (350 observations)

The division allows examination of both long-run patterns and high-frequency behavior surrounding the 2025 blackout period, as well as accounting for the consistency limitation of the energy deficit data prior to September 2024. Each subsample undergoes parallel estimation to test the robustness of results.

In the GARCH (1,1) specification, the variance equation is modeled as:

$$\sigma_t^2 = C + A\epsilon_{t-1}^2 + B\sigma_{t-1}^2$$

where C is the constant, A captures short-run volatility responses to recent shocks, and B measures the persistence of volatility over time. High values of $A + B$ approaching unity indicate long-lasting volatility effects.

Break detection is performed through the Andrews–Quandt and Andrews–Ploberger tests, which identify unknown structural changes in the variance process without pre-specifying event dates. These tests are particularly suited for capturing regime shifts associated with exogenous shocks such as nationwide blackouts.

Together, the F-tests, ARCH diagnostics, and GARCH modeling create a coherent framework for identifying and quantifying structural breaks in volatility. The approach provides both statistical and substantive evidence that Cuba’s March 2025 energy crisis corresponded with a transition to a higher and more persistent volatility regime in the informal FX market. This combined econometric design ensures that observed relationships reflect not only contemporaneous correlations but also deeper, dynamic changes in the underlying volatility structure of the series.

In summary, this methodological framework provides a systematic approach to identifying and quantifying the relationship between energy shortages and exchange rate volatility in Cuba’s informal market. By combining descriptive, variance-based, and GARCH modeling techniques, the analysis captures both the immediate and persistent effects of power disruptions on market dynamics, offering a robust basis for interpreting the volatility patterns observed in the results.

6. Results

6.1 Preliminary Analysis

As noted in the introduction, this research was motivated by the availability of DevTech’s high-frequency data on both the informal Cuban peso exchange rate and the island’s daily energy deficits. The coexistence of these two unique datasets prompted the central research question of whether fluctuations in electricity supply, manifested through energy deficits, are systematically related to volatility in Cuba’s informal foreign exchange market.

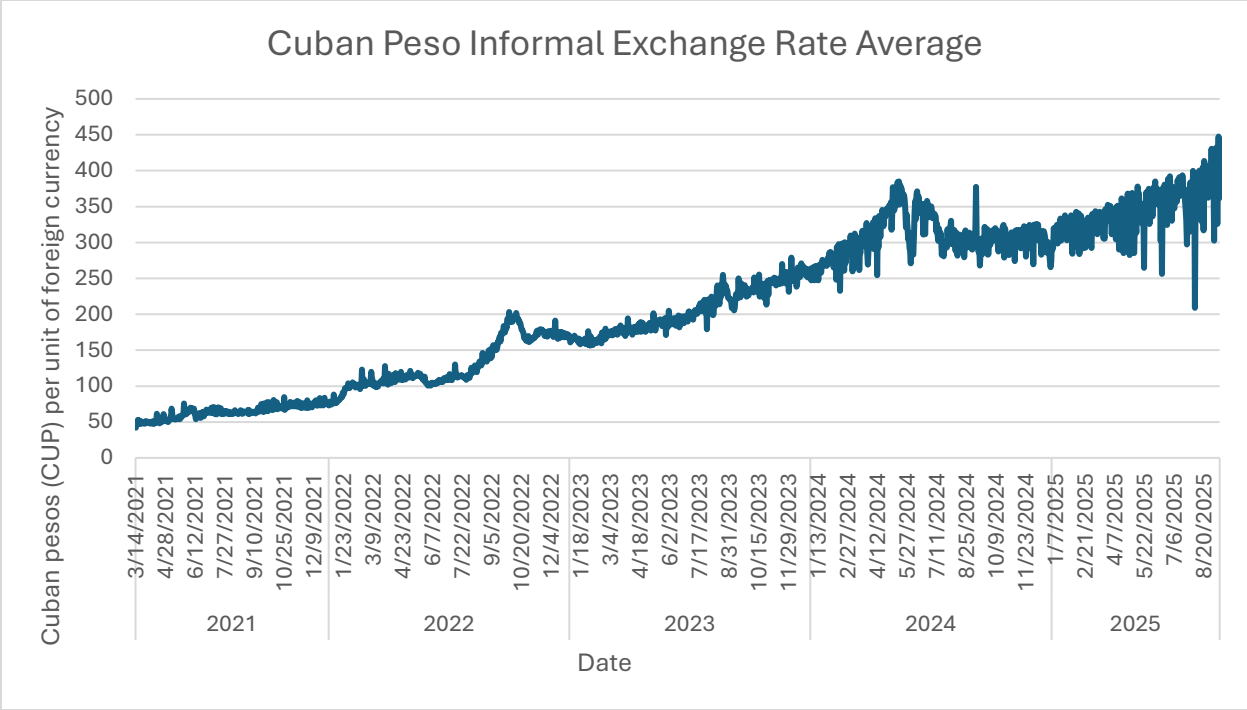
On one hand, the time series of the Cuban informal exchange rate displays a clear pattern of long-term depreciation punctuated by episodes of heightened volatility. Between 2021 and early 2023, the peso’s informal rate increased steadily with relatively contained fluctuations, suggesting gradual devaluation. However, from 2024 onward, volatility intensifies sharply, visible in more frequent and larger deviations from trend, culminating in extreme spikes and troughs during 2024–2025. These pronounced fluctuations coincide with documented energy shortages and macroeconomic disruptions.

Table 1: Notation

NOTATION	
DLCUP01	Difference of log (average) exchange rate
DEF01	Energy deficit
DLCUPVARIABILITY	Second difference of log exchange rate demeaned and squared

Source: DevTech Systems, Inc., 2025

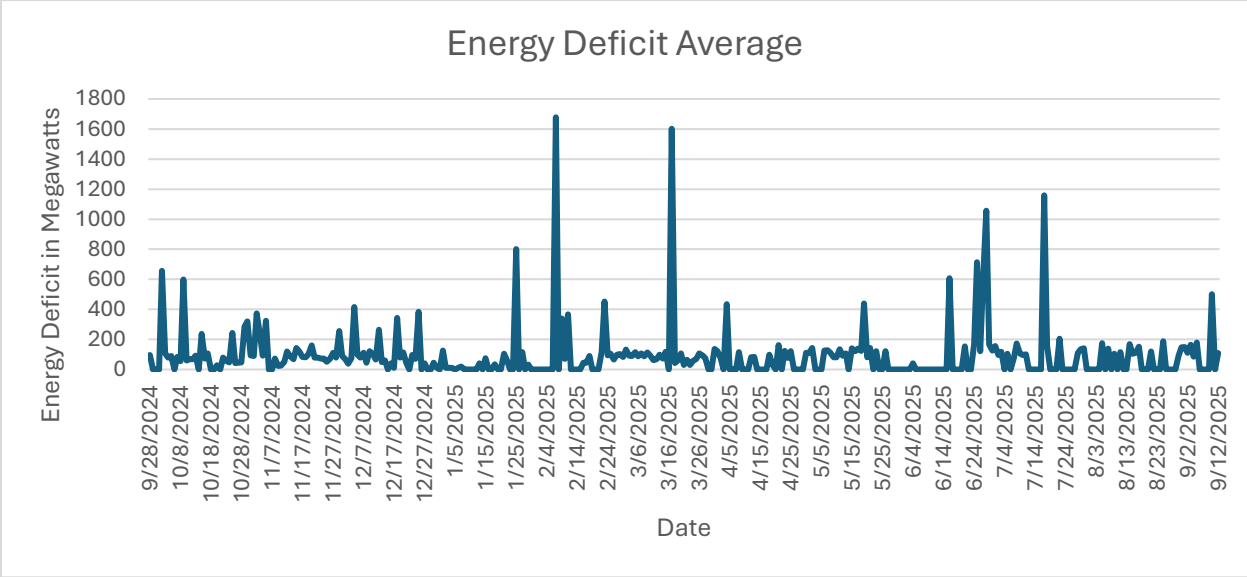
Figure 1: Cuban peso Informal Exchange Rate Average 2024-2025



Source: DevTech Systems, Inc., 2025

On the other hand, the Energy Deficit time series shows recurrent peaks in electricity shortages, with several major spikes exceeding 1,500 megawatts between February and March 2025, indicating severe system stress during this period. Smaller but notable surges appear again in June and July 2025. These peaks suggest cyclical instability in Cuba’s power generation capacity.

Figure 2: Energy Deficit Average 2024-2025



Source: DevTech Systems, Inc., 2025

Initial visual inspection of the two time series reveals a notable rise in exchange rate volatility following major power outages, particularly after February 7, 2025, and March 17, 2025, when the Cuban grid experienced its largest recorded energy deficits during the sample. The latter date marks the first instance of a major nationwide blackout in the continuous dataset, and it was therefore selected as the reference breakpoint for subsequent statistical analysis.

6.2 Descriptive Statistics

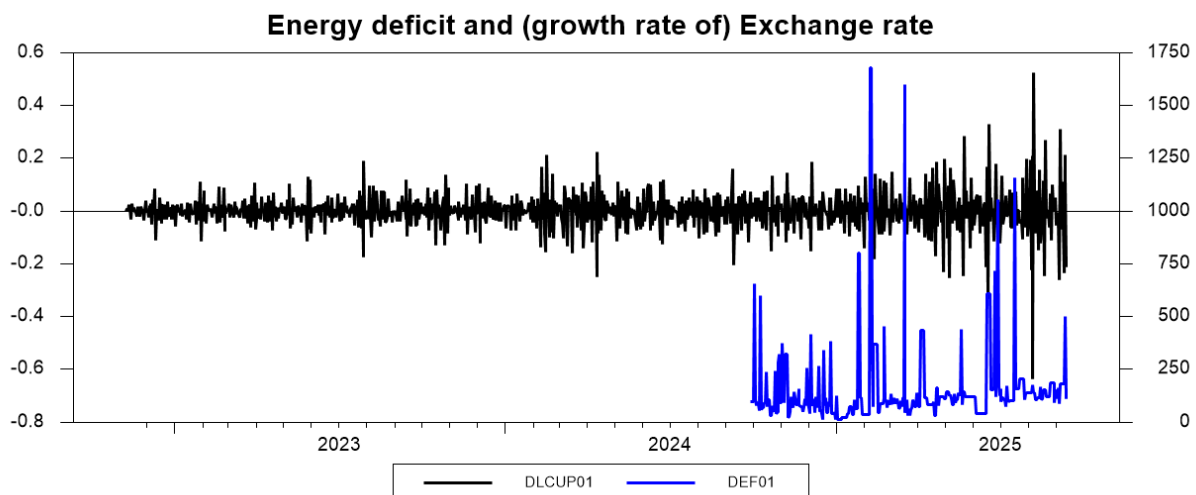
To assess changes in the distributional properties of the informal exchange rate, the data was divided into two sub-periods:

Period 1 (Pre-shock): November 8, 2022–March 16, 2025 (860 observations)

Period 2 (Post-shock): March 17, 2025–September 12, 2025 (180 observations)

When comparing available time series data for exchange rate (rate of growth measure of log difference) and energy deficit, it is observed an apparent permanent increase of exchange rate volatility after the two biggest peaks in energy deficit (2025/02/07 and 2025/03/17).

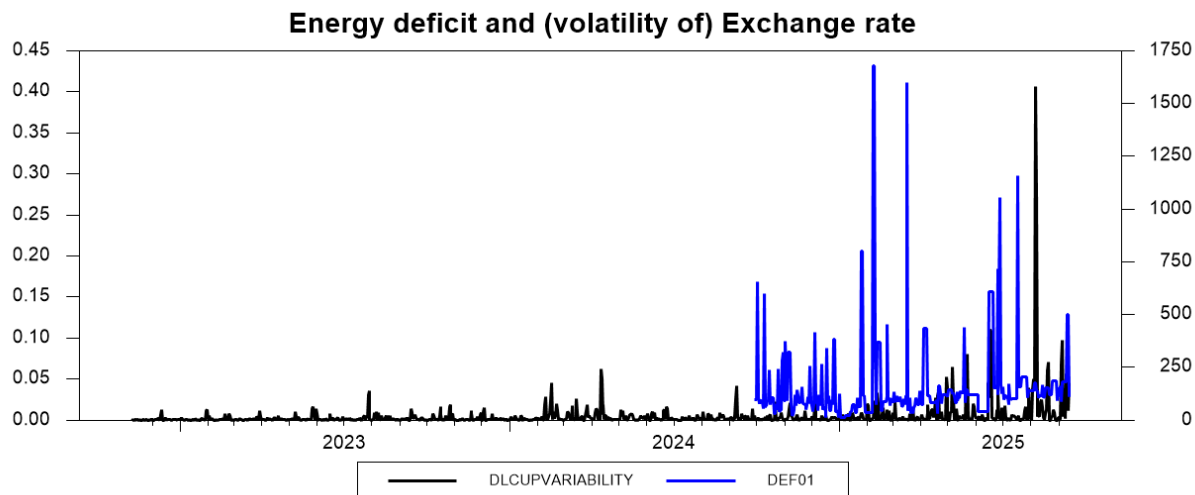
Figure 3: Energy Deficit and (growth rate of) Exchange Rate



Source: DevTech Systems, Inc., 2025

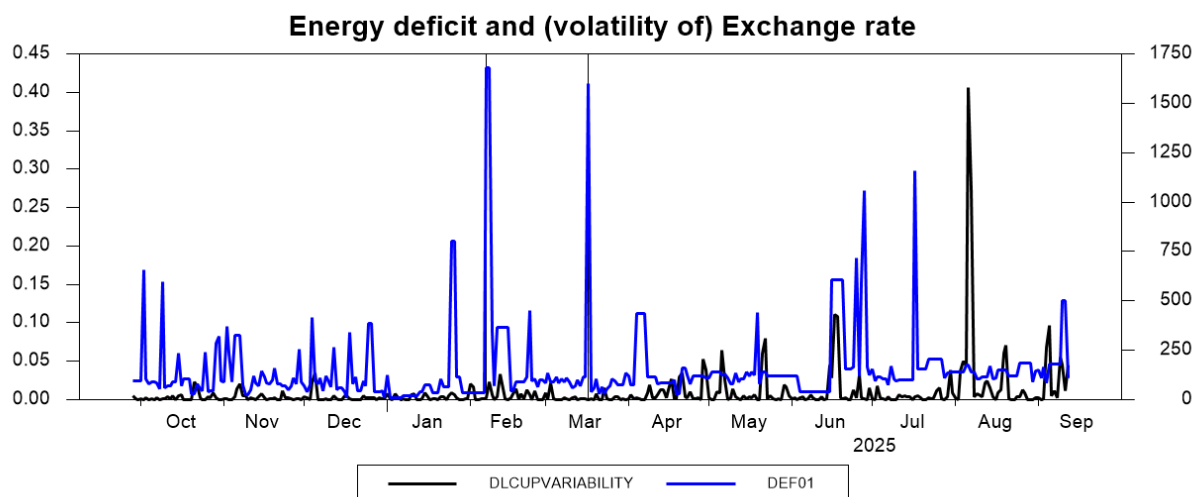
Using a better measure of exchange rate observed gross volatility (just second difference of log exchange rate demeaned and squared), the permanent increase in exchange rate volatility after 2025/03/17 is even more apparent.

Figure 4: Energy Deficit and (volatility of) Exchange Rate



Source: DevTech Systems, Inc., 2025

Figure 5: Energy Deficit and (volatility of) Exchange Rate



Source: DevTech Systems, Inc., 2025

In the following sub-section, we assess the statistical significance of the observed relationship.

6.3 Structural Variance Tests

Simple Descriptive Statistical Test

The results of the simple descriptive statistical test reinforce the visual impression of a marked increase in volatility after the March 17, 2025 blackout. Specifically, the standard deviation (STD) of the daily log difference of the informal exchange rate (DLCUP01) nearly doubles following the event.

Table 2: Comparing Standard Deviation (%) for DLCUP01 Before and After 2025/03/17

Comparing Standard Deviation (%) for DLCUP01 Before and After 2025/03/17	
Short Sample	
STD before 2025:03:17 (%):	6.11578
STD after 2025:03:17 (%):	12.1872
Whole Sample	
STD before 2025:03:17 (%):	5.51755
STD after 2025:03:17 (%):	12.1872

Source: DevTech Systems, Inc., 2025

In the short sample, the standard deviation rises from 6.12% before March 17, 2025 to 12.19% afterward, while in the full sample, it increases from 5.52% to 12.19%. This sharp increase in dispersion confirms that daily fluctuations in the informal exchange rate became substantially larger and more erratic after the energy crisis in both samples. The magnitude of this change suggests a structural shift in market behavior, consistent with the hypothesis that major energy deficits and nationwide blackouts heightened uncertainty, risk perceptions, and speculative activity in Cuba's informal FX market.

This simple variance comparison provides preliminary statistical evidence that the increase in volatility observed visually in the data is economically and statistically significant, warranting more formal testing through heteroscedasticity and GARCH-based analyses in the subsequent sections.

F-Test

We conducted an F-test for equality of variances to determine whether the volatility of the informal exchange rate changed significantly after the selected major event of March 17, 2025 blackout. In other words, the test checks if the variance (or volatility) of the exchange rate before and after the event comes from the same distribution, helping to identify whether a structural break or regime shift occurred in market behavior.

Whole Sample

The results of the F-test for equality of variance using the whole sample provide strong statistical evidence of a structural change in the volatility of Cuba's informal exchange rate following the March 17, 2025 blackout. In the pre-crisis period (November 8, 2022–March 16, 2025; 860 observations), the variance of the daily log-difference of the exchange rate was 0.002888, with a moderate excess kurtosis of 1.96, indicating a distribution that was only slightly fat-tailed relative

to normality. The corresponding Jarque–Bera statistic of 137.15 rejects the null hypothesis of normality, though the deviations were moderate and largely consistent with low-volatility conditions.

In contrast, during the post-crisis period (March 17–September 12, 2025; 180 observations), the variance increased sharply to 0.014853, roughly a fivefold rise, while the excess kurtosis surged to 5.68, reflecting a heavily fat-tailed and extreme-value distribution. The Jarque–Bera statistic rose to 244.77, signaling even stronger non-normality driven by high volatility and frequent large outliers.

The standard F-test for equality of variances, computed as

$$F = \frac{0.014853}{0.002888} = 5.14249,$$

with degrees of freedom (860, 180), yields a p-value effectively equal to zero, decisively rejecting the null hypothesis of equal variances. This confirms that the volatility of the informal exchange rate underwent a statistically significant structural break after mid-March 2025.

Table 53: Whole Sample Descriptive Statistics

Whole Sample Descriptive Statistics (DLCUP01)			
Statistics on Series DLCUP01			
Daily (7) Data From 2022:11:08 To 2025:03:16			
Observations	860		
Sample Mean	0.00079	Variance	0.002888
Standard Error	0.053742	SE of Sample Mean	0.001833
t-Statistic (Mean = 0)	0.431066	Significance Level (Mean = 0)	0.666528
Skewness	-0.00833	Significance Level (Sk = 0)	0.920742
Kurtosis (excess)	1.956298	Significance Level (Ku = 0)	0.000000
Jarque–Bera Statistic	137.1477	Significance Level (JB = 0)	0.000000
Statistics on Series DLCUP01			
Daily (7) Data From 2025:03:17 To 2025:09:12			
Observations	180		
Sample Mean	0.000514	Variance	0.014853
Standard Error	0.121872	SE of Sample Mean	0.009084
t-Statistic (Mean = 0)	0.056604	Significance Level (Mean = 0)	0.954924
Skewness	-0.31052	Significance Level (Sk = 0)	0.091675
Kurtosis (excess)	5.678885	Significance Level (Ku = 0)	0.000000
Jarque–Bera Statistic	244.76580	Significance Level (JB = 0)	0.000000
F (860,180)	5.14249		
Significance Level	0.000000		

Source: Authors' calculations based on DevTech Systems, Inc., 2025

Short Sample

The F-test for equality of variances applied to the short sample provides further confirmation of a statistically significant increase in exchange rate volatility following the March 17, 2025. In the pre-crisis period (September 28, 2024–March 16, 2025; 170 observations), the variance of the daily log-difference of the informal exchange rate was 0.003740, with a modest excess kurtosis of 0.71, indicating a distribution close to normality and relatively stable volatility. The Jarque–Bera statistic of 3.57 does not reject the null of normality (p = 0.168), reinforcing that the pre-crisis period was characterized by mild, well-behaved fluctuations.

In contrast, in the post-crisis period (March 17–September 12, 2025; 180 observations), the variance rose sharply to 0.014853, representing nearly a fourfold increase, while the excess kurtosis jumped to 5.68, suggesting a heavy-tailed distribution dominated by large and irregular swings in the exchange rate. The Jarque–Bera statistic increased dramatically to 244.77 (p ≈ 0.000), strongly rejecting normality and confirming the emergence of more extreme, fat-tailed volatility patterns.

The F-statistic, calculated as

$$F = \frac{0.014853}{0.003740} = 3.97104,$$

with (170, 180) degrees of freedom and $p < 0.001$, decisively rejects the null hypothesis of equal variances. This means that the volatility of the informal exchange rate changed structurally and significantly after March 2025.

Overall, the short-sample analysis supports the conclusion that the March 2025 blackout triggered a discrete volatility regime shift in Cuba’s informal FX market. Before the event, the series exhibited near-normal, low-volatility behavior; after the event, it transitioned to a high-volatility, non-normal distribution dominated by extreme fluctuations—consistent with heightened uncertainty, market illiquidity, and behavioral responses to the energy crisis.

Table 64: Short Sample Descriptive Statistics

Short Sample Descriptive Statistics (DLCUP01)			
Statistics on Series DLCUP01			
Daily (7) Data From 2024:09:28 To 2025:03:16			
Observations	170		
Sample Mean	0.000883	Variance	0.003740
Standard Error	0.061158	SE of Sample Mean	0.004691

t-Statistic (Mean = 0)	0.188260	Significance Level (Mean = 0)	0.850899
Skewness	0.010809	Significance Level (Sk = 0)	0.992384
Kurtosis (excess)	0.709811	Significance Level (Ku = 0)	0.064253
Jarque–Bera Statistic	3.568904	Significance Level (JB = 0)	0.167889
Statistics on Series DLCUP01			
Daily (7) Data From 2025:03:17 To 2025:09:12			
Observations	180		
Sample Mean	0.000514	Variance	0.014853
Standard Error	0.121872	SE of Sample Mean	0.009084
t-Statistic (Mean = 0)	0.056604	Significance Level (Mean = 0)	0.954924
Skewness	-0.310523	Significance Level (Sk = 0)	0.091675
Kurtosis (excess)	5.678885	Significance Level (Ku = 0)	0.000000
Jarque–Bera Statistic	244.76580	Significance Level (JB = 0)	0.000000
F (170,180)	3.97104		
Significance Level	0.000000		

Source: Authors' calculations based on DevTech Systems, Inc., 2025

Overall, these results indicate that the March 2025 nationwide power crisis marked a clear transition to a high-volatility regime in Cuba's informal FX market. The post-event period was characterized by not only greater variance but also more extreme and irregular exchange rate movements, consistent with a macroeconomic environment of heightened uncertainty, liquidity constraints, and amplified sensitivity to shocks. In plain terms, before March 17, 2025, the informal exchange rate exhibited relatively stable variance; after that date, volatility rose dramatically, and the distribution became substantially more erratic and fat-tailed, a change that is economically meaningful.

6.4 Statistical Models:

ARCH Diagnostics

ARCH tests were conducted to indicate whether conditional variance evolves over time rather than remaining constant.

Table 35: ARCH-TEST Rejects the Hypothesis of Homoscedasticity of the Exchange Rate Growth Rate

ARCH-TEST Rejects the Hypothesis of Homoscedasticity of the Exchange Rate Growth Rate				
Linear Regression - Estimation by Least Squares				
Dependent Variable DLCUPVARIABILITY				
Daily (7) Data From 2021:03:16 To 2025:09:12				
Usable Observations				1642
Degrees of Freedom				1640
Centered R ²				0.2469899
R-Bar ²				0.2465307
Uncentered R ²				0.3032289
Mean of Dependent Variable				0.004312953
Std Error of Dependent Variable				0.015185635
Standard error of Estimate				0.013181527
Sum of Squared Residuals				0.284954349
Regression F (1,1640)				537.9255
Significance Level of F				0.0000000
Log Likelihood				4779.2212
Durbin-Watson Statistic				1.8149
Variable	Coeff	Std Error	T-Stat	Signif
1 Constant	0.002171667	0.0003381440	6.42231	0.00000000
2 DLCUPVARIABILITY{1}	0.497734424	0.0214603398	23.19322	0.00000000

Source: Authors' calculations based on DevTech Systems, Inc., 2025

The results of the ARCH test reject the null hypothesis of homoscedasticity in the growth rate of the informal exchange rate, indicating that the series exhibits conditional heteroscedasticity. The regression output shows that the lagged value of exchange rate variability (DLCUPVARIABILITY{1}) is highly significant ($t = 23.19$, $p < 0.001$), with a coefficient of 0.4977, suggesting that nearly half of today's volatility carries over to the next day. The $R^2 = 0.25$ implies that past volatility explains roughly one-quarter of the variation in current volatility, while the highly significant F-statistic (537.9, $p < 0.001$) confirms a strong overall relationship. These results provide clear statistical evidence of volatility clustering in the Cuban informal exchange rate, periods of high volatility tend to be followed by more volatility, consistent with the dynamics observed in financial and informal currency markets under uncertainty.

Table 46: ARCH-TEST: Testing Structural Change in Selected Dates with Dummies

ARCH-TEST: Testing Structural Change in Selected Dates with Dummies	
Daily Data, 2021-03-16 to 2025-09-12	
Linear Regression - Estimation by Least Squares	
Dependent Variable DLCUPVARIABILITY	

Daily (7) Data From 2021:03:16 To 2025:09:12				
Usable Observations	1642			
Degrees of Freedom	1638			
Centered R ²	0.2634616			
R-Bar ²	0.2621126			
Uncentered R ²	0.3184075			
Mean of Dependent Variable	0.004312953			
Std Error of Dependent Variable	0.015185635			
Standard error of Estimate	0.013045416			
Sum of Squared Residuals	0.278211092			
Regression F (1,1640)	195.3055			
Significance Level of F	0.0000000			
Log Likelihood	4797.3795			
Durbin-Watson Statistic	1.8044			
Variable	Coeff	Std Error	T-Stat	Signif
1 Constant	0.001572848	0.0003517708	4.47123	0.00000083
2 DU20250207	0.001297216	0.0021447830	0.60482	0.54537974
3 DU20250317	0.005126856	0.0023373758	2.19342	0.02841698
4 DLCUPVARIABILITY{1}	0.46625562	0.0218648768	21.32441	0.00000000

Source: Authors' calculations based on DevTech Systems, Inc., 2025

The regression results provide strong evidence of volatility persistence in the Cuban informal exchange rate and a statistically significant structural break associated with the major blackout of March 17, 2025. The lagged dependent variable, DLCUPVARIABILITY{1}, has a positive and highly significant coefficient (0.4663, $t = 21.32$, $p < 0.001$), confirming that exchange rate volatility is strongly autocorrelated, periods of high volatility tend to be followed by continued turbulence rather than rapid stabilization. This finding is consistent with the presence of volatility clustering, a hallmark of financial and informal currency markets under stress.

Among the dummy variables capturing major blackout events, DU20250317 (March 17, 2025) is statistically significant at the 5% level ($t = 2.19$, $p = 0.0284$), while DU20250207 (February 7, 2025) is not ($t = 0.60$, $p = 0.5454$). The positive and significant coefficient on DU20250317 (0.0051)

indicates that the March 2025 nationwide blackout corresponded to a discrete and measurable increase in volatility in the informal exchange rate, even after controlling for autoregressive effects. The overall model fit is respectable (Adjusted $R^2 = 0.2621$), and the highly significant F-statistic ($p < 0.001$) confirms that the explanatory variables jointly account for a substantial portion of the observed variation in exchange rate variability. Taken together, these results suggest that the March 2025 energy crisis triggered a structural shift toward a higher and more persistent volatility regime in Cuba's informal FX market.

GARCH Model Estimation

We applied the GARCH test to model and confirm the time-varying nature of volatility in the informal exchange rate series. While the F-test established a structural break in variance before and after the March 2025 blackout, the GARCH framework allows us to capture how volatility evolves over time. Specifically, whether periods of high volatility tend to be followed by further instability. This approach tests for volatility clustering and persistence, providing a more accurate description of exchange rate dynamics in environments like Cuba's informal FX market, where shocks such as power outages can have lasting effects on market uncertainty and risk perception.

Whole Sample

The GARCH (1,1) model was estimated to examine whether volatility in the informal Cuban exchange rate (DLCUP01) exhibits persistence and structural instability over time. The model converged successfully after 19 iterations, with a log-likelihood of 1478.7, indicating a stable and well-specified fit for the daily data spanning November 8, 2022 to September 12, 2025.

In the conditional mean equation, the coefficient for the mean return, -0.00061 , is statistically insignificant ($p \approx 0.657$), implying that average daily changes in the informal exchange rate are effectively zero—typical for financial return series where mean movements are dominated by random fluctuations rather than trends.

In the conditional variance equation, all parameters are positive and statistically significant, confirming the presence of volatility clustering. The constant term ($C = 0.00022$, $p \approx 0.0046$) establishes a positive baseline variance. The ARCH term ($A = 0.2315$, $p < 0.00001$) captures short-run volatility effects—indicating that recent shocks to the exchange rate significantly increase current volatility. The GARCH term ($B = 0.7446$, $p < 0.00001$) measures volatility persistence: a value close to 0.75 suggests that once volatility rises, it tends to remain high for an extended period. The sum of $A + B = 0.9761$, very close to unity, implies highly persistent but mean-reverting volatility, meaning that shocks to the variance dissipate slowly but do not lead to explosive behavior.

The Andrews–Quandt and Andrews–Ploberger tests identify multiple points of structural change in the volatility process. Several statistically significant breakpoints emerge, particularly around

May 2024, March 2025, and May 2025 (p-values between 0.000 and 0.007). These dates coincide with periods of major power disruptions and heightened uncertainty, supporting the hypothesis that the Cuban informal FX market shifted into a higher and more persistent volatility regime following the energy crisis of early 2025.

Table 7: Whole Sample GARCH Model - Estimation by BFGS

Whole Sample GARCH Model - Estimation by BFGS					
Convergence in 19 Iterations. Final criterion was $0.0000009 \leq 0.000010$					
Dependent Variable DLCUP01					
Daily (7) Data From 2022:11:08 To 2025:09:12					
Usable Observations		1040			
Log Likelihood		1478.7001			
	Variable	Coeff	Std Error	T-Stat	Signif
1	Mean (DLCUP01)	-0.00061028	0.001373912	-0.44419	0.65690383
2	C	0.000212519	0.000074943	2.83573	0.00457205
3	A	0.231539087	0.040701206	5.68875	0.00000001
4	B	0.744633923	0.043677737	17.04836	0.00000000
Andrews-Quandt Test			Andrews-Ploberger Test		
	Test	P-Val	Date	Test	P-Value
1	2.905599	0.574	2024:01:30	0.662148	0.333
2	17.337037	0.001	2023:05:07	6.035070	0.000
3	16.004234	0.002	2025:04:07	4.738521	0.001
4	12.902937	0.007	2025:01:31	4.818848	0.001
All	21.769919	0.006	2023:05:07	7.246842	0.007

Source: Authors' calculations based on DevTech Systems, Inc., 2025

Short Sample

The GARCH (1,1) model estimated for the short sample (September 28, 2024–September 12, 2025) provides further confirmation that volatility in the informal Cuban exchange rate (DLCUP01) is highly persistent and exhibits signs of structural instability during 2025. The model converged smoothly after 15 iterations, with a log likelihood of 798.9, indicating a good overall fit and stable parameter estimation for the reduced time window.

In the conditional mean equation, the coefficient on the mean return, -0.00051 , is statistically insignificant ($p \approx 0.59$), implying that, as in the full sample, the average daily change in the informal exchange rate is approximately zero, consistent with a market driven primarily by short-term fluctuations rather than sustained directional trends.

The conditional variance equation reveals clear evidence of volatility clustering. The constant term ($C = 0.00018$, $p \approx 0.012$) establishes a positive baseline level of variance. The ARCH term ($A = 0.2674$, $p < 0.001$) captures short-run effects, showing that shocks to the exchange rate have an

immediate and statistically significant impact on current volatility. The GARCH term ($B = 0.7072$, $p < 0.001$) represents persistence, indicating that volatility shocks decay gradually rather than dissipating immediately. The combined magnitude of $A + B = 0.9746$, again very close to 1, demonstrates long memory in volatility, suggesting that once volatility rises, it remains elevated for an extended period before returning to baseline levels.

The Andrews–Quandt and Andrews–Ploberger tests detect multiple breakpoints in the volatility process, with particularly significant results around March 7, 2025 ($p = 0.001$) and May 7, 2025 ($p = 0.007$). These break dates align with the periods of major blackouts and disruptions identified earlier, pointing to energy shocks as triggers for structural breaks in the variance process.

Table 8: Short Sample GARCH Model - Estimation by BFGS

Short Sample GARCH Model - Estimation by BFGS					
Convergence in 23 Iterations. Final criterion was $0.0000037 \leq 0.0000100$					
Dependent Variable DLCUP01					
Daily (7) Data From 2024:09:28 To 2025:09:12					
Usable Observations		350			
Log Likelihood		382.2674			
	Variable	Coeff	Std Error	T-Stat	Signif
1	Mean (DLCUP01)	-0.00398665	0.00322555	-1.23596	0.21647376
2	C	0.004263357	0.000461046	9.24713	0.00000000
3	A	0.530714654	0.100662665	5.27221	0.00000013
4	B	-0.01490475	0.028064626	-0.53109	0.59535868
Andrews-Quandt Test			Andrews–Ploberger Test		
	Test	P-Val	Date	Test	P-Value
1	1.73396	0.852	2025:04:26	2.211089	0.776
2	14.608898	0.003	2025:04:07	5.140731	0.000
3	14.940071	0.003	2025:07:22	4.177826	0.003
4	15.621477	0.002	2025:07:22	4.859172	0.001
All	22.080793	0.005	2025:07:22	7.370678	0.006

Source: Authors' calculations based on DevTech Systems, Inc., 2025

4.5 Interpretation

From a macroeconomic perspective, the results suggest that energy deficits function as volatility shocks in Cuba's informal currency market. The fivefold increase in variance and the strong persistence of volatility imply that power shortages, particularly large-scale blackouts, may erode market confidence, alter liquidity conditions, and amplify speculative or precautionary behavior among FX traders and households.

These findings are consistent with the literature linking energy insecurity to financial instability (Fried and Lagakos 2023; Foster and Steinbuks 2009; IMF 2015) and with anecdotal evidence of

heightened uncertainty and demand for hard currency following major outages. While causality cannot be established definitively, the synchronization of volatility spikes with energy deficit peaks supports the hypothesis that energy instability contributes to informal exchange rate volatility in Cuba's constrained and expectation-driven economic environment.

7. Final Considerations

This study provides empirical evidence that energy shortages are a macro-critical source of volatility in Cuba's informal foreign exchange market. Using high-frequency data on daily electricity deficits and exchange rates, the analysis identifies a structural break in March 2025, coinciding with a nationwide blackout that marked a shift to a persistent, high-volatility regime. The results of F-tests, ARCH diagnostics, and GARCH estimations converge in showing that power shortages substantially amplify market uncertainty and speculative pressures, eroding confidence in the peso and generating volatility clustering typical of financial crises.

These results align with existing literature showing that in state-controlled economies with limited policy flexibility, energy instability acts as an exogenous monetary shock. In Cuba, where expectations are shaped through informal rather than formal financial channels, blackouts signal institutional fragility, driving currency substitution and precautionary demand for foreign exchange. Comparative evidence from Sri Lanka, Jamaica, the Dominican Republic, and Venezuela reinforces this pattern: in each, unreliable power supply amplified exchange rate pressures through confidence, trade, and liquidity effects. Cuba's distinctiveness lies in its closed economic structure, where such pressures emerge in the informal market rather than through formal devaluations, though the underlying mechanisms remain consistent across cases.

Policy implications are clear. Stabilizing the peso also requires addressing the energy system's structural fragility. Short-term measures could include better alignment of electricity tariffs with FX risks and limited use of hedging instruments for state fuel imports. Over the medium term, diversification toward renewable energy and greater efficiency in generation are essential to reduce the FX intensity of electricity supply. Reliable power is not merely a developmental goal but a prerequisite for monetary stability.

Further research should examine the causal direction between energy outages and exchange rate volatility. While this study shows a strong correlation, the relationship may be bidirectional, blackouts can trigger peso instability, but depreciation may also raise fuel import costs, worsening energy shortages.

To conclude, Cuba's experience demonstrates that energy insecurity can function as a systemic volatility shock in constrained economies. By quantifying this relationship, the paper extends existing macro-financial literature to one of the world's most data-scarce contexts and

underscores a broader principle: in state-dominated, import-dependent systems, the path to currency stability runs through the power grid.

References

Aenert. 2024. "Energy Industry in Cuba." Aenert Energy Portal. Accessed October 3, 2025.

<https://aenert.com/countries/america/energy-industry-in-cuba>.

Allcott, Hunt, Allan Collard-Wexler, and Stephen D. O'Connell. 2016. "How Do Electricity Shortages Affect Industry? Evidence from India." *American Economic Review* 106 (3): 587–624.

<https://doi.org/10.1257/aer.20140389> .

Business Insider Africa. 2023. "Nigeria Leads the Way in Generator Imports in Sub-Saharan Africa." *Business Insider Africa*, March 2023.

<https://africa.businessinsider.com/local/markets/nigeria-leads-the-way-in-generator-imports-in-sub-saharan-africa-says-new-report/ems2z1>

Caldera, Upeksha, Gulagi, Ashish, Jayasinghe, Nilan, and Breyer, Christian. 2023. "Looking island wide to overcome Sri Lanka's energy crisis while gaining independence from fossil fuel imports."

Renewable Energy, Volume 218, <https://doi.org/10.1016/j.renene.2023.119261>

Calvo, Guillermo A., and Carlos A. Végh. 1992. "Currency Substitution in Developing Countries: An Introduction." IMF Working Paper 92/40. Washington, D.C.: International Monetary Fund.

<https://www.elibrary.imf.org/view/journals/001/1992/040/article-A001-en.xml>.

Cambridge University Press. 2018. "Energy Production, Imports, and Consumption in Revolutionary Cuba." *Latin American Research Review*.

<https://www.cambridge.org/core/journals/latin-american-research-review/article/energy-production-imports-and-consumption-in-revolutionary-cuba/16B38B70004E0401D97248A663AE4B51>.

CBS News. 2025. "Cuba Widespread Power Outage: Millions in the Dark." March 15, 2025.

<https://www.cbsnews.com/news/cuba-widespread-power-outage-millions-in-the-dark/>.

CiberCuba. 2024. "Cuban Households Rush to Buy Generators amid Record Blackouts."

CiberCuba, March 2024. <https://www.cibercuba.com/noticias/2024-03-21-u199894-e199894-s27061-cuba-generators-blackouts-demand>.

Cibercuba. 2025. "Cuba al borde del colapso energético, con un déficit de casi 2,000 MW."

Cibercuba Noticias, October 3, 2025. <https://en.cibercuba.com/noticias/2025-10-03-u1-e43231-s27061-nid312240-cuba-al-borde-colapso-energetico-deficit-casi-2000-mw>.

CiberCuba. 2025. "Cuba Reporta Déficit Eléctrico de Más de 1,600 MW." CiberCuba Noticias, February 2025. <https://en.cibercuba.com/noticias/2025-09-26-u1-e42839-s27061-nid311763-jornada-critica-apagones-cuba-superaran-1600-mw>

CiberCuba. 2025. "Cuba Remains in the Dark as Blackouts Maintain a 1,400 MW Deficit." CiberCuba English Edition, March 14, 2025. <https://en.cibercuba.com/noticias/2025-03-14-u1-e42839-s27061-nid298872-cuba-ve-luz-apagones-mantienen-deficit-1400-mw>.

CiberCuba. 2025. "General Blackout Leaves Most of Cuba in Darkness; Hotels Remain Illuminated." CiberCuba English Edition, March 15, 2025. <https://en.cibercuba.com/noticias/2025-03-15-u1-e208933-s27061-nid298933-apagon-general-cuba-deja-oscuras-poblacion-hoteles>.

CiberCuba. 2025. "Cuba's Growing Dollarization: Citizens Turn to Hard Currency as Confidence in the Peso Collapses." CiberCuba, August 2025. <https://www.cibercuba.com/noticias/2025-08-10-u199894-e199894-s27061-cuba-dollarization-growing-citizens-look-stability>.

Cibercuba. 2025. "Unexpected Shutdown of Antonio Guiteras Power Plant Worsens Cuba's Blackout Crisis." Cibercuba, June 2025. <https://www.cubacibernews.com/articles/305230>.

Cuba Headlines. 2024. "Cuba Authorizes the Import of Electric Generators above 900 Watts." Cuba Headlines, February 2024. <https://www.cubaheadlines.com/articles/cuba-authorizes-import-electric-generators-900-watts.html>.

DevTech Systems, Inc. 2025. "The Actual Cuban Exchange Rate Dashboard." DevTech Systems, Inc. October 20, 2025. <https://devtechsys.com/projects/the-actual-cuban-exchange-rate-dashboard/>

EDF (Environmental Defense Fund). 2024. "Building a Cleaner, More Resilient Energy System in Cuba: Opportunities and Challenges." Energy Exchange Blog, August 16, 2024. <https://blogs.edf.org/energyexchange/2024/08/16/building-a-cleaner-more-resilient-energy-system-in-cuba-opportunities-and-challenges-report-blog/>.

El Toque. 2024. "Why the Mexican Peso Matters for Cuba's Informal Exchange Market." El Toque, December 2024. <https://eltoque.com/en/why-the-mexican-peso-matters-for-cubas-informal-exchange-market>.

El Toque. 2025. "Growing Dollarization in Cuba Raises Concerns About the MLC's Future." El Toque, June 2025. <https://eltoque.com/en/growing-dollarization-in-cuba-raises-concerns-over-the-future-of-the-mlc>.

EIU. 2022. "History Repeating Itself: Sri Lanka's Electricity Crisis." The Ceylon Chamber of Commerce, November 2022. https://www.chamber.lk/wp-content/uploads/2024/05/History-Repeating-Itself_Sri-Lanka-Electricity-Crisis_Final.pdf

Energy Transition Initiative (ETI). 2015. "Energy Snapshot : Jamaica." Energy Transition Initiative, April 2015. <https://docs.nrel.gov/docs/fy15osti/63945.pdf>

Foster, Vivien, and Jean-Philippe Steinbuks. 2009. Paying the Price for Unreliable Power Supplies: In-House Generation of Electricity by Firms in Africa. World Bank Policy Research Working Paper 4913. Washington, DC: World Bank. <https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/341551468191961797>

Fried, Stephanie, and David Lagakos. 2023. "Electricity and Firm Productivity: A General-Equilibrium Approach." American Economic Journal: Macroeconomics 15 (4): 67–103. DOI: 10.1257/mac.20210248
France 24. 2025. "Cuba Faces Widespread Power Outages and Growing Public Frustration." March 2025. <https://www.france24.com/en/americas/20250315-cuba-faces-widespread-power-outages-and-growing-public-frustration>.

France 24. 2025. "Cuba Suffers Fifth Nationwide Blackout in a Year as Crisis Deepens." France 24, September 11, 2025. <https://www.france24.com/en/americas/20250911-cuba-suffers-fifth-nationwide-blackout-this-year-as-crisis-deepens>.

Havana Times. 2022. "Cuba's Generator Market Grows as Blackouts Intensify." Havana Times, September 2022. <https://havanatimes.org/news/cubas-generator-market-grows-as-blackouts-intensify/>.

Havana Times / El Toque. 2025. "The Dollarization of Cuba, a Symptom of Structural Collapse." Havana Times, June 18, 2025. <https://havanatimes.org/features/the-dollarization-of-cuba-a-symptom-of-structural-collapse/>.

Huertas, Gonzalo. 2019. "19-13 Hyperinflation in Venezuela: A Stabilization Handbook." Peterson Institute for International Economics, September 2019. <https://www.piie.com/sites/default/files/documents/pb19-13.pdf?utm>.

Hsu, Lily. 2025. "Fixed income index lessons from the 2022 Sri Lankan sovereign default." LSEG, March 28, 2025. <https://www.lseg.com/en/insights/ftse-russell/fixed-income-index-lessons-from-the-2022-sri-lankan-sovereign-default#:~:text=In%20April%202022%2C%20Sri%20Lanka,the%20end%20of%20that%20month>

IEA. 2024. "Cuba: Electricity Data." International Energy Agency. <https://www.iea.org/countries/cuba/electricity>.

Inter-American Dialogue. 2024a. "The Rise of Dollarization in Cuba: Economic Adaptation or Structural Crisis?" Latin America Advisor, February 2024.

<https://www.thedialogue.org/blogs/2024/02/the-rise-of-dollarization-in-cuba/>.

Inter-American Dialogue. 2024b. "Remittances, Mexico, and Cuba: The Peso's Expanding Role." Latin America Advisor, February 2024.

<https://www.thedialogue.org/blogs/2024/02/remittances-mexico-and-cuba-the-pesos-expanding-role>.

International Monetary Fund. 2016. "Ghana: Second Review Under the Extended Credit Facility Arrangement and Request for Waiver for Nonobservance of Performance Criterion—Press Release; Staff Report; and Statement by the Executive Director for Ghana." IMF Country Report No. 16/16. Washington, D.C.: International Monetary Fund, January 2016.

<https://www.imf.org/external/pubs/ft/scr/2016/cr1616.pdf> International Monetary Fund (IMF). 2022. "Pakistan: 2022 Article IV Consultation, Staff Report." IMF Country Report No. 2022/001. Washington, DC: International Monetary Fund.

International Monetary Fund (IMF). 2024. "Sri Lanka: 2024 Article IV Consultation and Second Review Under the Extended Fund Facility, Request for Modification of Performance Criterion, and Financing Assurances Review—Press Release; Staff Report; and Statement by the Executive Director for Sri Lanka." International Monetary Fund, June 13, 2024.

<https://www.imf.org/en/Publications/CR/Issues/2024/06/13/Sri-Lanka-2024-Article-IV-Consultation-and-Second-Review-Under-the-Extended-Fund-Facility-550261>

Jamaica Gleaner. 2024. "OUR raises concerns over massive spike in JPS outages." The Gleaner, November 5, 2024. <https://jamaica-gleaner.com/article/lead-stories/20241105/our-raises-concerns-over-massive-spike-jps-outages>

Laya, Patricia. 2019. "Venezuela's Black Market Comeback Hints at Looming Devaluation." *Al Jazeera*, July 18, 2019. <https://www.aljazeera.com/economy/2019/7/18/venezuelas-black-market-comeback-hints-at-looming-devaluation?utm>.

L'Orient Today. 2021. "'National Suicide': A Breakdown of Lebanon's Deepening Dependence on Diesel Fuel for Private Generators." L'Orient Today, October 2021.

<https://today.lorientlejour.com/article/1287555/national-suicide-a-breakdown-of-lebanons-deepening-dependence-on-diesel-fuel-for-private-generators.html>

Mercopress. 2025. "Cuba Going Through Fourth Nationwide Blackout in Six Months."

MercoPress, March 15, 2025. Accessed October 20, 2025.

<https://en.mercopress.com/2025/03/15/cuba-going-through-fourth-nationwide-blackout-in-six-months>.

Mesa-Lago, Carmelo. 2021. "Cuba's Economic Reform: The Dual Currency System and Its Challenges." Washington, DC: Institute of Cuban and Cuban-American Studies." OnCuba News.

Oliveros Asdrubal, 2021. "Dollarization Can't Save the Venezuelan Economy." Americas Quarterly, October 5, 2021. <https://www.americasquarterly.org/article/dollarization-cant-save-the-venezuelan-economy>.

OnCuba News. 2023. "Cuba Imported More Fuel to Generate Less Electricity in 2023." OnCuba News. November 17, 2023. <https://oncubanews.com/en/cuba/economy/cuban-economy/cuba-imported-more-fuel-to-generate-less-electricity-in-2023> .

OnCuba News. 2023. "Cuba Imported More Fuel to Generate Less Electricity in 2023." OnCuba News, November 17, 2023. <https://oncubanews.com/en/cuba/economy/cuban-economy/cuba-imported-more-fuel-to-generate-less-electricity-in-2023/>.

OnCuba News. 2023. "Cuba's Electric Power System: The Paths of a Crisis." OnCuba News. November 21, 2023. <https://oncubanews.com/en/cuba/economy/cubas-electric-power-system-the-paths-of-a-crisis>. Popik, Thomas S. 2019. "*Venezuela Blackouts: Draft Situation Assessment and Implications*." Foundation for Resilient Societies, March 14, 2019. https://www.resilientsocieties.org/uploads/5/4/0/0/54008795/draft_situation_assessment_of_venezuela_blackout_20190314.pdf.

Punch Newspapers. 2023. "Manufacturers Spent N783bn to Generate Power in Nine Years – MAN." Punch, April 2023. <https://punchng.com/manufacturers-spent-n783bn-to-generate-power-in-nine-years-man/>

Rendón, Moisés. 2019. "Venezuela's Man-Made Power Outage." CSIS, March 14, 2019. [CSIS](https://www.csis.org/analysis/venezuelas-man-made-power-outage). <https://www.csis.org/analysis/venezuelas-man-made-power-outage>.

Reuters. 2024. "Nigeria Secures \$500 Million World Bank Loan for Electricity Sector." Reuters, May 2024. <https://www.reuters.com/world/africa/nigeria-secures-500-million-world-bank-loan-electricity-sector-2024-05-30/>

Reuters. 2025. "Cuba's Electrical Grid Collapses; Widespread Blackouts Reported." March 15, 2025. <https://www.reuters.com/world/americas/cubas-electrical-grid-fails-widespread-blackouts-reported-2025-03-15/>

Reuters. 2025. "Cuban Currency Hits Record Low as Dollarization Gains Ground." Reuters, August 11, 2025. <https://www.reuters.com/world/americas/cuban-currency-hits-record-low-dollarization-gains-ground-2025-08-11/>.

Rentschler, Jun, and Martin J. Klapp, eds. 2019. "Underutilized Potential: The Business Costs of Unreliable Infrastructure in Developing Countries." Washington, DC: World Bank. 10.1596/1813-

9450-8899.

https://www.researchgate.net/publication/347768671_Underutilized_Potential_The_Business_Costs_of_Unreliable_Infrastructure_in_Developing_Countries

Torres, Ricardo. 2025. "Cuba's Energy Crisis: A Systemic Breakdown," IEEE Spectrum, July 1 2025. <https://spectrum.ieee.org/cuba-energy-crisis>.

Savastano, Miguel A. 1992. "Dollarization in Latin America: Recent Evidence and Some Policy Issues." IMF Working Paper 92/33. Washington, D.C.: International Monetary Fund. <https://www.elibrary.imf.org/view/journals/001/1992/033/article-A001-en.xml>.

Sen Gupta, Abhijit, and Abhishek Singh. 2021. "Do Power Outage Hurt Export Performance? Asian Infrastructure Investment Bank Working Paper." <https://aiib-live-test.aiib.org/en/news-events/media-center/working-papers/pdf/Does-Power-Outage-Hurt-Export-Performance-June-2021.pdf>

TheGlobalEconomy. 2024. "Cuba: Electricity Imports." The Global Economy. https://www.theglobaleconomy.com/Cuba/electricity_imports.

The Guardian. 2021. "Lebanon Hit by Electricity Outage Expected to Last Several Days." The Guardian, October 9, 2021. <https://www.theguardian.com/world/2021/oct/09/lebanon-hit-by-electricity-outage-expected-to-last-several-days#:~:text=Lebanon's%20electricity%20grid%20collapsed%20on,for%20at%20least%20two%20days>.

The Guardian. 2025. "Cuba's Rolling Blackouts Deepen Economic Crisis and Public Discontent." The Guardian, April 2025. <https://www.theguardian.com/world/2025/apr/14/cuba-blackouts-economy-crisis>.

Translating Cuba. 2021. "Cuban Families Turn to Generators amid Ongoing Power Cuts." Translating Cuba, August 2021. <https://translatingcuba.com/cuban-families-turn-to-generators-amid-ongoing-power-cuts/>.

U.S. – Cuba Trade and Economic Council, Inc. "Since 2022, U.S.\$191+ Million U.S. Exports to Cuba's Re-Emerging Private Sector — Including U.S.\$128 Million in Vehicles." U.S. – Cuba Trade and Economic Council, Inc. (blog), September 7, 2025. Accessed [date of access]. <https://www.cubatrade.org/blog/2025/9/7/avw719i01mj73epxovwohtyunm2hvy>

Viscidi, Lisa, and Selwin Graham. "Blackouts in Venezuela: Why the Power System Failed and How to Fix It." Real Instituto Elcano Expert Comment, October 2019. <https://media.realinstitutoelcano.org/wp-content/uploads/2021/11/commentary-viscidi-graham-blackouts-venezuela-why-power-system-failed-and-how-to-fix-it.pdf>.

World Bank. 2017. “Zambia Economic Brief: How Zambia Can Borrow without Sorrow.” Washington, DC: World Bank. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/782221512459934813>

World Bank. 2021. “Lebanon Economic Monitor, Fall 2021: The Great Denial.” Washington, DC: World Bank. <https://documents.worldbank.org/en/publication/documents-reports/documentdetail/145691627718854510/lebanon-economic-monitor-the-great-denial>.

World Bank. 2023. “Cuba Economic Update 2023.” Washington, D.C.: World Bank. <https://www.worldbank.org/en/country/cuba/overview>.

World Bank. 2023. “Zimbabwe Economic Update: Electrifying Zimbabwe’s Growth Through Reliable and Universal Energy Access.” Washington, DC: World Bank. <https://www.sciencedirect.com/science/article/pii/S0140988324004924>

Appendix

Additional Case Studies

Lebanon: Diesel Dependence, FX Reserve Drain, and Pound Collapse

Lebanon’s experience between 2019 and 2022 provides a striking illustration of how electricity shortages can destabilize foreign exchange markets. Following years of underinvestment and corruption in the power sector, the country’s two largest plants, Zahrani and Deir Ammar, ran out of fuel in October 2021, precipitating a nationwide grid collapse that left much of the country in darkness for days (Chehayeb, 2023). With the state utility unable to provide supply, reliance shifted almost entirely to private diesel generators. This dependence proved catastrophic for Lebanon’s foreign reserves: L’Orient Today estimated that by 2021, more money was being spent on diesel imports for backup generators than on fuel for the state grid, amounting to nearly \$10 billion since 2010 (Szakola, 2022). Because these imports were priced in U.S. dollars, it drained what little foreign currency reserves remained at the central bank, accelerating the pound’s collapse, which by 2021 had already lost more than 90% of its value against the dollar (Chehayeb, 2023). The World Bank described Lebanon’s financial and energy crises as among the worst globally since the mid-nineteenth century, noting that energy dependence on imported diesel created an acute feedback loop between electricity shortages and FX depreciation (World Bank 2021). Together, these developments illustrate how a failing power system can deepen macroeconomic collapse by simultaneously increasing FX outflows and eroding confidence in the national currency.

Nigeria: Generator Imports, Industrial Costs, and Naira Volatility

Nigeria’s chronic electricity shortages have created a structural dependence on costly self-generation, making the country the single largest generator importer in Sub-Saharan Africa. Estimates suggest that Nigeria alone accounts for 3 million of the 6.5 million generators operating

in the region, underscoring the depth of the grid reliability crisis (Business Insider Africa 2023). This reliance on FX-priced diesel and petrol generators has drained foreign reserves and exacerbated naira volatility, with households and firms collectively spending an estimated \$14 billion annually on generator fuel (Business Insider Africa 2023).

The costs to industry have been equally stark. Between 2014 and 2022, Nigerian manufacturers spent approximately N783 billion on self-generation, with energy costs now absorbing 35–40% of total production expenses. This burden has undermined profitability and competitiveness, prompting some multinational firms to consider exiting the country (Punch 2023). To sustain this dependence, Nigeria spent over \$5.2 billion on generator imports and electrical machinery in just two years (2020–2021), further heightening FX outflows (Business Insider Africa 2023). The fiscal and financial dimensions of the crisis are visible in Nigeria’s repeated need for international support. In 2024, the World Bank approved a \$500 million loan to strengthen power distribution, reflecting the country’s persistent struggles with a failing grid, gas shortages, and high debt (Reuters 2024). Earlier policy appraisals emphasized how unreliable power supply remains the single greatest constraint to doing business in Nigeria, with more than a quarter of firms citing electricity as their top obstacle (World Bank 2018). The result has been a cycle of power unreliability, naira instability, and dependence on external financing, a vivid case of how energy insecurity translates into macroeconomic vulnerability.

Ghana: “Dumsor” - Load Shedding, Emergency Imports, and Cedi Depreciation

Ghana’s 2014–2016 electricity crisis, widely referred to as “Dumsor,” illustrates how prolonged energy shortages can destabilize both real and external sectors. Chronic load shedding sharply curtailed industrial production, particularly in energy-intensive industries such as manufacturing and mining, leading to losses in export revenues at a time when the country’s external position was already fragile. To stabilize supply, the government was forced to resort to costly emergency measures, including electricity imports and ad-hoc fuel purchases, which placed additional pressure on foreign exchange reserves (IMF 2016). The International Monetary Fund explicitly tied the energy crisis to Ghana’s macroeconomic deterioration, noting that disruptions in electricity supply compounded current-account imbalances and contributed to depreciation of the cedi. As the IMF observed, the “Dumsor” crisis created a dual shock: it simultaneously constrained tradable output and forced FX outflows for emergency imports, amplifying exchange rate volatility (IMF 2016). Ghana’s experience highlights the feedback loop between energy insecurity and currency instability, reinforcing the broader evidence that electricity shortages can trigger balance-of-payments crises in emerging markets.

Zambia: Hydropower Shortages, Copper Cutbacks, and FX Outflows

Zambia’s heavy dependence on hydropower has made its economy acutely vulnerable to drought-induced energy crises. During the mid-2010s and again in 2024–2025, severe reductions in rainfall drastically lowered generation capacity, forcing the state utility ZESCO to ration power and request mining companies to cut electricity consumption by up to 40% (Bloomberg News, 2024). Since copper accounts for roughly 70% of Zambia’s export earnings, power rationing directly

reduced mining output, weakening the country's external balance (GIZ 2016). To offset shortages, Zambia was compelled to import emergency electricity from neighboring countries and contract expensive short-term supply agreements with providers such as Aggreko and Karpowership, often at tariffs two to three times higher than domestic hydropower (GIZ, 2016). These measures significantly raised foreign exchange outflows at precisely the moment export revenues were curtailed. The World Bank emphasized in its 2017 *Zambia Economic Brief* that the dual shock of weaker copper exports and higher FX demand for emergency energy imports deepened macroeconomic imbalances, contributing to volatility in the kwacha and a worsening debt profile. Industry-level analyses further reveal that energy insecurity pushed up production costs across the copper sector, eroding competitiveness and fueling investor concerns about Zambia's economic resilience. The mining sector's reliance on over 50% of national electricity consumption made the crisis particularly severe, and firms were forced to consider costly diesel generation as a stopgap (World Bank 2017; GIZ 2016). . This pattern underscores the balance-of-payments vulnerability that arises when power reliability falters in economies heavily reliant on energy-intensive tradables like copper.

Pakistan: LNG Import Constraints, Blackouts, and Rupee Instability

Pakistan's 2022 energy crisis demonstrates the reverse channel in which foreign exchange scarcity and currency depreciation exacerbate electricity shortages. As global liquefied natural gas (LNG) prices surged following the Russia–Ukraine war, Pakistan, which is heavily dependent on LNG imports for power generation, faced severe difficulties in securing cargoes. By mid-2022, suppliers had defaulted on multiple long-term contracts, forcing the government to purchase LNG on the spot market at significantly higher prices or leave tenders unmet. The resulting supply gaps triggered rolling blackouts across the country, disrupting industrial production and worsening public discontent.

At the same time, the rupee came under acute pressure as rising LNG import costs increased demand for scarce foreign exchange reserves. The IMF noted that the inability to secure affordable LNG imports contributed to both widespread electricity shortages and heightened exchange rate instability, reinforcing one another in a self-reinforcing cycle (IMF 2022). With energy shortfalls cutting into export competitiveness and FX outflows surging to finance fuel imports, Pakistan experienced one of its sharpest currency depreciations in recent history, losing nearly 30% of its value in 2022 alone. The crisis highlights how external energy dependence, FX reserve adequacy, and exchange rate stability are tightly interconnected, with shocks in one domain quickly spilling into the others.

Zimbabwe: Power Sector Failures, Industrial Losses, and Currency Crises

The experience of Zimbabwe further highlight how electricity shortages and exchange-rate instability can reinforce one another in fragile economies.

Zimbabwe's recent economic updates paint a parallel picture of how electricity deficits fuel macroeconomic instability. The World Bank's *Zimbabwe Economic Update* (2023) estimates that unreliable electricity supply costs the economy the equivalent of 6.1% of GDP annually, with significant losses in mining, agriculture, and agro-processing. Rolling blackouts, sometimes lasting 12–14 hours per day, have directly reduced industrial output while raising costs for firms reliant on imported fuel for backup generation. These shortages have exacerbated inflationary pressures by disrupting supply chains and contributing to exchange-rate volatility, weakening the Zimbabwean dollar (World Bank 2023).

This case underscores how fragile states with weak institutional capacity face particularly acute risks when electricity shortages intersect with FX instability. In Zimbabwe, energy insecurity has not only reduced output but also deepened currency crises, illustrating the macro-critical nature of reliable power supply in contexts of economic fragility.

These diverse cases, from Lebanon to Zimbabwe, demonstrate how electricity shortages and currency instability can form mutually reinforcing crises, providing a comparative framework against which the Cuban experience can now be examined in greater depth.