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Bawuah, Bernard; Agyei-Ampomah, Samuel; Owusu-Ansah, Anthony; Atsu, Francis

Article

Currency reform, currency biases and Ghana's forex market fluctuations: Beyond the macroeconomic fundamentals

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*Corresponding author: Bernard Bawuah, School of Business, Department of Banking and Finance, SD Dombo University of Business and Integrated Development Studies UW 36, Wa, Ghana E-mail: bbawuah@ubids.edu.gh

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Currency reform, currency biases and Ghana's forex market fluctuations: Beyond the macroeconomic fundamentals

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economics & finance

Bernard Bawuah¹*, Samuel Agyei-Ampomah², Anthony Owusu-Ansah³ and Francis Atsu⁴

Abstract: Redenomination of currency has become a common phenomenon in recent past among emerging and transitional economies. In 2007, Ghana became one of the economies to redenominate in recent past. This currency policy adaptation has the potential of triggering certain individual behavioral biases on the forex market. This study provides evidence that currency biases that accompanied Ghana's currency reform adaptation in 2007 contribute to its forex market price (exchange rate) fluctuations. Using data from 1980 to 2018 with some estimated biases and some selected macro-economic fundamentals as covariates in an ANCOVA (Analysis of Covariance) model, the study revealed that estimated biases which were induced as a result of currency reform adaptation impact positively and significantly on Ghana's forex market prices. It is therefore recommended that policy makers, political leaders and stakeholders begin to look at human factors that may exist in the forex market and incorporate this information into future plans in addressing issues relating to forex market fluctuations.

Subjects: Social Psychology; Economics; Finance

Keywords: currency reform; behavioral biases; forex market; money illusion; macroeconomic fundamentals

1. Introduction

According to Dzokoto et al. (2010), when currency change occurs, there are psychological and cognitive processes that come to bear and drive economic agents' (stakeholders) behavior towards money management. These postulations connect with Mental Accounting and other related cognitive behaviors which are unique concepts in the research area of cognitive psychology and financial behavior. Under Mental Accounting concept, for instance, Thaler (1985, 1999) suggested that individuals organize, evaluate and keep track of financial activities in their mind, similar to how companies handle accounting and budgeting systems. The categorization of the financial and income activities into different mental accounts affects individuals' propensity to spend (Henderson & Peterson, 1992) and also violate the normative principle of fungibility (Raghubir & Srivastava, 2008). Generally, it has been proven in the literature that cognitive illusions on the part of economic individuals can have significant economic consequences. Raghubir and Srivastava (2002), Raghubir and Srivastava (2008), Shafir et al. (1997) and Shefrin and Thaler (1988) have also demonstrated that in the domain of money, the normative principle of descriptive invariance suggests that preferences should not vary when the same objective stimuli are represented (framed) in different forms (Raghubir & Srivastava, 2008)





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An evidence of these cognitive biases and their impact have been reported during the Euro transition. Lemaire and Lecacheur (2001) and Mussweiler and Englich (2003), for example, have reported that customers perceived prices to be cheaper in the new Euro than the old and familiar currencies of countries during the Euro transition, and the attributed reason for this perception of cheaper prices was that the nominal value of familiar currency (old) was higher than that of the Euro. The authors have indicated that the situation had occurred within certain demographic groups (Lemaire & Lecacheur, 2001) and also at early stages of the introduction of the Euro currency (Mussweiler & Englich, 2003). Aligning with the findings of these authors, one could conclude that similar occurrences could happen in Ghana in line with the currency reform in 2007. This is because redenomination exercises have some similar features like the Euro currency transition and some individual perceptions reported by the authors in connection with the Euro transition (cheaper prices relative to the currency face value) may occur in Ghana especially when the nominal value of the old cedi (familiar) currency was higher than the new Cedi (10000: 1). These reported behaviors under currency reform constitute irregular financing behaviors which are inconsistent with rational theory. These irregular financing behaviors will occur because the perceptions of economic agents will drive them to make inadequate adjustment of the old and new currencies leading to less accurate estimation of prices (Marques & Dehane, 2004) and, consequently, an irregular decision.

Consistent and similar argument could be made with respect to the face value effect (Raghubir & Srivastava, 2002) which suggests that individuals' spending intentions may be based on the nominal face value rather than the real value of the currency. The face value effect is one bias associated with foreign currency face value being a multiple or fraction of the domestic currency (Raghubir & Srivastava, 2002). This theory of bias suggests that economic agents overspend or underspend given the face value (multiple or fraction) of the foreign currency relative to the domestic currency. Thus, a multiple face value case (\$1: \$\varnothing 7\$ for example) makes foreigners to see product prices in the domestic country to be expensive if the foreigner anchors on the same product price in his/her currency with inadequate capacity for exchange rate adjustment. The aggregate effect is that foreigners will likely underspend in the domestic country because the perception is that price of product is expensive. Parallel situation occurs when the face value between the two currencies is a fraction case (1: 0.5). The bias drives foreigners to think that product prices in such economy are cheaper under less capacity for exchange rate adjustment, leading to overspending in aggregate terms. Overspending suggests frequent exchange of currency by foreigners who visit the economy and underspending will likely reduce the frequency of the exchange between foreign and domestic currency. Given that Ghana's redenomination policy adaptation changed the nominal values of the country's currency, and, the fact that the face value becomes a multiple of the foreign currencies (especially the major trading currencies), raises a possibility of this bias impacting on Ghana's forex market. The implication is that products are expensive, and, therefore, foreigners will spend less. Less foreigners spending may trigger shortage in the supply side of the foreign currency function of the economy. With an expected demand function for foreign currency constant, all things being equal, exchange rate will rise. This suggests that inconsistencies surrounding foreigner behavior with regards to their inflows of foreign currency may lead to forex market instability. Given the fact that tourism expenditure constitutes a greater proportion of foreign exchange inflows to economies (WTO, 2011), Ghana's economy cannot escape the possibility of the face value effect (bias from foreigners). The proportion of Ghana's tourism expenditure to GDP for the study period is presented in table 1 and attached at the appendix.

One study in Ghana regarding the currency reform (Dzokoto et al., 2010) employed qualitative design to assess the impact of money illusion on Ghanaian consumers. The authors through interviews concluded on the presence of money illusion by indicating that respondents value prices in nominal terms than the real terms. For lack of inferential data and inferential analysis, the authors could not assess how macroeconomic variables have been impacted by the effect of money illusion and how the impact transcend to the forex market. Already, Calomiris (2007)

provided evidence on redenomination impacting on exchange rate in Argentina's economy. This evidence gives a clue to the possible happenings in the forex market relating to Ghana's redenomination policy adaptation. The exchange rate between the Cedi and the Dollar after redenomination in Ghana, for instance, has not been stable. The question is, can these expected biases that accompanied policy adaptation, account for Ghana forex market fluctuation? Do expected biases impact more on nominal rate in the forex market than the real effective rate, as postulated in the money illusion literature (Fehr & Tyran, 2001, 2014, Luba & Winn, 2014; Shafir et al., 1997) with regards to non-forex market? Adusei and Gyapong (2017), Alagidede and Ibrahim (2017) and Amoah and Aziakpono (2017) are some of the latest authors who have examined forex market fluctuation in Ghana. These authors have argued in favor of various macroeconomic fundamentals as causes and drivers of the exchange rates fluctuation in Ghana. However, one may ask, are these fundamental arguments that are anchored on rational assumptions sufficient to fully explain the forex market fluctuation? Concentrating on the macroeconomic fundamentals alone would limit research focus on exchange rate debate in Ghana and may hinder exploration of other possibilities that may account for Ghana's forex market reactions. Ramasamy and Abar (2015), after observing that predictions of macroeconomic variables are contrary to a priori expectation in relation to exchange rate, they concluded that psychological factors (such as investors' confidence) are likely dominating economic variables in deciding exchange rate fluctuation. This conclusion seems to support the position of the adversaries that macroeconomic fundamentals is not the only probable cause of the Cedi depreciation post-redenomination.

This study makes contribution to the exchange rate and macroeconomic fundamental argument. Significantly, this study distinct itself by considering the effect of currency reform (redenomination) on the forex market so as to ascertain whether Ghana's forex market dynamics can be attributed to expected currency biases that resulted from the adapted currency reform. The rest of the research is organized as follows; literature review, empirical strategy, variable data and data sources, analysis presentation and discussion, and conclusion and recommendation.

2. Literature review

2.1. Studies on currency redenomination

Some authors who have conducted research on currency reform and redenomination on countries and across countries are Mosley (2005), Ioana (2005), Lianto and Suryaputra (2012), Žídek and Chribik (2015). These authors have used Turkey, Poland, Russia, Romania, Argentina and Indonesia. In finding answers to why some governments of developing countries elect to redenominate while others do not redenominate under conditions of high inflation, Mosley (2005) used a set of data from developing and transition nations, covering the 1960-2003 period analysis. Employing survey responses and seven research hypothesis, Mosley (2005) reported with a baseline hazard rate of 1 (cox regression) that countries with high inflation and weak domestic currency to Dollar ratio are likely to redenominate to bring stabilization to their economies. The author also found that inflation is an important predictor of redenomination. Given these findings, Mosley (2005), therefore, concluded that dropping zeros (redenomination) matter and that the exercise is an illusion that drives inflationary expectation. The weak domestic currency to Dollar finding in Mosley's (2005) study, and a similar finding from Lianto and Suryaputra (2012) signified that Ghana was ripe for redenomination policy adaptation at the time of implementation because there was a clear signs of dollarization in the Ghanaian economy where most investors preferred to transact in Dollars instead of the Cedi (Tweneboah et al., 2019). The fourth effect identified by the study has to do with domestic currency effect against foreign currencies even though the authors warned that this effect is not direct. This finding of Lianto and Suryaputra (2012) confirms Mosley's reported result and connect well with one of the reasons why Ghana redenominated her currency in 2007.

According to Žídek and Chribik (2015), the main goal of the Turkish redenomination was to ease dealing with prices and costs in the economy which is similar to Ghana's rationale for her currency redenomination. The central authorities of Turkey decided to respond to long period of high

inflation and economic cost by redenominating the Lira at the beginning of 2005 by removing six zeros. In order to assess the effect of this decision on the Turkish economy, Žídek and Chribik (2015) tried to find out if Turkish redenomination contributed to its disinflation by 2015. The authors employed the Chow test and Vector-Autoregressive model to ascertain whether or not redenomination created a structural break in inflation development. Even though, the study exposed a break in the inflationary development in the country, they could not conclude on whether the break could be attributable to the redenomination policy using chow test. Also, in a comparative analysis, Ioana (2005) analyzed the long- and short-run paybacks, the motives for selecting the period for a redenomination, the technical facets, the impact it will have on prices and the means through which the new currency was acknowledged. Among other things, the author concluded that redenomination should not trigger inflation even though the author acknowledged the potential rounding up (or down) of prices. With this view, Ioana (2005) aligned with Turkish authorities (Central Bank) who had indicated prior to the redenomination implementation that the currency reform will have no effect on consumer prices, exchange rate and interest rate. A situation that is similar to the slogan "the value is still the same" which was adduced by the Central Bank of Ghana at the time of policy implementation.

2.2. Theoretical and empirical review of currency biases

There are numerous heuristics (cognitive biases) discussed in the irrational behavior theories in the literature. Despite the doubt that characterizes money illusion, Shafir et al. (1997), Fehr and Tyran (2014, 2001) Noussair et al. (2012) and Luba and Winn, (2014) provided evidence that the phenomenon really exists and it manifests itself in diverse ways when people make economic decisions. According to the authors, the nature and how this phenomenon manifests itself in practice cannot be readily eliminated by learning. It is probably because the phenomenon is embedded in psychology which is also based on economic agent's subjective judgment. One of the reasons ascribed to this irrational behavior by cognitive psychology researchers is that alternative representations of the same situation could lead to systematically different responses. This logic depends on how the available situation is framed to trigger the individual's cognitive function. Literature suggests that alternative framings of the same options can give rise to different choices. And under situations where no reference is made to change in wealth, individuals seem to prefer rising prospect which tends to have higher expected value (Kahneman & Tversky, 1979; Tversky & Kahneman, 1991). Under framing conditions, economic agents fail to take decisions which are guided by strategic calculations. They rather consider how salient, simpler, or more natural the situation may seem to them. Therefore, alternative framings of the same options can result in different choices of the same economic agents. Shafir et al. (1997) and Noussair et al. (2012) have posited that individuals have often made decisions on nominal basis. This is because nominal representations have been deemed much simpler, appealing and more salient, even though the real representations are the ones that capture the true value of transactions.

Therefore, evaluations of economic transactions by individuals have often represented a mixture of nominal and real assessments, and the consequences have often given rise to money illusion (Shafir et al., 1997). This suggests that judgments of economic agents do not correspond fully to either the real or the nominal evaluation in the case of money illusion (Luba and Winn, 2014). It is rather a mixture of the two with the nominal evaluation dominating between the two in individual evaluation decisions. This means that economics agents are generally aware that there is a difference between real and nominal values. However, they often think of transactions in predominantly nominal terms because money is a salient and natural unit that pricks human conscience. Evidently, in the real world, economic agents are faced with multiple representations than a single representation with regards to decision making on economic transactions. Thus, individuals are confronted with conflicting intuitions about value as they earn, spend, save, borrow and invest money. Their intuitive accounting is often subjected to multiple representations rather than a single representation of the transaction. Therefore, biases induced by cognitive and mental accounting come to play when individuals are evaluating economic transactions. Given these facts, Shafir et al. (1997) posited that the tendency of money illusion driving individuals to think in

nominal terms instead of real terms will likely persist despite economist's attempts to educate the public. Biases triggered by multiple representations could be observed in perception as well according to Shafir et al. (1997) and referred to as visual illusion.

Fisher (1928) cited in Shafir et al. (1997) and Noussair et al. (2012) posited that money illusion may affect multinational trade tourism as well. The author suggested that the issue of money illusion affects almost everyone in relation to their home country's currency. Individuals seem to think that the home currency is stationary while the money of other countries seems to be changing. This perception, therefore, drives individual's decision when it comes to transactions that may involve foreign currency or transactions that may need currency conversion. The nature of redenomination changes the face value of the home currency in nominal terms. This change of face value automatically changes the existing exchange rate in nominal terms for both citizens and foreigners. The result of this change in exchange rate under redenomination circumstances has significant implication on trade and spending behaviors. This is because individuals treat and use foreign currency differently from their home currency and there is some level of difficulty in aetting used to and spending foreign currency (Raghubir et al., 2012). Raghubir and Srivastava (2002) demonstrated that foreigner's spending behavior is influenced by two factors; these are, whether foreign currency is a multiple or fraction of a unit of the home currency. These authors attributed this functional relationship between spending behavior and whether foreign currency is a multiple or fraction of home currency to the "face value effect". The face value effect is likened to the money illusion effect which suggests that judgment of economic agents on economic transactions involving the use of foreign currency are often a combination of nominal and real values, with a bias towards nominal values. The nominal bias in terms of the nominal value of a foreign currency is equivalent to the effect of the face value of a currency one possesses.

According to Raghubir and Srivastava (2002) the face value effect results from accessibility and perceptual salience of a foreign currency's face value. The authors theorized that this bias effect depends on the extent to which individuals have the opportunity or available time to process exchange rate information and also the experience these persons have in using a particular foreign currency. Based on anchoring and judgment heuristic (Barberis & Thaler, 2003), individuals spending decision is influenced by the face value or price of representations. Anchoring and judgment suggest that individuals form initial judgment of alternative representations available to them by anchoring the more salient and easy representation and then adjust that initial judgment to reflect other remaining attributes of the available representation. Most often, it becomes difficult for foreigners to ascertain values in real terms in the visited country since they may be unfamiliar with a foreign currency (especially after redenomination) so it becomes more convenient to convert the foreign currency to their home currency by adjusting for the exchange rate. In the case where prices of products are mostly not displayed (common situation in Ghana), foreigners reflect on the amount they would have paid in their home currency as referent and they adjust this referent subject to the foreign exchange rate. The cumbersome processes for foreigners will force them to make sub-optimal decisions; and for easy of issues, they will dwell more on nominal values than real values for transactional decisions.

In all these mental accounting activities (Thaler, 1999), whether prices are posted in the foreign currency for conversion to be done to home currency as a result of unfamiliarity with foreign currency or a referent in the home currency terms is converted to a foreign currency, the adjustment may likely to be inadequate and erroneous, leading to a bias in favor of the face value of the foreign currency (Raghubir & Srivastava, 2002). The processing stages above may not require the individual to use scarce cognitive resources because perceptual salient anchors are automatically impacted (Gilbert, 1989). Overweighing the face value of a foreign currency and insufficiently adjusting for exchange rate will lead to systematic biases. Lack of ease of exchange rate conversion enhances foreigners (tourists) to use rounding off strategies to simplify exchange rate conversions and can likely affect their spending behavior, especially, in the availability of alternative price cues (Raghubir et al., 2012). The theoretical concern is how foreigners through anchor and

judgment, integrate the two pieces of information (nominal value and real value) in arriving at their subjective valuations under post-redenomination situation. Mostly, the final decision taken by these foreigners in line with the face value and inadequate adjustment of the exchange rate will determine how they spend, subject to the rate of foreign transactions in currency terms between the local currency and the foreign currency. More spending will require more exchange of foreign currency for domestic (local) currency and less spending will require less exchange of foreign currency for the domestic currency. These spending can naturally affect the supply side of the foreign currency in the economy given the size of foreigners visiting and staying in a particular country (tourism). This effect can lead to improvement or otherwise of the country's exchange rate given the demand and supply forces for foreign currency.

Therefore, if foreigners spend less, they exchange fewer foreign currency and the aggregate effect will be negative towards supply of foreign currency given constant demand for foreign currency, leading to a rise in exchange rate. Raghubir and Srivastava (2002) demonstrated that there is a relationship between individual's willingness to spend and the face value of foreign currency relative to the home currency. In fact, their evidence suggested that individuals tend to underspend under situations where the face value of the foreign currency is a multiple of the home currency, and, overspend when the face value of the foreign currency is a fraction of the unit of the home currency. The intuition is that when individuals are pressed with time, they are not able to convert the exchange rate well or even ignoring it and depend on the face value of prices of products with their home currency. If the domestic currency is a multiple unit of the foreigner's currency, the product is deemed expensive leading to underspending. In connection with time, individuals are expected to reduce or increase the face value effect with available time in processing exchange rate. If individuals have enough time to process exchange rate information (adeauate adjustment) their actions are likely to be less or no bias. However, individuals' bias (face value effect) increase if there is limited time to process exchange rate information. Therefore, an inverse relation is expected between the face value effect and time for one to process exchange rate information (Raghubir & Srivastava, 2002). This bias is prevalent just like other heuristics posited by Kahneman and Tversky (1974) to influence bias judgment. Interestingly, Raghubir et al. (2012) posited that these biases may still exist even when product prices are presented in both domestic currency and foreign currency with the lower nominal redenominated currency influencing foreigners spending decisions.

The authors provided evidence that presenting prices in both currencies simultaneously do not seem to be an adequate method for attenuating the uncertainty associated with prices. In fact, processing exchange rate information is not as simple as people see it. This study considers the fact that redenomination policy adaptation can come with this inherent bias because it currently places Ghana's currency on a multiple unit scale against the major trading currencies, for example, and the consequences of this bias effect will connect with availability and supply of foreign currency in Ghana's economy. The aggregate effect of this bias will impact on the forex market since the face value of domestic currency (Cedi) is a multiple unit against the major trading currencies in Ghana's forex market. The significance of this impact is that it will lead to underspending and less supply of foreign currency in the forex market. Consequently, it will also lead to a shortage of foreign currencies of the major trading currencies given that the economy's demand for these currencies remain constant or even increasing in demand (in the case of Ghana). With the above argument, this study therefore predicts a positive relationship between individual bias judgment in the forex market and the exchange rate. Again, the study expects that the effect of the bias should be less severe in the real exchange rate than the nominal exchange rate for two reasons. First, the bias of money illusion is a combination of both real and nominal terms but often tilt towards nominal values than real value (Noussair et al., 2012; Shafir et al., 1997). Second, the basket of currencies (real exchange rate) may not be equally affected by the face value bias because some foreign currencies are frequently traded than others, making the passively traded less bias effected. Therefore, the aggregate effect should be less significant in terms of impact magnitude. Additionally, the fact that some of the currencies in the basket may be a fraction of a unit of the cedi, it will lead to overspending of economic agents (foreigners) per the proposition of the face value axiom (Raghubir & Srivastava, 2002) and this may neutralize the underspending in the case of the major trading currencies.

2.3. Macroeconomic variables and exchange rate issues in Ghana

Some of the latest empirical studies relating to which macroeconomic variables account for exchange rate volatility in Ghana were conducted by Adusei and Gyapong (2017). Using the Partial Least Squares Structural Equation Modelling approach, the authors submitted evidence that Inflation, Monetary Policy Rate and Current Account Balance have negative relationship with their study regressand (Cedi-Dollar Exchange Rate) while Gross Domestic Product (GDP) growth rate, Quasi Money Supply and External Debt having a positive relationship with their regressand. Adusei and Gyapong concluded that the six (6) macroeconomic variables significantly account for the Cedi-Dollar exchange rate volatility in Ghana. Alagidede and Ibrahim (2017) also set out to answer the question "What drives exchange rate volatility, and what are the effects of fluctuations in the exchange rate on economic growth in Ghana?" Using Foreign Direct Investment, Government Expenditure, output, Money Supply and Terms of Trade as variables, the authors findings show that only Output is significant in the short-run while Output and Terms of Trade are both significant in the long-run in driving exchange rate in Ghana. Among other things, their analysis shows that while shocks to the exchange rate are mean reversal, the disparity tends to correct very slowly in the short run.

In assessing exchange rate behavior in Ghana, Amoah and Aziakpono (2017) used Behavior Equilibrium Exchange Rate (BEER) and Johansen and Juselius (1992) framework to measure the exchange rate misalignment in Ghana. Among their variables, Investment, Real Interest Rate and Terms of Trade were reported to have a long-run positive relationship with Real Effective Exchange Rate by the authors. These relationships were established to be statistically significant. However, Import and Export had statistically insignificant long-run relationship with the dependent variable per their model estimates. Interestingly, all the intersectional variables among these studies in Ghana have shown consistent relationships irrespective of the analytical techniques that have been employed by various authors (example: Terms of Trade, Money Supply, etc.). However, there are inconsistencies with their level of significance. Probably, the differences may be as a result of the individual proxies adopted by the authors. Antwi et al. (2020) examined the effect of macroeconomic variables on exchange rate in Ghana using a multivariate modeling technique of the Vector Autoregression (VAR). The authors concentrated on how the study variables have helped in managing exchange in Ghana. Their results indicated that, real GDP granger causes exchange rate in Ghana. However, inflation, money supply and lending rate do not granger cause exchange rate in Ghana but they affect exchange rate indirectly. In all these studies, the impact of currency biases, resulting from redenomination policy adaptation, on exchange rate and for that matter forex market have not be considered.

2.4. Economic policy uncertainty and forex market pressure

At the global level also, forex market pressure remains an issue of concern probably because the market is most liquid and by far the largest among financial markets. The pressure in this market therefore attracts attention in research areas with a common objective of finding answers to what accounts or explains forex market pressure. Interestingly, most of these researches have dwelled largely on macroeconomic fundamentals in seeking answers for the forex market fluctuation to the neglect of factors of economic uncertainties that are not directly measured as macroeconomic fundamentals.

Lately, researchers are beginning to look at other possible factors that account for forex market pressure. Olanipekun et al. (2019) in assessing the causal relationship between economic policy uncertainty (a measure constructed by Baker et al., 2016) and exchange market pressure revealed that domestic economic policy uncertainty mutually interact with exchange market pressure and both influence each other. This finding provides trajectory that outcomes of behavioral responses from domestic policy will likely influence exchange market pressure as well. The authors have established this evidence using BRIC countries. In a similar study using 20 countries, Olanipekun et al. (2019) established a long-run relationship between economic policy uncertainty.

Similar study (Olanipekun et al., 2019) on economic policy uncertainty and exchange market pressure equally found long-run relationship between the two study variables using 20 counties. In this study, the authors controlled for known macroeconomic fundamentals and established a positive relationship between economic policy uncertainty, financial openness, trade openness, consumer price index and exchange market pressure. Then, a negative relationship was established between gross domestic product (GDP), foreign direct investment (FDI), domestic credit and forex market pressure. In the midst of all the covariates, the economic policy uncertainty measure was significant in their model results irrespective of the exchange market pressure by Olasehinde Williams and Olanipekun (2020) on Africa economies reported a causal relations between the US economic policy uncertainty and exchange market pressure among selected Africa economies (Ghana inclusive). The finding is expected because of the reliance of some of these countries on the US economy. In this case, any policy shock may be transmitted indirectly to these economies. Usually, the effects of some of these shocks are unnoticed to these affected economies and its impact on the foreign exchange market cannot be attributed to macroeconomic fundamentals.

Recent finding reported by Olasehinde Williams et al. (2021) suggests that foreign exchange market response to pandemic induced fear that arises within forex market participates. This finding actually draws on potential behavioral responses of investors resulting from the COVID-19 pandemic its impact on the foreign exchange market. Similar to this investor response to pandemic fear is the announcement and the implementation of currency redenomination. By policy and implementation, currency redenomination changes asset values from billion to million and even thousands depending on the number of zeros to be removed from a currency figure. The panic responses from individuals who own assets, even though the real values remain the same, can impact the currency market just like the effect of the COVID-19 pandemic, the authors reported that the fear index is capable of predicting the exchange rate returns of some major foreign currencies (Eg. Swiss France, Yuan, Euro, Canadian Dollar and Australian Dollar) using both systematic and asymmetric test. Given this result, this study expects that human biases that accompanied redenomination policy implementation in Ghana may contribute to the forex market pressure.

3. Methodology

3.1. Variables and data sources

Following Edwards (1988), Alagidede and Ibrahim (2017), Amoah and Aziakpono (2017) and Adusei and Gyapong (2017), seven (7) macroeconomic fundamentals are selected as covariates for the empirical estimation. The selected variables are terms of trade which is measured as the percentage ratio of the export unit to import unit value indexes. Given that Ghana is an importing economy, the term of trade will help assess the impact of net trade on the exchange rate. GDP measured at constant prices and denote economic performance, real interest rate measured as the difference between lending rate and inflation and it represents how investment reward influence capital flows and exchange rate. Fiscal deficit measured as budget balance as a percentage of GDP and it denotes the contribution and impact of excess government spending on exchange rate. Inflation is the change in the consumer price index in annual percentage terms and represents macroeconomic stability and instability. The nominal exchange rate measured by cedi/dollar exchange rate and real effective exchange rate measured as a basket of foreign currencies. The sources of data were as follows terms of trade (WDI), GDP (WDI), real interest rate (EIU), fiscal deficit (WDI), nominal exchange rate (EIU), and real effective exchange rate (WDI). The data is annual for all variables and each variable data was retrieved from 1980 to 2018 based on data availability. These variables exclude the estimated biases that are also included in the empirical estimation.

3.2. Empirical strategy

The empirical strategy for this study is in three parts. The first part deals with structural break analysis to select macroeconomic indicators that are impacted by Ghana's redenomination implementation in 2007. The structural break analysis and the critical value benchmarks for selection are performed following Bai and Perron (1998, 2003). The second part deals with the estimation of expected biased based on selected variables from the structural break results. The third part considers the empirical model the study follows to test the effect of these estimated bias on the forex market.

3.2.1. Structural break test

From the structural break Tables 2 and 3 (Appendix), three indicators emerged as having being impacted significantly by the redenomination policy implementation. The three variables are Gross domestic product (GDP), nominal exchange rate (NER) and fiscal deficit (FD). The revelation from the structural break analysis suggested that the mean value of these indicators before redenomination and after redenomination differs significantly. Since literature has indicated that GDP influences exchange rate (Adusei & Gyapong, 2017; Edwards, 1988; Ramasamy & Abar, 2015), any abnormal impact that affects GDP may likely impact exchange rate and for that matter the forex market. Moreover, macroeconomic variables are, at times, influenced by its lags and leads and that is why dynamic econometric models consider lags and leads (Fabozzi et al., 2014; Gujarati & Porter, 2009). Therefore, any abnormal impact on nominal exchange rate for a particular period can impact on itself or the forex market basket of foreign currencies in the current period, which impliedly affects the forex market as a whole.

Furthermore, fiscal deficit suggests government expenditure exceeds revenue, and, government expenditure is not limited to only domestic expenditure but external expenditure as well. Such external transactions demand foreign exchange and volumes of these transactions can impact on the forex market. Therefore, any abnormal impact on fiscal deficit resulting from Ghana's currency reform may impact on the forex market transitively. It is on this basis that this research estimates the expected biases from these variables as selected by the structural break outcomes and test them on the forex market prices to establish whether or not, these biases account for Ghana's forex market reaction after the currency reform (Redenomination). The assumption is that the observed values of these indicators after redenomination adaptation are different from what ought to be, given the economy trends as predicted by existing fundamentals and growth of the economy, before redenomination.

3.2.2. Estimation of bias

The bias in this study is measured as the absolute deviation between subjective value (expected) and the actual observation of selected indicators. The subjective value in this study is a univariate technique that estimates time series observations without considering the effect of other variables. The study follows Raghubir and Srivastava (2002) subjective value model of a simple average of information which is given as; $V = \gamma V_n + (1 - \gamma) V_r$ where γ lies within 0 and 1.

However, a modification is made by inputting univariate forecasting concept into the model because of the study intuition and also the fact that macroeconomic time series data is being used in the empirical estimation. Macroeconomic variables are known to have lag effect and hence the need to capture its dynamic effect. Therefore, the subjective valuation of this study is estimated as:

$$V_t = Y_t + (1 - \gamma)V_{t-1}$$

Where

- Y_t; is the actual observed value from our data,

- V_{t-1}; is the previous subjective value, and

- γ ; is the average economic growth rate bounded by 0 and 1.

(1)

To calculate Y the study used ten (10) years of economic growth data in the period before redenomination implementation (1997–2006). The data for this period was sourced from World Bank National Growth data (data.worldbank.org). Based on the growth rate data, γ which is calculated as the average of the ten (10) years period growth rate was computed. The study avoided the use of the simple average method (arithmetic mean approach) because its standard deviation was large signifying a wide spread of data values or outliers. Additionally, according to Moosa (2000), the simple average may not always be appropriate, especially, when the observed time series has trend and seasonality. Therefore, this study employed the moving average to estimate γ . Apart from the moving average producing a lower mean square error relative to the simple average method by this study estimation, Moosa (2000) indicated that this method is better because it captures "recency effect".

Thus, the method allows recent observations to be more relevant than old observations in arriving at the current average value. Following Moosa (2000), the study assumes a moving average of order K to estimate the average of observations $S_1 \dots S_k$, as M_K for the time K+1. That is;

$$S_{k+1} = M_k = \frac{1}{K} = \sum_{i=1}^k S_i$$
 (2)

Where; M_k is the value of a moving average of order K. Again, a moving average of order K up to a point in the time K+1 will generate time K+2 and a value of M_{k+1} . Mathematically, M_{k+1} is expressed as

$$S_{k+2=} = M_{k+1} = \frac{1}{K} \sum_{i=2}^{k} S_i$$
(3)

In general, using moving average of order K to calculate M_{k+j} for the values of S ranging between S_{k+1} and S_{k+j} is presented as

$$S_{k+j} = M_{k+j} = \frac{1}{K} \sum_{i=j+1}^{k} S_i$$
(4)

Empirically, using K = 3 (three years moving average), the study obtained an average growth value (γ) of 5.967, with a mean absolute deviation (MAD) of 0.752 and mean standard error (MSE) of 0.644. The table that presents this information can be found at the appendix (Table A4). Substituting γ , the average growth rate in equation (1) allows the subjective valuation model to predict averagely what ought to be the annual statistical value for a particular year for each of the selected indicators, given the growth pattern and conditions of the economy. The absolute value of the difference between an actual observation and its corresponding subjective value within a particular period suggests an error (bias magnitude) which is influenced by changes brought about by the effect of redenomination implementation. These errors (deviations) occur as results of irrational behaviors of economic agents resulting from sub-optimal financial and economic decisions they have made during and after the policy implementation. These estimated errors are termed as the bias. The expectation of this study is for these biases to impact on the forex market. The intuition is that since money illusion and rounding off are proven to influence these variables significantly, it is expected that biases from these indicator variables could account for reactions in Ghana's forex market. Since the redenomination period starts from the year 2007, the subjective value for year 2007 will depend on market reaction of the previous period (2006) which also happens to be the previous actual observation. Therefore, the first subjective value depends on the assumption that $Y_t = V_t$ in the subjective valuation model (equation 1). The tables below (1, 2, 3)present the empirical estimates from the actual observations of the three variables and the subjective values that were generated from the subjective valuation model (equation 1).

Table 1, 2, 3 report the actual observations (column 2), the subjective values based on equation 1 (column 3) and the bias estimates (column 3) for the three indicators (β_1 , β_2 and β_3). The absolute value of the difference between these two columns [2–3] is bias estimates. The bias results from Nominal Exchange Rate is labelled β_1 , followed by bias from Gross Domestic Product which is also labelled β_2 and lastly bias from Fiscal Deficit is labelled β_3 . The estimation of these biases started from 2007–2018, representing the year of redenomination up through to 2018. β_1 , β_2 and β_3 are used in the ANCOVA model to represent biases for the redenomination period to ascertain whether their effects are statistically significant in influencing Ghana forex market price.

Table 1. Estimated bias from nominal exchange rate				
Years	Actual Observation(1)	Subjective Value(2)	BIAS Error (B ₁)	
2006	-0.087			
2007	-0.067	-0.086	0.019	
2008	0.056	-0.077	0.133	
2009	0.343	-0.052	0.395	
2010	0.358	-0.027	0.385	
2011	0.413	-0.000	0.413	
2012	0.585	0.034	0.551	
2013	0.670	0.074	0.596	
2014	1.065	0.134	0.931	
2015	1.300	0.205	1.095	
2016	1.363	0.276	1.087	
2017	1.470	0.349	1.121	
2018	1.523	0.420	1.103	

Note: The table presents a forecasted bias based on the subjective values obtained from the subjective model and the actual data observations of the study variable (NER). The deviation between the two columns; the actual observations and the subjective values produce the expected bias values (last column). The data starts from 2007 because that is the year of redenomination policy adaptation. The bias for Nominal Exchange Rate is B₁.

Table 2. Estimated bias from Gross domestic product					
Years	Actual Observation	Subjective Value	BIAS Error (B ₂)		
2006	23.652				
2007	23.865	23.652	0.213		
2008	24.130	23.665	0.465		
2009	24.323	23.693	0.630		
2010	24.553	23.732	0.821		
2011	24.815	23.782	1.033		
2012	24.045	23.798	0.247		
2013	25.541	23.904	1.637		
2014	25.769	24.017	1.752		
2015	25.918	24.133	1.785		
2016	26.094	24.253	1.841		
2017	26.271	24.375	1.896		
2018	26.429	24.501	1.928		

Note: The table presents a forecasted bias based on the subjective values obtained from the subjective model and the actual data observations of the study variable (GDP). The deviation between the two columns; the actual observations and the subjective values produce the expected bias values (last column). The data starts from 2007 because that is the year of redenomination policy adaptation. The bias for Gross Domestic Product is B₂.

Table 3. Estimated bias from fiscal deficit					
Years	Actual Observation	Subjective Value	BIAS Error (B ₃)		
2006	-4.710				
2007	-5.590	-4.748	0.842		
2008	-8.490	-4.800	3.690		
2009	-5.820	-5.073	0.747		
2010	-6.520	-5.161	1.359		
2011	-4.010	-5.091	1.081		
2012	-11.60	-5.487	6.113		
2013	-7.650	-5.619	2.031		
2014	-6.840	-5.693	1.147		
2015	-4.860	-5.643	0.783		
2016	-6.880	-5.549	1.331		
2017	-5.540	-5.548	0.008		
2018	-3.410	-5.418	2.008		

Note: The table presents a forecasted bias based on the subjective values obtained from the subjective model and the actual data observations of the study variable (FD). The deviation between the two columns; the actual observations and the subjective values produce the expected bias values (last column). The data starts from 2007 because that is the year of redenomination policy adaptation. The bias for Fiscal Deficit is B_3 .

3.2.3. Empirical model

Following Gujarati and Porter (2009) dummy transformation function; T = x + Dy, where (0, 1) \rightarrow (x, y) and y represent expected bias for the period after redenomination and the period before redenomination to be x = 0. The resulting transformation from (0, 1) is given by (0, y) with a scalar of y (bias) being D = 1. The nominal scale transformation for the study is represented by

 $Z_{ij} = \left\{ \begin{matrix} y_j \dots \dots after \\ 0 \dots \dots before \end{matrix} \right.$

Where y_j represents estimated bias for the period after redenomination, zeros for the period before redenomination, $i \in \{1, \ldots, g-1\}$ and $j \in \{g, \ldots, n\}$. Following the nominal scale transformation, the ANCOVA model for the study is estimated as

$$Y_{ij} = \lambda + \sum_{g}^{n} \alpha_j Z_{ij} + \beta X_{ij} + \mathbf{e}_{ij}$$
(5)

Where λ is the coefficient of the model intercept and the α_j measures the main bias effect of the model, β represents the coefficient of all covariate variables in the model, and X_{ij} is the covariate term in the model, while Z_{ij} is the subject with the two categories (qualitative term) and Y_{ij} is the regressand measured on continuous scale. e_{ij} is the error term in the model. The interaction of these covariates with the outcome variable (regressand) follows a sequential order.

ANCOVA is a technique that enables researchers to analyze the relationship between a dependent (continuous) variable and independent (categorical) variables, while controlling for the effects of covariates (which are also continuous variables). ANCOVA is appropriate when establishing linear relationship between two variables which one is continuous and other is categorical in nature using time series data. The model is superior to the ANOVA because it allows the researcher to control the effects of other covariates which are commonly continuous variables (in the case of time series data) and helps improve the accuracy of the analysis. It's appropriateness in this study is the fact that the dependent variables and the independent variables (biases) for this study are measured on a continuous scale and nominal scale respectively. Additionally, the five covariates that are used in the model estimation are also measured on continuous scale.

The empirical modelling is performed with two different regressand (one at a time) and they are REER (real effective exchange rate) and NER (nominal exchange rate in dollar terms). This is because the theory of money illusion suggests that currency bias affect nominal values more than real values, even though, the effect is a combination of the two (real and nominal). This study tries to ascertain whether the situation is same or otherwise for forex market currency. Since REER is a basket of currencies and the expectation that these estimated biases will not affect currencies equally, depending on the frequency with which a particular currency is traded on the forex market, an aggregated effect on the basket might be neutralized by less frequently traded currencies. To test the effect on nominal currency, the Dollar exchange rate is selected as the proxy for NER in model 2 because of the peculiar case that the Dollar is the most traded foreign currency in Ghana. As such, the expectation is that currency bias will likely impact more on the Dollar exchange than any single foreign currency. Using the same covariate, the first model is estimated as;

$$RER_{ij} = \lambda + \sum_{g}^{n} \alpha_{j} Z_{ij} + \beta X_{ij} + \mathbf{e}_{ij}$$
(6)

Where RER_{ij} is the real exchange rate used as the proxy for forex market rate in the model, while, all other variables remain as defined in the equation 3.5 above and the second model is estimated as;

$$NER_{ij} = \lambda + \sum_{g}^{n} \alpha_j Z_{ij} + \beta X_{ij} + \mathbf{e}_{ij}$$
(7)

Where NER_{ij} is the nominal exchange rate used as the proxy for forex market rate in the model, all other variables remain as defined in equation 5 above. All the two models test the null and alternative hypotheses $\alpha = 0$, $\alpha \neq 0$ and $\beta = 0$, $\beta \neq 0$ respectively.

3.3. Unit root and stationarity test

Unit root test is necessary when one is using time series data for empirical estimation. In this study, the unit root test is conducted at levels and first difference. Also, the test considers constant **(C)** and constant with trend **(CT)** analysis under levels or first difference. Based on criticisms levelled against the ADF, this study has employed DF-GLS test, Phillip and Perron test and the KPSS tests to support establish stationarity of variables and their order of integration. This exercise is similar to robustness check and it is to help establish consistency of stationarity of the study data irrespective of choice of model. DF-GLS, PP and ADF test the null hypotheses of unit root and KPSS tests the null hypothesis of stationarity. Table 4 presents the various test results based on the four described models. The order of integration of the various variables as produced by the various models is either I(0) or I(1) and this conclusions have been arrived at by either rejecting a null hypothesis at 1% or 5% or 10% (in the case of DF-GLS, PP and ADF) or failed to reject the null hypothesis (in the case of KPSS).

3.4. Descriptive and other diagnostic test

From table A5 (Appendix), these variables (B_1 , B_2 and B_3) have kurtosis values greater than 3 and skewness greater or less than 0 (zero) indicating a state of outliners. This means the data of these variables are not symmetric based on the skewness values and Jarque-Bera probabilities. This is expected because these variables are categorical in nature bounded by 0 and computed value. The rest of the variables are less skewed and normally distributed in terms of residuals. This is because their skewness values are closer to zero and/or kurtosis closer to 3 when rounded to the nearest whole number. Also, based on Jarque-Bera hypothesis and probabilities, these variables can be concluded to be normally distributed (approximately). The p-values do not reject any of the null

Table 4. Stationarity test					
	Lev	/el	First di	fference	
Variables	C	CT	U	СT	Ю
Elliott-Rothenberg-Stock DF-GLS te	est				
LGDP	0.1960	-1.6595	-2.2714^{**}	-3.4461**	I(1)
LER	-0.4772	-1.9489	-3.3067***	-4.0635***	I(1)
LREER	-0.9355	-1.9255	-5.0280***	-1.9417*	I(1)
LINF	-3.1530***	-5.4856***			I(0)
LTOT	-4.1770***	-4.8126***			I(0)
RIR	-3.7610***	-5.8295***			I(0)
FDEF	-4.1770***	-4.8126***			I(0)
B1	0.4412*	0.8972	-4.1714***	-4.9891	I(1)
B2	0.7304	-0.9191***			I(0)
B ₃	-3.8975***	-5.0778***			I(0)
Phillips-Peron test					
LGDP	2.7734	-3.4109*	-3.4559**	-3.4935*	I(1)
LNER	-5.6094***	-2.0681			I(0)
LREER	-1.5295	-1.8621	-6.2827***	-6.8304***	I(1)
LINF	-3.5223**	-5.4417***			I(0)
ГТОТ	-1.8832	-3.0571	-6.8353***	-7.5745***	I(1)
RIR	-4.0807***	-5.7193***			I(0)
FDEF	-4.1856***	-4.7320***	-17.300***		I(0)
B1	0.5470	-1.1358	-3.6574***	-1.6275	I(1)
B2	-4.0633***	-4.1875**			I(0)
B ₃	-3.3044**	-2.8620			I(0)
Kwiatkowski-Phillips-Schmidt-Shin	(KPSS) test				
					(Continued)

Table 4. (Continued)					
	Le	vel	First di	fference	
Variables	U	J	υ	J	Ю
LGDP	0.7448	0.2115	0.5284	0.1335***	I(1)
LNER	0.7304	0.2086	0.4913	0.0777***	I(1)
LREER	0.5769	0.1627	0.1276***	0.1030***	I(1)
LINF	0.7537	0.0844***			I(0)
LTOT	0.3103***	0.1852			I(0)
RIR	0.6051	0.0965***			I(0)
FDEF	0.4999	0.1414***			I(0)
B1	0.5678	0.2089	0.3532***	0.1781	I(1)
B2	0.4742	0.0963***			I(0)
B ₃	0.7642	0.1817	0.5489	0.0916***	I(1)
ADF Test					
LGDP	0.8527	-2.8375	-3.5777**	-3.7525**	I(1)
LNER	-3.5470**	-1.7876			I(0)
LREER	-1.6566	-2.5239	-6.2827***	-6.4816***	I(1)
LINF	-3.6380***	-5.3548***			I(0)
LTOT	-0.4445	-3.0066	-6.0254***	-6.2737***	I(1)
RIR	-4.1421^{***}	-5.6735***			I(0)
FDEF	-4.1856***	-4.7696***			I(0)
B1	-0.0248	0.7397	1.5939*	3.4574	I(1)
B2	-4.0174***	-4.1875**			I(0)
B ₃	-2.7609*	-2.8290	-6.3077***	-7.1293***	I(1)
Note: LNER = Nominal Exchange represents rejection at 1%, 5%	Rate; LREER = Real Effective Excha and 10% level of significance for / 	ınge Rate; RIR = Real Interest Rate; ADF, DF-GLS and PP estimates whi	LGDP = Gross Domestic Product; le it represents no rejection for	FD = Fiscal Deficit; LTOT=Terms of T KPSS estimate.	rade; LINF = Inflation. ***,** and *
source: computed from study (lata by kesearcner.				

hypotheses for each of the variables except for the categorical variables that meet the assumption of the ANOVA component in the ANCOVA model.

Other diagnostic tests that are performed to help identify both strengths and weaknesses of the ANCOVA model and the reliability of data variables are Multicollinearity test and Autocorrelation. The correlation between any two independent variables indicate that there are no multicollinearity issues because none of the correlation coefficients between any two independent variables is up to 0.8. In fact the highest is approximately 0.7 or less. This information is contained in Appendix A6 (Appendix). The Box test is also performed to test for autocorrelation and the Table A7 (Appendix) report the results from 1 to lag 16. The results suggest that the null hypothesis of no autocorrelation is not rejected using Q-stat and p-value benchmark.

4. Presentation of results

The analysis presented below indicates how estimated biases affect Ghana's forex market as a result of currency reform. Table 5 presents the empirical results from an ANCOVA model. Interestingly, the main effects of the model (being the biases) are highly significant in the presence of covariates representing major economic fundamentals that are known to be the drivers of exchange rate in Ghana.

Table 5. Results o	f REER estimates			
Variables	Sequential Sum of Squares	Degrees of Freedom	F-Statistic	P-Value
B ₁ LGDP LINF RIR LTOT FD Model Residual R-Squared Adjusted R-Squared Observations	5.9774 15.7209 0.4953 5.8718 1.7648 0.1054 29.9357 4.3935 0.8720 0.8480 39	1 1 1 1 1 1 6 32	43.54 114.50 3.61 42.77 12.85 0.77 36.34	0.0000*** 0.0666* 0.0000*** 0.0011*** 0.3874 0.0000***
B2 LGDP LINF RIR LTOT FD Model Residual R-Squared Adjusted R-Squared Observations	6.2061 15.7293 0.4268 5.9225 1.5909 0.1538 30.0293 4.2999 0.8747 0.8513 39	1 1 1 1 1 6 32	46.19 117.06 3.18 44.08 11.84 1.14 37.25	0.0000*** 0.0842* 0.0000*** 0.0016*** 0.2927 0.0000***
B₃ LGDP LINF RIR LTOT FD Model Residual R-Squared Adjusted R-Squared Observations	2.9586 16.5308 1.5929 4.9885 3.2781 0.1273 29.4763 4.8529 0.8586 0.8321 39	1 1 1 1 1 6 32	19.51 109.00 10.50 32.89 21.62 0.84 32.39	0.0001*** 0.0000*** 0.0028*** 0.0000*** 0.0001*** 0.3664 0.0000***

Note: ***, ** and * represent 1%, 5% and 10% respectively.

Source: Computed from study data by Researcher.

The table presents an ANCOVA results where REER is the dependent variable and the rest of the variables presented in table are independent variables including the bias estimates. The effect of each bias is estimated independently and all 3 biases are statistically significant at 1% after controlling for some major macroeconomic fundamentals that are known in the literature to be drivers of exchange rate.

From Table 5, all three estimated biases exhibited statistically significant effect on real exchange rate (REER) at 0.01% (β_1 = 5.977, *P* < 0.0001; β_2 = 6.206, *P* < 0.0001 and β_3 = 2.987, *P* = 0.0001). All these variables of interest (biases) have positive effects on the dependent variable suggesting that real exchange rate rises in the forex market as a response to increases in these biases. The results are an indication that the forex market generate its own bias and the effect is positive one on itself. That is, money illusion driven by perception of forex market players (dealers and speculators) on their marginal spread coupled with possible rounding off in line with non-existing coins for other smaller denominations as a result of redenomination adaptation impact heavily on the forex market thereby pushing forex market prices (exchange rate) up. A positive relation also suggests that lessening money illusion and rounding off in the forex market can stabilize the exchange rate.

 β_2 effect depicts that bias from gross domestic product impact positively on real effective exchange rate. This bias is on the basis that individual's willingness to spend and spending increase when individuals are exposed to smaller denominations (denomination effect) or worn out denomination (physical appearance effect). Under these biases, individuals' consumption increases through increased spending which leads to an increase in gross domestic product (GDP) (through the expenditure approach). Consumption increases means resorting to importation if the country's production is not sufficient to meet domestic demand. In the case of Ghana, where importation of products is less rare, increased consumption will precipitate increase importation which also increases the demand for foreign exchange. The effect is simply increase in exchange rate, all things being equal. This argument justifies why β_2 and gross domestic product (GDP), one of the covariates, have a positive relationship with the dependent variable. This direct relationship between GDP and real effective exchange rate (REER) result is consistent with theory.

Government is a larger consumer in most developing economies. Larger consumption precipitates high government expenditure. Under currency reform where rounding off is likely synonymous to rounding up prices, high government expenditure will likely lead to an increase in government outlay. Now since government spending is not limited to only domestic consumption but foreign consumption as well, two issues come to play. First, rounding off increases government expenditure which will affect gross domestic product (GDP), which is also evident in this study, to be affected by currency bias. Second, higher foreign consumption puts pressure on demand for foreign currency leading to a possible increase in exchange rate. Therefore, a direct relationship between β_3 , fiscal deficit covariate and real exchange rate, the dependent variable in the model, is an expected result. However, where β_3 is statistically significant, the covariate term (fiscal deficit) is not statistically significant in all three of the estimated model under REER. Apart from fiscal deficit, all other covariates in the REER model are highly significant at 1% at least and the nature of association between these covariates and the dependent variable is a positive one. The nature of association between inflation (INF), terms of trade (TOT), gross domestic product (GDP) and REER are expected results and consistent with theoretical expectations too. However, a positive relationship between real interest rate and REER is a rare situation and inconsistent with theoretical expectation. In general, the study results suggest that an increase in the biases leads to an increase in real effective exchange rate. Overall model estimations are significant at $R^2 = 0.872$, F = 36.34, P < 0.0001; $R^2 = 0.875$, F = 37.25, P < 0.0001; $R^2 = 0.859$, F = 32.39, P < 0.0001 (for β_1, β_2 and β_3 models respectively). This signifies that an average variability of 86% (approximately) of the dependent variable (REER) is explained jointly by the covariates. Levene's test for homogeneity of variance confirms equal variance across samples in the model (β_1 , β_2 and β_3 df (12, 16) P>F = 0.2480). This result is reported in Table A8, A9, A10 (Appendix).

Replacing REER with NER and maintaining the covariates as same in the earlier model, produces the result in Table 6. Here the interest is to assess the predicting power of the estimated biases in the model and to ascertain whether or not the prediction power of these biases are better relative to the REER model. The intuition is to compare the estimated

parameters of the two models to confirm or otherwise the money illusion theory prediction between real and nominal values with respect to bias effects. This study argues that REER is a measure of basket of trading currencies relative to the domestic currency. Therefore, collective (total) effect of the basket may be influenced by either active or non-active trading effect of greater proportion of the currencies in the basket. The size of the effect of currency reform depends on the frequency of trade of a particular currency in the forex market. That is, the more participant trade, the more their (participant) behavioral effects come to play, hence, its impact on the market. Since most of the currencies in Ghana are passively traded with the exception of the dollar, euro and pounds, this study argues that the currency reform impact has been minimized on the REER through the non-active trading effect of the other currencies in the basket. Thus, the total effect of redenomination is neutralized by small effect associated with the non- active trading currencies in the basket (REER). To justify this argument, the Cedi/ Dollar is selected for this second analysis (stage II). The cedi/dollar is selected because (i) it is one of the most actively traded currencies in the Ghanaian forex market (ii) the Cedi/Dollar exchange rate is a contemporary issue in most economic debate platforms in Ghana and (iii) the dollar is globally traded in the forex market and represents about 90% of all currencies traded worldwide (Bloomberg report).

Table 6. Results o	f NER estimates			
Variables	Sequential Sum of Squares	Degrees of Freedom	F-Statistic	P-Value
B ₁ LGDP LINF RIR LTOT FD Model Residual R-Squared Adjusted R-Squared Observations	98.4966 173.2797 0.2033 9.5749 10.7334 0.6694 292.9573 12.7045 0.9584 0.9506 39	1 1 1 1 1 6 32	248.09 436.46 0.51 24.12 27.04 1.69 122.98	0.0000*** 0.0000*** 0.4794 0.0000*** 0.0000*** 0.2034 0.0000***
B2 LGDP LINF RIR LTOT FD Model Residual R-Squared Adjusted R-Squared Observations	103.8556 168.1965 0.1252 9.7544 9.9970 1.0126 292.9413 12.7206 0.9584 0.9506 39	1 1 1 1 1 6 32	261.26 423.12 0.32 24.54 25.15 2.55 122.82	0.0000*** 0.0000*** 0.5785 0.0000*** 0.0000*** 0.1203 0.0000***
B₃ LGDP LINF RIR LTOT FD Model Residual R-Squared Adjusted R-Squared Observations	52.1344 202.3458 3.8672 6.6929 21.7524 0.2583 287.0510 18.6108 0.9391 0.9277 39	1 1 1 1 1 1 6 32	89.64 347.92 6.65 11.51 37.40 0.44 82.26	0.0000*** 0.0000*** 0.0147** 0.0019*** 0.0000*** 0.5099 0.0000***

Note: ***, ** and * represent 1%, 5% and 10% respectively.

Source: Computed from study data by Researcher

The table present an ANCOVA results where NER is the dependent variable and the rest of the variables presented in table are independent variables including the bias estimates. The dependent variable is changed in this second model because there is the need to check the nominal inertia of money illusion. The effect of each bias is estimated independently and all 3 biases are statistically significant at 1% after controlling for some major macroeconomic fundamentals that are known in the literature to be drivers of exchange rate.

The nature of association between the bias estimates and the covariates in relation to the nominal exchange rate is most similar to the estimates of the real exchange rate except for some few differences. Even though, the *P*- values of both model (REER and NER) are highly significant for each of the biases, all *P*- values under NER model have P < 0.0001 unlike the REER model that has P \leq 0.0001 (that is P = 0.0001 for β_3 in REER model). With this acknowledged fact, it is also important to indicate that inflation under β_1 and β_2 models of NER are not statistically significant. What it means is that inflation does not influence nominal exchange rate under β_1 and β_2 within the study's targeted confidence interval, even though, the expected relationship between inflation and the dependent variable is present in the model. This result is a bit surprising because the expected rounding ups as a result of lack of available coins (smaller denomination) to deal with certain transactions in times of redenomination is expected to lead to inflation in the economy which will in turn impact severely on the dependent variable (NER). Also consistent is the fact that fiscal deficit is not statistically significant for all bias models under NER just like it occurred under REER. Levene's test for homogeneity of variance confirms equal variance across samples in the model (β_1 , β_2 , β_3 df (12,16) P>F = 0.5341). This result is reported in Table A11, A12, A13, A14 (Appendix).

It is important to note that the only obvious changed variable in the second estimation is the dependent variable (NER) and the overall model estimate (statistic) has changed from $R^2 = 0.87, R^2 = 0.87, R^2 = 0.87, R^2 = 0.86$ (for $\beta_1, \beta_2, \beta_3$ models respectively) under REER to $R^2 = 0.93, R^2 = 0.95, R^2 = 0.96$ (for β_1, β_2 and β_3 models respectively) under NER. This single evidence suggests that the significant covariates explain NER better than REER. It also implies that the biases impact greatly on the nominal exchange rates than real effective exchange rate confirming the money illusion proposition. This result is expected because the Cedi/Dollar exchange is predominant in Ghana's forex market than the other foreign currencies. Therefore, the frequency of the Cedi/Dollar exchange transactions is likely to be affected by these biases than the REER which is a basket of currencies that may contain very low frequency traded currencies. The analysis, therefore, concludes that estimated biases which were induced as a result of currency reform adaptation impact positively on Ghana's forex market. The implication is that exchange rate in the forex market will continue to rise as long as these biases are not identified and the necessary remedial measures taken to curb its impact on the forex market.

5. Discussion

The study results indicate a positive relationship between estimated biases and exchange rate in Ghana's forex market. This is a suggestion that an increase in these biases in the forex market leads to higher exchange rates. This result is consistent with the face value effect (Raghubir & Srivastava, 2002) which suggests that foreigners underspend in the domestic countries whose domestic currency is a multiple of the foreigner's currency in nominal currency value terms. If foreigners spend less, it means they exchange less of the foreign currency which also leads to lesser of available foreign currency (supply of foreign currency) to meet forex market demand. The plausible consequence will be a shortage of foreign currencies in excess of demand (all things being equal) which leads to rising exchange rate. Therefore, as these biases increase, foreign currency shortages increase and this will result in higher prices is the forex market. Since Ghana's exchange rate situation is a multiple domestic currency to most of the major trading currencies, it calls to confirm the face value effect argument and the consequent result that is produced in this study analysis.

Also consistent with this study results are the effect of money illusion (Fehr & Tyran, 2014, 2001, Luba and Winn, 2014; Noussair et al., 2012; Shafir et al., 1997) and rounding off (Lombra, 2001, 2007) of transactions in the absence of available currencies (coins) in the economy to deal with certain levels of economic transactions. Bid and Ask spread in the forex market for dealers and speculators are usually marginal and the advert of redenomination made the spread nominally smaller, though, its intrinsic value (real value) remained the same (money illusion), instigating market players to round them off (usually up than down) as a result of sometimes lack of coins or uninspired value in nominal terms (money illusion). Reasonably, the result of these rounding off (especially up) increases the exchange rate

artificially without any fundamental cause backing it. Interestingly, the model result for NER indicated that inflation is not a strong determinant of nominal exchange rate in the presence of the biases but was not the case for real exchange rate (REER) model. This implies that rounding in the Cedi/Dollar transactions alone in the forex market has insignificant impact. However, the collective effect of inflation on basket of currencies (REER) is enough to adjust forex market prices in Ghana. Empirical estimates for real values (REER) and nominal value (NER) as dependent variables for the same model supported a fact predicted by money illusion effect (Fehr & Tyran, 2014, 2001, Luba and Winn, 2014; Shafir et al., 1997). According to Shafir et al. (1997), the effect of money illusion is a combination of both real and nominal values but it tilts toward the nominal than the real. In this study results, R^2 and adjusted R^2 of the real model estimation (REER) and nominal model estimation (NER) indicated a higher effect of the biases on the nominal exchange rate model than the real exchange rate, though, both effect were statistically and significantly high. This is a confirmation of the money illusion effect.

The result also depicted that the bias created out of GDP at current price directly affect exchange rate in Ghana's forex market. This bias suggests that individual's spending increased significantly as a result of redenomination adaptation and as an importing economy the demand for foreign exchange will be affected thereby pushing exchange rate up. According to the bias for the whole (Mishra et al., 2006) and denomination effect (Raghubir & Srivastava, 2009), holding a higher denomination is a check on the individual against unplanned spending. This is because individuals have special interest in the whole (big denomination) than part of the whole (Mishra et al., 2006) and at the same time use the large denomination as a self-control and self-regulation (Raghubir & Srivastava, 2009) by individuals. This bias effect simply suggests that when currency denomination is in parts than whole or small denominations, individuals' willingness to spend and spending increases because they lose their self-control. This is exactly the situation that happens under redenomination policy adaptation. Since redenomination policy changes large nominal denomination currencies to small nominal denomination (rebasing), even though real value remained same, individuals' cognitive bias shift towards the nominal values through money illusion thereby treating the new smaller currencies like play money. GDP bias increases and exchange rate rises as an evidence in this study and the result is consistent with currency denominational biases advocated by Mishra et al. (2006), Raghubir and Srivastava (2009) and even physical appearance effect (DiMuro & Noseworthy, 2013).

Lastly, this study results exhibit patterns of consistency with other literature works that have studied exchange rate dynamics in Ghana. Most of the macroeconomic fundamental relationships with the exchange rate in the literature are consistent with this study's relationship even in the present of the estimated bias in the estimation model. A positive and significant relationship between Terms of Trade, for instance, is a consistent finding with Alagidede and Ibrahim (2017), Amoah and Aziakpono (2017) and Olanipekun et al. (2019). Also, Amoah and Aziakpono (2017) found positive and significant relationship between Real Interest Rate and exchange rate in their study and this relationship is similar to the result this study has produced. Although the findings produced by Adusei and Gyapong (2017) with regards to Gross Domestic Product (GDP) and exchange rate confirms the result this study has produced, Inflation and exchange rate relationship has been inconsistent between these two studies. The authors found negative and significant relationship between Inflation and Cedi-Dollar exchange rate while this study reports a positive relationship. The consistencies in the study's results with other works in terms of the relationship suggest that currency biases present an additional effect to the exchange rate and macroeconomic fundamentals nexus in the Ghanaian context. This study has therefore established a strong evidence that currency bias is one of the factors that contribute to exchange rate dynamics in Ghana's forex market. The situation actually confirms the suspicions of Ramasamy and Abar (2015) that exchange rate fluctuation is due to other behavioral factors after their a priori expectation of macroeconomic fundamental relationship with the exchange rate went contrary to their empirical findings.

6. Conclusion and recommendation

The objective of this study is to ascertain whether or not currency biases contribute to prevailing forex market reactions in Ghana after the currency redenomination adaptation and further ascertain whether the impact of money illusion (biases) on the forex market is similar

to their effect on other markets as postulated in the literature. Given this objective, currency biases are estimated from three economic indicators and they nominal exchange rate (NER), aross domestic Product (GDP) and Fiscal Deficit (FD). These variables are selected based on Bai and Perron (1998, 2003) structural break estimation. These estimated biases are tested on the forex market, proxied by REER and NER, using ANCOVA model. The study revealed that perception, cognitive biases and subjective judgment of forex market participants aggregately impacted on the forex market. That is, currency redenomination adaptation triggered certain sub-optimal decisions (biases) of market participants in the forex market and these biases contribute significantly to the Ghanaian forex market reactions, in terms of both real effective exchange rate effect and the Cedi/Dollar instability. This evidence suggests that the determinants of Ghanaian forex market go beyond only macroeconomic fundamentals. Most of the responses in the exchange rate fluctuation debate (in Ghana) have pointed to the macroeconomic fundamentals and all efforts to address this forex market issue have been directed at the macroeconomic fundamentals alone but the exchange rate still remains volatile. It is time for policy makers to acknowledge that the forex market is also driven by behavioral concepts that are anchored in the formation of irrational behaviors in the market.

Formally, the central bank of Ghana has been dealing with the financial institutions in managing the operations of the forex market in terms of policy strategies. However, the secondary forex market (also termed "black market") in Ghana is by far active than the formal and registered institutions because market participants believe they can get any foreign currency even when the commercial banks are not having. Therefore, individual market players are fond of the secondary forex market in terms of foreign currency trading in Ghana. Since this group of market participants dominates the general forex market and are far from the reach of the central bank in terms of interaction, certain relevant behavioral information about this group which will be needed to help the central bank to make good policies will not be available. In order to deal with these behavioral (non-fundamental) issues in Ghana's forex market, this study recommends that the central bank finds a way to infiltrate into the secondary forex market indirectly to be able to deal with non-economic fundamentals issues. Specifically, the central bank can recruit some individuals in the secondary forex market and formally set them up with electronic gadgets that can be controlled and monitored from their offices. With these gadgets, the central bank can directly pick information on frequency of transactions and real market rate for exchange of currencies to make informed decisions. Given this strategy, the central bank will be indirectly controlling the secondary forex market and also getting access to first-hand information concerning the behavioral attitudes of market participants from the secondary forex market. This will enable the central bank to incorporate this information into their policy strategies and also help them drive policies that can deal with both fundamental and non-fundamental issues relating to the forex market.

Author details

Bernard Bawuah¹

E-mail: bbawuah@ubids.edu.gh ORCID ID: http://orcid.org/0000-0002-2975-7491 Samuel Agyei-Ampomah² Anthony Owusu-Ansah³ ORCID ID: http://orcid.org/0000-0003-2373-7550

Francis Atsu⁴

- ¹ School of Business, Department of Banking and Finance, SD Dombo University of Business and Integrated Development Studies, Wa, Ghana.
- ² School of Liberal Arts and Social Science, Department of Economics, Ghana Institute of Management and Public Administration (GIMPA), Accra, Ghana.
- ³ Department of Land Economy, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.
- ⁴ School of Business (Department of Accounting and Finance), Ghana Institute of Management and Public Administration (GIMPA), Accra, Ghana.

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Appendix A

Table A1. Proportion of tourism figures in GDP Terms					
YEAR	GDP (Billions Dollars)	Tourism (Dollars)	% of GDP		
1997	6.891308594	35000000	0.5079		
1998	7.480968858	304000000	4.0636		
1999	7.719354839	325000000	4.2102		
2000	4.983024408	357000000	7.1643		
2001	5.314909954	374000000	7.0368		
2002	6.166330136	383000000	6.2112		
2003	7.632406553	441000000	5.7780		
2004	8.881368538	495000000	5.5735		
2005	10.74467521	867000000	8.0691		
2006	20.44089302	91000000	4.4519		
2007	24.82784495	99000000	3.9875		
2008	28.67870189	97000000	3.3823		
2009	26.04810819	84900000	3.2594		
2010	32.19727280	706000000	2.1927		
2011	39.33731481	797000000	2.0261		
2012	41.27095474	1154000000	2.7962		
2013	62.82304370	101000000	1.6077		
2014	51.71748262	1027000000	1.9858		
2015	47.49890669	911000000	1.9179		
2016	54.49945183	952000000	1.7468		
2017	58.84521200	919000000	1.5617		
2018	65.31595512	996000000	1.5249		

Note: The table reports Ghana's annual GDP and tourism figures in dollars term. The percentage terms, which show the proportion of tourism amount that is represented in the total GDP, are also presented in the last column of the table. The trend of interest is the year 2007 upwards.

Table A2. Result of bre	ak Test		
Variables	L vs L + 1	F. Statistics	Critical Values**
NER	0 Vs 1*	73.74	8.58
	1 Vs 2*	98.15	10.13
	2 Vs 3*	50.95	11.14
	3 Vs 4*	42.45	11.83
	4 Vs 5*	14.59	12.25
тот	0 Vs 1*	80.68	8.58
	1 Vs 2*	13.38	10.13
	2 Vs 3*	15.90	11.14
	3 Vs 4*	13.05	11.83
	4 Vs 5*	15.32	12.25
NFA	0 Vs 1*	50.83	8.58
	1 Vs 2*	72.57	10.13
	2 Vs 3*	56.11	11.14
	3 Vs 4	2.24	11.83
REER	0 Vs 1*	10.85	8.58
	1 Vs 2	9.94	10.13
САВ	0 Vs 1*	15.56	8.58
	1 Vs 2	2.15	10.13

(Continued)

Variables	L vs L + 1	F. Statistics	Critical Values**
RIR	0 Vs 1*	8.78	8.58
	1 Vs 2*	12.97	10.13
	2 Vs 3*	25.49	11.14
	3 Vs 4	5.41	11.83
GDP	0 Vs 1*	100.15	8.58
	1 Vs 2*	63.80	10.13
	2 Vs 3*	48.15	11.14
	3 Vs 4*	43.51	11.83
	4 Vs 5*	23.06	12.25
FD	0 Vs 1*	15.55	8.58
	1 Vs 2	1.94	10.13
GD	0 Vs 1*	109.49	8.58
	1 Vs 2*	28.58	10.13
	2 Vs 3*	12.74	11.14
	3 Vs 4*	31.74	11.83
	4 Vs 5	11.92	12.25
MS	0 Vs 1*	94.31	8.58
	1 Vs 2*	61.89	10.13
	2 Vs 3	8.28	11.14

Source: Computed from study data by Researcher.

Table A3. Result of break Dates				
Variables	Sequential	Repartition		
NER	1994 2000 2012 1985 2007	1985 1993 2000 2007 2014		
ТОТ	2008 1985 2002 1990 1995	1985 1990 1995 2002 2009		
NFA	2014 2000 2004	2004 2009 2014		
REER	1985	1985		
CAB	1992	1992		
RIR	1985 2000 2012	1985 2000 2012		
GDP	1998 2007 2013 1988 1993	1986 1993 2000 2006 2013		
FD	2007	2007		
GD	1986 1993 2004 2013	1986 1994 2005 2013		
MS	1997 1992	1992 2000		

Note: This table reports the date (year) within which a particular break occurred in each of the partitions under each of the study variables using Bai and Perron Sequential Selection. Ghana's currency redenomination took place in 2007 so this table identifies which of the variables have 2007 as one of the break years. From the table, 3 variables (NER, GDP, FD) are found to have break in line with the policy adapted year. Source: Computed from study data by Researcher.

Table A4. Estimation of Ghana's average growth rate					
Year	Actual Observation	Forecast Averages	Absolute Deviation	Square of Deviation	
1997	4.196				
1998	4.700				
1999	4.400				
2000	3.700	4.432	0.732	0.536	
2001	4.000	4.267	0.267	0.071	
2002	4.500	4.033	0.467	0.218	
2003	5.200	4.067	1.133	1.284	
2004	5.600	4.567	1.033	1.067	
2005	5.900	5.100	0.800	0.640	
2006	6.400	5.567	0.833	0.694	
2007		5.967			

MAD = 0.752 MSE = 0.644

Note: In estimatingafor the subjective valuation (equation 3.1), the three month moving is employed. The table reports the estimated average (5.967) from the actual growth values with absolute and square deviations of 0.752 and 0.644 respectively.

Table A5. Descriptive Statistics of study Variables					
Variables	LGDP	FD	LNER	LREER	RIR
Skewness Kurtosis Jarque-Bera Probability	-0.1427 2.8622 2.1212 0.3462	-0.273 3.276 5.303 0.171	-0.4237 2.8610 4.3608 0.1730	0.8710 3.6733 32.6059 0.1210	-0.8461 3.7183 87.310 0.1110
Variable	LINF	B ₁	B ₂	B ₃	тот
Skewness Kurtosis Jarque-Bera Probability	0.8253 3.3593 4.3985 0.1109	1.7048 4.3371 21.7974 0.0000	1.5551 3.7306 16.5872 0.0003	3.1208 13.5211 243.1855 0.0000	0.163 1.762 2.665 0.264

Note: LNER = Nominal Exchange Rate; LREER = Real Effective Exchange Rate; RIR = Real Interest Rate; LGDP=Gross Domestic Product; FD = Fiscal Deficit.

TOT = Terms of Trade; LINF = Inflation; B_1 = First Bias; B_2 = Second Bias and B_3 = Third Bias

The essence of this table is to report the statistical (descriptive) properties of the variables that are being used for the empirical analysis in this study. There are 10 variables in all.

Table A6. Correlation Matrix							
	B ₁	B ₂	B ₃	LTOT	LINF	RIR	LGDP
B ₁	1.0000						
B ₂	0.6621	1.0000					
B ₃	0.4245	0.3736	1.0000				
LTOT	0.6294	0.6414	0.4868	1.0000			
LINF	-0.3875	-0.3912	-0.4342	-0.1090	1.0000		
RIR	0.3481	0.3534	0.2704	-0.1087	-0.6533	1.0000	
LGDP	0.8018	0.6146	0.5620	0.4960	-0.6423	0.5646	1.0000

Note: The result represents correction between any two independent variables as used in the ANCOVA model. It is being used to check multicollinearity issues.

Table A7. Box test for autocorrelation (REER)				
	AC	PAC	Q-Stat	Prob.
1	0.022	0.022	0.0208	0.885
2	0.113	0.113	0.5637	0.754
3	-0.292	-0.300	4.2554	0.235
4	-0.108	-0.111	4.7795	0.311
5	-0.099	-0.026	5.2352	0.388
6	-0.040	-0.109	5.3124	0.504
7	0.002	-0.050	5.3126	0.622
8	0.053	0.024	5.4566	0.708
9	0.020	-0.038	5.4780	0.791
10	0.028	-0.014	5.5198	0.854
11	-0.121	-0.129	6.3481	0.849
12	-0.059	-0.074	6.5484	0.886
13	-0.038	-0.008	6.6369	0.920
14	0.055	-0.003	6.8304	0.941
15	0.048	-0.013	6.9843	0.958
16	0.132	0.100	8.1798	0.943

Note: This is autocorrelation test result on dependent variable (REER) which is a time series data in the ANCOVA model. The result suggests there is no autocorrelation within the lags.

Table A8. Box test for autocorrelation (NER)					
	AC	PAC	Q-Stat	Prob.	
1	0.463	0.463	8.8084	0.103	
2	0.025	-0.241	8.8344	0.112	
3	0.111	0.282	9.3690	0.125	
4	0.079	-0.165	9.6488	0.147	
5	0.013	0.117	9.6564	0.156	
6	0.037	-0.044	9.7207	0.177	
7	0.018	0.013	9.7375	0.204	
8	-0.008	-0.012	9.7406	0.284	
9	0.069	0.108	9.9929	0.351	
10	0.085	-0.025	10.390	0.407	
11	0.026	0.028	10.427	0.492	
12	0.004	-0.035	10.428	0.578	
13	0.047	0.076	10.562	0.647	
14	0.031	-0.057	10.623	0.715	
15	-0.040	-0.022	10.729	0.772	
16	0.101	0.204	11.437	0.782	

Note: This is autocorrelation test result on dependent variable (NER) which is a time series data in the ANCOVA model. The result suggests there is no autocorrelation within the lags

Table A9. Levene's test NER and B ₁				
B ₁	Mean	Std. dev.	Freq	
0	-3.1012775	2.6201999	27	
0.0188	06694371	0	1	
0.0212	.05624642	0	1	
0.2914	.34273827	0	1	
0.3313	.35839096	0	1	
0.4129	.41333407	0	1	
0.5495	.58545989	0	1	
0.5959	.66990411	0	1	
0.9306	1.0646331	0	1	
1.0871	1.3634862	0	1	
1.0946	1.2996534	0	1	
1.1029	1.5231862	0	1	
1.1214	1.4703463	0	1	

Note: W0 = 1.3564906 df(12, 26) Pr > F = 0.2480187

This is homogeneity test result for the dependent variable NER (continuous) and the independent variable B_1 (categorical) in the ANCOVA model. The result suggests there is equality of variance.

Table A10. Levene's test NER and B				
B ₂	Mean	Std. dev.	Freq	
0	-3.1012775	2.6201999	27	
0.2130	06694371	0	1	
0.2474	.58545989	0	1	
0.4650	.05624642	0	1	
0.6297	.34273827	0	1	
0.8214	.35839096	0	1	
1.0334	.41333407	0	1	
1.6372	.66990411	0	1	
1.7516	1.0646331	0	1	
1.7849	1.2996534	0	1	
1.8415	1.3634862	0	1	
1.8956	1.4703463	0	1	
1.9285	1.5231862	0	1	

Note: W0 = 1.3564906 df(12, 26) Pr > F = 0.2480187

This is homogeneity test result for the dependent variable NER (continuous) and the independent variable B_2 (categorical) in the ANCOVA model. The result suggests there is equality of variance.

Table A11. Levene's test NER and B				
B ₃	Mean	Std. dev.	Freq	
0	-3.1012775	2.6201999	27	
0.0084	1.4703463	0	1	
0.7472	.34273827	0	1	
0.7826	1.2996534	0	1	
0.8418	06694371	0	1	
1.0808	.41333407	0	1	
1.1467	1.0646331	0	1	
1.3311	1.3634862	0	1	
1.3591	.35839096	0	1	
2.0082	1.5231862	0	1	
2.0311	.66990411	0	1	
3.6905	.05624642	0	1	
6.1128	.58545989	0	1	

Note: W0 = 1.3564906 df(12, 26) Pr > F = 0.2480187

This is homogeneity test result for the dependent variable NER (continuous) and the independent variable B_3 (categorical) in the ANCOVA model. The result suggests there is equality of variance.

Table A12. Levene's test REER and B				
B ₁	Mean	Std. dev.	Freq	
0	5.3594735	1.0172047	27	
0.0188	4.6924009	0	1	
0.0212	4.6426759	0	1	
0.2914	4.5521436	0	1	
0.3313	4.6051702	0	1	
0.4129	4.5561223	0	1	
0.5495	4.4597659	0	1	
0.5959	4.4572368	0	1	
0.9306	4.1953349	0	1	
1.0871	4.3070745	0	1	
1.0946	4.169261	0	1	
1.1029	4.3020364	0	1	
1.1214	4.2989697	0	1	

Note: W0 = 0.92887265 df(12, 26) Pr > F = 0.53412492

This is homogeneity test result for the dependent variable REER (continuous) and the independent variable B_1 (categorical) in the ANCOVA model. The result suggests there is equality of variance.

Table A13. Levene's test REER and B				
B ₂	Mean	Std. dev.	Freq	
0	5.3594735	1.0172047	27	
0.2130	4.6924009	0	1	
0.2474	4.4597659	0	1	
0.4650	4.6426759	0	1	
0.6297	4.5521436	0	1	
0.8214	4.6051702	0	1	
1.0334	4.5561223	0	1	
1.6372	4.4572368	0	1	
1.7516	4.1953349	0	1	
1.7849	4.169261	0	1	
1.8415	4.3070745	0	1	
1.8956	4.2989697	0	1	
1.9285	4.3010364	0	1	

Note: W0 = 0.92887265 df(12, 26) Pr > F = 0.53412492

This is homogeneity test result for the dependent variable REER (continuous) and the independent variable B_2 (categorical) in the ANCOVA model. The result suggests there is equality of variance.

Table A14. Levene's test REER and B3				
B ₃	Mean	Std. dev.	Freq	
0	5.3594735	1.0172047	27	
0.0084	4.2989697	0	1	
0.7472	4.5521436	0	1	
0.7826	4.169261	0	1	
0.8418	4.6924009	0	1	
1.0808	4.5561223	0	1	
1.1467	4.1953349	0	1	
1.3311	4.3070745	0	1	
1.3591	4.6051702	0	1	
2.0082	4.3010364	0	1	
2.0311	4.4572368	0	1	
3.6905	4.6426759	0	1	
6.1128	4.4597659	0	1	

Note: W0 = 0.92887265 df(12, 26) Pr > F = 0.53412492

This is homogeneity test result for the dependent variable REER (continuous) and the independent variable B3 (categorical) in the ANCOVA model. The result suggests there is equality of variance.