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Effect of electronic payment systems, and financial inclusion on the forex market in Ghana

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Abstract--The study examines the impact of electronic payment systems and financial inclusion on the forex market in Ghana, using data from the world development indicators, spanning 2012 to 2023. The autoregressive distributed lag (ARDL) method was used since the variables were integrated of order one I(1) and I(0) respectively. The increasing adoption of digital payment platforms and financial services accessibility has transformed the financial ecosystem, influencing exchange rate dynamics. Findings reveal that electronic payment systems enhance transactional efficiency, reduce reliance on cash, and formalize remittance flows, stabilizing forex market demand. Similarly, financial inclusion expands access to credit and savings, strengthens domestic economic activity, and mitigates pressure on foreign currency demand. However, these benefits depend on robust infrastructure, financial literacy, and effective regulatory frameworks. The study underscores the need for policy measures to foster digital finance adoption, enhance financial literacy, and align financial inclusion efforts with broader economic strategies to ensure sustainable forex market stability.

Keywords---Forex Market, Electronic Payment System, Digital Finance, Remittance, Exchange Rate.

Introduction

Forex market in Ghana consists of principal participants, including the Bank of Ghana, commercial banks, forex bureaus, and enterprises involved in import and export activities, the Bank of Ghana (BoG) functions as the regulatory authority, overseeing adherence to foreign exchange regulations and administering the nation's foreign reserves. The Ghanaian Cedi serves as the national currency, with the foreign exchange market facilitating its trade against prominent currencies including the US Dollar, Euro, and British Pound. The Dollar and the Cedi pair is the most actively traded, indicating Ghana's dependence on dollar transactions for its imports and exports. Ghana employs a controlled floating exchange rate regime, the currency rate is dictated by market factors, and however the Bank of Ghana intervenes to stabilize the cedi during times of significant volatility (Adam, 2024).

The adoption of electronic payment systems (EPS) has transformed Ghana's financial landscape by enhancing transactional efficiency and broadening financial inclusion (Olunuga & Ashoghon, 2024; Awan & Parveen, 2024; Chukwuekwu, 2024). These systems, which include mobile money platforms, internet banking, and fintech innovations, have a profound impact on the dynamics of the foreign exchange (forex) market. The nexus between EPS and the forex market in Ghana is shaped by both macroeconomic factors and the operational efficiencies that EPS introduces (Paudel, 2024). Ghana's EPS ecosystem, led by services such as MTN Mobile Money, Telecel Cash, and various banking apps, has grown exponentially in recent years. The Bank of Ghana reported a 65% increase in mobile money transactions from 2020 to 2022, highlighting the role of EPS in facilitating both domestic and international transactions (Esely & Taonezvi, 2024; Ahmodu *et al.*, 2024). These systems enable seamless cross-border payments, which affect the demand for foreign currency, particularly the U.S. dollar (Tamraparani, 2024; Chuen & Zhao, 2024). Electronic payment systems (EPS) simplifies the process of obtaining foreign exchange for purposes such as trade, remittances, and travel (Mahesh & Bhat, 2022). For instance, businesses use EPS to purchase goods and services from international markets, which increases the demand for forex. Similarly, remittance inflows, a significant source of foreign exchange for Ghana, are facilitated by digital platforms like WorldRemit and Wave (IMF, 2024). These inflows enhance forex supply but can create disparities when they are funneled into informal market channels. The ease of forex accessibility through EPS has introduced volatility in the forex market. Individuals and businesses frequently use these platforms to hedge against currency depreciation, leading to sudden spikes in forex demand during economic uncertainties. For instance, in 2021, increased forex demand through EPS coincided with a depreciation of the Ghanaian cedi against the dollar, indicating a direct impact of EPS-driven transactions on forex market dynamics (World Bank, 2021).

Electronic payment systems facilitate cross-border transactions, allowing businesses and individuals to procure products and services with reduced obstacles. This convenience results in an increased demand for dollars, as importers necessitate foreign currency to fulfil international transactions (Thiébaud, 2024; Olalekan *et al.*, 2024). The expansion of e-commerce and digital subscription services priced in U.S. dollars has resulted in a heightened frequency and volume of transactions conducted in dollars (Demyen, 2024). Platforms such as PayPal and mobile money integrations facilitate these transactions, consequently increasing the demand for dollars (Nair & Kannan, 2023). In times of currency depreciation, electronic payment systems offer an effective mechanism for individuals and businesses to retain dollars as a protective measure. The speculative demand for dollars is intensified by the readily available access to foreign exchange trading via digital platforms (Molina, 2023). Digital payment systems facilitate the efficient processing of remittance inflows, which constitute a significant source of dollar liquidity in Ghana. Platforms such as Western Union, WorldRemit, and MTN Mobile Money significantly improve the accessibility and expediency of fund transfers, thereby augmenting the availability of dollars in the foreign exchange market.

Exporters of cocoa, gold, and oil utilize electronic systems to facilitate the receipt of payments, resulting in expedited repatriation of export revenues (Yhip & Alagheband, 2024). This augments the official supply of dollars within the economy. Digital platforms have significantly enhanced the facilitation of transactions within informal foreign exchange markets (Senyo *et al.*, 2023).

Although this facilitates access to real currency, it may diminish the official supply of dollars, thereby complicating the stability of the market (Subair, 2023). The simplicity of converting cedis to dollars for speculative endeavors exacerbates the strain on the local currency, thereby contributing to fluctuations in the exchange rate. The central bank must enhance its supervision mechanisms to effectively monitor and regulate substantial foreign exchange transactions executed through digital platforms, ensuring their alignment with the objectives of monetary policy (Soana & deArruda, 2024). Promoting the utilization of local currency in electronic transactions may diminish dependence on the dollar, thereby contributing to the stabilization of demand for foreign currency. Electronic payment systems exert a dual influence on the demand and supply of United State currencies within Ghana. While they enhance efficiency and promote financial inclusion, they simultaneously contribute to an increased demand for dollars, particularly in relation to imports, speculative activities, and cross-border transactions (Oorkolil, 2024). Policymakers must devise strategies that harmonize the advantages of digital payments with initiatives aimed at alleviating their impact on exchange rate stability.

The expansion of electronic payment systems (EPS) in Ghana has unequivocally facilitated financial transactions and enhanced financial inclusion (Joshi & Aggarwal, 2024; Gitonga, 2023). Nevertheless, their swift adoption has also introduced specific challenges that adversely impact the foreign exchange (forex) market (Almutairi *et al.*, 2024). These challenges arise from the heightened accessibility to foreign exchange markets, speculative trading practices, and deficiencies in regulatory frameworks. Electronic payment systems (EPS)

platforms facilitate enhanced accessibility to foreign exchange markets for both enterprises and individuals. This accessibility may give rise to speculative demand during times of economic uncertainty, for instance, when the Ghanaian cedi exhibits indications of depreciation, individuals may utilize electronic payment systems (EPS) to convert their funds into more stable currencies, such as the United States dollar (Islahiyah, 2024; Nambie et al., 2024). This speculative activity intensifies volatility within the foreign exchange market, as demand escalates uncontrollably, frequently exacerbating depreciation pressures. Notwithstanding endeavors to formalize financial transactions, a considerable segment of foreign exchange transactions transpires within the informal sector, enabled by electronic payment systems (EPS) platforms (Bennett, 2021). This situation presents challenges in monitoring and regulating foreign exchange transactions, thereby compromising the stability of the foreign exchange market. The absence of transparency regarding these transactions may also facilitate black-market activities, thereby exacerbating the instability of official exchange rates (Johnson & Johnson, 2020). Electronic payment systems (EPS) platforms facilitate effortless international transactions; however, a significant number of these transactions are conducted in foreign currencies, predominantly the US dollar, this situation engenders currency discrepancies, thus amplifying the demand for foreign exchange (Ahmed *et al.*, 2024). In circumstances where enterprises and individuals are required to make payments in United States dollars while generating revenue in Ghanaian cedis, there is an increased strain on the local currency, resulting in its depreciation (Zubairu *et al.*, 2024).

The swift proliferation of electronic payment systems (EPS) platforms in Ghana has surpassed the development of corresponding regulatory frameworks. Inadequate supervision facilitates unregulated foreign exchange trading via digital platforms, thereby heightening the potential for fraudulent activities and market manipulation (Wronka, 2024). Furthermore, the regulation of electronic payment systems (EPS) utilized for speculative foreign exchange trading presents significant challenges, as transactions can be executed instantaneously across international borders. The convenience of transferring funds via the Electronic Payment System (EPS) complicates the Bank of Ghana's endeavors to regulate exchange rate volatility, for example, heightened foreign exchange outflows facilitated by electronic payment systems (EPS) during periods of economic crisis diminish the central bank's capacity to stabilize the currency through intervention measures (Nambie *et al.*, 2024). The influence of electronic payment systems (EPS) on the forex market underscores the need for robust regulatory frameworks, the Bank of Ghana's efforts to integrate electronic payment systems (EPS) into formal financial systems and monitor forex transactions are critical in mitigating market volatility. Policies encouraging the settlement of transactions in local currency through EPS could alleviate forex demand pressures and stabilize the exchange rate (Prabheesh *et al.*, 2024). The role of EPS in Ghana's forex market is both transformative and complex, by enabling efficient transactions, these systems drive forex demand and supply dynamics, often influencing exchange rate stability. Ongoing research and data monitoring are crucial to understanding and managing these impacts to ensure that EPS contributes positively to Ghana's economic growth.

Ghosh *et al.* (2024) conducted an investigation into the economic uncertainty index and its effects on financial markets, the study demonstrated that increased economic uncertainty adversely impacts stock market performance and investment decisions. Furthermore Dar *et al.* (2024) conducted an evaluation of market factors that affect asset pricing, demonstrating that profitability and investment serve as significant predictors of market trends. Pooja *et al.* (2024) conducted a seminal study on Option Pricing Theory, elucidating the mathematical modelling that serves as the foundation for derivative markets. The paper demonstrated its practical significance for financial stability and concluded that a substantial relationship exists between financial markets and financial stability. In the study conducted by Sanyaolu *et al.* (2024) the authors examined the impact of mobile banking innovations on African financial markets, specifically focusing on how these advancements are transforming market dynamics by enhancing access to capital. Akin and Akin (2024) examined the behavioral determinants within financial markets, demonstrating how investor biases can affect exchange rate volatility and the dynamics of stock market behavior.

Yussif *et al.* (2024) conducted an analysis of the effects of exchange rate volatility on economic growth across 14 emergent nations over the period from 1990 to 2020, the analysis revealed that exchange rate volatility exerts a detrimental impact on economic growth, both directly and indirectly. Bahmani-Oskooee *et al.* (2023) conducted an investigation into the impact of exchange rate volatility on international trade, the findings indicate that elevated volatility deters trade due to an increase in perceived risk, particularly among firms exhibiting a high degree of risk aversion. Jegerson and Hussain (2023) conducted an analysis of 177 scholarly articles published from 2001 to 2021 to assess the research activity pertaining to electronic and mobile payment systems. Their findings indicate a discernible upward trend in studies focusing on payment frameworks, technology acceptance, and user preferences. Bojjagani *et al.* (2023) conducted a systematic review of digital payment technologies, classifying them into four distinct categories, card payments, mobile payments, electronic payments, and crypto currencies. The study identified obstacles including social and economic impediments, technical difficulties, and deficiencies in regulatory frameworks. The findings underscored that the transition to digital payments is fundamentally altering the financial sector, propelled by factors such as cost efficiency, and convenience.

In view of the existence of literature on electronic payment systems and financial markets in developing countries, there exists a paucity of empirical research regarding the extent to which the adoption and proliferation of electronic payment systems (EPS) influence financial market stability or volatility, especially within emerging and developing economies. Although there also some evidence regarding the influence of electronic payment systems (EPS) on domestic transactions, their specific function within foreign exchange (forex) markets particularly concerning their impact on the demand for foreign currencies remains inadequately examined. The novelty of this study is its emphasis on an underexplored area, relevance to current economic challenges, and potential to inform innovative policies that incorporate digital finance, financial inclusion, and foreign exchange management in Ghana. This study will investigate the effect

of electronic payment systems on the forex market in Ghana using secondary data from the world development indicators.

The study will have five (5) sections, first section delineates the background of the study, elucidates the problem statement, and articulates the research objectives and enquiries. It further elucidates the importance of the study, its extent, and its limitations. This chapter establishes a foundational framework for comprehending the influence of electronic payment systems on financial markets. Section Two analyses the prevailing theories and empirical research pertaining to electronic payment systems and financial markets. Section Three delineates the research design, methodologies for data acquisition, and analytical techniques utilized in the study. Section Four delineates and analyses the findings of the investigation. The analysis encompasses statistical and regression methodologies, as well as tables and figures, to elucidate the correlation between electronic payment systems and the volatility of exchange rates. The concluding chapter encapsulates the principal findings and examines their implications. It provides recommendations for policymakers, financial institutions, and researchers, while also identifying potential avenues for future research aimed at enhancing the comprehension of electronic payment systems within financial markets.

Literature Review

The theory of Purchasing Power Parity (PPP) asserts that the exchange rates between two currencies will, over time, adjust to equalize the price levels of a standardized basket of products and services across different nations (Kadochnikov, 2013; Holmes, 1967). It posits that in a theoretical market devoid of transportation costs or trade barriers, the valuation of currency is indicative of relative price levels. In the realm of financial markets, Purchasing Power Parity (PPP) provides a fundamental framework for understanding long-term fluctuations in exchange rates and aids in the assessment of whether a currency is overvalued or undervalued. The incorporation of electronic payment systems within financial markets has significant ramifications for Purchasing Power Parity (PPP), as these systems directly impact the costs associated with cross-border trade, the transparency of pricing, and the velocity of money circulation. Each of these factors plays a crucial role in determining exchange rates and currency equilibrium. Electronic payment systems, including mobile money platforms, online payment gateways, and crypto currencies, facilitate price transparency by enabling consumers and businesses to compare prices across different countries in real time. This transparency has the potential to diminish arbitrage opportunities and harmonize prices on a global scale, thereby reinforcing the theoretical foundations of Purchasing Power Parity (PPP). For instance, e-commerce platforms that utilize electronic payment systems facilitate consumers' access to international markets, thereby allowing them to compare prices for various products and services. This enhanced transparency may impart a deflationary influence on prices in regions characterized by elevated costs, thereby fostering price convergence and facilitating the exchange rate adjustments anticipated by Purchasing Power Parity (PPP).

A fundamental aspect of Purchasing Power Parity (PPP) is the presumption that trade barriers and associated costs do not substantially impede the equalization

of prices. Electronic payment systems contribute to the reduction of costs by optimizing cross-border transactions, decreasing fees, and removing intermediaries. For example, digital payment technologies such as PayPal and block chain-based solutions provide more cost-effective alternatives to conventional bank remittances. By diminishing transaction costs, these systems facilitate the participation of businesses and individuals in international commerce, thereby potentially augmenting currency flows. The enhancement of trade and capital mobility may result in exchange rates adjusting more closely to the relative purchasing power of currencies, thereby conforming to the predictions of Purchasing Power Parity (PPP). Although electronic payment systems provide a multitude of advantages, they concurrently introduce hazards that may destabilize the equilibrium of public-private partnerships (PPPs). The enhanced accessibility to international markets results in an escalation of speculative trading and short-term capital transfers, which can contribute to increase volatility in exchange rates. For instance, real-time settlement systems facilitate swift, large-scale transactions that have the potential to destabilize currency markets in reaction to minor economic or political occurrences.

This volatility may result in transient divergences from the Purchasing Power Parity (PPP) equilibrium, as speculative activities have the potential to distort the intrinsic relationship between price levels and exchange rates. Policymakers must consider these dynamics when incorporating electronic payment systems into the wider financial ecosystem. Electronic payment systems facilitate economic integration by facilitating seamless cross-border transactions and promoting the development of global trade networks. For developing economies, this integration presents opportunities to engage in international markets, consequently impacting their exchange rates and the valuation of their currencies. For instance, mobile money platforms such as M-Pesa in Africa have significantly enhanced financial inclusion and facilitated increased participation in international trade. As an increasing number of enterprises and individuals in emerging markets participate in global markets, the movement of products and services escalates, thereby potentially aligning exchange rates more closely with the expectations of Purchasing Power Parity (PPP).

A study undertaken by Yuorkuu *et al.* (2024) examined the influence of exchange rate volatility on domestic investment in Ghana, utilizing annual time series data spanning from 1980 to 2015 and applying the Autoregressive Distributed Lag (ARDL) estimation methodology, the authors determined that exchange rate uncertainty exerts a detrimental effect on domestic investment in the short term; conversely, it yields a beneficial impact in the long term. This illustrates the intricate dynamics by which uncertainty in foreign exchange markets impacts economic decision-making in Ghana. A study conducted by Zhao *et al.* (2024) investigated the factors influencing financial dollarization in Ghana and identified a significant correlation between the depreciation of the exchange rate and the rise in dollarization. It was observed that financial development served to mitigate this trend. The findings underscore the interrelationship among fluctuations in exchange rates, inflationary trends, and the advancement of the financial system.

Research undertaken by Abba *et al.* (2024) has revealed that foreign exchange markets in subSaharan Africa demonstrate considerable volatility, which is

affected by exogenous shocks, fluctuations in commodity prices, and macroeconomic imbalances. For example, nations that are significantly dependent on commodity exports, such as Nigeria, encounter fluctuations in exchange rates that are closely associated with variations in crude prices. In a comparable manner, in Ghana, fluctuations have been associated with inflationary pressures and fiscal deficits, besides, research conducted by Korsah *and* Mensah (2024) underscores that financial globalization exerts varying impacts on the stability of foreign exchange markets across various African nations. Although it has the potential to mitigate volatility during stable periods, it may exacerbate volatility in times of turbulence. This phenomenon highlights the significance of institutional and policy frameworks in the regulation of capital flows and the maintenance of currency stability. An empirical analysis conducted by Kyriazis *and* Corbet (2024) indicates that interventions by central banks, the nature of exchange rate regimes, and the implementation of monetary policies play a substantial role in influencing the behavior of the foreign exchange market. For example, floating exchange rate systems may lead to heightened volatility, whereas managed regimes can provide greater stability, albeit at the cost of potential market distortions.

Research conducted by Abdallah (2024) has identified that variables such as trade openness, government expenditure, terms of trade, and capital flows exert a significant influence on exchange rate fluctuations within African economies. A study encompassing ten African nations from 1980 to 2018 revealed bidirectional relationships between exchange rates and economic growth, thereby corroborating established theories such as the J-Curve and the Marshall Lerner hypotheses. Kuttu *et al.* (2024) assert that exchange rate volatility significantly influences macroeconomic performance in Africa, as fluctuations can disrupt trade and investment flows, particularly in economies characterized by underdeveloped financial markets. This situation is further aggravated by external disruptions and a reliance on commodity exports.

Tajuddin *et al.* (2024) investigate the relationship between exchange rates and foreign direct investment within the context of globally integrated capital markets that are influenced by informational asymmetries. These imperfections result in external financing being more costly than internal financing, thereby causing fluctuations in wealth to influence the demand for direct investment. By methodically diminishing the relative wealth of domestic agents, a depreciation of the domestic currency may facilitate foreign acquisitions of specific domestic assets. The study formulates a straightforward model of this phenomenon and evaluates its significance in influencing international capital flows.

Data and Methodology

The study employed time series secondary data from 2012 to 2023 to empirically analyze the impact of electronic payment systems on the forex market in Ghana. Data was obtained from the World Bank's world development indicators, and the justification for its use is derived from the research objectives established, which include the availability of data and the research methodology employed for the study. A vector autoregressive model is therefore implemented to accurately represent the interdependencies among the numerous time series data in the

investigation. Debit card ownership, the percentage of the population aged 15 and older who made or received digital payments, and account ownership at financial institutions or mobile money services are all measures of the electronic payment system. The forex market is an index in the global development indicators that is measured by exchange rate volatility. The stationarity test conducted indicates that certain variables are stationary at the first difference and at the level, indicating that an ARDL model is more suitable than a vector error correction model (vecm).

One of the key advantages of the ARDL model lies in its flexibility concerning the integration order of variables. Unlike traditional cointegration techniques such as the Johansen or EngleGranger methods, the ARDL model does not require all variables to be of the same integration order. It can handle a mix of $I(0)$ and $I(1)$ variables, making it less restrictive and more robust (Hassan *et al.*, 2024). Another significant benefit of the ARDL framework is its ability to estimate both short-run and long-run relationships simultaneously. By incorporating lagged differences and levels of the variables, the model captures the immediate effects of changes in independent variables and their cumulative impact over time. This dual capability is particularly important in policy analysis and forecasting (Pesaran *et al.*, 2001). The ARDL model is often employed in conjunction with the bounds testing approach to cointegration, which determines the existence of a long-run relationship between variables. The test involves estimating an unrestricted error correction model (UECM) and conducting an F-test to compare the computed statistic against critical values provided by Pesaran *et al.* (2001). If the statistic falls outside the bounds, the presence or absence of cointegration can be inferred.

This approach eliminates the need for pre-testing variables for stationarity, as long as none of the variables are integrated of order two, $I(2)$. Consequently, the ARDL bounds testing method is less prone to errors arising from incorrect unit root test results (Sam *et al.*, 2024). The ARDL model has been widely applied in various fields to explore dynamic relationships, and in macroeconomics, it has been used to analyze the impact of fiscal and monetary policies on economic growth (Aisyah *et al.*, 2024). In finance, researchers have employed the ARDL framework to examine the determinants of stock market performance and exchange rate dynamics (Ghumro *et al.*, 2024). Its ability to handle small sample sizes further enhances its practicality in empirical studies. Despite its advantages, the ARDL model has certain limitations. First, it assumes a linear relationship between variables, which may not hold in all cases. Nonlinear dynamics or structural breaks in the data could lead to biased estimates. Additionally, the selection of appropriate lag lengths is crucial, as over fitting or under fitting the model can distort results (Polyzos & Siriopoulos, 2024). Another limitation is that the ARDL bounds testing approach cannot accommodate variables integrated of order two, $I(2)$, therefore, researchers must carefully verify the stationarity properties of their data to avoid invalid inferences (Pesaran *et al.*, 2001).

Econometric Models

The Autoregressive Distributed Lag (ARDL) model has emerged as a versatile instrument for analyzing time series data in the field of financial econometrics. The ARDL model, which was created by Pesaran *and* Shin (1995) is particularly advantageous for simulating the relationships between variables, irrespective of whether they are integrated of order zero, I(0), or order one, I(1). It is a favored choice for applied research in the social sciences, finance, and economics due to its broad applicability and distinctive characteristics. The ARDL model integrates autoregressive and distributed lag components to account for the dynamics of a dependent variable and the effects of independent variables over time. The general form of an ARDL model for a dependent variable Y_t is as follows:

$$Y_t = \alpha + \sum_{i=1}^p \beta_i Y_{t-i} + \sum_{j=0}^q \gamma_j X_{t-j} + \varepsilon_t \text{-----} (1)$$

Where β_i and γ_j are coefficients, α is a constant, and ε_t represents the error term. The lag lengths p and q are determined through selection criteria, such as the Akaike Information Criteria (AIC) or the Schwarz Bayesian Criteria (SBC) (Pesaran & Shin 1995). The dependent variable is influenced by its previous values, as well as the current and past values of other exogenous variables in the model. To be able to perform the bounds test for cointegration, the conditional ARDL (p, q_1, q_2) model with three (3) variables is specified as follows:

$$\Delta FOREX_t = \alpha_0 + \sum_{i=1}^p \beta_i \Delta FOREX_{t-i} + \sum_{j=0}^q \gamma_j \Delta EPS_{t-j} + \sum_{k=0}^r \delta_k \Delta FI_{t-k} + \phi_1 FOREX_{t-1} + \phi_2 EPS_{t-1} + \phi_3 FI_{t-1} + \varepsilon_t \text{-----} (2)$$

$$\Delta EPS_t = \alpha_0 + \sum_{i=1}^p \beta_i \Delta EPS_{t-i} + \sum_{j=0}^q \gamma_j \Delta FOREX_{t-j} + \sum_{k=0}^r \delta_k \Delta FI_{t-k} + \phi_1 EPS_{t-1} + \phi_2 FOREX_{t-1} + \phi_3 FI_{t-1} + \varepsilon_t \text{-----} (3)$$

$$\Delta FI_t = \alpha_0 + \sum_{i=1}^p \beta_i \Delta FI_{t-i} + \sum_{j=0}^q \gamma_j \Delta FOREX_{t-j} + \sum_{k=0}^r \delta_k \Delta EPS_{t-k} + \phi_1 FI_{t-1} + \phi_2 FOREX_{t-1} + \phi_3 EPS_{t-1} + \varepsilon_t \text{-----} (4)$$

Δ represents the first-difference operator, capturing short-run dynamics, $FOREX_t$ is forex market indicator, EPS_t is electronic payment systems indicator, FI_t is financial inclusion indicator, lagged differences and levels of the variables, α_0 is the constant term, $\beta_i, \gamma_j, \delta_k$ are short-run coefficients, ϕ_1, ϕ_2, ϕ_3 , and long-run coefficients, p, q, r are the optimal lags determined via criteria such as AIC or BIC, and ε_t captures the error term unexplained variation.

Table 1. Variables Definitions, and Measurements

S/No	Variable	Notation	Measurement	Source of Data
1	Forex Market	Forex	<p>These variables directly measure aspects of the forex market:</p> <ul style="list-style-type: none"> • Official Exchange Rate (LCU per USD): The exchange rate determined by the national authorities or in the legally sanctioned exchange market. • Real Effective Exchange Rate (REER): Measures the value of a country's currency relative to a weighted average of several foreign currencies adjusted for inflation. <p>Parallel Market Exchange Rate (if available): Reflects the unofficial or black-market exchange rate, which may diverge from the official rate in some countries.</p>	WDI of World Bank
2	Electronic Payment System	EPS	<p>These variables directly measure electronic payment usage:</p> <ul style="list-style-type: none"> • Made or Received Digital Payments in the Past Year (% age 15+): Measures the percentage of adults who have used digital payment systems. <p>Used the Internet to Pay Bills or Buy Something Online in the Past Year (% age 15+): Reflects the adoption of e-commerce and online payments. □ Received Wages or Government Transfers Digitally in the Past Year (% age 15+): Captures the extent to which wages or social benefits are paid through electronic systems.</p>	WDI of World Bank
3	Financial inclusion	FI	<p>These variables measure how actively people use financial services:</p> <ul style="list-style-type: none"> • Made or Received Digital Payments in the Past Year (% age 15+): Reflects the extent of digital payment adoption. 	WDI of World Bank

- **Saved at a Financial Institution in the Past Year (% age 15+):** Measures the use of formal savings services.

- **Borrowed from a Financial Institution or Mobile Money Service in the Past Year (% age 15+):**

Indicates access to formal credit.

- **Frequency of Account Use (number of transactions per month):** Captures how often financial accounts are used.

Authors Compilation (2024)

Analysis and Discussion of Results

The Analysis and Discussion of Results section offers an in-depth interpretation of the findings derived from the study. This section explores the empirical findings, assessing their consistency with the research goals, hypotheses, and theoretical framework. The analysis emphasizes the connections between the variables being studied, assesses both the immediate and extended effects, and juxtaposes the results with current scholarly work. The analysis focusses on key patterns, trends, and anomalies identified in the data, providing valuable insights into the study's implications. This section also examines the statistical significance and robustness of the results, providing a comprehensive understanding of their relevance within the context of the study. The analysis also addresses any unforeseen findings or limitations, ensuring a comprehensive and clear presentation of the study's results. Stationarity test, optimal lag selection, bounds test for cointegration, estimation of the ARDL model, and interpretation of results will be performed at this section.

Stationarity Test

Prior to advancing with the model estimation, it is crucial to assess the stationarity of the variables being examined. Stationarity is a crucial characteristic of time series data, guaranteeing that its statistical properties, including mean and variance, stay consistent over time (To & Chan, 2024). Non-stationary data can produce misleading regression outcomes, making any statistical conclusions questionable. To evaluate stationarity, various unit root tests are utilized, including the Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) test, and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. The tests assess the integration order of the variables, revealing if they exhibit stationarity at levels (I(0)) or at first differences (I(1)) (Tiwari & Albulescu, 2016). The outcomes of these tests will inform the selection of the suitable econometric approach for the analysis, especially for models such as ARDL, which can handle a combination of I(0) and I(1) variables.

Table 2. Data Stationarity Test
Unit root test

Augmented Dickey-Fuller test statistic				Phillips-Perron test statistic				Kwiatkowski-Phillips-Schmidt-Shin test statistic				test
Variable	Level	First Diff	Order	Variable	Level	First Diff	Order	Variable	Level	First Diff	Order	
Forex	-1.6637***	-4.4406***	I(0)	Forex	-1.4528***	-4.3355***	I(0)	Forex	0.3179***	0.1056***	I(0)	
EPS	-1.3689	-5.9173***	I(1)	EPS	-1.4045***	-6.4728***	I(0)	EPS	0.3091***	0.1053***	I(0)	
Fi	-1.6863***	-4.4286***	I(0)	Fi	-1.4341	-4.3482***	I(1)	Fi	0.5258***	0.1946***	I(0)	

Authors' computation (2024)

The variables in table 2 are of mixed integration of I(1) and I(1). Consequently, ARDL is the preferred method for handling this mixed integration, as it does not necessitate that all variables be at the same level of integration. Autoregressive Distributed Lag is a robust approach for datasets of this nature, as it can effectively estimate both short-run and long-run relationships. ARDL is not appropriate if any variable is integrated of order 2 (I(2)). Variables that are integrated at I(2) violate the assumptions of ARDL and necessitate differencing until they are integrated at order (1) or alternative methods, such as fully modified OLS (FMOLS) or nonlinear methods.

Table 3. Optimal Lag Length selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	316.7964	NA	2.06e-11	-16.09212	-15.96415	-16.04621
1	412.1649	171.1743	2.46e-13*	-20.52128*	-20.00941*	-20.33762*
2	417.3175	8.455457	3.03e-13	-20.32397	-19.42821	-20.00258
3	429.1459	17.59106*	2.68e-13	-20.46902	-19.18936	-20.00989

Authors Computation (2024)

The ARDL framework is intended to simulate dynamic relationships between variables. The inclusion of insufficient lags can contribute to omitted variable bias, which can result in inaccurate parameter estimates. In contrast, the inclusion of an excessive number of lags introduces unnecessary complexity, reduces degrees of freedom, and poses a risk of overfitting. Optimal lag selection guarantees that the model accurately represents the underlying dynamics without the use of excessive or insufficient lags. The appropriate inclusion of lagged variables is essential for the stability of an ARDL model. The model may generate unstable coefficients, which can result in unreliable predictions and invalid inferences regarding short-term and long-term relationships, if the lag duration is incorrectly specified. The predictive potential of an ARDL model is contingent upon its capacity to strike a balance between complexity and parsimony. A lag length that is optimally selected reduces forecast errors by incorporating pertinent past information and excluding irrelevant lags that contribute noise. Based on the data in table 3, the Akaike Information Criteria is the preferable lag order for the dataset, as it has the highest lag value of 20.52128. This value corresponds to lag one (1) in the lag order.

Table 4. ARDL Bounds-Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	6.754579	10%	2.63	3.35
k	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
Finite Sample: n=65				
Actual Sample Size	65	10%	2.74	3.455
		5%	3.285	4.07
		1%	4.538	5.475

Authors Computations (2024)

There is substantial evidence to suggest that the dependent and independent variables are in a longterm equilibrium relationship (cointegration). Despite short-term fluctuations, the variables are inextricably linked in the long term. The F-statistics value is 6.8 which is higher than the upper bound critical value of 3.87 indicating that there is cointegration amongst the variables, and it is therefore anticipated that, any short-term deviation from equilibrium will be rectified over time. An error correction term (ECT) may be incorporated into the model to quantify the rate at which short-term disequilibria converge to the long-term equilibrium. The restoring force towards equilibrium should be confirmed by a negative and significant ECT coefficient.

Table 5. Long-run dynamics
Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EPS	0.793854	0.126153	6.292776	0.0000
FINANCIAL	0.463621	0.052301	8.864476	0.0000
C	0.411445	0.062600	6.572603	0.0000

EC = FOREX - (0.7939 *EPS + 0.0636*FINANCIAL -0.1114)

Authors Computations (2024)

In table 5 there exist a long run positive significant relationship between electronic payment systems and forex markets in Ghana. The efficiency of cross-border transactions, which are directly associated with forex market activities,

has been substantially enhanced by EPS. Digital wallets and mobile money platforms facilitate the seamless receipt of remittances from abroad by Ghanaians. Remittances to Ghana constituted approximately 5% of GDP in 2021, with a substantial proportion of them being processed through digital channels, according to World Bank data. EPS enhances the supply of foreign currency by increasing forex inflows, thereby contributing to a more stable exchange rate. Additionally, the accessibility of international trade to small and medium-sized enterprises (SMEs) is enhanced by the reduction of transaction costs and processing delays associated with digital payment systems (Musyaffi, *et al.*, 2024). The demand for tangible foreign currency is diminished by the proliferation of EPS. Individuals and businesses can settle payments electronically without converting substantial quantities of currency into cash through the use of digital platforms. By alleviating the pressure on the cedi, this decrease in demand contributes to the stabilization of the forex market. According to (Lai *et al.*, 2024) the adoption of EPS is positively correlated with decreased exchange rate volatility, as digital transactions facilitate the smoothing of currency flows.

Electronic Payment Systems (EPS) enhances the implementation of monetary policy by furnishing the Bank of Ghana with more precise data on transaction patterns and money supply. For instance, policymakers can enhance their interventions in the forex market during periods of volatility by monitoring real-time foreign currency transfers through digital payment platforms. In a study conducted by Musthafa *et al.* (2024) it was discovered that countries with a higher adoption of EPS experience improved monetary policy transmission, which results in more stable exchange rate dynamics over the long term. The forex market is significantly bolstered by financial inclusion. EPS has facilitated the integration of millions of unbanked Ghanaians into the formal financial system, thereby allowing them to engage in international trade and investment activities. This inclusion enhances the cedi's resilience against external disruptions by increasing forex inflows through remittances and exports. Furthermore, the tax base is expanded by the increased participation in the formal economy, which provides the government with the necessary resources to effectively manage forex market interventions (Jafari & Faghihi, 2024). Some critics contend that EPS can exacerbate forex market volatility by enabling speculative trading. Individuals and enterprises may capitalize on short-term currency fluctuations by utilizing real-time exchange rates. Nevertheless, this risk is substantially mitigated by regulatory frameworks, including the Payment Systems and Services Act of 2019, which guarantees transparency and accountability in digital transactions. Additionally, the short-term risks are outweighed by the long-term advantages of enhanced market efficiency and increased forex inflows.

Another issue is the digital divide, which restricts the adoption of EPS in rural areas. Although this is a legitimate concern, the gap is being progressively bridged by ongoing investments in digital infrastructure and education. It is anticipated that the government's initiatives to increase mobile network coverage and promote digital literacy will increase EPS penetration across the country, thereby further enhancing its favorable influence on the forex market. The long-term relationship between EPS and the forex market is strongly supported by empirical studies, for instance, Alvarez-Perez *and* Fuentes (2024) discovered that

countries with a high adoption of EPS experience decreased exchange rate volatility as a result of steadier currency flows. Mahama *et al.* (2024) shown that a 10% increase in mobile money transactions results in a 2% decrease in exchange rate volatility. These results emphasize the substantial contribution of EPS to the maintenance of forex market stability.

In table 5, there is also a significant long run relationship between financial inclusion and forex market in Ghana. The facilitation of remittance inflows is one of the most direct connections between the forex market and financial inclusion. Ghanaians in the diaspora can send money home more efficiently as financial services become more accessible, particularly through mobile money platforms. The World Bank (2021) estimates that remittances to Ghana amounted to approximately \$4.5 billion, which is a significant source of foreign exchange reserves. Financial inclusion guarantees that these inflows are directed through formal financial systems, thereby augmenting the supply of foreign currency and promoting exchange rate stability. A 2% improvement in forex market stability is associated with a 10% increase in formal remittance channels, as demonstrated by research conducted by Gurira *and* Parwada (2024).

Financial inclusion facilitates the participation of small and medium-sized enterprises (SMEs) in international trade by offering them access to digital payment solutions, trade financing, and credit. The base of foreign transactions is widened by this increased participation, as businesses engage in imports and exports. The forex market becomes more resilient to external disruptions as a result of this diversification, which reduces dependence on a limited number of foreign currency sources over time (Mulenga, 2024). Informal currency trading is responsible for a substantial portion of the forex market instability in Ghana. Increasing the number of individuals who are incorporated into the formal financial system, financial inclusion decreases the prevalence of these informal transactions. For instance, mobile money platforms facilitate the exchange of foreign currencies through regulated channels, which guarantees enhanced supervision and mitigates speculative activities that may undermine the exchange rate (Wu & Zhu, 2024). Financial inclusion contributes to more predictable currency flows by encouraging savings and investments through formal channels. For instance, individuals who have access to banking services are less inclined to accumulate foreign currency during periods of uncertainty. This behavior promotes a more stable exchange rate environment in the long term and alleviates pressure on the cedi (Yeboah & Baffour, 2024).

Critics may contend that financial inclusion alone is insufficient to resolve structural issues within Ghana's forex market, including trade imbalances and an excessive dependence on commodity exports. Although this is accurate, financial inclusion is a fundamental component that enhances the scope of broader economic reforms. For example, the increase in access to financial services enables small and mediumsized enterprises (SMEs) to broaden Ghana's export base, thereby decreasing the country's susceptibility to fluctuations in commodity prices. Another issue is the unequal distribution of financial inclusion, with rural areas lagging behind urban centres. Nevertheless, the Ghana Financial Sector Development Project and other targeted government programs, such as ongoing investments in digital infrastructure, are bridging this

divide. Rural populations are anticipated to increase their contributions to forex market stability as they acquire access to financial services. The positive correlation between financial inclusion and forex market stability is underscored by empirical studies. For instance, Hidayah (2024) discovered that countries with high levels of financial inclusion experience less exchange rate volatility as a result of diversified forex sources and enhanced currency flows. The role of financial inclusion in fostering resilience was underscored by Falaiye *et al.* (2024) in Ghana, who demonstrated that increased mobile money adoption reduces the impact of external disruptions on the cedi.

Table 6 Error Correction Model
ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EPS)	0.413870	0.068063	6.080686	0.0000
CointEq(-1)*	-.234908	0.086534	-2.714633	0.0087
R-squared	0.769308	Mean dependent var		0.002050
Adjusted R-squared	0.759297	S.D. dependent var		0.017500
S.E. of regression	0.014008	Akaike info criterion		-5.668104
Sum squared resid	0.012362	Schwarz criterion		-5.601200
Log likelihood	186.2134	Hannan-Quinn criter.		-5.641706
Durbin-Watson stat	2.242571			

Authors Computation (2024)

In Table 6, the coefficient of the error correction term is negative and statistically significant, the pace of adjustment is indicated by the p-value (0.0087), which is less than the conventional significance levels (0.01, 0.05). This implies that the rate at which deviations from the long-term equilibrium are rectified is significant. In an Error correction term (ECM), the coefficient's negative sign is anticipated and essential, implying that the system reverts to equilibrium whenever a deviation occurs. Deviation from equilibrium, which is typically undesirable in economic models, would be indicated by a positive coefficient. The value of -0.234908 indicates that approximately 23.49% of the deviation from the long-term equilibrium is rectified in each period. In the event that the exchange rate or financial inclusion deviates from its equilibrium value as a result of a disruption, 23.49% of the discrepancy will be adjusted in the subsequent period. This relatively moderate adjustment speed suggests that the system is indeed moving towards equilibrium, but it does so at a measured tempo rather than instantaneously. The dependent variable's shortterm dynamics are influenced by deviations from the long-term equilibrium, as evidenced by the negative and significant speed of adjustment. For instance, mechanisms such as increased financial accessibility, policy adjustments, or market responses are implemented to restore equilibrium when there is a disequilibrium in the relationship between financial inclusion and exchange rates. This correction mechanism emphasizes the stability of the long-term relationship, preventing persistent imbalances from resulting from disruptions or short-term fluctuations.

Table 7. Granger causality test

Null Hypothesis:	Obs	F-Statistic	Prob.
FINANCIAL does not Granger Cause EPS	64	0.39651	0.0032
EPS does not Granger Cause FINANCIAL		1.09807	0.0000
FOREX does not Granger Cause EPS	64	5.58313	0.0060
EPS does not Granger Cause FOREX		0.17649	0.0000
FOREX does not Granger Cause FINANCIAL	64	0.53060	
FINANCIAL does not Granger Cause FOREX		0.43747	0.0000

Authors Computation (2024)

In table 7, the null hypothesis that financial inclusion does not cause EPS is rejected due to the fact that the p-value is less than 0.05. This suggests that EPS is significantly predicted by past financial inclusion values. The relationship implies that the dynamics of electronic payment systems are positively impacted by advances in financial inclusion, such as access to financial services. Additionally, the null hypothesis that EPS does not induce financial inclusion is denied due to the p-value of 0.0000, which is statistically significant at all conventional levels. This suggests that financial inclusion is substantially predicted by past EPS values. This implies that financial inclusion and EPS are bidirectionally causally related, suggesting that they mutually reinforce one another. Additionally, the null hypothesis that the forex market does not contribute to EPS is denied due to the fact that the p-value is less than 0.05. This suggests that the forex market's historical exchange rates are a significant predictor of EPS. The relationship may be attributed to the impact of exchange rate fluctuations on cross-border transactions and remittances, which in turn effect the usage and adoption of EPS. The null hypothesis that EPS does not cause the forex market is denied due to the p-value of 0.0000. This suggests that changes in demand for foreign currency in transactions or remittance flows could potentially influence exchange rate dynamics through electronic payment systems, as past values of EPS have been shown to substantially predict movements in the forex market.

The null hypothesis that the forex market does not contribute to financial inclusion is denied due to the pvalue of 0.0000. This suggests that financial inclusion is substantially predicted by the forex market's historical values. Financial inclusion is likely to be influenced by exchange rate fluctuations through mechanisms such as remittance inflows and accessibility to foreign capital. The null hypothesis that financial inclusion does not cause the forex market is refuted due to the p-value of 0.0000. This implies that the forex market is substantially predicted by past values of financial inclusion. By fostering formal financial channels for foreign currency transactions and decreasing informal market activities, enhanced financial inclusion has the potential to influence forex market dynamics.

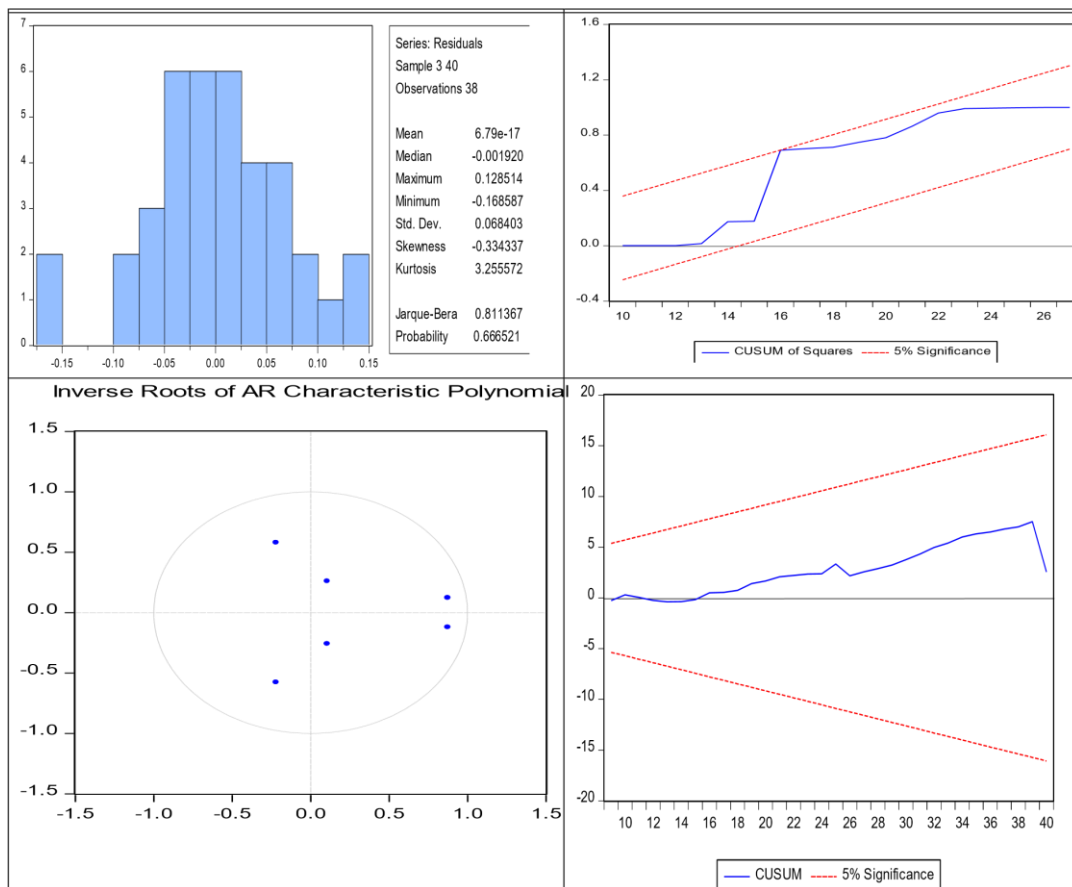
Table 8. Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	263.0974	(3, 60)	0.0000
Chi-square	789.2923	3	0.0000

Authors Computation (2024)

The Wald test results in table 8 signifies joint significance of the set of parameters in the regression model, it evaluates whether the coefficients of the variables are simultaneously zero, indicating that the p-values for both the F-statistic and the Chi-square statistic are 0.0000, which are significantly lower than the conventional standard significance levels (e.g., 0.01, 0.05). This suggests that the null hypothesis may be rejected. The null hypothesis for the Wald test typically asserts that the coefficients of the variables under investigation are jointly equal to zero. The rejection of the null hypothesis implies that the coefficients under investigation are not jointly zero. This implies that the dependent variable in the model is significantly influenced by the variables included in the test. The results suggest that the explanatory variables under investigation are crucial in elucidating the variations in the dependent variable. These variables should be taken into account by policymakers or researchers as significant contributors to the model.

Figure 1 Diagnostic-Test for Normality and Stability of Model



Diagnostic tests are an indispensable component of the estimation and validation of econometric models. The model's reliability, robustness, and validity are guaranteed through the examination of its underlying assumptions in these evaluations. One of the primary objectives is to evaluate whether the model satisfies the criteria for precise forecasting and inference. As indicated by the histogram normality test in figure one (1), the probability value is greater than 0.05, which indicates that the residuals are normally distributed. The inverse root of the AR characteristics polynomial also demonstrates that all of the roots are located within the unit circle, meaning that their modulus is less than 1, thereby indicating that the model is dynamically stable. Furthermore, the cusum test, which evaluates the stability of the parameters over the line, remains within the critical bounds, indicating that the parameters are stable. The cusum of squares test also verifies that the model's variance is stable, and it also conducts additional diagnostic checks on serial correlation to verify that the model is free of serial correlation.

Conclusion, recommendation, and policy implication

The forex market has been significantly impacted by the profound transformation of Ghana's financial landscape as a result of the integration of electronic payment systems and financial inclusion (Ebirim & Odonkor, 2024). The accessibility and efficacy of financial services have been improved by electronic payment systems, which offer secure and convenient platforms for financial transactions (Putrevu & Mertzanis, 2024). Similarly, financial inclusion, which emphasizes the provision of financial services to underbanked and unbanked populations, has facilitated the formalization of economic activities and the mobilization of savings. The forex market is collectively impacted by these developments, which alter the demand and supply of foreign exchange, shape exchange rate stability, and improve the overall efficacy of financial markets. The results indicate that electronic payment systems promote a transition to formal, traceable financial activities by decreasing dependence on cash-based transactions. This change has the potential to stabilize foreign exchange demand and promote international remittances through formal channels. In the same way, financial inclusion strengthens domestic economic activity and decreases the dependence on foreign currency by increasing the participation of previously excluded populations in the economy and enhancing savings mobilization. Nevertheless, these advantages are contingent upon the existence of a favorable policy environment, financial literacy, and a robust infrastructure. The government and private sector should invest in the expansion and upgrade of digital payment infrastructure, particularly in rural and underserved areas, to optimize the impact of electronic payment systems. Additionally, it is imperative to prioritize interoperability among platforms to guarantee the smooth execution of financial transactions. It is imperative to implement financial literacy campaigns in order to inform the public about the advantages of utilizing electronic payment systems and institutional financial services. In order to optimize their integration into the financial system, these initiatives should concentrate on marginalized communities. In addition to increasing the adoption of electronic payments and financial services, the reduction of transaction costs will also make these systems more appealing and accessible to low-income populations (Dalton *et al.*, 2024).

It is relevant that policymakers implement regulations that guarantee the security and transparency of electronic transactions, thereby fostering confidence in these systems. This encompasses measures to mitigate cybercrime and deception. Financial inclusion initiatives should be consistent with overarching national strategies that aim to stabilize exchange rates, reduce reliance on foreign capital, and encourage domestic investment. The formalization of economic activities through financial inclusion and electronic payment systems reduces dependence on informal forex markets. This creates a more predictable environment for trade and investment by reducing volatility and promoting stability in exchange rate dynamics. The emergence of digital financial systems and the expansion of financial inclusion require modifications to monetary policy. The Bank of Ghana must take into account the broader participation of the population in financial systems and the increased velocity of money when designing monetary interventions. The dominance of informal channels will be reduced by promoting the use of electronic payment systems for remittances,

which will increase the transparency of foreign exchange flows and support exchange rate stability.

Economic empowerment is promoted by financial inclusion, which grants marginalized populations access to savings and credit. This alleviates destitution and fortifies the domestic economy, thereby reducing the pressure on forex markets that is a result of external borrowing and foreign currency dependence. Supporting Ghana's integration into the global economy, efficient electronic payment systems facilitate cross-border trade and investment. The attractiveness of Ghana as a trade and investment destination is further enhanced by a stable forex market (Hanson, 2024). The potential to revolutionize Ghana's forex market and financial ecosystem is present through the implementation of electronic payment systems and the promotion of financial inclusion. These innovations encourage sustainable economic growth, reduce exchange rate volatility, and support economic formalization (Challoumis, 2024). By investing in infrastructure and instituting targeted policies, Ghana can capitalize on these advancements to establish a financial system that is both inclusive and resilient, thereby improving the country's economic competitiveness on a global scale.

Future research can investigate the precise mechanisms by which electronic payment systems affect the volatility of the forex market. This could entail an analysis of cross-border payment transfers, transaction patterns, and their influence on exchange rate fluctuations. Financial inclusion in Ghana has been significantly influenced by mobile money. Research could evaluate the impact of mobile money adoption on the demand for foreign currency, as well as its potential impact on the stability of the forex market and remittance flows.

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