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Foreign exchange market disequilibrium, bitcoin price volatility, and macroeconomic performance: Comparative analysis of selected African and ASEAN countries

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Abstract This study has empirically examined the impact of foreign exchange market disequilibirum and Bitcoin price volatility on macroeconomic performance in African (Nigeria and Ghana) and ASEAN (Singapore and Malaysia) nations. The quantile regression method was executed. The research findings are as follows: A 1 percent increase in exchange rate disequilibrium contributed to GDP of Singapore by 0.001319 percnt while improves the GDP of Malaysia by 0.0086 percent respectively. The significance of such forex market has tended towards stability. Comparatively, the disequilibrium in the exchange rate signficantly reduces GDP of Nigeria. Nevertheless, the magnitude of the impact from the 10th quantile was seemingly in decreasing order. A similar declining size effect was found for Ghana from the 10th to the 40th quantile, and from the 50th to the 90th quantile, the size effect on Ghana's GDP increased in magnitude. The economic significance of these findings is a reirnforncement of the instability of the foreign exchnaeg market in Nigeria and Ghana. The first and seventh quantiles in Singapore and Malaysia were mostly affected by the fluctuations in bitcoin prices. Bitcoin's price volatility had a considerable impact on the GDPs of Ghana, Malaysia, and Nigeria in every quantile (10th to 90th). GDP was positively impacted by significant inflation from the 10th to the 40th percentile. In the 90th quantile, there was just an inverse relationship between inflation and real GDP. All quantiles of Nigeria's GDP were inveresely impacted by the inflation rate, while it had negligible effects on Ghana's GDP . By quantitatively identifying the effects that foreign currency market disequilibrium and Bitcoin price volatility have on the real GDP growth rate in the countries covered by the study, the research findings additionally supplement the scant available evidence. The government should ensure that they always have a buffer stock of foreign currency such as the United States Dollar (USD) so as to be able to manage any shock that may create unfavourable volatility in the local foreign exchange market in Nigeria.

Keywords: exchange rate, macroeconomic performance, quintile regression, markov regime switching modeling, ASEAN countries, Nigeria

1. Introduction

The necessity to analyze the link between Bitcoin and the rate of currency conversions of nations is becoming more desirous since investors and businesses can use the new digital money (Bitcoin) as an acceptable means to effect payment while also using the rate of currency exchange as a basic macroeconomic tool to determine how to best balance their trading partners. In most economies, exchange rate variability exists irrespective of the type of exchange rate regime that is implemented (Godfrey & Agwu, 2020; Attarzadeh & Balcilar, 2022). Akani (2024) has recognized market disequilibrium as a significant endogenous factor influencing economic performance. This is true because enhancing economic performance requires both a suitable exchange rate and a solid exchange rate policy. In actuality, though, no exchange rate is totally set by market forces or a pure float. Instead, a controlled float system is in place, in which monetary authorities periodically intervene in the foreign exchange market and bitcoin prices in the cryptocurrency market in order to achieve strategic goals (Ewubare & Ushie, 2022). Bitcoin (BTC) is a virtual currency that serves as a method of payment independent of any organizations, or other control.

Since the financial crisis in 1997, ASEAN (Association of South East Asia Nations) member states have undergone significant transformations in their exchange rate systems to address the financial turmoil. Japan's monetary authorities chose to freely float the yen against the US dollar in 1973. Indonesia shifted to a floating exchange rate system in 1997. In 1970, the Philippine government initiated the float of the peso against the US dollar. South Korea began allowing the won to float freely against other currencies in 1990. In 1997, Thailand decided to adopt a managed-float system for the baht, which aligns with inflation-targeting objectives. Vietnam, on the other hand, has not yet moved to allow the dong to float freely, citing the

underdeveloped state of its financial market as a reason and concerns about the associated risks of foreign currency trading. Under a free-floating system, countries need to maintain sufficient reserves to ensure stability in the foreign exchange markets. China maintained a peg for the Yuan from 1995 to 2005, after which it gradually moved towards liberalizing its currency policy by implementing a narrow trading band. Malaysia replaced the Malaysian dollar with the ringgit in 1993, transitioning from a free-float period until 1998 to a pegged era and eventually de-pegging from the dollar. Myanmar introduced a managed float for the kyat in 2012, aimed at reducing the various exchange rate regimes that had been hindering economic growth. Singapore allowed the Singapore dollar to float freely, with the Monetary Authority of Singapore (MAS) monitoring its strength based on the Singapore Dollar Nominal Effective Exchange Rate (S$NEER). Finally, Brunei operates a currency board system, effectively pegging its exchange rates (Nyunt, 2019). The International Monetary Fund has categorized exchange rate regimes into five distinct classifications: the fixed exchange rate to a single currency, the fixed exchange rate to a basket of currencies, managed floating, restricted floating, and freely floating (IMF, 1980). The fixed and floating exchange rate systems exhibit inherent distinctions.

As Bitcoin's impact on international currency markets and potential impact on economic stability grow, it is imperative to investigate the relationship between Bitcoin's fluctuations and exchange rates. To that end, this study examinines the extent to which foreign exchange and Bitcoin price dynamics impact real GDP growth rates in African and ASEAN nations; investigating whether the impact of foreign exchange and Bitcoin price dynamics on real GDP growth rates varies across quartile levels in African and ASEAN nations; and examining the changes in real GDP growth rates and Bitcoin price regimes in African and ASEAN nations. This study examines the impact of foreign exchange market dynamics and Bitcoin price volatility on macroeconomic performance in African and ASEAN nations. The is guided by the following research questions, which help to clarify the wider implications for investors and policymakers.To what extent do foreign exchange and Bitcoin price dynamics impact macroeconomic growth measured as real GDP growth rate in African and ASEAN nations? Does the impact of foreign exchange and Bitcoin price dynamics on real GDP growth rate vary across quartile levels in African and ASEAN nations? And are there changes in the real GDP growth rate and Bitcoin price regimes in African and ASEAN nations? The main objective of this study is to examine the impact of foreign exchange market dynamics and Bitcoin price volatility on macroeconomic performance in African and ASEAN nations. The two (2) African nations covered in the WAMZ include Nigeria and Ghana only. Only two the ten ASEAN member nations, including Malaysia and Singapore, were included. The other ASEAN nations—Indonesia, Thailand, Vietnam, the Philippines, Myanmar, Lao PDR, Cambodia, and Brunei Darussalem—were not covered due to either incomplete data or a lack of access to data within the study period. Also, the choice of Nigeria and Ghana for and Malaysia and Singapore for ASEAN is rooted on the fact that the foreign exchange markets of these countries exhibit considerable dynamic fluctuations and real market instability. This has resulted in the depreciation of the local currencies of those countries. Numerous empirical studies have been undertaken with differing degrees of success on the impact of Bitcoin prices and exchange rates on macroeconomic performance measured in terms of balance of payments (Musa, Izuchukwu, & Saint-Akadiri, 2024). While some research (Odey & Agunobi, 2024; Akani, 2024) suggests that the depreciation of the currency rate has a contractionary effect on domestic output, other research, namely, Irmiya, Agbo, & Odumu (2023), finds that the depreciation of the exchange rate has an expansionary effect on output. Several studies have, in addition, investigated how the exchange rate has changed over time, focusing on the trend towards short-term equilibrium while there are studies that have investigated how foreign currency dynamics affect global investment and finance (Salisu, Rufai, & Nsonwu, 2024; Urgessa, 2024).

Regrettably, recent studies (Irmiya, Agbo, & Odumu, 2023; Urgessa, 2024; Salisu, Rufai, & Nsonwu, 2024) on exchange rate dynamics have failed to investigate the combined effects of Bitcoin price fluctuation on macroeconomic performance in Africa and the ASEAN region. To the best of the researcher’s knowledge, none of the studies investigated the impact of foreign exchange market dynamics and Bitcoin price volatility on macroeconomic performance in a combination of African and ASEAN nations. This research fills the gap. The research findings also augment the scarce amount of existing evidence by precisely determining the effects that foreign exchange market disequilibirum and Bitcoin price volatility have on the real GDP growth rate in the countries covered by the study. The significance of this study is further rooted in the following: Exchange rate movements also have a significant impact on monetary policy. Central banks often dynamically adjust their policy settings in response to movements in the exchange rate to manage inflation and stabilize the economy. For instance, if currency depreciation is causing inflation to rise, a central bank might respond by raising interest rates to reduce inflationary pressure (Yellen, 2020). Businesses also need to make dynamic adjustments in response to exchange rate movements. For multinational corporations, exchange rate fluctuations can affect the value of their foreign earnings and assets. Hence, businesses may need to adjust their pricing strategies, supply chain management, and risk management strategies in response to exchange rate movements (Eiteman, Stonehill, & Moffett, 2020). In financial markets, exchange rate movements stimulate shifts in investment flows. For example, depreciation in the domestic currency makes domestic assets low-priced for foreign investors and hence attracts foreign capital. Conversely, an appreciation in the domestic currency makes foreign assets inexpensive for domestic investors, leading to capital outflows (Bodie et al., 2021). By hedging foreign exchange risk, deposit money banks would benefit from the research. When a bank has assets or obligations denominated in foreign currencies, it incurs foreign exchange risk, which can have an effect on the bank's capital and profitability because of variations in exchange rates. Within a free market economy, it is impossible for anybody to forecast the exchange rate for the upcoming time; it is subject to

fluctuations, either upward or downward, based on estimations and expectations. The bank's capital and profitability are at risk due to this erratic volatility. A commercial bank's foreign exchange risk stems from both its trade and non-trade activities. The time coverage spans from 2013 to 2023 (10 years).

2. Review of Literature

2.1. Studies on the relationship between Bitcoin transaction price volatility and exchange rate

Nguyen & Lee (2022) focused on the impact of Bitcoin transaction volumes and volatility on the South Korean Won (KRW/USD). Employing an EGARCH model to analyse the asymmetrical effects of volatility, they gathered data from 2019 to 2022. Their study revealed that significant inflows and outflows in Bitcoin markets tend to precede shifts in the KRW exchange rate, suggesting a predictive relationship that could be utilised by financial analysts and traders. Furthermore, their findings indicate that negative news related to Bitcoin tends to have a more pronounced effect on the KRW compared to positive news, highlighting the sensitivity of national currencies to developments in the cryptocurrency markets. Ortiz & Müller (2022) examined the volatility spillover effects between Bitcoin and multiple Latin American currencies, including the Brazilian Real (BRL) and the Mexican Peso (MXN). Employing a Copula-GARCH model, they analysed cross-market dependencies and found that volatility spillovers were significantly enhanced during regional political or economic crises from 2019 to 2022. Their research underscores the increasing integration of cryptocurrency markets with traditional financial systems in emerging markets, where Bitcoin often reacts to and influences fiat currency volatility. Lee & Park (2022) conducted a comprehensive study on the volatility spillover effects between Bitcoin and the South African Rand (ZAR/USD), using a multifractal volatility analysis (MVA) to explore the complex behaviours and scaling properties of market data from 2019 to 2022. Their research found that the ZAR is particularly susceptible to spillovers from Bitcoin during periods of political unrest in South Africa. The findings highlight how cryptocurrencies can influence emerging market currencies in significant ways, especially in contexts of domestic instability. Gomez & Patel (2022) focused their research on the volatility transmission between Bitcoin and a basket of emerging market currencies, including the Brazilian Real, the Indian Rupee, and the South African Rand. Utilising a VAR-BEKK-GARCH model, they examined the cross-market dynamics from 2019 to 2022. Their findings suggest that emerging market currencies exhibit higher sensitivity to Bitcoin volatility compared to developed market currencies. This higher sensitivity may be due to the relatively smaller market size and lesser liquidity, which makes these currencies more susceptible to external shocks from the cryptocurrency market. This study provides valuable insights into how emerging markets need to prepare for the increasing influence of cryptocurrencies. Moore & Kato (2022) studied the volatility spillover effects between Bitcoin and the Brazilian Real (BRL). They employed a spillover index model adjusted for skewness and kurtosis, allowing for a more nuanced understanding of the distributional characteristics of volatility spillover. Analysing data from 2019 to 2022, they discovered that the BRL is significantly influenced by Bitcoin, particularly in the context of Brazil's economic reforms and monetary policy adjustments. This study highlights how emerging markets with volatile economic environments may experience pronounced impacts from global cryptocurrency movements.

2.2. Studies on the relationship between foreign exchange market disequilibrium and economic growth

Amongst the several empirical findings regarding the variations in exchange rates and economy activities; Okeke & Ibiam (2024) focused on the nexus between foreign exchange market disequilibrium and economic growth in Nigeria, analysing data from 2008 to 2023. The researchers applied a Vector Error Correction Model (VECM) to determine how these elements interact over time. The findings indicated that the disequilibrium in the foreign exchange market, particularly the volatility and unpredictability of exchange rates, significantly hampered economic growth, with a significance level less than 0.05. The study also found that these disequilibria explained approximately 40% of the variations in economic growth during the period studied. It suggested that Nigeria should focus on enhancing the stability of its foreign exchange market through policies aimed at increasing foreign exchange reserves and encouraging stable capital flows to promote economic growth. Urgessa (2024) based findings on a GARCH execution of quarterly series and reported that volatility in the real exchange rate adversely affected exportation in Ethiopia ’s export earnings using quarterly data covering 2007 to 2021.

The studies conducted by Nuraddeen, Ibrahim, and Mukhtar (2021), Agu, Obodoechi, and Nebo (2022), Nnamdi (2022), Orji (2022), and Irmiya, Agbo, and Odumu (2023) validate the weakened naira effect and the weakened country’s external balance payments position following the devaluation of the local currency. On their part, Ukangwa, Onyenze, and Uke-ejibe (2023) and Ogbonna and Ichoku (2023) establish a considerable negative asymmetric effect on Nigeria’s trade balance with China and the UK. Ikwuagwu & Yagboyaju (2023) examined exchange rate volatility and trade flows in the Nigerian context. The study adopted the ex-post factor research approach, incorporating the unit root test. Secondary data was collected from the CBN statistical bulletin. The data were analysed using the ARDL analysis technique. The result from the analysis reveals that EXR has had a positive but insignificant relationship with BOI over the period. Also, the result shows that the model was a good fit since the f-statistics value of 3.523913 is greater than the p-value of 0.022842 at the 5% significance level. Furthermore, EXR has had a negative and insignificant relationship with BOT over the period. The result shows that the model was a good fit since the f-statistics value of 12.9852 is greater than the p-value of 0.000001 at the 5% significance level. The study concluded that

Nigeria, during the post-structural adjustment program period, has relaxed the fixed exchange rate regime, which has contributed significantly to the high depreciation of the naira value against foreign currencies, especially the US dollar.

Ramos-Herrera & Sosvilla-Rivero (2023) focused their research on the on the association between economic growth rate per capita and the deviations from the equilibrium foreign exchange market amongst a diverse spread of countries, totalling 103. Utilising the novel grouped fixed effects estimator, they examined the 1996–2016 period. Their findings suggested that the relationship differed among country groups, with an endogenous identification of six groups showing diverse temporal trends and varying estimated effects (ranging from -0.0643 to -0.0014). The results suggested that deviations from the equilibrium exchange rate slowed down the rate of real economic growth across all income categories. The study revealed that the impact was most significant in advanced economies, followed by low-income developing countries, and lastly, in emerging economies.

Asante & Mensah (2023) examined the effects of foreign exchange market disequilibrium on economic growth in Ghana from 2010 to 2022. The study gathered data on foreign exchange rates, GDP growth, inflation, and trade balances from the Bank of Ghana and the Ghana Statistical Service. The researchers utilised unit root tests to ensure the stationarity of the data, followed by co-integration testing to explore the long-term relationships among the variables, and a VECM to investigate the dynamics of these relationships. The study found that significant disequilibrium in the foreign exchange market, indicated by persistent deviations from the fundamental exchange rate, negatively affected economic growth, with a significance level below 0.05. The long-term analysis revealed that the speed of adjustment towards equilibrium was approximately 7% per year, indicating a relatively slow response to shocks. The study recommended the implementation of more stringent foreign exchange control measures and economic policies to stabilise the currency and foster sustainable economic growth. Buthelezi (2023) investigated the correlation dynamics between foreign exchange market misalignment uncertainty and both short-run and long-run economic growth in South Africa, which had previously received little focus in this particular context, through the use of vector error correction and GARCH models. The study spanned data from 1960 to 2022 and revealed a negative correlation between exchange rate uncertainty and short-term economic growth, with varied outcomes in the long term, while also noting that increased exchange rate misalignment is associated with favourable impacts on economic growth. This correlation appears to reflect a broader sentiment that foreign exchange market disequilibrium has a favourable impact on the economic growth of developing countries.

Ramos-Herrera (2022) conducted an extensive study on the impact of deviations in the foreign exchange market in the long run on the real economic growth rate. The study explored such an impact in 27 European nations, examining data from 2000–2016. The study utilised the panel ARDL model to determine the relationship between REER disequilibrium and economic growth, taking into consideration both long-run and short-run effects. The findings reveal that foreign exchange misalignments significantly impact the economic growth of European countries. A deviation in the real exchange rate negatively influences growth in the long term. The analysis also highlighted that when the real exchange rate is closer to its equilibrium level, it stimulates output growth in the short run. Ayele (2022) estimated the pooled mean group (PMG) and ARDL models using the dynamic OLS estimators for the panel; they analysed data from 1980–2019. Their analysis revealed that in the long run, the real exchange rate appreciated due to an improved trade balance and a stronger net foreign asset position. Conversely, the REER depreciated as a result of increased trade openness and a broader money supply. In the short run, REER misalignment impeded the growth of Ethiopia while promoting the growth of Kenya. This study suggests foreign exchange market disequilibrium can have both positive and negative effects on economic growth in the short run, while the two variables have a direct relationship in the long run.

Magubane & Theron (2022) analysed the impact of foreign exchange market disequilibrium on economic growth in South Africa from 2010 to 2021. Utilising data from the South African Reserve Bank and Statistics South Africa, the study examined key variables, including exchange rate volatility, inflation rates, foreign investment flows, and GDP growth. The research approach included unit root tests to assess data stationarity, followed by co-integration analysis to explore the relationships among these variables, and a VECM to understand the dynamics and speed of adjustment. The findings revealed that significant disequilibrium in the foreign exchange market, characterised by frequent and unpredictable fluctuations in the exchange rate, had a detrimental effect on economic growth, with a significance level below 0.05. The long-term correction towards equilibrium was calculated at an annual rate of 6%, indicating a slow adjustment process. In the short term, a 1% increase in exchange rate misalignment resulted in a 0.25% reduction in GDP growth. It was recommended that policy measures aimed at enhancing exchange rate stability and increasing foreign reserve levels could mitigate these negative impacts and support sustained economic growth. Yensu (2022) undertook a comprehensive analysis to evaluate the connection between foreign exchange market volatility and economic growth in the Ghanaian economy. Employing the generalised autoregressive conditional heteroskedasticity (GARCH) model, they analysed data spanning from 2000 to 2020. The results suggest that foreign exchange market disequilibrium had a detrimental impact on GDP growth, with the negative effects being more pronounced in the long run than the short term. The study recommends that the government should foster economic growth by promoting industrial diversification, which involves encouraging the development of various industries to increase exports and thereby offset the significant imports that the country currently relies on. Ramoni-Perazzi & Romero (2022) focused on the volatility of the foreign exchange market on economic growth using panel data from one hundred and ninety-

four countries. Using the dynamic panel data models, which considered the volatility of the exchange rate as an independent variable based on the coefficients of the GARCH model, they analysed how exchange rate fluctuations can affect the growth of the economy in various countries with different levels of corruption. Covering the period from 1995 to 2019, their results showed a consistent notable adverse impact of foreign exchange market volatility on economic growth, with this impact lessening as the financial system progressed. The results also show that, in countries with high corruption levels, the impact of volatility was observed to be lower, possibly due to their familiarity with managing economic instability linked to poor governance and integrating it into their cost considerations.

Seraj & Coskuner (2021) explored the effect of an undervaluation in the foreign exchange market on economic growth in 93 countries. They utilised the fundamental equilibrium exchange rate (FEER) model and the Balassa-Samuelson-based Rodrik approach (BS) to explore the dynamics of these variables, examining data from the period 1990 to 2018. The study found that undervaluation had a significant influence on economic growth. However, the results using the FEER measure were more significant compared to the results using the Balassa-Samuelson (BS) measure. The results also show that the first difference in undervaluation had a significant effect on the growth of the economy. Ahmad et al. (2021) investigated the effect of foreign exchange market fluctuations on economic growth, in this case, investment, in countries of ASEAN membership, which included Indonesia, Vietnam, Thailand, and Cambodia. They applied the path analysis to capture whether the import, export, or both channels play an essential role in determining a country's investment and, by implication, economic growth, focussing on data from 998–2019. The study found that all determinants, i.e., exchange rate volatility, imports, and exports, influenced GDP. The study also revealed that exports and imports played a mediating role between fluctuations in the exchange rate and GDP growth. The findings suggest that the flow of export and import investment influenced the connection between exchange rate volatility and economic growth. Özata (2020) examined the connection between foreign exchange market disequilibrium and GDP growth in the Turkish economy. Employing the ARDL model, they analysed the effect of real effective exchange rate disequilibrium on GDP growth in Turkey from 1998 to 2019. The Lagrange Multiplier (LM) test was used to check for autocorrelation, and the Ramsey RESET test was employed to detect specification errors. The research found that real effective exchange rate volatility had a negative impact on GDP growth in Turkey. Similarly, imports and foreign exchange market disequilibrium had significant negative effects on real GDP.

Chilufya & Mulenga (2021) investigated the effects of foreign exchange market disequilibrium on economic growth in Zambia, analysing data spanning from 2008 to 2020. The study gathered data from the Bank of Zambia and the Central Statistical Office, focussing on variables such as exchange rate instability, economic policy uncertainty, international trade volumes, and GDP growth. By employing unit root tests to confirm the stationarity of the dataset, followed by co-integration testing to establish long-term relationships, and a VECM for dynamic analysis, the research highlighted that prolonged periods of exchange rate disequilibrium significantly hindered economic growth, with a significance level less than 0.05. The study found that the equilibrium adjustment speed was about 8% per year, reflecting a relatively sluggish response to currency misalignments. The short-run effect showed that a 1% increase in exchange rate disequilibrium could decrease economic growth by 0.3%. The study concluded that maintaining a stable foreign exchange market through consistent economic policies and adequate foreign exchange reserves is crucial for economic stability and growth in Zambia. Nkemdilim & Azuka (2021) conducted an examination of the consequences of sustained exchange rate changes on Nigeria's growth rate using the ARDL approach. The study concluded that high levels of currency rate volatility are harmful to economic performance in Nigeria. Based on the data, this report advocates for expanding Nigeria's agricultural exports and agro-investment opportunities.

Mohammed & Nuhu (2021) found that the exchange rate has a negative effect on BoP in Nigeria, while Priyatharsiny (2017) asserted that the relationship is positive. However, the researcher found that most of the previous literature made use of nominal values of the exchange rate to measure its volatility. None of the existing literature captured the volatility of the foreign exchange rate and Bitcoin price on quintile regression and Markov-regime switching modelling using African and ASEAN nations as case-country focus. Seraj (2020) studied the effect of foreign exchange market undervaluation on GDP growth in eighty-two countries. In the study, it was discovered that real exchange rate undervaluation had a notable effect on economic growth in developing countries, while its impact was not statistically significant in developed nations. The findings suggest that the impact of exchange rate undervaluation is felt in developing economies characterised by high levels of importation compared to developed economies, which rely less on importation. Morina (2020) analysed the effect of foreign exchange market fluctuations on economic growth in Central and Eastern European (CEE) countries. They utilised the fixed effect panel model to reduce bias and multicollinearity problems, examining the annual data of 14 CEE countries from 2002 to 2018. Their findings indicated that exchange rate disequilibrium had a significant negative relationship with economic growth. The study suggests that national regulatory environments in CEE countries adopt alternative policies to maintain a stable exchange rate, which would contribute to promoting economic growth.

Ominyi et al. (2020) examined the linkage between foreign exchange market disequilibrium and economic growth in the Nigerian economy. They utilised the Granger causality test and the ARDL model to analyse extensive data from 1986 to 2018. The study found negative growth effect of foreign exchange market disequilibrium and hence recommended diversification away from oil into the manufacturing and agro sectors as a way to increase the supply of foreign exchange and reduce demand for international commodities. Jehan & Irshad (2020) focused on the interaction between foreign exchange

market disequilibrium and economic growth in Pakistan. By utilising the financial development channel method of analysis, they were able to ascertain both the direct and indirect impact of disequilibrium on economic growth. Their study spanned from 1980 to 2016 and revealed that real exchange rate (RER) misalignment had a detrimental effect on economic growth. Notably, financial development was found to mitigate the negative impact of RER misalignment, although it did not completely eliminate it. The study's findings suggest that exchange rate policies need to be handled more carefully. In Africa and ASEAN nations, recent research works relating to foreign exchange dynamics and Bitcoin price impact on macroeconomic performance are generally uncommon, while the few studies on foreign exchange dynamics focused on one country only. Also, many of the reviewed studies made use of heteroskedastic and autoregressive modelling. The present research-based estimations are based on the quantile and Markov-regime switching regression methodologies.

3. Methodology

This research made use of the quantile regression approach and the Markov-switching regression method. The MSRM analysis was conducted to disentangle the structural disturbances in the data set on basis of two regimes, expansionary and contractionary regimes, an MSRM analysis was carried out. By use of regime-switching, MSR model regression is able to capture transitory changes in macroeconomic growth performance and furnish valuable quantitative estimates regarding the dynamics of GDP growth. The model's ability to quantify regime transitions in GDP growth patterns—including those unique to disequilibrium in the foreign exchange market and volatility in the price of bitcoin—remains is an added explanation for chosen methods of analysis. For the quantile regression method, we minimize the least-absolute-deviation errors, that is, $\sum_i |e_i|$ from the regression equation:

$$GDP_{it} = \beta_0 + \beta_1 EXR_{it} + \beta_2 BTCPRIZ + \beta_3 INF_{it} + e_{it} \quad (1)$$
$$\beta_0 > 0, \beta_1 > 0, \ \beta_2 > 0, \ \beta_3 < 0$$

where: *GDP* is the real gross domestic product (%), *EXR* is exchange rate disequilibrium, *BTCPRIZ* is the price of Bitcoin proxied by the United States dollar transaction price (USDT price), INF is inflation rate (%), α_0 is the constant, $\beta_1, \beta_2, \beta_3$, are regression parameters, *i* is cross sectional components (individual country), *t* is time period covered (2010-2023), e is error term. Given the dependent variable, which in our model is macroeconomic growth performance measured as real *GDP* growth rate and the q^{th} quantile, the quantile minimization function that corresponds to equation (1) following the steps of Adrian, Boyarchenko & Giannone (2019) is specified as:

$$\beta_q = \arg\min \sum_{t=1}^{T-s} (q.1_{(GDP_{t+s}^{(s)} \geq x_t^{'}\beta_q)} \left| GDP_{t+s}^{(s)} - x_t^{'}\beta_q \right| + (1-q).1_{(GDP_{t+s}^{(s)} < x_t^{'}\beta_q)} \left| GDP_{t+s}^{(s)} - x_t^{'}\beta_q \right| \quad (2)$$

The parameter vector, β_q is the set of coefficients which correspond to the q^{th} quantile. The vector of coefficients was estimated with the quantile regression method by minimizing the weighted sum of absolute deviations. Accordingly, the quantile regression estimates the model parameters for a given q^{th} quantile conditional on the distribution of the dependent variable (*GDP*). Specifically, we estimated the impact of exchange rate disequilibrium, Bitcoin prices, and inflation on the macroeconomic growth performance (*GDP*) of each country for a range of quantile values measured as *q* of the empirical distribution, where *q* = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9. The quantile $q \in (0,1)$ is that growth variable which splits the data into proportions *q* below and $1 - q$ above such that

$$S(GDP_q) = q \quad (3)$$
$$\text{and} \quad GDP_q = S^{-1}(q) \quad (4)$$

The rationale for the applicability of the quantile regression is that the regression measures the predictive causal relations between a response variable and explanatory variables beyond the mean-to-mean effects but estimates the conditional median and the conditional quantiles of the response variable across all values of the predictor variables. In the presence of asymmetries and heavy tales, the 50^{th} quantile provides an enhanced verdict of centrality than mean. For the interest of robustness check of the quantile estimations, we estimated the Markov-switching regression for macroeconomic growth having considered its performance was characterized by two states as specified in equations (5) and (6) below:

$$State\ 1:\ GDP_t = \phi_{11} + \phi_{12} GDP_{t-1} + \phi_{13} EXR_t + \phi_{14} BTCPRIZ_t + \phi_{15} INF_t + e_{1t} \quad (5)$$
$$State\ 2:\ GDP_t = \phi_{21} + \phi_{22} GDP_{t-1} + \phi_{23} EXR_t + \phi_{24} BTCPRIZ_t + \phi_{25} INF_t + e_{2t} \quad (6)$$

where $\phi_{11}, \phi_{13}, \phi_{14}, \phi_{15}, \varphi_{21}, \varphi_{23}, \varphi_{24}, \varphi_{25}$ are the parameters to be estimated, ϕ_{12} and ϕ_{22} are the AR parameters, e_1 and e_2 are the error terms for state 1 and state 2, respectively. The presence of shift between the two states gives rise to state-dependent intercept MSAR model specified as equation (7):

$$GDP_t = s_t\phi_{11} + (1 - s_t)\varphi_{21} + \beta_1 GDP_{t-1} + \beta_2 EXR_t + \beta_3 BTCPRIZ_t + \beta_4 INF_t + e_t \quad (7)$$

where s_t is 1 if the process is in state 1 and 0 otherwise. Since the actual state of the process is unknown to us, s_t is unobserved and so follows a Markov chain process such that:

$$\begin{cases} \phi_{s_t} = \phi_{11} & if \quad s_t = 1 \\ \phi_{s_t} = \phi_{21} & if \quad s_t = 2 \\ \phi_{s_t} = \phi_k & if \quad s_t = k \end{cases} \quad (8)$$

By definition, $\phi_{s_t} = \phi_{11}$ when s_t =1, $\phi_{s_t} = \phi_{21}$ when $s_t = 2, \cdots$, and $\phi_{s_t} = \phi_k$ when $s_t = k$. The conditional density of GDP_t is conditional only on the realization of the current state s_t and is given by:

$$f(GDP_t | s_t = i, GDP_{t-1}, EXR_t, BTCPRIZ_t, INF_t; \beta), \quad (9)$$

where β is a vector of parameters. The probability that s_t is equal to $j \in (1, \ldots, k)$ be influenced and governed by only the most recent realization, s_{t-1}. Hence, we:

$$Pr(s_t = j | s_{t-1} = i) = p_{ij} \quad (10)$$

Accordingly, all possible transitions from State 1 to State 2 and vice- versa were composed in a $(k \times k)$ transition matrix given as:

$$Pr(S_t = s_t | S_{t-1} = s_{t-1}) = \begin{bmatrix} p_{10} & p_{20} \\ 1 - p_{10} & 1 - p_{20} \end{bmatrix} \text{ for } S_t \in \{0, 1\} \quad (11)$$

Data on foreign exchange rate was obtained from the IMF Financial Statistics, GDP and inflation data were obtained from World Bank development indicators while Bitcoin prices were collected from Bitcoin price magazine available at https://bitcoinmagazine.com/guides/bitcoin-price-history.

4. Results

The data shows that the GDP of Singapore is higher than that of Malaysia among the ASEAN member nations, while Ghana's GDP is higher than Nigeria's GDP among African nations. From Figure 1 to 3, the trend of the foreign exchange rate market in Nigeria and Ghana, representing African nations, shows a lot of dynamic changes and possible volatility. For instance, Nigeria's exchange rate showed that the exchange rate rose from 2010 to its peak in 2014 and later began to fall from 2015 to 2017. Throughout the period, there was a rise in selected years in 2017, 2019, and 2022. Ghana's exchange rate has been relatively unstable as well but has largely fallen since 2010. Between 2010 and 2022, it fell to its lowest in 2015, rose in 2016, and maintained a slow drop until 2022. For Singapore among the ASEAN nations, there was a rise from 2010 to 2013, while from 2014 to 2021, there was a slow drop in exchange, which later rose after 2021. On the contrary, Malaysian exchange has been on a decline from 2010 to 2014 and on a sharp decline from the later part of 2014 to 2017. It rose from 2017 through 2018 but fell afterwards until 2022.

The market for inflation rates in Nigeria and Ghana, two countries that are representative of Africa, exhibit a lot of dynamic fluctuations and potential instability. For example, Nigeria's inflation rate indicated that between 2012 and 2015, the exchange rate was at its lowest point since 2010. Not long afterward, in the final quarter of 2015, Nigeria's inflation rate started to climb. Through the Buhari administration's economic growth recovery plan (EGRP), efforts were made to regulate this in 2017 and 2019. Nonetheless, inflation is still rising in 2019. Ghana's inflation rate increased from 2013 to 2016 between 2010 and 2022. It slightly decreased before rising soon after 2021. Among the ASEAN countries, Singapore saw a substantial decline in inflation from 2011 to 2015, but a sharp increase from 2020 to 2022. The COVID-19 pandemic may have contributed to this latter increase. In contrast, the Malaysian inflation rate increased in certain years (2011, 2014, 2017, and 2022) but decreased in some years (2010, 2012, 2015, 2016, 2018, and 2020).

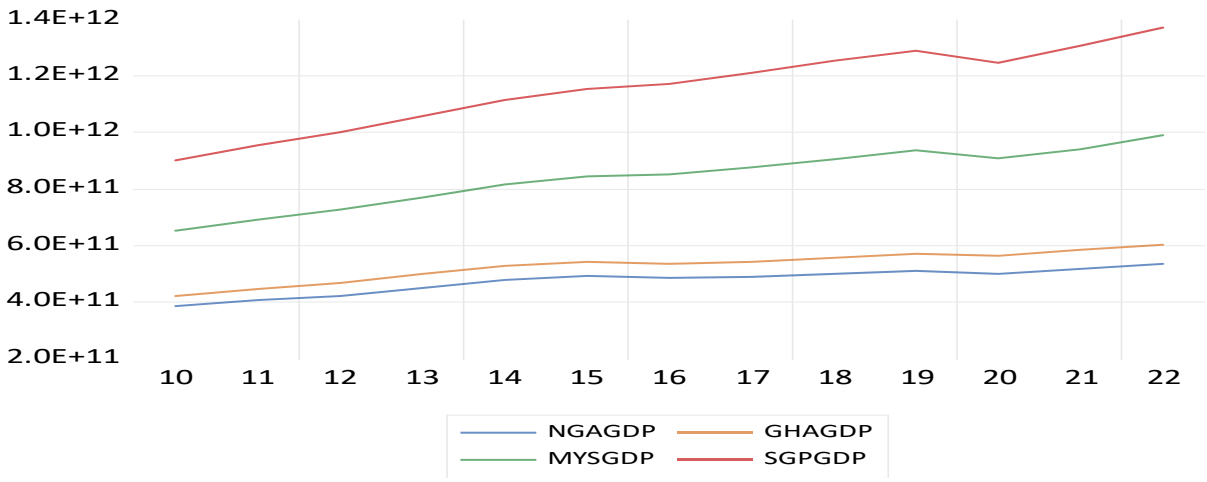

Figure 1 GDP in African and ASEAN nations. *Source: Authors' Eviews 13 plot.*

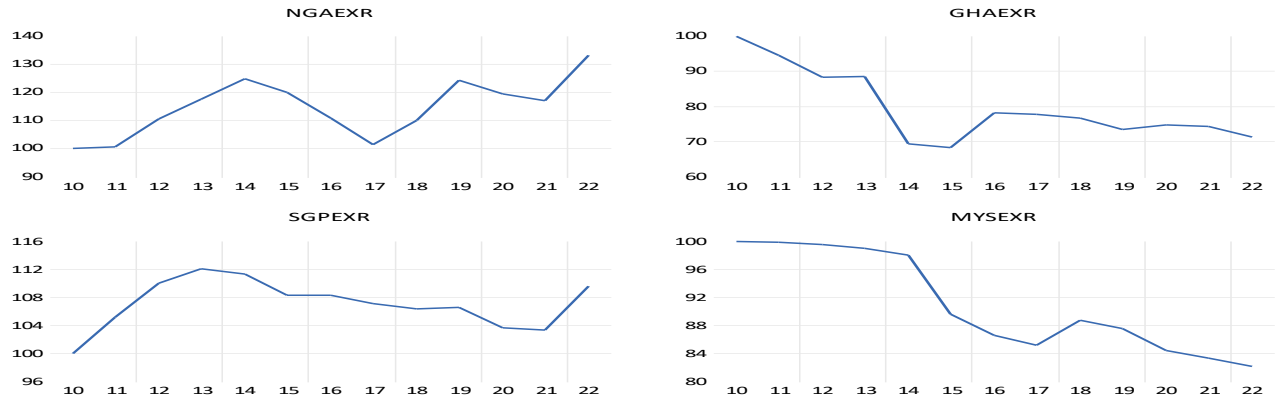

Figure 2 Exchange rate in African and ASEAN nations. *Source*: Authors' Eviews 13 plot

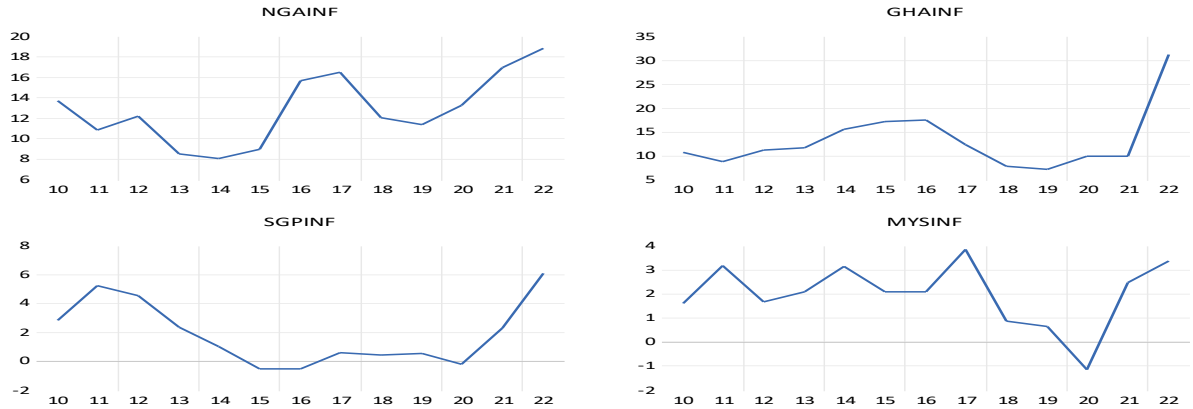

Figure 3 Inflation rate in African and ASEAN nations. *Source:* Authors' Eviews 13 plot.

Bitcoin prices (BTCPRIZ) rose from 2017 to 2018, fell in 2019 during the CoVID-19 era but rose from 2020 to 2022. According to Table 1 to 2, the GDPs of Ghana and Nigeria averaged 529 and 475 million dollars, respectively, while Singapore and Malaysia had the highest GDPs at 3.16 and 3.11 billion dollars. This demonstrates that within their respective country blocks of ASEAN and African nations, respectively, Singapore and Ghana have larger GDPs than Malaysia and Nigeria. Furthermore, among the four countries, Nigeria had the highest average exchange rate of 114.5 naira to a US dollar, while Ghana had the lowest of 79.6 cedis to a US dollar. Conversely, the average inflation rate in Ghana and Nigeria was double digits, at 12 and 13, respectively, whereas it was only about 2 percent in Singapore and Malaysia. Furthermore, from a base price of US$0.003 in 2010 to US46,379 in 2023, at an average of US$7,890, the price of Bitcoin increased. The results of the Jarque-Bera test indicate that all of the series are normally distributed, with the exception of GHAINF and BTCPRIZ, which are not ($p > 0.05$).

From quantile regression estimations in Table 3, exchange rate disequilibrium and bitcoin price had a significant positive impact on the real GDP of Singapore and Malaysia (prob< 0.05). This direct impact shows that a 1 percent increase in exchange rate disequilibrium contributes 0.13 percent and 0.86 percent to the GDP of Singapore and Malaysia, respectively.

Inflation had a negative but insignificant impact on the GDP of both Singapore and Malaysia, while the price of bitcoin had a significant positive impact on the GDP of both countries.

Table 1 Data analysis of the series.

Measures	NGAGDP	GHAGDP	SGPGDP	MYSGDP	NGAEXR	GHAEXR
Mean	4.759011	5.293210	3.162117	3.113711	114.5570	79.62660
Median	4.890291	5.112610	3.190115	3.15211	117.0205	76.62642
Maximum	5.314178	6.809710	3.800118	3.879011	133.1504	100.0000
Minimum	3.862710	3.520102	2.485711	2.335611	100.0000	68.17976
Std. Dev.	4.518100	1.021710	4.062310	4.95210	10.18321	10.01230
Skewness	-0.76570	-0.093233	-0.151610	-0.16417	0.030694	0.818245
Kurtosis	2.450051	1.929241	1.968115	1.76029	2.141838	2.427392
Jarque-Bera	1.438646	0.639868	0.626562	0.883297	0.400948	1.628239
Probability	0.282485	0.726197	0.731045	0.642976	0.818343	0.443029

Source: Authors' Eviews 13 estimation

Notes: *NGAGDP is Nigeria's gross domestic product, GHAGDP is Ghana's gross domestic product, SGPGDP is Singapore's gorss domestic product, MYSGDP is Malaysia's fross domestic product, NGAEXR is Nigeria's exchange rate, GHAEXR is Ghana's exchange rate.*

Table 2 Contd. Data analysis of the series.

Measures	SGPEXR	MYSEXR	NGAINF	GHAINF	SGPINF	MYSINF	BTCPRIZ
Mean	107.0462	91.03537	12.85227	13.14209	1.907697	2.003058	7890.177
Median	107.0640	88.66210	12.22424	11.18634	1.025148	2.104390	805.0000
Maximum	112.0564	100.0000	18.84719	31.25590	6.121060	3.871201	46379.00
Minimum	100.0000	82.05928	8.047411	7.143640	-0.532269	-1.138702	0.003000
Std. Dev.	3.436295	7.079639	3.405126	6.358951	2.235411	1.338041	14244.47
Skewness	-0.422396	0.247013	0.207270	1.874098	0.662567	-0.817916	1.890191
Kurtosis	2.528151	1.359854	1.981702	6.130835	2.140628	3.425860	5.304993
Probability	0.776013	0.451734	0.720813	0.001565	0.508854	0.461232	0.004944
Observations	13	13	13	13	13	13	13

Source: Authors' Eviews 13 estimation

Note: *SGPEXR is singapore's exchange rate, MYSEXR is Malaysia's exchange rate, NGAINF is Nigeria's inflation rate, GHAINF is Ghna's inflation, SGPINF is singapore's inflation, MYINF is Malaysia' inflation, BTCPRIZ is bitcoin price.*

Table 3 Quantile regression analysis for ASEAN countries.

Variables	SGPGDP				Diagnostics
	Coefficient	S. D	t-value	Prob.	
C	26.60119	0.027291	974.7249	0.0000	Pseudo R-sqd = 0.7925
EXR	0.001319*	0.000264	4.996212	0.0000	Adjusted R-sqd = 0.7880
INF	-0.000953	0.000710	-1.343808	0.1812	Quasi-LR stat = 685.1912
BTCPRIZ	0.019661*	0.000556	35.36692	0.0000	Prob(Quasi-LR) = 0.000
		MYSGDP			
C	23.62547	0.088856	265.8837	0.0000	Pseudo R-squared = 0.7887
EXR	0.008602*	0.000937	9.179432	0.0000	Adjusted R-squared = 0.7842
INF	-0.001081	0.000805	-1.342504	0.1816	Quasi-LR statistic = 838.973
BTCPRIZ	0.062008*	0.001934	32.05717	0.0000	Prob(Quasi-LR stat) = 0.000
Dependent variable: GDP					

Source: Authors' Eviews 13 estimation

Note: ***, ****** Coefficient is significant at 0.05, 0.01 levels of significance.

In Table 4, beginning from the 10th to the 90th and the 90th quartile, the coefficients of SGPEXR were all significant with a positive impact on the GDP of Singapore. The magnitude of the impact was also in increasing order, from 0.00123 to 0.000682. Similarly, the coefficients of Bitcoin price in the 1st to 9th quartile had a positive and significant impact on the GDP of Nigeria. The impact of the Bitcoin price was strongest in the first and seventh quarters. In addition, the inflation rate from the 10th to the 40th quartile was significant, with a positive impact on GDP. Only in the 90th quartile was inflation negatively related to real GDP, but the impact was insignificant. Based on the Wald test, the chi-square coefficient shows that the slope equality test is significant. Hence, the hypothesis of non-slope equality is rejected, which implies that slope equality is different across quartile levels.

Table 4 Quantile Process Estimate for Singapore (SGP).

Quantile Process Estimates					
Specification: LOG(SGPGDP) C SGPEXR SGPINF LOG(BTCPRIZ),					
	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
SGPEXR	0.100	0.001231**	0.000178	6.927832	0.0000
	0.200	0.001252**	0.000204	6.145747	0.0000
	0.300	0.001272**	0.000219	5.810772	0.0000
	0.400	0.001248**	0.000236	5.290585	0.0000
	0.500	0.001319**	0.000264	5.000626	0.0000
	0.600	0.001337**	0.000265	5.052674	0.0000
	0.700	0.000791	0.000520	1.519710	0.1308
	0.800	0.000666	0.000379	1.755783	0.0813
	0.900	0.000682*	0.000349	1.953546	0.0527
SGPINF	0.100	0.002335**	0.000524	4.455607	0.0000
	0.200	0.002663**	0.000532	5.010813	0.0000
	0.300	0.002509**	0.000543	4.619591	0.0000
	0.400	0.001986**	0.000592	3.357573	0.0010
	0.500	0.000953	0.000710	1.343808	0.1812
	0.600	0.000670	0.000726	0.922018	0.3581
	0.700	6.79E-05	0.000926	0.073341	0.9416
	0.800	0.000816	0.000895	0.911916	0.3634
	0.900	-0.001644	0.001002	-1.641052	0.1030
LOG(BTCPRIZ)	0.100	0.020537**	0.000517	39.72978	0.0000
	0.200	0.019901**	0.000439	45.28753	0.0000
	0.300	0.019386**	0.000445	43.51537	0.0000
	0.400	0.019570**	0.000495	39.55712	0.0000
	0.500	0.019661**	0.000556	35.36692	0.0000
	0.600	0.019195**	0.000620	30.96759	0.0000
	0.700	0.020530**	0.001474	13.92770	0.0000
	0.800	0.018366**	0.001814	10.12590	0.0000
	0.900	0.018921**	0.001872	10.10883	0.0000
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.	
Wald Test		78.06604	24	0.0000	
Dependent variable: GDP					

Source: Authors' Eviews 13 estimation

Note: ***, ** Estimate is significant at 0.05, 0.01 level of significance.***

In Table 5, beginning from the 20th to the 90th quantile, the coefficients of MYSEXR were all significant, with a positive impact on the GDP of Malaysia. The magnitude of the impact differed for each quantile, with the 50th quartile having the highest impact at 0.0086. Similarly, the coefficients of Bitcoin price in all the quartiles (10th to 90th) had a direct and significant impact on the GDP of Malaysia ($p<0.05$). With an increasing order of impact, the impact of the Bitcoin price was strongest in the 90th quarter. On the contrary, the inflation rate in the 80th to 90th quantiles was inversely and significantly related to GDP. This explains why an increase in the inflation rate decreases GDP in the 80th and 90th quantiles ($p > 0.05$). Based on the Wald test, the chi-square coefficient of 108.34 shows that the slope equality test is significant ($P<0.05$). Hence, the hypothesis of non-slope equality is rejected, which implies that slope equality is different across quartile levels.

From Table 5 below, for African member nations, the exchange rate had an indirect and significant impact on the GDP of both Nigeria and Ghana, while Bitcoin prices had a direct significant impact on GDP. This shows that an increase in the exchange rate decreases GDP, while an increase in Bitcoin prices promotes GDP. The inflation rate had a significant adverse impact on Nigeria's GDP but also had an insignificant adverse impact on Ghana's GDP. All the equations had a goodness of fit of 0.806 and 0.848 percent, as shown by the pseudo-R-squared, and also, all the coefficients showed the existence of joint significan As shown in Table 6, from the 10th to 90th quartile, the coefficients of NGAEXR were all significant and inversely correlated with GDP of Nigeria. The magnitude of the impact from the 10th quartile was seemingly in decreasing order. Similarly, the coefficients of Bitcoin price in all the quartiles (10th to 90th) had a direct and significant impact on GDP ($p<0.05$). On the contrary, the inflation rate from the 50th to 90th quartile had a direct and significant impact on GDP. This explains why the inflation rate increases with GDP from the 50th and 90th quantiles ($p<0.05$). Based on the Wald test, the chi-square

coefficient of 8.29 shows that the slope equality test is insignificant (P > 0.05). Hence, the hypothesis of non-slope equality is retained, which implies that slope equality is indifferent across quartile levels.

Table 5 Quantile process estimate for Malaysia (MYS).

Specification: LOG(MALGDP) C MALEXR MALINF LOG(BTCPRIZ)					
	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
MYSEXR	0.100	0.003207	0.007480	0.428710	0.6688
	0.200	0.007175**	0.002244	3.198142	0.0017
	0.300	0.007237*	0.003070	2.357405	0.0198
	0.400	0.007795**	0.001600	4.872238	0.0000
	0.500	0.008602**	0.000937	9.179432	0.0000
	0.600	0.007782**	0.000821	9.478911	0.0000
	0.700	0.007153**	0.000793	9.019433	0.0000
	0.800	0.006840**	0.000848	8.069097	0.0000
	0.900	0.007622**	0.000914	8.342452	0.0000
MYSINF	0.100	-0.005960	0.014009	-0.425455	0.6712
	0.200	0.003746	0.003399	1.101990	0.2723
	0.300	0.002251	0.004654	0.483738	0.6293
	0.400	0.000632	0.002339	0.270143	0.7874
	0.500	0.001081	0.000805	1.342504	0.1816
	0.600	0.001003	0.000772	1.299788	0.1958
	0.700	0.000303	0.000718	0.421513	0.6740
	0.800	-0.001368*	0.000698	-1.960240	0.0519
	0.900	-0.001736**	0.000446	-3.892739	0.0002
LOG(BTCPRIZ)	0.100	0.044264**	0.014656	3.020261	0.0030
	0.200	0.052866**	0.004476	11.81139	0.0000
	0.300	0.055707**	0.006544	8.512228	0.0000
	0.400	0.059696**	0.003172	18.81761	0.0000
	0.500	0.062008**	0.001934	32.05717	0.0000
	0.600	0.060076**	0.001696	35.42296	0.0000
	0.700	0.059456**	0.001621	36.68696	0.0000
	0.800	0.061020**	0.002121	28.77407	0.0000
	0.900	0.062132**	0.002156	28.81590	0.0000
Test Summary		Chi-Sq. Statistic		Chi-Sq. d.f.	Prob.
Wald Test		108.3377		24	0.0000
Depednet variable: GDP					

Source: Authors' Eviews 13 estimation

Note: *, ** Estimate is significant at 0.05, 0.01 level of significance.

Table 6 Quantile regression analysis for African countries.

Variables	NGAGDP				
	Coefficient	S. D	t-val	Prob.	Diagnostics
		NGAGDP			
C	26.76743	0.130604	204.9511	0.0000	Pseudo R-sqd = 0.8062
EXR	-0.004499*	0.001224	-3.674658	0.0003	Adjusted R-sqd = 0.8020
INF	-0.004790*	0.002040	-2.347702	0.0203	Quasi-LR stat = 699.805
BTCPRIZ	0.030495*	0.000850	35.88596	0.0000	Prob(Quasi-LR) = 0.000
		GHNGDP			
C	27.35971	0.065796	415.8286	0.0000	Pseudo R-sqd = 0.8478
EXR	-0.011071*	0.000627	-17.66529	0.0000	Adjusted R-sqd = 0.8446
INF	-0.007714	0.004494	-1.716639	0.0882	Quasi-LR stat = 982.587
BTCPRIZ	0.019161*	0.000975	19.65712	0.0000	Prob(Quasi-LR) = 0.000

Source: Authors' Eviews 13 estimation

As shown in Table 7, from the 10th to 90th quartile, the coefficients of NGAEXR were all significant and inversely correlated with GDP of Nigeria. The magnitude of the impact from the 10th quartile was seemingly in decreasing order.

Similarly, the coefficients of Bitcoin price in all the quartiles (10th to 90th) had a direct and significant impact on GDP ($p<0.05$). On the contrary, the inflation rate from the 50th to 90th quartile had a direct and significant impact on GDP. This explains why the inflation rate increases with GDP from the 50th and 90th quantiles ($p<0.05$). Based on the Wald test, the chi-square coefficient of 8.29 shows that the slope equality test is insignificant ($P > 0.05$). Hence, the hypothesis of non-slope equality is retained, which implies that slope equality is indifferent across quartile levels.

Table 7 Analysis on Quantile process estimate for Nigeria (NGA).

Specification: LOG(NGAGDP) C NGAEXRDQ NGAINF LOG(BTCPRIZ)					
	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
NGAEXR	0.100	-0.008385**	0.000516	-16.23975	0.0000
	0.200	-0.008045**	0.000642	-12.52330	0.0000
	0.300	-0.006668**	0.001193	-5.586803	0.0000
	0.400	-0.005693**	0.001297	-4.388767	0.0000
	0.500	-0.004499**	0.001224	-3.674658	0.0003
	0.600	-0.003780**	0.001105	-3.420591	0.0008
	0.700	-0.003235**	0.001022	-3.164572	0.0019
	0.800	-0.003109**	0.001098	-2.831680	0.0053
	0.900	-0.003866**	0.001274	-3.033769	0.0029
NGAINF	0.100	-0.008615	0.004692	-1.836114	0.0684
	0.200	-0.006690	0.004471	-1.496361	0.1368
	0.300	-0.005583	0.003350	-1.666321	0.0979
	0.400	-0.005144	0.002812	-1.829491	0.0694
	0.500	-0.004790**	0.002040	-2.347702	0.0203
	0.600	-0.004359**	0.001528	-2.853354	0.0050
	0.700	-0.004102**	0.001128	-3.635200	0.0004
	0.800	-0.003514**	0.000992	-3.543489	0.0005
	0.900	-0.004047**	0.000928	-4.361751	0.0000
LOG(BTCPRIZ)	0.100	0.030184**	0.001766	17.08950	0.0000
	0.200	0.030285**	0.001668	18.15168	0.0000
	0.300	0.030488**	0.001301	23.44257	0.0000
	0.400	0.030431**	0.001141	26.66030	0.0000
	0.500	0.030495**	0.000850	35.88596	0.0000
	0.600	0.030677**	0.000653	46.96054	0.0000
	0.700	0.030800**	0.000534	57.71032	0.0000
	0.800	0.031042**	0.000556	55.82711	0.0000
	0.900	0.030732**	0.000699	43.94471	0.0000
Test Summary		Chi-Sq. Statistic		Chi-Sq. d.f.	Prob.
Wald Test		8.299602		16	0.9394

Source: Authors' Eviews 13 estimation

In Table 8, beginning from the 10th to 90th quartile, the coefficients of GHNEXR were all significant and inversely correlated with the GDP of Ghana. The magnitude of the impact from the 10th quartile seemingly decreased from the 10th to the 40th quantile, and from the 50th to the 90th quartile, the GHNEXR impact increased on GDP. Similarly, the coefficients of Bitcoin price in all the quartiles (10th to 90th) had a significant positive effect on GDP ($p<0.05$). On the contrary, the inflation rate from the 60th to the 90th quartile had an indirect and significant impact on GDP. This explains why the inflation rate increases with GDP from the 10th and from the 60th to the 90th quantiles ($p<0.05$). The chi-square coefficient of 103.27 indicates that the slope equality test is not significant ($P > 0.05$) according to the Wald test. Therefore, the non-slope equality hypothesis, which suggests that slope equality is constant throughout quantile levels, is maintained.

5. Discussion

The results show that exchange rate disequilibrium had considerable impact on economic growth. By implication, the outcome of this study shows that the rise in exchange rate disequilibrium in the foreign exchange markets of Singapore and Malaysia has an expansionary effect on industries and real sector output. This could be due to the fact that many manufacturing firms depend largely on external exchanges for the import of intermediate and semi-finished products for processing and reprocessing. Hence, border openness and the exchange rate increase may have made it more possible for businesses to thrive through the activities of the Bureau de Change. In contrast, exchange rate disequilibrium and output growth are inversely

correlated in Nigeria and Ghana. This sign change agrees with theoretical expectations from the PPP theory. This explains why the depreciation in the exchange rate had a counterproductive impact on macroeconomic growth in Nigeria and Ghana, respectively. This explains why exchange rate depreciation adversely affect producers in the economy who expect lower foreign exchange to buy more goods at lower exchange prices. Bitcoin price fluctautions have a direct impact on economic growth. This result could suggest that any credit policy that boosts Bitcoin trading brings about an increase in trade in both the formal and informal markets of the real sector. This could also lead to an increase in investment demand and output growth. The inflation rate was inversely related to economic growth in Nigeria and Ghana. This explains why inflation reduced the purchasing power of consumers and producers, making them spend a large amount of money to purchase very few goods and services at high prices. In sum, the results revealed that increases in (i) foreign exchange dynamics increase economic growth in ASEAN nations, (ii) foreign exchange dynamics decrease economic growth in Africa, and (iii) the price of bitcoin increases economic growth in both African and ASEAN nations.

Table 8 Analysis on Quantile process estimate for Ghana (GHN).

Specification: LOG(MYSGDP) C GHNEXR GHNINF LOG(BTCPRIZ)					
	Quantile	Coefficient	Std. Error	t-Statistic	Prob.
GHNEXR	0.100	-0.009636**	0.000547	-17.60194	0.0000
	0.200	-0.009997**	0.000549	-18.21748	0.0000
	0.300	-0.010531**	0.000476	-22.14607	0.0000
	0.400	-0.010396**	0.000518	-20.06610	0.0000
	0.500	-0.011071**	0.000627	-17.66529	0.0000
	0.600	-0.011312**	0.000694	-16.30354	0.0000
	0.700	-0.011396**	0.000761	-14.97676	0.0000
	0.800	-0.012366**	0.000832	-14.86805	0.0000
	0.900	-0.013835**	0.000763	-18.13270	0.0000
GHNINF	0.100	-0.007002*	0.002973	-2.354805	0.0199
	0.200	-0.004724	0.003087	-1.530258	0.1282
	0.300	-0.001960	0.002593	-0.755673	0.4511
	0.400	-0.003610	0.002595	-1.390902	0.1664
	0.500	-0.007714	0.004494	-1.716639	0.0882
	0.600	-0.012568**	0.004498	-2.794132	0.0059
	0.700	-0.015587**	0.003940	-3.956304	0.0001
	0.800	-0.018550**	0.003480	-5.330414	0.0000
	0.900	-0.021900**	0.003134	-6.988646	0.0000
LOG(BTCPRIZ)	0.100	0.018182**	0.000641	28.35750	0.0000
	0.200	0.018320**	0.000710	25.80577	0.0000
	0.300	0.018233**	0.000772	23.62969	0.0000
	0.400	0.018843**	0.000889	21.19902	0.0000
	0.500	0.019161**	0.000975	19.65712	0.0000
	0.600	0.019331**	0.000974	19.83931	0.0000
	0.700	0.019706**	0.001044	18.87479	0.0000
	0.800	0.018728**	0.001155	16.20973	0.0000
	0.900	0.016892**	0.001043	16.19791	0.0000
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.		Prob.
Wald Test		103.2686	24		0.0000

Source: Authors' Eviews 13 estimation

From Table 9, the Markov switching probabilities with two regimes and constant transition probabilities in the low and high volatility regimes. From the results, there is a high probability of 0.99 staying in State 1, while the corresponding expected durations in a regime are approximately 102.189 to 168.76 periods for States 1 and 2 in Nigeria, respectively. In Ghana, the duration times in a state are approximately 151.5 to 135.58 periods for regimes 1 and 2, respectively. From Table 10, the result for Singapore (SGP) shows that the durations in a regime are approximately 137.36 to 141.24 periods for States 1 and 2 in Singapore's GDP, respectively, while the durations in a state are approximately 137.36 to 141.24 periods for regimes 1 and 2 in Nigeria's GDP, respectively. For Bitcoin prices, the durations in a state or regime are approximately 65.132 to 173.58 periods for regimes 1 and 2 in Nigeria.

The outcome is at odds with that of Odey & Agunobi (2024), who discovered that the GDP of the real sector is not much boosted by the coefficient of FX. The outcome in terms of the coefficient's sign also deviates from the empirical results of

Ukangwa, Onyenze, and Uke-ejibe (2023), which discovered that the exchange rate only has a negative and substantial influence on Nigeria over the long term. Additionally, the outcome is consistent with the findings of Alawattage (2002), who discovered that increasing the trade balance, especially GDP growth, does not significantly depend on the real effective exchange rate. The trade balance and real effective exchange rate have a long-term relationship, as indicated by the cointegration tests; however, this link has relatively little long-term influence on trade balance and growth in Sri Lanka. Additionally, the outcome differs from that of Ikwuagwu and Yagboyaju (2023), who discovered a weak and negative correlation between exchange rate and balance of trade across the time period. Additionally, the outcome disagrees with that of Ukangwa, Onyenze, and Uke-ejibe (2023), who discovered that the exchange rate only has a negative and substantial influence on Nigeria over the long term. Furthermore, although not statistically significant, the results contradict those of Agu, Obodoechi, and Nebo (2022), who showed that the exchange rate had a negative impact on Nigeria's balance of payments. Furthermore, the outcome is consistent with Mohammed & Nuhu's (2021) findings, which showed that the exchange rate had a negative effect on the country's external balance position.

The results of this investigation, on the other hand, are consistent with those of Akani (2024), who discovered that 83.6 and 90.2 percent of the variation in the financial performance of the small and medium-sized enterprises quoted can be attributed to variations in the depreciation of the naira exchange rate over the study's period. While still in accord, the outcome is also in line with research by Urgessa (2024), who discovered that real effective exchange rate appreciation has a major direct impact on Ethiopia's overall export profits as well as export earnings from items connected to vegetables, meat, and oilseeds. Furthermore, Akani (2024) discovered a favourable and substantial association between the nation's output, business success, and the average naira exchange rate. Furthermore, Ikwuagwu and Yagboyaju (2023) discovered that Nigeria had loosened the fixed exchange rate regime during the post-structural adjustment program era, which had a substantial impact on the naira's strong depreciation against other currencies, particularly the US dollar. The outcome also supports the research of Nawaz, Rizwan, Imamuddin, Rana, and Unaib (2014), which discovered that stable currency rates help foster investment and strengthen economic growth in Pakistan by creating a favourable environment. The outcome is consistent with that of Irmiya (2023), who discovered that Nigeria's balance of payments had been upset as a result of the recent highly unstable exchange rate. The conclusion of the study was that the value of the Nigerian naira has been undermined by an erratic exchange rate. This result corroborates the findings of Nawaz, Rizwan, Imamuddin, Rana, and Unaib's (2014) study, which found that stable exchange rates facilitate investment and bolster economic growth in Pakistan by establishing a conducive atmosphere. The result also agrees with Irmiya's (2023) findings, according to which Nigeria's balance of payments had been disrupted by the recently volatile exchange rate. In the end, the study concluded that an unstable exchange rate has damaged the value of the Nigerian naira.

Besides, the outcome is consistent with that of Nwanekezie & Onyiro (2018), who discovered that nominal foreign exchange rate, rate of inflation, real interest rate, and government spending, accounted for the systematic fluctuation in external output. The findings also showed a long-term correlation between the BOP and exchange rate volatility. It supports Priyatharsiny's (2017) results, which indicated that there is a positive equilibrium over the long term between the currency rate and Sri Lanka's balance of payments. Also, it supports results of Nwaolisa & Ananwude (2016) which indicated that fluctuations in foreign currency rates frequently have an impact on a number of macroeconomic variables, including production. Furthermore, the outcome is consistent with the research conducted by Agundu, Akani, and Kpakol (2013), which confirmed that foreign exchange is a strong predictor of production changes. It concurs with Oladipupo & Ogheneovo's (2011) findings that the exchange rate significantly affects Nigeria's production situation and balance of payments. It is in line with Okwuchukwu's (2014) results, which revealed that the balance of payments and exchange rate had a positive and statistically significant association over the long term and a positive and insignificant link over the short term. Additionally, it supports the findings of Martins & Olarinde (2014), who discovered that a one-standard deviation of innovation on exchange rate reduces BOP in Nigeria.

Additionally, the results concur with those of Imoisi (2012), who discovered a noteworthy correlation between BOP, interest rate, and exchange rate. It is consistent with the findings of Ngene (2010), who discovered that changes in exchange rates had a major and detrimental impact on Nigeria's trade with the US. It is consistent with research by Ogundipe, Ojeaga & Ogundipe (2013) that discovered that an exchange rate over time creates a strong and inelastic relationship with trade balance. It is consistent with research by Damoense and Agbola (2005), which indicated that interest rates and foreign money supply have a favourable effect on trade balances while exchange rates have a negative influence. The investigation's results, which continue to corroborate earlier research, are consistent with those of Aliyu (2009), who found that real economic growth in Nigeria is positively impacted by currency rate appreciation. It is more satisfying when the currency appreciates than when it depreciates, even if an increase in exchange rates would result in a loss of competitiveness since the economy cannot primarily absorb gains via competition. This is because appreciation will raise savings, raise domestic investment, reduce inflation, and raise living standards. It is consistent with the results of Aliyu (2011), who stated that an appreciation of the exchange rate results in a decrease in exports and an increase in imports, whereas depreciation would result in an expansion of exports and a decrease in imports. Furthermore, a depreciation of the exchange rate is probably going to cause a shift in the balance of trade from importing to exporting countries, which causes a diversion of earnings from importing to exporting countries. The

results support findings of Akpan (2008), who discovered a positive correlation between economic growth and exchange rates. It concurs with the findings of Obansa, Okoroafor, Aluko, & Millicent (2013), who discovered that exchange rate liberalization, enhances economic growth and is beneficial to the Nigerian economy. This aligns with the conclusions given by Azeez, Kolapo, and Ajayi (2012) about the impact of exchange rate volatility on Nigeria's macroeconomic performance between 1986 and 2010. They demonstrated that the GDP and exchange rate had a favourable relationship. The outcome supports the findings of Odusola and Akinlo (2003), which discovered that although exchange rate depreciation has an expansionary effect on production over the long term; it does not increase output in the near term. It is consistent with research by Iyoboyi & Muftau (2014), which discovered that while exchange rate depreciation has been prevalent in Nigeria since the mid-1980s, it hasn't done much to advance the positive BOP of the nation. It is in line with the research of Abdullahi, Abubarkar, Fakunmoju, and Giwa (2016), which discovered that the money supply and exchange rate positively and substantially impact Nigeria's balance of payments at a 5% significance level. It also aligns with the results of Nwani (2006), who discovered that trade transparency, the international debt load, currency rate volatility, and domestic inflation might all contribute to variations in Nigeria's balance of payments.

Table 9 Markov-regime Switching models for Africa nations.

Country						Transition probability	Constant expected duration
			Regime 1				
	C	4.18E+11	5.20E+09	80.44840	0.0000	0.9902	102.189
NGA			Regime 2				
	C	4.98E+11	2.01E+09	247.8766	0.0000	0.9941	168.767
			Common				
	LOG(SIGMA)	23.57116	0.057093	412.8563	0.0000		
			Regime 1				
	C	4.60E+10	7.55E+08	60.90667	0.0000	0.9934	151.536
GHA			Regime 2				
	C	6.19E+10	7.46E+08	82.92767	0.0000	0.9926	135.582
			Common				
	LOG(SIGMA)	22.21172	0.051813	428.6893	0.0000		
			Regime 1				
	C	2.83E+11	4.24E+09	66.84249	0.0000	0.9925	137.361
SGP			Regime 2				
	C	3.45E+11	3.32E+09	104.0335	0.0000	0.9929	141.247
			Common				
	LOG(SIGMA)	23.60595	0.047061	501.6059	0.0000		
			Regime 1				
	C	2.69E+11	5.20E+09	51.66594	0.0000	0.9927	137.361
MYS			Regime 2				
	C	3.47E+11	3.96E+09	87.55580	0.0000	0.9933	149.734
			Common				
	LOG(SIGMA)	23.73506	0.047555	499.1115	0.0000		
			Regime 1				
	C	33304.46	2978.684	11.18093	0.0000	0.9846	65.132
BTCPRIZ			Regime 2				
	C	2843.935	486.0560	5.851044	0.0000	0.9942	173.578
			Common				
	LOG(SIGMA)	8.497011	0.076140	111.5971	0.0000		

Source: Authors' Eviews 13 estimatio

Table 10 Markov-Regime Switching Models for developing ASEAN nations.

Country	Regime effects				Transition probability	Constant expected duration
		Regime 1				
	C	2.83E+11	4.24E+09	66.84249	0.0000	0.9925	137.361
SGP		Regime 2				
	C	3.45E+11	3.32E+09	104.0335	0.0000	0.9929	141.247
		Common				
	LOG(SIGMA)	23.60595	0.047061	501.6059	0.0000		

			Regime 1				
	C	2.69E+11	5.20E+09	51.66594	0.0000	0.9927	137.361
MYS			Regime 2				
	C	3.47E+11	3.96E+09	87.55580	0.0000	0.9933	149.734
			Common				
	LOG(SIGMA)	23.73506	0.047555	499.1115	0.0000		
			Regime 1				
	C	33304.46	2978.684	11.18093	0.0000	0.9846	65.132
BTCPRIZ			Regime 2				
	C	2843.935	486.0560	5.851044	0.0000	0.9942	173.578
			Common				
	LOG(SIGMA)	8.497011	0.076140	111.5971	0.0000		

Source: Authors' Eviews 13 estimation

5. Conclusion

The quantile regression was executed for the study to evaluate the impact of foreign exchange market disequilibirum, and bitcoin price volatility on macroeconomic performance Nigeria, Ghana, Singapor and Malaysia repestcivly. The Markov-switching regression was estimated as a robustness check. The Markov-switching regression's capacity to measure changes in GDP growth patterns during regime transitions, including those particular to volatility in the price of bitcoin and disequilibrium in the foreign exchange market, is nevertheless a justification for the robustness analysis provided by the Markov-switching regression model. The study's findings and empirical analysis support the following recommendations:

To lessen the effects of fluctuating energy prices and currency exchange rates, economic diversification is essential. This fosters resilience in the economy. The central banks should be more flexible in their foreign exchange intervention policy during periods of high exchange rates and decrease it during periods of low exchange rates. To strengthen the home currency and stop future depreciation of local currencies in ASEAN and African countries, the government should promote cryptocurrency trading and maintain a surplus trade balance. To be able to withstand any shock that might cause detrimental fluctuation in the foreign exchange rate market, the government should make sure that they maintain an emergency reserve of foreign currency (such as the US dollar). It would be effective for the central monetary authorities to control the degree of exchange rate volatility utilizing the available foreign currency if the top bank of nations is able to boost the amount of foreign currency (particularly the US dollar) in its coffers. The importance of the foreign exchange market cannot be overemphasized in an open economy. Based on the findings, it is concluded that a rise in foreign exchange market disequilibrium adversely affects macroeconomic growth performance, while an increase in bitcoin prices has a positive impact on macroeconomic performance in African and ASEAN nations. Other econometric modeling approaches like M-GARCH and O-GARCH are suggested in further studies. Also, more frequent data, such as daily or weekly data, should be used for bitcoin modeling. In this study, the researchers were confronted with some limitations that were managed to ensure the objectives of the study were attained. First, only two countries in Africa and ASEAN nations were included in the analysis. Prior to estimation, the researcher made an effort to collect data on the needed series from at least five African countries and five ASEAN nations. However, obtaining these data was quite difficult, as there seemed to be a paucity of data (within the time period covered) for some nations from the World Bank database on development indicators and other relevant sources. However, the researcher made use of the data for the two available nations for the equation estimation.

Ethical Considerations

This study adhered to ethical guidelines as it relates to tehuse of other researchers works and data collection

Conflict of Interest

Authors hereby declare that there are no conflicts of interest whatsoever in this study.

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