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MEASURING FOREIGN EXCHANGE PRESSURE: A TEXT MINNING APPROACH

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ABSTRACT : This study investigates the effectiveness of sentiment analysis, using text-mining approach within the context of big-data analytics, in measuring foreign exchange pressure in Nigeria. It begins with the construction of two sentiment-based index of foreign exchange pressure; the first, labelled EMP, constructed by text-mining public sentiments about foreign exchange management in Nigeria, within the platform of twitter, while the second, labelled EMP_Trend, constructed from Google Trend as an index of sampled search of related words around foreign management in Nigeria. Thereafter, the study tested the effectiveness of both indices in signaling movement in exchange rate (IEW) in Nigeria relative to existing traditional measures of foreign exchange pressure in Nigeria. The Predictive Regression Model (PRM) and Clark and West (2007) frameworks were employed. Findings from the study suggest that foreign exchange market pressure index using Sentiment Analysis may hold sufficient information in predicting and signaling movement in exchange rate (IEW) in Nigeria. Specifically, EMP_Trend and EMP were found to improve the forecast of IEW, as their estimated Clark and West coefficients were both positive and statistically significant at 5 per cent. The study recommends that monetary authorities leverage sentiment analysis to monitor future direction in exchange rate, with a view to implementing policies that would moderate the prevailing instability in the foreign exchange market in the Nigeria.

KEYWORDS: *Foreign Exchange Pressure, Sentiment Analysis, Text-mining, leading indicator, predictive regression model.*

I. INTRODUCTION

The outbreak of the COVID-19 pandemic had a profound impact on Nigeria's foreign exchange earnings, primarily due to a significant global economic slowdown. During this period, capital inflows into Nigeria experienced a significant decline. The pandemic exacerbated the reduction in foreign portfolio investment as investors began divesting from existing portfolios and redirecting investments to emerging preferred destinations like Egypt and Angola. These destinations, despite offering lower yields compared to Nigeria, had relatively stable foreign exchange markets, reducing concerns about potential delays in repatriating funds. Remittances were also affected as Nigerians abroad faced reduced incomes and increased cross-border payment costs.

In contrast, Nigeria's demand for foreign currency remained high due to trade obligations, the service of external debt, and international payments. There was a net outflow of foreign financial resources as a result of the increase in demand. Any dreams of the Nigerian foreign exchange market reverting to some degree of relative stability were dashed by the ensuing pressure on foreign exchange, which was made worse by a widening supply shortfall. The Central Bank of Nigeria (CBN) claimed the devaluation of the naira, the country's currency, as justification for its frequent interventions in the foreign exchange market. Despite these measures, the naira continued to devalue and reached record high exchange rates in September 2022, hitting N400 per dollar at the I&E window and N700 per dollar on the black market, according to the CBN Statistical Bulletin (2021).

Attempts to correct this inconsistency would benefit, immensely, from research that can provide an indication of the level and direction of foreign exchange pressure, and its relationship with CBN's foreign exchange interventions, in addition to capturing market sentiments and public perceptions about the management of the foreign exchange market in Nigeria. While there are several ways to measuring foreign exchange pressure, such as the approaches by Eichengreen et al. (1996), Sachs et al. (1996), Kaminsky et al. (1998), and IMF (2000), these approaches all fail to capture market sentiments in the construction of the foreign exchange pressure index (EMP).

Interestingly, however, the literature reveals a growing interest in the role of Sentiment Analysis in providing signal for economic indicators (see Niesert et. al., 2020; Baker, Bloom & Davis 2016; Cerón-Guzmán & León-Guzmán, 2016; and Simionescu, 2022).

Arising from the above, the main objective of this study is to construct a Foreign Exchange Pressure Index (EMP) for Nigeria using Sentiment Analysis, and evaluate its effectiveness in signaling movement in exchange rate in Nigeria. Consequently, the study constructs a foreign exchange pressure index, using sentiment analysis, and evaluating its effectiveness as a leading indicator of exchange rate movements in Nigeria.

The Sentiment Analysis employed in the study encompasses two main approaches. The first utilizes text-mining techniques, developed in conjunction with the Application Programming Interface (API) of the social media platform Twitter. The second approach involves data generated from Google Trends. The study focuses on tweets from Nigerian-based accounts, considering that Nigeria has a substantial presence on Twitter, with over fifty-seven million accounts as of the second quarter of 2021. Twitter was chosen due to its API's ease of interaction, providing extensive access to information on the platform.

This study holds significance as it aims to introduce a new measurement of foreign exchange pressure in Nigeria. This involves developing indicators like the sentiment index of foreign exchange pressure using machine learning and data mining techniques, departing from the conventional approaches mentioned in the literature. These new insights can be valuable to the monetary authorities, helping them deploy multiple tools with a keen focus on country-specific considerations.

The subsequent sections of the paper are organized as follows: after the introductory in Section 1, Section 2 delves into the literature review, encompassing theoretical and empirical aspects literature reviews. Section 3 outlines the study's methodological framework, offering insights into model specifications, data collection sources and methods, and analytical approaches. In Section 4, the study's findings are presented, and an in-depth discussion of the outcomes derived from the models estimated is provided. Lastly, Section 5 offers a conclusive summary of the research and subsequently puts forward policy recommendations that stem from the study's findings.

II. LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Foreign Exchange Pressure

Weymark (1995) defined foreign exchange pressure as the change in exchange rate required to eliminate excess demand for the currency without intervention in the foreign exchange market. Furthermore, Jayaraman & Choong (2008) opined that exchange market pressure measures the total excess demand for a currency in international markets as the exchange rate change that would have been required to remove the excess demand in the absence of exchange market intervention, given the expectations generated by the exchange rate policy implemented. It is a concept that deals more with countries that are majorly import dependent. Developing countries, Nigeria inclusive, depend on huge amount of import, and thus are faced with foreign exchange pressure (Gustavo & Rui, 2016).

Eichengreen et al., (1996) opined that foreign exchange pressure is a weighted average of the changes in exchange rate, interest rate and foreign reserves. This definition brings to limelight the role of liquidity in the interaction between domestic money and foreign exchange markets. According to Ratnasari & Widodo (2017) foreign exchange market pressure refers to the scale of money market disequilibrium that must be controlled through foreign reserves or exchange rate changes.

Exchange market pressure measures the demand for foreign currency against the domestic currency. When the demand for foreign exchange exceeds its supply, there will be pressure in the foreign exchange market (CBN, 2016). Exchange market pressure shows the tendency of a domestic currency to increase or decrease its value and the equilibrium of the domestic money market. Jager and Klaassen (2010) defined exchange market pressure as a situation where there exists an excess of domestic currency in the foreign exchange market, which can depreciate the domestic currency if the monetary authorities do not intervene to protect it.

Gilal et al. (2016) opined that exchange market pressure is a situation where there is an excess demand for domestic currency in the foreign exchange market. Excess demand for domestic currency in the foreign exchange market is directly related to its appreciation against the foreign currency. Furthermore, when there is a decrease in the demand for foreign exchange, it leads to depreciation of the domestic currency and makes it lose its value against the foreign currency. Exchange market pressure defines the excess demand for a currency in the foreign exchange markets as the exchange rate change which would be required to remove this excess demand in the absence of money or foreign exchange market intervention, given that the exchange rate policy implemented generates expectations (Spolander, 1999). For this study, foreign exchange pressure will be defined as the disequilibrium which exists in the foreign exchange market when there is an unprecedented increase in the demand for foreign exchange that cannot be met by the supply of foreign exchange. Excess demand for the supply of foreign exchange causes the home currency to depreciate and the lower demand for foreign currencies leads to the appreciation of home currencies. It has become a given that, developing countries that constantly depend on importation of goods and services tend have excess

demand for foreign exchange to meet up with the resources to carry out international trade; this is basically the cause of foreign exchange pressures.

Girton and Roper (1977) introduced the concept of foreign exchange pressure to illustrate the effect of either excess demand or excess supply of foreign exchange on the prices of exchange rate and on the foreign reserves of the home nation which in most instances are developing countries and are highly import dependent (Jayaraman & Choong, 2008). The effect of foreign exchange pressure is felt both in the flexible or floating exchange rate system and in the fixed exchange rate system. Waymark (1995) and Pentecost (2001) opined that real exchange rates, changes in monetary policies and wealth accumulation are key drivers of foreign exchange pressure. However, the major drivers of foreign exchange pressures in developing countries, believed to be macroeconomic, are fiscal deficits, external debt, private sector domestic credit and political instability.

Exchange market pressure is usually examined from the perspective of a fixed exchange rate regime. Under this system of exchange rate management, monetary authorities, especially the Central Banks of various countries, intervene or meditate to maintain equilibrium in the foreign exchange market. Weymark (1995) defined such a system of exchange rate as an intermediate system, under which interventions generate simultaneous changes in the exchange rate and foreign exchange reserves. Under the fixed exchange rate system, the supply of money in the economy has two components which include: domestic credit and net foreign assets. Under the assumption that the authorities did not employ domestic credit changes to influence the exchange rate levels, Girton and Roper (1977) assert that the term exchange market pressure refers to the magnitude of money market disequilibria that must be corrected either through reserve or exchange rate changes. In such circumstances, exchange market pressure is the simple sum of the percentage changes in exchange rate and in foreign exchange reserves. Using a different model, which allowed intervention in terms of changes in domestic credit as well as changes in reserves, Roper and Turnovsky (1980) found that excess demand for money was equal to a linear combination of changes in exchange rate and in the monetary base.

In the literature, there are basically four approaches for constructing the exchange market pressure index (EMPI. These approaches are discussed, herein, within the context of the Eichengreen et al. (1996), Sachs et al. (1996), Kaminsky et al. (1998), and IMF (2000).

According to Eichengreen et al. (1996), EMP can be measured as follows:

$$EMP_t = \frac{1}{\sigma_e}\frac{\Delta e_t}{e_t} - \frac{1}{\sigma_r}\left(\frac{\Delta \underline{r}_t}{\underline{r}_t} - \frac{\Delta \underline{r}_{US_t}}{\underline{r}_{US_t}}\right) + \frac{1}{\sigma_i}\left(\Delta\left(i_t - i_{US_t}\right)\right) \quad (2.1)$$

Where;

- EMP_t= exchange rate market pressure at period t;
- e_t= Naira to USD exchange rate at time t;
- $\underline{r}_t$= ratio of international reserves to money base in Nigeria at period t;
- $\underline{r}_{US_t}$= ratio of external reserves to money base in US at period t;
- i_t= monetary policy rate in Nigeria;
- i_{US_t}=federal funds rate in the US;
- σ_e= the standard deviation of the relative change in Naira to USD exchange rate;
- σ_r= standard deviation of the difference between the relative changes in the ratio of international reserves to money base in Nigeria vs. the US; and
- σ_i= the standard deviation of the interest rate differential.

Sachs et al. (1996) measures EMP as:

$$EMP_t = \left[\frac{\frac{1}{\sigma_e}}{\left(\left(\frac{1}{\sigma_e}\right)+\left(\frac{1}{\sigma_r}\right)+\left(\frac{1}{\sigma_i}\right)\right)}\right]\frac{\Delta e_t}{e_t} - \left[\frac{\frac{1}{\sigma_r}}{\left(\left(\frac{1}{\sigma_e}\right)+\left(\frac{1}{\sigma_r}\right)+\left(\frac{1}{\sigma_i}\right)\right)}\right]\frac{\Delta r_t}{r_t} + \left[\frac{\frac{1}{\sigma_i}}{\left(\left(\frac{1}{\sigma_e}\right)+\left(\frac{1}{\sigma_r}\right)+\left(\frac{1}{\sigma_i}\right)\right)}\right]\Delta i_t \quad (2.2)$$

Where;

- The resulting formula includes the same e_t and i_t variables; however, instead of using the ratio of reserves to monetary base, it uses r_t which is simply international reserves (excluding gold) in period t.
- As for other variables,
  - σ_e refers to standard deviation of the rate of change in the exchange rate;
  - σ_r is the standard deviation of the rate of change in reserves; and
  - σ_i is standard deviation of the change in nominal interest rate.

In their study, Kaminsky et al. (1998), presents EMP as:

$$EMP_t = \frac{\Delta e_t}{e_t} - \frac{\sigma_e}{\sigma_r}\left(\frac{\Delta r_t}{r_t}\right) + \frac{\sigma_e}{\sigma_i}\Delta i_t \quad (2.3)$$

Where;

- The variables have the same interpretation as in the case of Sachs et al. (1996), the only difference is the weighing method.

Finally, according to IMF (2007), EMP can be measured as:

$$EMP_t = \frac{1}{\sigma_{\Delta\%r_t}}\Delta\%r_t + \frac{1}{\sigma_{\Delta res_t}}\Delta res_t \quad (2.4)$$

Where;

- $\Delta\%r_t$ = the percentage change in exchange rate of Naira to USD;
- Δres_t =the change in net foreign assets by monetary base $(NFA_t - NFA_{t-1})/MB_{t-1}$; and
- $\sigma_{\Delta\%r_t}$ and $\sigma_{\Delta res_t}$ = the standard deviations of these variables, respectively.

The different approaches utilised a variation of three main variables – interest rate, exchange rate and international reserves, with the main differences in the approaches being the:

- utilisation of the ratio of international reserves to monetary base (MB) by Eichengreen, Rose, & Wyplosz (1996);
- utilisation of international reserves (excluding gold) by Sachs, Tornel, & Velasco (1996);
- inclusion of weighing methods by Kaminsky, Lizondo, & Reinhart (1998); and
- the exclusion of interest rate and the use of the ratio of change in the net foreign assets (NFA) to monetary base by IMF (2000).

2.2 Theoretical Literature

2.2.1 Theories of Foreign Exchange Market Pressure (EMP)

Exchange market pressure (EMP) depicts money market disequilibrium. The notion of EMP was defined precisely for the first time in 1977 by Girton, and Roper, in their study "A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience" Typically, the two main monetary approaches employed in literature to evaluate money market disequilibrium are (i) the monetary approach to exchange rate and (ii) the monetary approach to balance of payments. Changes in foreign reserves help to restore equilibrium under the monetary approach to balance of payments, while changes in exchange rates would result in the restoration of equilibrium under the monetary approach to exchange rates (Frankel, 1996; and Mussa, 1976). Changes in foreign reserves or currency rates, when considered separately, would not be sufficient indicators to disclose the characteristics and a complete picture of any economy's external balance. For instance, if foreign reserves are drained to infuse foreign currency into the international market, monetary authorities can delay or partially avoid exchange rate depreciation.

On the other hand, foreign currency could be purchased from the market to bolster foreign reserves, which limits the rate of exchange's gain in response to the underlying fundamentals. These illustrate how emphasizing one of the two intervention tools (changes in foreign reserves and exchange rates) at the expense of the other would lead to an inaccurate perception of an economy's external position. This supports the need for a comprehensive definition and account of EMP in the model-dependent evaluation. When describing the pressure on the currency market, this composite definition of EMP considers changes in foreign reserves and exchange rates. Depending on the prevailing exchange rate regime, the EMP values signify the degree of the foreign currency market's disequilibrium, which should thereafter be addressed by corresponding changes in exchange rates and/or foreign reserve positions.

2.2.2 Theories of Market Sentiments

Market sentiments were put forward by Benjamin Graham in the year 1949 in his acclaimed book "The Intelligent investor. Known as the father of value investing, he laid the foundation for the theories of market sentiments that have been extended over the years.

2.2.2.1 Cognitive Narrative Theory (Market Sentiments):

The Market Mind Hypothesis

The Market Mind Hypothesis (MMH) is the frontier foundation of the cognitive theory (Schotanus, 2016). The theory seeks to extend a psychophysical perspective of the mind–body paradigm to systematic economic processes. Formally, the hypothesis opines that the market interaction between investors and their accompanying technologies engage is a sharing of knowledge but doing so intersubjectively, which can be perceived as the extension of their consciousness collectively (Hayek, 1945). The measure of this then would be their associated prices as well as the patterns; with the market's mood swaying between depression or mania, these human experiences being felt in real time.

There are basically 4 tenets of cognitive perspective upon which the MMH is hinged, known as the '4E' cognition (Newen, et al., 2018; Ward & Stapleton, 2012). These doctrines include embodied, embedded enacted and extended. The embodied doctrine opines that the psychological state is not absent of the organism but a part of the whole (Clark, 2011). The embedded axiom espouses that the mind is impacted by the environment in which it exists such as laws, biases, among others. Enacted refers to the emergence of the mind from a series of tangible interactions with the world (Ward et al., 2017). Finally, the extended principle implies that the physical basis of the psychological state can be extended beyond the brain (Schotanus, 2022).

Economic agents, active in a functional foreign exchange market process information for their various self-driven motives; these accompanied by expressed physical moods, which uniformly can vary between despair and exuberance. For these Participants who derive utility from the consumption of this information, there is an acute 'taste' for it; this dual realization, therefore being considered as a general case of conscious experience.

2.3 Empirical Literature

In a study by Akram & Byrne (2015), capital controls, real money supply, real exchange rate, fixed and intermediate exchange rate regimes, reserve import ratio, and real income were identified to influence EMP. Also, Pollard (2010) applied the Girton-Roper model of EMP to Guyana, Jamaica and Trinidad & Tobago and finds that the US money supply had a major impact on the EMP in Barbados and Guyana whereas changes in US interest rate and US inflation rate impact EMP in Jamaica and Trinidad & Tobago. These EMP determinants differ from his previous study where Wohar & Lee's (1992) model was used. The study indicates that domestic credit, foreign price, domestic real income, the US Treasury Bill Rate, money multiplier and deviations from purchasing power parity are the main determinants of EMP (Pollard, 1999). The expansion in world prices, income, and domestic credit have been identified to cause EMP and outflow of international reserves in Jamaica (Ghartey, 2002).

Attempts have been made to identify the underlying causes of EMP during financial crisis. Aizenman et al. (2012), find that differences in EMPs (Exchange Market Pressure) faced among nations during the financial crisis can be fairly attributed to the differences in per capita income, inflation, and trade balance before it. In their study, Frankel & Saravelos (2012) state that the level of reserves prior to the crisis and the preceding real exchange rate appreciation serve as reliable leading indicators of pressures in the exchange market. Countries with significant external portfolio liabilities that exceed international reserves have difficulties in absorbing the external shocks because they allow for more currency rate depreciation and relatively less reserve loss (Aizenman and Hutchison (2012) Also, Obrimah (2014) observed that exchange rate depreciation pressure was exacerbated by persistent private sector profitability in Nigeria.

Studies on emerging market economies reveal that increase in global liquidity has impact on the appreciation pressure of emerging markets currencies. However, the impact is only seen during times of relatively low financial market stress and disappears during periods of high volatility, when emerging economies frequently experience sharp and sudden currency depreciation. Hence, in times of tranquility, the provision of liquidity in advanced economies could contribute to the accumulation of financial stability risks in emerging market economies, also, additional liquidity injections during crisis will not immediately relieve the depreciation pressure on emerging market currencies.

Considering the significance of EMP in predicting other economic phenomena aside from exchange rate and the fact that about 89 per cent of global currencies are somewhat fixed of managed float (Klaassen and Jager, 2011; IMF, 2009), the need for monetary authorities to pay more attention to EMP cannot be overemphasized. It has been used to predict crises and explain the connection between crises and capital flows (Eichengreen et al., 1995, 1996; Frankel and Rose, 1996; Kaminsky et al., 1998; Calvo, 2006).

The arguments on the appropriate model for the exchange rate market pressure (EMP) index of an economy have been settled by the need to consider the structural peculiarity of an economy. Thus, the EMP index should be derived from a structural macroeconomic model of exchange rate determination (Akram and Byrne, 2015). Girton and Roper (1977) pioneered a simple sum of exchange rate and foreign reserves changes to construct a monetary model of exchange rate determination and derived an EMP index. The model assigns equal weights to both exchange rate and foreign reserves changes; hence, it does not require the estimation of any model parameters to derive the weights of the index. Weymark (1995) improves the work of Girton and Roper (1977) by assigning weights to the exchange rate and foreign exchange reserves component of the EMP index. The advantage of weighting is that it gives a clear economic meaning to the extent that the specification of the model is correct (Klaassen and Jager, 2011). Another related EMP index model was developed by Roper and Turnovsky (1980), specifically to identify the trade-off that monetary authorities face between targeting domestic credit and the exchange rate when stabilizing domestic output. The EMP index derived is the sum of the exchange rate and foreign exchange reserves changes. However, both index components are not equally important, requiring the estimation of six parameters to construct these weights.

On the contrary, Pentecost et al. (2001) develop an EMP index using a wealth augmented monetary model. The index is the simple sum of changes in the exchange rate, foreign exchange reserve, and relative interest differential. But for the construction, only one parameter needs to be estimated. In comparison to other models, Eichengreen et al. (1996)'s statistical measure of market pressure is arguably superior because it standardizes each index component and considers interest rate variations. This well-liked approach makes use of the weighted sum of changes in the spot exchange rate, relative interest rate, and foreign exchange reserves. Thus, an increase in the exchange and interest rates, and a decrease in foreign exchange reserves all indicate an increase in the pressure on the exchange market. EMP index models that use exchange rate and foreign reserves are said to be suitable for economies practicing fixed exchange rate regimes while those that use exchange rate, interest rate and foreign reserves are suitable for economies practicing floating exchange rate regimes (Central Bank of Nigeria, 2016).

Klutse, et al. (2022) examined the issues surrounding the appropriate EMP threshold in South Africa and Ghana adopting a host of methodologies including Dynamic Ordinary Least Squares, District threshold and ridge regression. Employing monthly data set from February 2002 to December 2017; variables modelled include exchange rates, discount rate-related interest rate, foreign reserves, official reserve assets of the country; broad money, reserve money and the total reserves, and the US Dollars as a proxy for Gold at Market Price. For both

countries, the study found that the variables representing the maximum threshold were significantly divergent; thus, affirming the difference between both indexes. Similarly, it was revealed that South Africa had 31 and 27 crises episodes when the first and second lags of EMP were used as dependent variables, with the greatest responses occurring in 2008, the latter period of 2011 to the first quarter of 2012, 2013 and 2015.

III. METHODOLOGY

3.1 Sources of Data and Measurement

This study begins by constructing a foreign exchange market pressure index for Nigeria using two approaches, the text-mining approach, within the context of Big-Data Analytics (EMP) and Google Trend (EMP_Trend). Thereafter, the predictive power of the two indices in signaling movements in exchange rate is evaluated using the framework of Predictive Regression Models (PRM). It utilises the exchange rate at the Importers' and exporters' (IEW) segment of the market as for analysis. In addition, the study utilises the ecosystem of Twitter, through interaction with its Application Programming Interface (API), and Google Trend, to conduct the proposed Sentiment Analysis.

Consequently, the data requirement for this study is strictly monthly time series data, covering the periods 2017M4 and 2022M6, sourced mainly from the Central Bank of Nigeria (CBN) *Statistical Bulletin*, Twitter API, and Google Trend. The start-date of 2017M4 is significant, as it coincides with the introduction of the importers and exporters' window (IEW) of the foreign exchange market by the CBN. The end-date of 2022M6 is strictly due to data availability. This period coincides with the period of significant volatility in the foreign exchange market in Nigeria, resulting in the most depreciation in the history of exchange rate. Table 3.1 presents a brief description of the variables, their unit of measurement, and source.

3.2 Technique for Data Analysis

This study utilises a mix of techniques for data analysis. In constructing the Foreign Exchange Pressure Index using Sentiment Analysis, the study employs text-mining approach, within the framework of Big-data Analytics, and Google Trend. Consequently, two sentiment-based index of foreign exchange pressure were constructed. The first, labelled EMP, was constructed by text-mining public sentiments about foreign exchange management in Nigeria, within the platform of twitter, while the second, labelled EMP_Trend, utilises Google Trend to generate an index of sampled search of related words around foreign management in Nigeria. The predictive power of the constructed indices is evaluated using the framework of the Predictive Regression Model (PRM).

3.2.1 Constructing Foreign Exchange Pressure Index using Sentiment Analysis

3.2.1.1 Constructing Foreign Exchange Pressure Index using Text-Mining on Twitter (EMP)

In constructing the Foreign Exchange Pressure Index (EMP), this study adopts the text-mining technique, within the framework of Big-data Analytics. This approach has been utilised in several studies, including Clements and Reade (2020), Kraaijeveld and De Smedt (2020), and Xu, Change, and Jayne (2022), among others. It involves two key stages: the data extraction stage and the sentiment analysis stage. The first stage, called the extraction stage, involves extracting the data from the Twitter, in form of text, which contain preselected words relating to foreign exchange pressure in Nigeria, over the scope of this study. The text, also called tweets, covers issues related to news, individual sentiments, and market expectations, and are extracted in unstructured form. In this study, the phrase ''exchange rate of the naira" shall be utilised as the keyword needed in generating related tweets about Nigeria's foreign exchange market. This phrase has been carefully selected, as it contains words that all bear close association with Nigeria's foreign exchange market. Consequently, only tweets that contain at least one of the words of the phrase shall be extracted for analysis, and included in the Index, EMP.

The second stage involves converting the unstructured data into structured form, using a Natural Language Processing (NLP) system in Python software. This process classifies the polarity of each tweet into positive, negative, or neutral, after assigning values to each tweet. However, before the conversion of the data to a structured form, the data are processed by removing special characters and punctuation marks such as #, @,!, and?. Next, each sentence decomposed into various parts, also called tokens, through a process called tokenization. Following the decomposition, the tokens are categorized into their respective parts of speech, ranging from noun, verb, pronoun, etc., to preserve the context in which the word was used. At this stage, also, irrelevant words, which do not value the sentence, are regarded as noise, and are removed from the corpus using the NLTK's list of stop words. Irrelevant words which are not included in the list of stop words, such as http and https are added as custom stop words. The stemming stage of pre-processing normalizes tokens by reducing them to their base forms after removing the suffixes. In this stage, a word, such as rising, is reduced to rise.

The second stage of this section utilises the dictionary-based approach of the lexicon technique to generate the polarity of tweets. The wordnet dictionary of the NLTK is employed. This stage depends on the availability of pre-defined words in dictionaries which the compilers of the wordnet dictionary have already scored. With sentiments categorized as positive, neutral, and negative, the scores attached to words ranged from -1 to +1. Negative words

tended towards -1, neutral words are assigned a score of 0 while positive words are scored positive values tending towards +1. The total score of each tweet is computed as the average of all the sentiments scored in that tweet. The tweets are summed for each day in a month to obtain the sentiment index for foreign exchange pressure for Nigeria in monthly series.

3.2.1.2 Constructing Foreign Exchange Pressure Index using Google Trend (EMP_Trend)

Google Trend is one of the search engines of Google, which provides information about trending topics and issues. It provides access to a largely unfiltered sample of actual search requests made to Google over a period of time and has become popular among researchers who seek to generate information about trending topics, and events that shape public opinion. It can be used to generate, among other things, sampled counts or number of times a particular phenomenon or keywords, has been searched on Google within a particular area, topic, space, and time. In generating the Index of foreign market pressure using this approach, this study adopted the following key words: Naira, Depreciation, exchange rate, US dollars, on the platform of google trend, over the period 2017M4 to 2022M12. To this end, four new variables, each representing each of the keywords Naira, exchange rate, dollars, were generated. These words are seminar to those utilised in generating EMP. The difference is in the fact that, while in the case of EMP, the words were used together as a single text/phrase, in the case of EMP_Trend, each was employed one at a time. Google trend was used to generate a variable that represents the number times, for example, exchange rate has been searched on google in Nigeria, every month, over the preselected scope, 2017M4 to 2022M12. This was also be done for Naira and Dollars. The final index (EMP_Trend) was estimated as the average of the three variables generated for exchange rate, naira, and dollars.

3.2.2 The Predictive Regression Model (PRM)

3.2.2.1 The Framework of PRM

The framework of a Predictive Regression Model (PRM) was employed in testing the predictive powers of the constructed Indices (EMP and EMP_Trend) in predicting movements in IEW, against the traditional approaches of measuring foreign exchange market pressure. The PRM adopted for this study follows the works of Tule *et al.* (2019) and Westerland and Narayan (2012), who have independently employed this technique in forecasting inflation and stock market returns, respectively. The predictive regression model for study, in its Baseline, is an autoregressive model with q lags:

$$\pi_t = \alpha + \sum_{i=1}^{q} \beta_i \pi_{t-\mathrm{i}} + u_{\pi,t} \quad (3.1)$$

Where π_t is exchange rate. Restricting the parameter β to zero captures the null of no predictability. Equation (3.1) is extended to incorporate each measure of foreign exchange pressure index (EMP and EMP_Trend), one at a time. This is necessary, according to Tule et al. (2019), to isolate the impact of each indicator from the other. Consequently, Equation (3.1) is re-specified for the different measures of EMP, using the form in equation (3.2) below:

$$\pi_t = \alpha + \sum_{i=1}^{q} \beta_i \pi_{t-\mathrm{i}} + \gamma z_{t-1} + u_{\pi,t} \quad (3.2)$$

Here, z_{t-1} represents either EMP or EMP_Trend at time $t-1$. Again, restricting γ to zero captures the corresponding null hypothesis of no predictability of EMP or EMP_Trend, as the case may be.

To measure the effectiveness of EMP or EMP_Trend in predicting exchange rate, Equation (3.2) was estimated, using the EMP or EMP_Trend as a regressand, and eventually, the in-sample forecasts of exchange rate (IEW) was generated, conditioned on EMP and EMP_Trend. The forecasts were compared with the forecast of IEW from the baseline model (Equation 3.1). This was done within the framework of the Clarke and West (2007) technique.

The baseline model (Equation 3.1) is a restricted version of the predictive model (Equation 3.2), as the imposition of relevant zero (0) restrictions on the coefficients of the predictive model would lead to an explicit derivation of the baseline model from the predictive model. For example, in Equation 3.2, restricting γ to zero reduces Equation 3.2 to Equation 3.1. Further restricting β to zero reduces π to its historical average (α), and this is the long-run level of π from its random walk model. Consequently, the random walk model is contained in Equation 3.2. The random walk model, and by extension, the long-run value of π can therefore be referred to as the restricted model, while Equation 3.2, estimated with EMP or EMP_Trend, is the unrestricted model.

The Clarke and West (CW) technique involves bootstrapping the differences in the forecast errors from the unrestricted models. It is estimated using the following CW statistics:

$$\hat{F}_t = (\pi_t - f^{res}(\pi_t))^2 - \{(\pi_t - f^{unres}(\pi_t))^2 - (f^{res}(\pi_t) - f^{unres}(\pi_t))^2\} \quad (3.3)$$

Where $(\pi_t - f^{res}(\pi_t))^2$ is the square of the forecast error from the restricted model, $(\pi_t - f^{unres}(\pi_t))^2$ is the squared forecast error from the unrestricted models, and $(f^{res}(\pi_t) - f^{unres}(\pi_t))^2$ is the squared deviation of the forecasts between the restricted and unrestricted model. In its application, $\hat{F}_t$ is regressed against a constant in the form:

$$\hat{F}_t = \partial + u_f \quad (3.4)$$

Where ∂ is the CW test statistic and u_f is the error term. The CW statistic evaluates the relative performance of the unrestricted model over the restricted model, in predicting movements in exchange rate.

A positive and statistically significant CW statistic suggests that the forecasts from the unrestricted model are statistically better than that gotten from the restricted model. Consequently, CW statistics was used to test Hypothesis that Foreign Exchange Pressure Index using Sentiment Analysis (EMP and EMP_Trend) does not provide a significant signal of exchange movement in Nigeria, through the evaluation of its statistical significance. Specifically, and according to Westerlund and Narayan (2012), where the CW is statistically significant, at 5 per cent level of significance, the proposed null hypothesis of no-predictability is rejected.

3.2.2.2 Robustness Check in PRM

As robustness check, foreign exchange pressure was constructed for Nigeria using other measures. Specifically, foreign exchange pressure, using the approaches by Eichengreen et al. (1996), Sachs et al. (1996), Kaminsky et al. (1998), and IMF (2007) were constructed. These are all traditional approaches to foreign exchange pressure, which do not really on public sentiments around the foreign exchange management. Consequently, the PRM was used to evaluate the relative effectiveness of the various measures of foreign exchange pressure, in signalling movements in exchange in Nigeria. To do this, Equation 3.1 was estimated, including each of the other measures of foreign exchange pressure, one at a time, to form the various restricted models of IEW under the condition of each of the measures, respectively, while the corresponding unrestricted models of IEW for each of the measures was constructed by including EMP and EMP_Trend, respectively. This approach enabled a comparative analysis of the role of EMP and EMP_Trend in predicting movements in IEW over each of the traditional measures of foreign exchange pressure.

IV. RESULTS AND ANALYSIS

This study proposed the construction of two measures of foreign exchange market pressure, using sentiment analysis. The first involves text-mining public opinion within the platform of Twitter, while the second utilises Google trend to regenerate an index of foreign market pressure. Consequently, two sets of data are presented for evaluation in this section. The first is the set of data for the proposed predictive model. This set of data include the EMP and EMP_Trend, which are the foreign exchange market pressure index constructed using sentiment analysis and Google trend, respectively, and the traditional measures of foreign exchange pressure index, which are the Eichengreen, Sachs, Kaminsky, and IMF measures.

4.1 Data Analysis

4.1.1 The Constructed Foreign Exchange Pressure Indices (EMP and EMP_Trend) using Sentiment Analysis

Figure 4.1A presents the graphical plot of both EMP and IEW. The chat reveals some co-movements between EMP and IEW over the scope of the data. EMP appears to be oscillating downwards between 2017 and 2019, during which IEW was relatively low and stable. However, as EMP began an upward oscillation in 2019, IEW began to rise, resulting in significant depreciation of the naira.

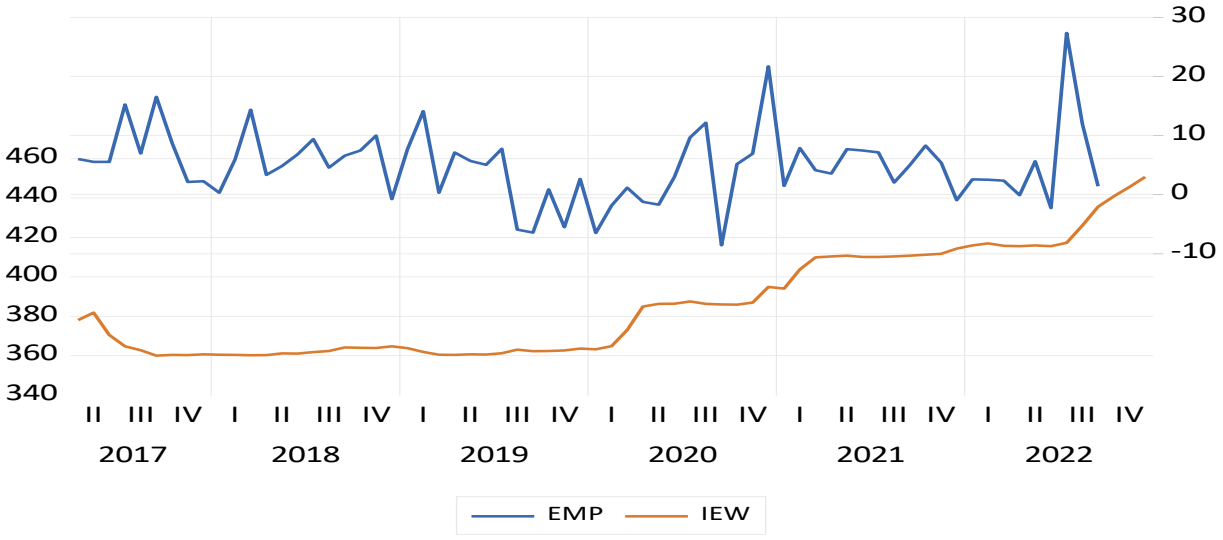

Figure 4.1 A: Plot of EMP and IEW
Source: Author's construction and CBN

Similarly, the constructed index of foreign exchange market pressure using Google trend (EMP_Trend) in Figure 4.1B tends to exhibit co-movements with IEW. Particularly, over the scope of the data, EMP_Trend appears to mimic movements in IEW. The plot, which appear to be oscillating, reveal various episodes of volatility/instability

in the foreign exchange market in Nigeria. Specifically, the data shows various episodes of troughs (deepening) and spikes (upswings), in 2020 and 2022, during which exchange rate observed significant depreciation in value. This situation presents some early indication of the effectiveness of sentiment analysis in predicting and providing signal for movements in IEW.

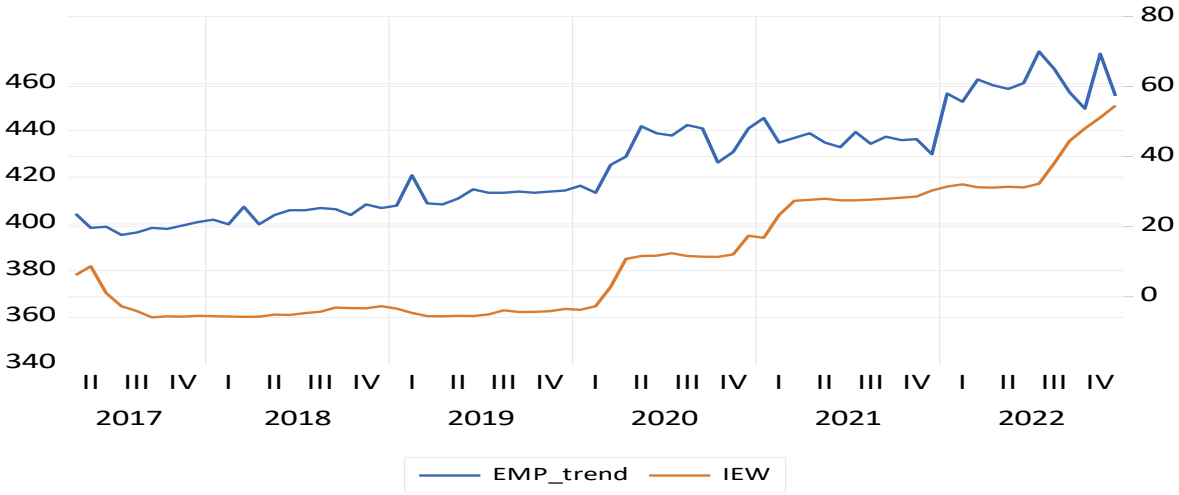

Figure 4.1 B: Plot of EMP and IEW
Source: Author's construction

4.2.2 The Traditional Measures of Foreign Exchange Pressure Indices (Eichengreen, Sachs, Kaminsky, and IMF measures)

Figure 4.2 is the plots of variables. However, the data on other measures of foreign exchange pressure, the Eichengreen, Sachs and Kaminsky, appears to reveal little information about the movement in exchange rate in Nigeria, as these indices only reveal spikes in the year 2020.

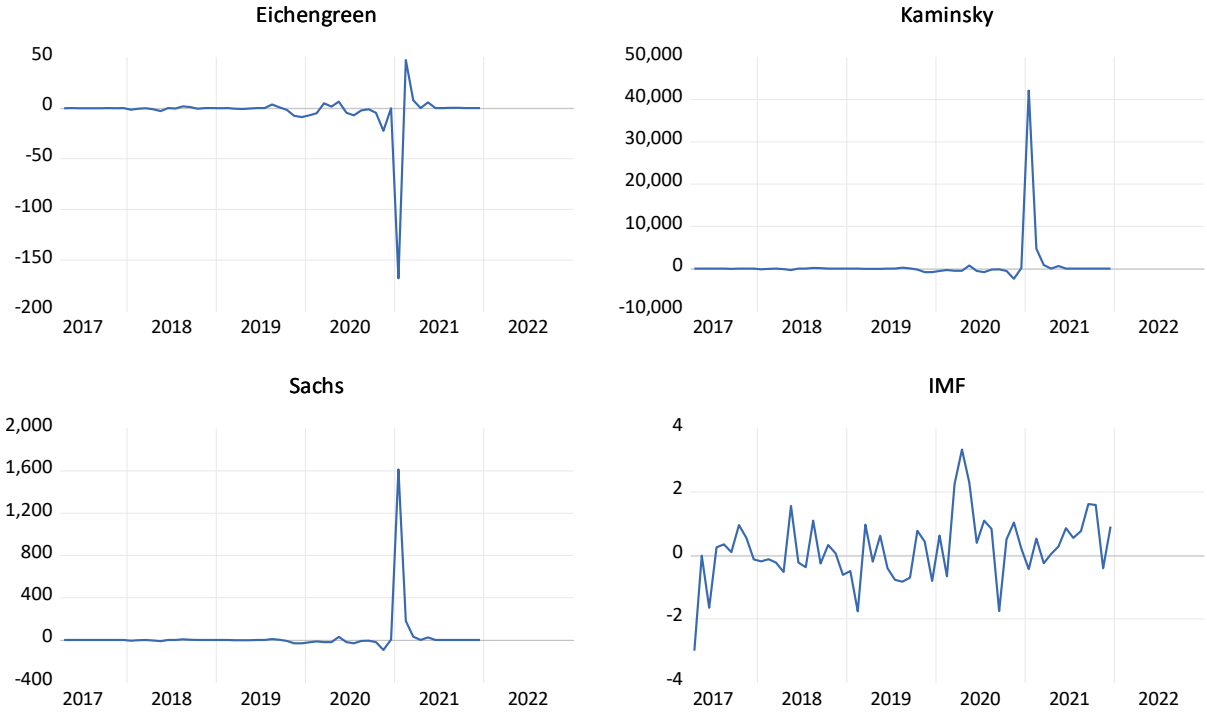

Figure 4.1 B: Plot of EMP and IEW
Source: Author's construction

4.2 The Results of the Predictive Regression Model (PRM)

The PRM framework is employed to measure the relative effectiveness of the constructed indices of foreign exchange market pressure (EMP and EMP_Trend) in predicting movements in exchange rate in Nigeria.

4.2.1 Predictive Regression Model (PRM) of IEW using EMP

Having constructed the foreign exchange pressure index (EMP), its predictive power in predicting movement in exchange rate (IEW) is evaluated, using the Predictive Regression Model (PRM). As stated in the methodology, the predictive power of EMP was evaluated using the Clark and West (2007) framework. Table 4.1 captures the Clark and West coefficients from each of the regression model, the Mean Square Errors (MSEs) from the forecasts of IEW using each of EMP, Eichengreen, Kaminsky, Sachs and IMF measures foreign exchange market pressure, for both the restricted and unrestricted models.

The results in Table 4.1 shows that, using EMP as the measure of foreign exchange market pressure, the Clark and West coefficient (∂ from Equation 3.4) is 3454.16. This coefficient is positive and statistically significant, at 5% level of significance, implying that the forecast of IEW improved with the inclusion of EMP in the forecast model of IEW. In other words, the forecast of IEW from the unrestricted model (Equation 3.2) is significantly better than the forecast of IEW from the restricted model (Equation 3.1). This is further confirmed by the results of the MSEs from the unrestricted model (32.06), which is smaller than the MSE from the restricted model (38.62).
Similarly, the results from the other measures of foreign exchange market pressure, Eichengreen, Kaminsky, Sachs, and IMF, reveal the relative importance of EMP is signalling movements in IEW. Specifically, the Clark and West coefficients of 128.73, 97.08, 97.08 and 115.14, for Eichengreen, Kaminsky, Sachs, and IMF, respectively, are positive and statistically significant at 5% level of significance. These coefficients reveal that the inclusion of EMP in each of the models of IEW, which originally includes each of Eichengreen, Kaminsky, Sachs, and IMF, at a time, improves the forecast of IEW over those with only Eichengreen, Kaminsky, Sachs, and IMF, each. Consequently, EMP produces a better forecast of IEW compared to each of Eichengreen, Kaminsky, Sachs, and IMF measures of foreign exchange market pressure.

This above inference is validated by the results of the MSEs for both the restricted and unrestricted models of IEW, using each of Eichengreen, Kaminsky, Sachs, and IMF. Here, the respective MSEs from the restricted models, 752.11, 521.73, 521.73 and 585.33, are greater than their corresponding values from the unrestricted models, 631.63, 432.10, 432.10 and 479.70, respectively.
This implies that the inclusion of and use of EMP, which is the measurement of foreign exchange market pressure, using sentiment analysis from text-mining of social media information, significantly improved the forecast of IEW over the traditional measures of foreign exchange market pressure. More so, the smaller MSEs for both the restricted and unrestricted models of IEW when using EMP alone, 38.62, and 32.06, respectively, confirms the superiority of EMP in predicting IEW better than traditional measures of foreign exchange market pressure, Eichengreen, Kaminsky, Sachs, and IMF.

Table 4.1: The Clark and West Results of the Predictive Regression Model (PRM)

Measurement of Exchange Market Pressure	Clark and West Coefficient	MSEs from the Restricted Model	MSEs from the Unrestricted Model
EMP	3454.16***	38.62	32.06
Eichengreen	128.73***	752.11	631.63
Kaminsky	97.08***	521.73	432.10
Sachs	97.08***	521.73	432.10
IMF	115.14***	585.33	479.70

Source: EViews, 2023.
Note: * significant at 5%.**

Figure 4.3 is the graphical plot of the forecasts of IEW from both restricted and unrestricted models of IEW, when using each of the measures of foreign exchange market pressure, at a time. Panel A represents the graph of the forecasts of IEW from both the restricted and unrestricted models, IEW_RES and IEW_UNRES, respectively, plotted against the actual value of IEW, when using EMP, as the measure of foreign exchange market pressure. Similarly, Panel B, C, D and E capture the forecasts of IEW from both the restricted and unrestricted models of IEW when using Eichengreen, Kaminsky, Sachs, and IMF, as measures of foreign exchange market pressure, respectively.
These plots clearly reveal the superiority of EMP over the other measures of foreign exchange market pressure in predicting IEW, as both the forecasts of IEW from the restricted and unrestricted models are strongly associated with IEW in Panel A than Panels B to E.

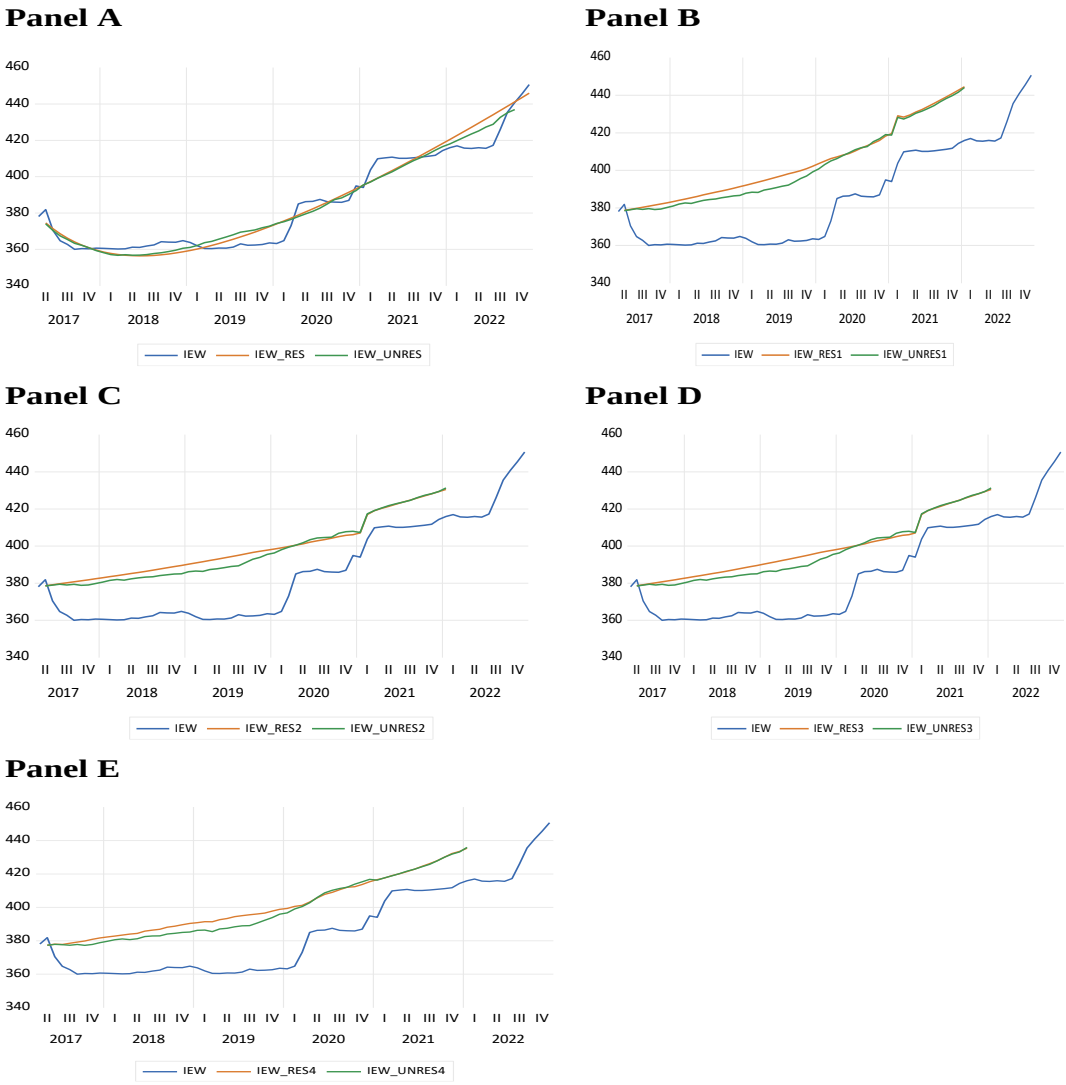

Figure 4.3: Graphical plots of Forecasts of IEW both restricted and unrestricted models of IEW, when using **EMP** and each of the measures of foreign exchange market pressure, at a time, as regressors.
Source: EViews, 2023.

4.2.6.3 Predictive Regression Model (PRM) of IEW using EMP_Trend

Table 4.2 presents the outcome of the Clark and West, and MSE of the predictive regression model of EMP_Trend and the other traditional measures of foreign exchange market pressure. Appendix 6-10 presents the regression results of the Clark and West variable ($\hat{F}_t$ from Equation 3.7), for EMP, Eichengreen, Kaminsky, Sachs and IMF measures foreign exchange market pressure, respectively. The predictive power of the constructed EMP_Trend is further established, as the Clark and West coefficient of 6.90 is positive and statistically significant at 5% level of significance. This implies that the forecast of IEW form the unrestrcted model, which includes EMP_Trend, is better than its forecast from the baseline or restricted model. Consequently, EMP_Trend improves the forecast of IEW. The results of the MSEs further confirms this inference, as the MSE from the unrestricted model (32.84) is smaller than the one from the restricted model (38.62).

In the case of the traditional measures of foreign exchange market pressure, the Clark and West coefficients of 1432.85, 961.10, 961.10 and 1098.78, for Eichengreen, Kaminsky, Sachs, and IMF, respectively, are positive and statistically significant at 5% level of significance, showing that the inclusion of EMP_Trend in each of the models of IEW, which originally includes each of Eichengreen, Kaminsky, Sachs and IMF, at a time, improves the forecast of IEW over those with only Eichengreen, Kaminsky, Sachs and IMF, each. To this end, EMP_Trend produces a better forecast of IEW compared to each of Eichengreen, Kaminsky, Sachs, and IMF measures of foreign exchange market pressure.

Furthermore, and as a confirmatory test, the MSEs for both the restricted and unrestricted models of IEW, using each of Eichengreen, Kaminsky, Sachs, and IMF, are presented in the Table. Specifically, the respective MSEs from the restricted models, 752.11, 521.73, 521.73 and 585.33, are greater than their corresponding values from the unrestricted models, 32.84, 22.82, 22.78, 22.78 and 21.19, respectively. The conclusion is that the inclusion of and use of EMP_Trend in the models of IEW alongside each of the traditional measures of foreign exchange market pressure, tends to improve the forecast of IEW.

Table 4.2: The Clark and West Results of the Predictive Regression Model (PRM) using EMP_Trend and other measures of Foreign Exchange Market Pressure

Measurement of Exchange Market Pressure	Clark and West Coefficient	MSEs from the Restricted Model	MSEs from the Unrestricted Model
EMP _Trend	6.90***	38.62	32.84
Eichengreen	1432.85***	752.11	22.82
Kaminsky	961.10***	521.73	22.78
Sachs	961.10***	521.73	22.78
IMF	1098.78***	585.33	21.19

Source: EViews, 2023.
Note: * significant at 5%.**

The graphical plot of the forecasts of IEW both restricted and unrestricted models of IEW are presented in Figure 4.3. Panel A is the plot of the forecasts of IEW from both the restricted and unrestricted models, IEW_RES and IEW_UNRES, respectively, plotted against the actual value of IEW, when using EMP_Trend, as the measure of foreign exchange market pressure. Similarly, Panel B, C, D and E capture the forecasts of IEW from both the restricted and unrestricted models of IEW when using Eichengreen, Kaminsky, Sachs, and IMF, as measures of foreign exchange market pressure, respectively. The graphical plots reveal minimal forecast errors in the unrestricted models for each of the cases, confirming the relative effectiveness EMP_Trend in predicting movement in IEW, compared with the traditional measures of foreign exchange market pressure.

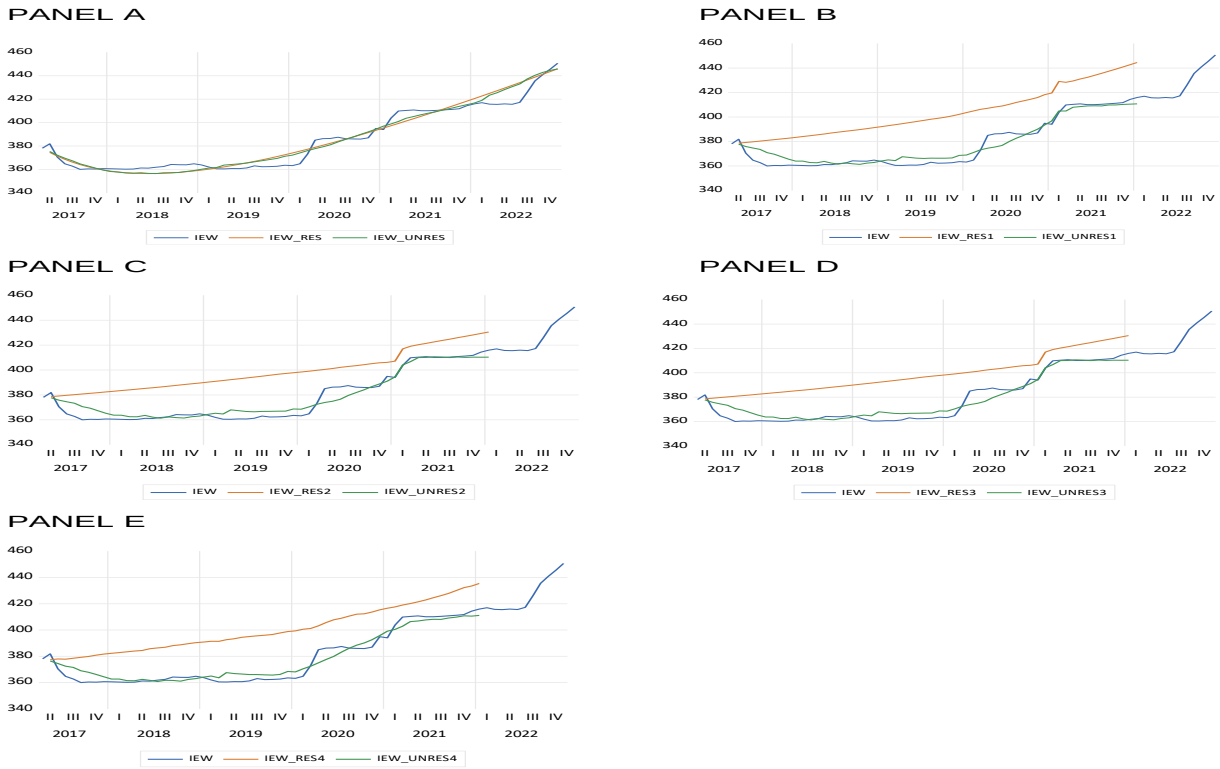

Figure 4.3: Graphical plots of Forecasts of IEW from both the restricted and unrestricted models of IEW, when using **EMP_Trend** and each of the measures of foreign exchange market pressure, at a time, as regressors.
Source: EViews, 2023.

In summary, this study attempted to construct a foreign exchange using sentiment analysis. This approach has become popular among researchers interested in capturing public sentiments on varying economic phenomena. Two approaches were considered in this study: the text-mining approach and the Google trend approach, and their relative effectiveness in signalling movements in the exchange rate were evaluated using the framework of Predictive Regression Model (PRM) and the Clark and West approaches for testing the predictive powers of constructed indices.

The results from the study reveals that the constructed foreign exchange pressure index have significant predictive powers in signalling movements in exchange rate in Nigeria. Particularly, the foreign pressure index using the Google trend approach (EMP_Trend) outperformed the one constructed using text-mining approach (EMP) in signalling movements in exchange rate in Nigeria (IEW). This outcome was based on the Clark and West coefficients generated from bootstrapping differences in forecast errors under both approaches. In addition, an evaluation of the relative performance of EMP_Trend and EMP in signalling movements in IEW over the traditional measures of foreign exchange pressure index, the Eichengreen et al. (1996), Sachs et al. (1996), Kaminsky et al. (1998), and IMF (2007) approaches, revealed that both EMP_Trend and EMP are better predictors of IEW than the traditional approaches. Sentiment Analysis shows immense potential as a reliable source of leading indicators for predicting exchange rate movement in Nigeria. This presents a valuable opportunity for monetary authorities to utilize this technique in order to monitor and assess the future direction of the exchange rate. By doing so, they can implement appropriate policies that aim to mitigate the prevailing instability observed in Nigeria's foreign exchange market.

V. CONCLUSION AND RECOMMENDATION

This study provides valuable insights into the Nigerian foreign exchange market and offers important policy recommendations. It underscores the potential of sentiment analysis as a tool for predicting exchange rate movements and emphasizes the role of external reserves in managing exchange rate stability. Sentiment analysis involves analyzing and interpreting the collective sentiment or opinion expressed in social media posts, news articles, and other textual data sources. By applying sentiment analysis techniques to the vast amount of available data, monetary authorities can gain valuable insights into the overall market sentiment towards the Nigerian exchange rate. These insights can serve as leading indicators, providing early signals of potential shifts in the exchange rate. By leveraging sentiment analysis, monetary authorities can proactively monitor and anticipate changes in market sentiment towards the exchange rate. This enables them to develop and implement timely policies to address any potential instability in the foreign exchange market. By closely tracking sentiment trends and patterns, monetary authorities can better understand the underlying factors that influence market sentiment and take appropriate actions to maintain stability.

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