**Return and Volatility Connectedness in Sierra Leone Foreign Exchange Markets**

**Leroy N. Johnson1**

**Abstract**

The study was conducted to explore the return and volatility nexus in Sierra Leone Forex Markets. Exchange rate excessive volatilities have been a serious concern as it translates to propel inflationary pressures and erodes the strength of the currency. The methodology of Diebold and Yilmaz (2012, 2014) indicator of connectedness was employed to unravel the intensity of connectedness among the selected forex markets in Sierra Leone for the period January 2011 to December 2021. The study then used, Leone/USD, Le/ Euro and Le/Pound sterling official exchange rate from the central bank to measure exchange rate dynamics in the market. The study found connectedness among the forex markets in Sierra Leone to be highly time-varying and appear to be higher during the period of high depreciation of the Leone which coincides with the period of falling iron-ore and oil prices and domestic economic meltdown of 2014 and 2016, respectively. This shows that, relative to external shocks, connectedness among financial markets is likely to get amplified during the time of domestic turbulence. The paper, therefore portends the build-up of reserves by the Central Bank of Sierra Leone which serves as buffers to contain and assuage internal and external shocks in a timely and efficient manner.

**JEL Codes:** C58; F31; G11; G12

**Keywords**: Connectedness, Foreign Exchange, Return Spillover, Volatility

The views expressed in this article are those of the author(s) and do not necessarily represent the views of their affiliated institutions.

1. **Introduction**

It is true that interconnectedness of domestic financial markets that are interlocked with global financial markets spurs trade amongst nations. Herring(1994) portends that the inception of computer hardware and software have largely dampened the costs of collecting and analyzing data, commencing and firming transactions, clearing and settlement payment; and tracking financial flows. However, the associated likely vicissitude have created an albatross. The ramifications of these materialized dynamics is onerous to financial markets. These transmitting spillovers sometimes compound an already challenged conditions in financial markets including pricing and portfolio diversification dynamics. A correction to these vicissitudes is portended by Agenor (2003) that financial integration should be well crafted and managed to ensure that benefits outweigh the short run risks. A corollary to minimizing risks is sharing information about likely spillover effects between markets (with financial flows) in order to guide both investors and policy makers in decision making.

In this context, a better comprehension of the interconnectedness amongst markets (with financial flows) by market participants, policy makers, and investors amongst others is crucial. The major forex markets (with financial flows) in Sierra Leone are the USD pair and Euro pair, and pounds pair. As such, these variants of forex markets are the significant and catalytic in the financial markets space. The interconnectedness or pass-through amongst these markets are vital for policy-makers, investors and market participants but also to identify vulnerabilities (weaknesses) and take appropriate actions to handle them. For instance, when the USD market experiences tight liquidity situation, the leones depreciates further and these dynamics are permeated across the pounds and euro markets. This reflects that the USD dollar is leading the way as the prime mover. Consequently, this study attempts to provide evidence based research on the direction and magnitude of connectedness amongst these major market (especially the forex market) in Sierra Leone. This translates in providing insights on asset diversification and maximization of returns.

The recent International Financial Crises (GFC) revealed that financial markets can easily permeate risks across economies and this dampened the world economy over that period. Despite these dynamics, a plethora of studies largely dive into nexus of these markets in developed countries in particular, Diebold and Yilmaz (2012) for the U.S., Sensoy and Sobaci (2014) for Turkey, Liow (2015) for G7, and Kal et al. (2015) for Australia, United Kingdom, Canada and Japan. Kakinuma,(2021); Singhal et al.(2021);Sheku et al(2020);Sawar et al.(2020); Nyugen et al.(2020); Rastogi et al.(2021)

Regardless, Sierra Leone is a small developing economy that is import driven reflecting it is highly vulnerable to exogenous shocks (shocks such as dramatic price decrease in commodity prices and fossil fuels compounded by the lingering impact of the GFC). The study is further motivated by the need to provide insights on the hedging capability of these financial markets, revealing diversification benefits to investors, market participants, and policymakers. In other words, it serves as bedrock for ‘evidence-based policy-making’ which has gained wide currency and acceptability. To the best knowledge, this is the first attempt that explores the links between money market and forex market. Therefore, the study attempts to fill this gap.

The supplement of this paper to the empirical literature is three-pronged. Primarily, the paper delves into interconnected of a low income country using major forex markets (Le/USD, Le/Euro, Le/Pounds) as the country of interest. Subsequently, the study then encapsulates both volatility and returns spill-overs using major forex markets in Sierra Leone. Moreover, the study employs both Diebold and Yilmaz(2012, 2014)[Thereafter called DY] spillover indices methodology to gauge the intensity(strength) of the nexus between the these markets, and more so portray the different cyclical dynamics potentially to affect the magnitude of the returns and gyration of the Sierra Leone forex markets. The methodology is unique in that it is the first time it is applied for Sierra Leone and also innovative as it explores interesting insights as a potential safeguards to investors, policy-makers, market participants and academics as well on the strength and weaknesses of the Sierra Leone major forex markets. This is evident that it serves as early warning signs for any untoward event in these markets.

The rest of the study is structured as follows, Section 2 then elicits some stylized facts, whilst Section 3 analyses the methodology and empirical results. Section 4 concludes and portends some policy implications.

**2.0 Stylized Facts**

91-day T-bills, foreign exchange rate (Le/USD) are the indicators of the major financial markets and monetary policy rate as the key signal rate for all other market rates to follow. By visual inspection the 91-day rates trended downwards and monetary policy rate (mpr) was on averaged loosened reflective that liquidity conditions spur interbank market activities. However, the trend of forex indicates on average depreciation.

**Figure 1: 91-Day Treasury Bills, Monetary Policy Rate & foreign exchange rate (Le/US$) over the review period**

Source: Bank of Sierra Leone

Over the period under review, 91-day T-bills rate moved largely in tandem with the monetary policy rate reflecting some degree of mimicking at least in terms of direction. In the same vein, the exchange rate depreciated largely over the review period driven by largely by supply-side dynamics and minimally by demand-side play-out.

With regards to assessing the dynamics between the domestic market (3-months T-bills) and the foreign exchange market (exchange rate), the key point is that the forex market is leading the way in terms of attractiveness and profitability for investors relative to the 3-months T-bills market.

**Figure 2: FOREX VS 91-DAY T-BILLS**

**Source: Bank of Sierra Leone**

Figure 2 reflects the scattered diagram of the two major markets namely, money market (91-day treasury-bills rate) and the foreign exchange market (Le/USD), superimposed with a line of best fit to show the degree of association between the two markets during the review period

**3. Data, Methodology and Preliminary Analyses**

**3.1 Data**

The study does a rendition of statistical analysis of returns and volatilities of the three major currencies (namely, LE/USD, LE/POUND and LE/EURO) driving the foreign exchange market (using the BSL official mid-rate) in order to reveal their statistical characteristics. Monthly data spanning 2001 to 2021 is employed and sourced from the BSL website. The coverage of this analysis is driven by the operationalization of foreign exchange policies which came into existence during this vintage and the availability of monthly data over the period.

**3.2 Methodology and Model Specifications**

Diebold –Yilmaz (DY) Approach was employed. The underlying framework for the DY spillover indexes is the generalized vector autoregressive (VAR) model of KPPS. Specifically, the study leverages on the DY (2012, 2014) approach to set up a directional spillover indexes in a generalized VAR framework that is invariant to ordering (i.e. it eradicates the possible dependence of the outcomes on ordering) of the variables. Setting up the spillover indexes starting from equation (1), a covariance stationary N-variable VAR(p) was considered.

In setting up the spillover indexes, a stationary VAR is considered :

 --------------(1)

Where: is an of vector of return/volatility series,  is an  matrix matrix of parameters,  is a vector of independently and identically distributed disturbances &  is the variance matrix for the error vector .

The moving average representation can be written as:  -------------(2)

Where: ;  is an identity matrix with an  dimension and  for . Equation (2) forms the basis for the derivation of variance decompositions required to determine the spillover indexes.

Prior to providing the representations for the various indexes, the following preliminary considerations are important:

* Own variance shares are defined as the fractions of the H-step-ahead error variances in forecasting  that are due to shocks to  , for 
* Cross variance shares or spillovers are defined as the fractions of the H-step-ahead error variances in forecasting  that are due to shocks to  for such that 
* Based on the generalized VAR framework of KPPS, the H-step-ahead forecast error variance decompositions denoted by  is written as:

(3)
Since the sum of the elements in each of the variance decompositions as defined in (3) is not equal to 1:  ; DY (2012) normalized each entry of the variance decomposition matrix by the row sum in order to use the full information of the matrix.

The normalized KPPS -step-ahead forecast error variance decompositions represented by  is expressed as:

 (4) where  and  by construction. Given these preliminaries, the total spillover index is written as:



Essentially, equation (5) measures the contribution of spillovers of return/volatility shocks across the assets under consideration. Also, it is possible to assess quantitatively the direction of spillovers across the assets.

These directional spillovers are classified into two :

* ‘*Directional Spillover To’ *
* *‘Directional Spillover From’ *

‘*Directional Spillover To’* measures the spillovers transmitted by  market to all other markets .

 (6)

‘*Directional Spillover From’* measures the spillovers received by market  from all other markets  .

 (7)

Net Spillover Index: It is the difference between (6) and (7).  (8)

**3.3 Preliminary Analysis**

The returns of the series (rt) are computed as the first difference of the natural logarithm of the level series (Pt); this is expressed in equation (1a) below:

****---------------------------------(1a)

Where:= represents the calculated treasury bill/exchange rate returns, Pt is the level t-bills rate/exchange rate, and expression in the braces is the first difference lag operator. Hence the positive/ negative returns will mimic the direction of depreciation or appreciation of the exchange rate (Le/USD, Le/Pound, Le/Euro).

Consequently, the volatility series, is derived by the estimation of GARCH (1, 1) model

() indicative of all variables in their estimated forms. Table 1 and 2 present the summary statistics for the three series.

**Table 1: Summary Statistics for log of returns of three major trading currency pairs (full sample)**

|  |  |  |  |
| --- | --- | --- | --- |
| **STATS** | **ER** | **PR** | **UR** |
|  Mean |  0.865954 |  0.719527 |  0.762629 |
|  Median |  0.676691 |  0.610122 |  0.378103 |
|  Maximum |  29.81489 |  33.47919 |  7.449413 |
|  Minimum | -38.16170 | -31.01035 | -6.162724 |
|  Std. Dev. |  5.156039 |  3.949980 |  1.379306 |
|  Skewness | -1.110244 |  0.212071 |  1.076541 |
|  Kurtosis |  21.53320 |  36.72013 |  10.42309 |
|  Jarque-Bera |  3643.788 |  11893.50 |  624.7604 |
|  Probability |  0.000000 |  0.000000 |  0.000000 |
|  Sum |  217.3545 |  180.6012 |  191.4198 |
|  Sum Sq. Dev. |  6646.184 |  3900.586 |  475.6211 |
|  Observations |  252 |  252 |  252 |

**\*Note: ER is the returns from the Le/Euro, PR is the returns from the Le/Pounds and UR is the returns from the Le/USD**

**Source: Compiled by the Researcher**

Table 1 shows the descriptive statistics for the return series of all the three (3) major currency pairs in the foreign exchange market over the coverage period. Inference from the table indicates that the mean represents the average returns in these currencies traded in the forex market. Inference from the three currency pairs in terms of returns show that all three of the currencies in the forex market elicits positive average returns implying that the leones depreciated against the Euro, Pounds and the USD with the mean statistic showing euro yielding the highest returns. This behavior of the return series is further analyzed using visualizations.(See figure 3). Figure 3 reflects that the leones depreciated against the euro pounds and the USD consistently over the period under consideration indicating an upward sloping trend. The observations are consistent with the computed summary statistics.

**Figure 3: Combined Graph for currency pairs and their returns**







The maximum and minimum values including the skewness and kurtosis statistics of the returns from the three major currencies are also illustrated. The return series of the pounds and dollar are positively skewed whilst the euro returns negative skewness. The kurtosis statistics also revealed that the return series of all three currency pairs are highly peaked or leptokurtic.

Table 2 shows the descriptive statistics for the volatility series of all the three currency pairs under the whole sample period. Drawing from figure 4, all the three currency pairs are volatile (though some are more volatile than others.

**Table 2: Summary Statistics for volatility series three major trading currency pairs (full sample)**

|  |  |  |  |
| --- | --- | --- | --- |
| **STATS** | **ER\_VOL** | **PR\_VOL** | **UR\_VOL** |
|  Mean |  33.26035 |  13.02951 |  6.415819 |
|  Median |  14.71961 |  7.091839 |  1.178256 |
|  Maximum |  1337.829 |  552.7571 |  107.0076 |
|  Minimum |  0.000707 |  5.528319 |  0.071035 |
|  Std. Dev. |  102.1163 |  41.36994 |  15.28257 |
|  Skewness |  9.800504 |  10.94232 |  4.401044 |
|  Kurtosis |  114.7473 |  131.4471 |  25.16757 |
|  Jarque-Bera |  134079.8 |  176849.9 |  5925.814 |
|  Probability |  0.000000 |  0.000000 |  0.000000 |
|  Sum |  8315.088 |  3257.378 |  1603.955 |
|  Sum Sq. Dev. |  2596507. |  426156.5 |  58155.66 |
|  Observations |  252 |  252 |  252 |

**Source: Compiled by the Researcher**

others) with indication of volatility clustering, i.e., periods of high volatility are tracked by periods of relatively low volatility. Also, virtually all these currency pairs exhibit notable spikes The average unpredictability nature of each currency pair is encapsulated by the mean in table 2. The LE/USD\_VOL has the least mean value while the ER/ USD-VOL has the highest mean value. In terms of deviation from the mean, the UR\_VOL has the least value followed by the PR\_ VOL and ER\_VOL in ascending order. Thus, the ER\_VOL is more volatile than others judging by the standard deviation. In addition, all the volatility series are positively skewed and have fat tails.

**Figure 4: Volatility Graph for currency pairs**







**4. Analysis of Spillover Tables**

The DY methodology is a double machine learning technic that can help move beyond prediction to understand causation, in the context of an effort to estimate connectedness using proxies for Sierra Leone’s forex markets (that account for over 90% of the foreign exchange trading). These are the Leones/USD, Leones/pounds and the Leones/Euro. DY methodology is commonly divided into the Spillover Tables and the Rolling Window Analysis. The Spillover Tables produces a single fixed (scalar) value for each of the indices during the period of interest. This is insightful where the focus is to gauge the total spillovers during a given period. Yet, a profound and innate meaning can be elicited wherein unexpected episodes mimicking the dynamics of the spillovers are embedded in the analysis. This brings to the fore the significance of rolling window analysis which complements the spillover tables as it mirrors cyclical and secular dynamics depicting these features of spillovers per period.

Consequently, the study depicts the spillover tables for both returns and volatilities of the three major currency pairs in the Foreign exchange market in Sierra Leone (see table 3&4 respectively). Table 3 illustrates the return spillovers estimated for the whole sample based on a second order 3-variable VAR with 10-step ahead forecasts. The off-diagonal column aggregates compute the “contribution to others” while the off-diagonal row sums provide the “contribution from others”. Both are directional spillovers where “Directional spillovers to” is represented by “contribution to others” while “Directional spillovers from” is denoted by “contribution from others” in both tables. Thus, each element in each column, other than the main diagonal elements, captures individual market’s contribution to the forecast error variance of other markets. Similarly, each component in each row, excluding the main diagonal components, gauges the amount of contributions of other markets to the forecast error variance of a specific market under consideration. Technically, “contribution to others” measures the total contribution of shocks to a particular market to the forecast error variance of other markets while “contribution from others” measures the total contribution of shocks to other markets to the forecast error variance of a particular market. In essence, the spillover table is similar to the input-output table as it shows how shocks are immersed and propagated within the system of interest.

The net spillovers are obtained by deducting the “contribution from others” from “contributions to others” or vice versa. In other words, the net spillovers reflect the difference between the contribution a market gives to and receives from others. Using the former definition, a positive magnitude is an indication that the market under consideration has a greater influence in other markets than the influence it receives from them. This makes the market under consideration less vulnerable to external shocks. Conversely, a negative magnitude implies that the market under scrutiny is more vulnerable to shocks to other markets. Furthermore, the total spillover index is presented in the lower right corner of the spillover table and it is computed by expressing the sum of “contributions to others” (or the sum of “contributions from others”) as a percentage of sum of “contributions including own”. This condenses the various directional spillovers into a single index; therefore, it effectively captures the total spillovers conveyed among the markets under consideration.

With regards to the interpretation, the spillover table for the return series reflects that in terms of the individual directional spillovers from others, Starting with return connectedness, the empirical estimates in Table 3 with the total spillover index at 10.2% is an indication of low level of return connectedness among the three major currency pairs (Euro, Pounds and the US Dollar) in Sierra Leone. A deeper analysis of the total spillover index reveals that the computed value of 10.2% mirrors that marginally over 10% of the total variance of the forecast errors during the sample is explained by shocks across the currency pairs, whilst the residual 89.8% is explained by idiosyncratic shocks. For instance, the examination of the gross directional return spillover suggests that only 6.8% of the variations in euro returns might be due to spillover of shocks from other currency pairs. For pounds and euro currency pairs in the foreign exchange market, the magnitude of spillover effect from other markets is 18.1% and 5.8%, respectively. However, the net spillovers reveal returns on US dollar with 7.7% net spillovers as highest net transmitter of shocks followed closely by the euro with 5.9%, however the net spillover of the pounds was negative 13.6%.

With regards to volatility spillover, the empirical estimates in Table 4 indicates the total spillover index at 9.4% is an indication of low level of return connectedness among the three major currency pairs(Euro, Pounds and the US Dollar) in Sierra Leone. A deeper and more intuitive perusal of total spillover index, the computed value is 9.4%, which is reflective that slightly under 10% of the total variance of the forecast errors during the sample is explained by shocks across the currency pairs, whilst the remaining 90.6% is explained by idiosyncratic shocks. In particular, the examination of the gross directional volatilities spillover suggests that 25.1% of the variations in euro volatilities might be due to spillover of shocks from other currency pairs. For pounds and euro currency pairs in the foreign exchange market, the magnitude of spillover effect from other markets is 0.1% and 3.2%, respectively.

However, the net spillovers reveal volatilities on US dollar with 21.7% net spillovers as highest net transmitter of shocks followed by the euro and the pounds with insignificant impact. The USD appears the least transmitter of shocks in euro and pounds volatilities and yet stands out as the net receiver of volatility transmission from other markets currency pairs. This however, is expected of a country practicing managed float exchange rate regime. Therefore, the overall connectedness among the USD currency pairs appears to be more pronounced for spillovers due to volatility in these currency pairs relative to connectedness due to return spillovers.

**Table 3: Return Spillover of 3 major foreign exchange market from Jan 2001-Dec 2021 with insignificant**

|  |  |  |  |
| --- | --- | --- | --- |
|   | FROM |   |   |
| TO | er | pr | ur | Contribution From Others | Net Spillover |
| er | 93.2 | 1.8 | 4.9 | 6.8 | 5.9 |
| pr | 9.5 | 81.9 | 8.6 | 18.1 | -13.6 |
| ur | 3.2 | 2.7 | 94.2 | 5.8 | 7.7 |
| Contribution to others | 12.7 | 4.5 | 13.5 | 30.7 |   |
| Contribution including own | 105.9 | 86.4 | 107.7 | Spillover index: 10.2% |   |
|  |  |  |  |  |  |

Note: The *ij*th entry gives the *ij*th pairwise directional connectedness

**Source: Compiled by the researcher**

**Table 4: Volatility Spillover of 3 major foreign exchange market from Jan 2001-Dec 2021**

|  |  |  |  |
| --- | --- | --- | --- |
|   | FROM |   |   |
| TO | er\_vol | pr\_vol | ur\_vol | Contribution From Others | Net Spillover |
| er\_vol | 74.9 | 0.1 | 25 | 25.1 | -21.9 |
| pr\_vol | 0.1 | 99.9 | 0 | 0.1 | 0 |
| ur\_vol | 3.1 | 0.1 | 96.8 | 3.2 | 21.8 |
| Contribution to others | 3.2 | 0.1 | 25 | 28.3 |  |
| Contributionincluding own | 78.1 | 100 | 121.9 | Spillover index 9.4% |   |

Note: The *ij*th entry gives the *ij*th pairwise directional connectedness

**Source: Compiled by the researcher**

* 1. **Rolling-Sample Analysis**

While the spillover table and index buttressed with other relevant analysis has given a background of the “average” spillover features amongst the three major currency pair in the forex market, however Diebold and Yilmaz (2012) averred that it may not reveal passably, the significance of some notable episodes of financial gyrations and or economic slumps. Consequently, the study leverages on the rolling sample framework using 200-month sub sample rolling windows in order to address these inadequacies and properly capture events or crises episodes that may have occurred during the period under consideration. The resultant plots for total spillover indexes for both returns and volatilities are presented in figures 3 and 4 respectively. Both total spillovers start at a value above 12 percent with return spillover slightly higher than volatility spillover in the first window. Precisely, the total return spillover plot mostly fluctuates between 11.6% and 27.8% during the review period.

In terms of the total volatility spillover plot in figure 5, it was observed that the most pronounced of them is in 2012 march where the total volatility spillover appears to be at its peak at 27.8% wherein FDI inflows emanated from the inception of African minerals, London mining and Sugar Magbass industries being operational. A synopsis of this period shows that 2012 saw a propulsion in economic growth recording annual GDP Growth of 15.18% (See WDI). This translated into prompting an accretion in reserves and relative stability in the foreign exchange market. Thereafter, the spate of volatilities declined till it tailed away at 12 percent in 2021. This was driven by a cocktail of factors including the rolling out of forex policies to use of the domestic currency (leone) and de-dollarize the domestic economy dynamics .It is worthy to note that Sierra Leone experienced Covid-19 shock in 2020 the disruptive economic activities ensuing in the a recession of 2.2% over this period. The smart economic recovery package (quick action) implemented during this period assuaged the inimical impact of these dynamics. The net effect of this is due to cross market volatility transmission during or in the reverberation of a turbulent economic period.

In sum, a cursory look at the two graphs depicts that return spillovers exhibit both trends and bursts over the period under consideration while volatility spillovers display significant bursts but no trends.

Figure 4



**Source: Author’s estimation from research data**

Figure 5



**Source: Author’s estimation from research data**

**5.1 Directional Spillovers**

This section assesses directional spillovers from and to others amongst the major currency pairs for both returns and volatilities. In this context, directional spillovers provide information on how spillover is being transmitted from one currency pair to others and from other currency pairs to a specific currency pair( in Sierra Leone forex market). An examination of directional return spillovers are presented in figures 6 and 7 respectively. In Figure 6, are the directional return spillovers to each of the major currency pairs from others (corresponding to the “directional spillovers from others”) in Table 4. Among the three currency pairs, the return spillover from other currency pairs to foreign exchange market seems generally higher than that of other market irrespective of the period. The Figure 6 reveals the following: Directional return spillovers to others seem to follow dissimilar patterns. It depicts currency pairs that witnessed somewhat increasing trends for the euro returns, dollar returns but somewhat, but the returns on the pounds followed a declining trend thereafter, there was a smaller and unsteady increase in the spillovers. The second group-directional spillovers from in reflected in figure 7 shows what appears to be a steep trend. The spillovers recorded somewhat major increases especially for the returns on the euro and the dollar, however, with a somewhat downward trend afterwards.

Despite the groupings, the two figures indicate substantial directional return spillovers among the currency pairs. The directional return spillovers display both trends and bursts over the rolling window.

Looking at the direction volatility spillovers (see figures 7 and 8), we find a pattern that is similar to the total volatility spillovers. In other words, the directional volatility spillovers also display significant bursts like the total volatility spillovers. All the currency pairs recorded substantial volatility spillovers implying that they are all vulnerable to volatility shocks in the global FX markets.

Taken in one breath, the rolling window analyses signal large return and volatility spillovers for some periods than the others due to some cyclical events as emphasized. These variations are usually not readily visible in the spillover tables. This clarifies why it is vital to complement the spillover indexes with rolling window analyses.

**Figure 6: Directional Spillovers to the individual return series**



**Source: Author’s estimation from research data**

**Figure 7: Directional Spillovers from the individual return series**



**Source: Author’s estimation from research data**

***Figure 8: Directional Spillovers to the individual volatility series***



**Source: Author’s estimation from research data**

**6.0 Concluding Remarks**

Catalyzed by interdependence and interrelationships among Sierra Leone’s forex markets which accounts for over 90 percent of Sierra Leone’s forex trading (IMF Staff Report 2022). This paper assessed and modelled the intensity of connectedness among forex markets in Sierra Leone. It leveraged on the novel DY (2012) approach which is measure of connectedness index, and it was observed that for an emerging economy such as Sierra Leone, its forex markets are likely to be more responsive to external shocks and domestic economic turbulence.

The striking findings of the study can be classified into two-pronged strata. First, we find evidence of cross-market spillovers among the selected forex currency pairs, feeding through from the US dollar to the euro and then to the pounds sterling. This pass through mechanism may also follow the reverse order.

Secondly, the paper implied that the US dollar market in Sierra Leone has the highest transmitter of volatility spillovers when compared to euro and pound sterling forex markets. This means that the US Dollar market in Sierra Leone appear to exert more influence on the behavior of returns of the of the other selected FX markets.

In this regard, the Central Bank of Sierra Leone (BSL) mandated with pursuing financial stability would be expected to manage the volatilities of the selected forex markets which are the drivers.

**6.1 Policy Recommendations**

It is recommended that policymakers in Sierra Leone should look both inward and outward whenever policy discussion gyrate around the increasing integration of forex markets so as to soften the inimical impact on the economy from exacerbations of contagion. This recommendation is in line with our findings, coupled with the structure of the Sierra Leone economy and its high reliance on iron-ore. Thus, in its pursuit of price and exchange rate stability BSL needs to capture not only the inherent contagions associated with the internal connectedness of the country’s forex markets, but also their vulnerability to external shocks. This means that BSL should leverage on the accretion of reserve buffers to contain these risks through the timely intervention in the forex market and this reinforces confidence and trust.

**REFERENCES**

Ahmad, W., Mishra, A. V., & Daly, K. J. (2018). Financial connectedness of BRICS and global sovereign bond markets. Emerging Markets Review, 37, 1-16. https://doi.org/10.1016/j.ememar.2018.02.006

Andersen T.G, Bollerslev T, Diebold, F.X., & Vega, C. (2007). Real-time price discovery in global stock, bond and foreign exchange markets. Journal of International Economics, 73, 251-277.

Antonakakis, N., & Vergos, K. (2013). Sovereign bond yield spillovers in the Euro zone during the financial and debt crisis. Journal of International Financial Markets, Institutions and Money, 26, 258-

272.

Claeys P., & Vašicek, B. (2014). Measuring bilateral spillover and testing contagion on sovereign bond markets in Europe. Journal of Banking and Finance, 46, 151-165.

Diebold, F.X., & Yilmaz, K. (2014). On the network topology of variance decompositions: Measuring the connectedness of financial firms. Journal of Econometrics, 182, 119-134.

Diebold, F.X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. International Journal of Forecasting, 23, 57-66.

Fernández-Rodríguez, F., Gómez-Puig, M., & Sosvilla-Rivero, S. (2015). Volatility spillovers in EMU sovereign bond markets. International Review of Economics & Finance, 39, 337-352.

Hakim, A., & McAleer, M. (2009). Forecasting conditional correlations in stock, bond and foreign exchange markets. Mathematics and Computers in Simulation, 79(9), 2830-2846.

Kakinuma, Y. (2021). Nexus between Southeast Asian stock markets, bitcoin and gold: spillover effect before and during the COVID-19 pandemic. Journal of Asia Business Studies, 16(4), 693-711. http://dx.doi. org/10.1108/JABS-02-2021-0050

Kal, S. H., Arslaner, F., & Arslaner, N. (2015). The dynamic relationship between stock, bond and foreign exchange markets. Economic Systems, 39(4), 592-607

Koop, G., Pesaran, M. H., & Potter, S. M. (1996). Impulse response analysis in nonlinear multivariate models. Journal of Econometrics, 74(1), 119-147.

Liow, K.H. (2015). Volatility spillover dynamics and relationship across G7 financial markets. North American Journal of Economics and Finance, 33, 328-365.

Nguyen, T. T., Nguyen, V. C., & Tran, T. N. (2020). Oil price shocks against stock return of oil-and gas-related firms in the economic depression: A new evidence from a copula approach. Cogent Economics & Finance, 8(1), 1799908. https://doi.org/10.1080/2 3322039.2020.1799908

Ogbuabor, J.E., Orji, A., Aneke, G.C., & Erdene-Urnukh, O. (2016). Measuring the real and financial connectedness of selected African economies with the global economy. South African Journal of Economics, 84(3), 384-399.

Pesaran, M. H., & Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. Economics Letters, 58(1), 17-29.

Rastogi, S., Doifode, A., Kanoujiya, J., & Singh, S. P. (2021). Volatility integration of gold and crude oil prices with the interest rates in India. South Asian Journal of Business Studies. https://doi. org/10.1108/SAJBS-02-2021-0074

Salisu, A. A., Oyewole, O. J., & Fasanya, I. O. (2018). Modelling return and volatility spillovers in global foreign exchange markets. Journal of Information and Optimization

Sciences, 39(7), 1417-1448.

Sarwar, S., Tiwari A. K., & Tingqiu, C. (2020). Analyzing volatility spillovers between oil market and Asian stock markets. Resources Policy, 66, 101608. https://doi.org/10.1016/j.resourpol.2020.101608

Sensoy, A., & Sobaci, C. (2014). Effects of volatility shocks on the dynamic linkages between exchange rate, interest rate and the stock market: The case of Turkey. Economic Modelling, 43, 448-457.

Sheikh, U. A., Asad, M., Ahmed, Z., & Mukhtar, U. (2020). Asymmetrical relationship between oil prices, gold prices, exchange rate, and stock prices during global financial crisis 2008: Evidence from Pakistan. Cogent Economics & Finance, 8(1), 1757802-175. https://doi.org/10.10 80/23322039.2020.1757802 ]

Singhal, S., Choudhary, S., & Biswal P. C. (2021). Dynamic linkages among international crude oil, exchange rate and Norwegian stock market: evidence from ARDL bound testing approach. International Journal of Energy Sector Management, 16(5), 817- 833. https://doi.org/10.1108/ IJESM-10-2020-0006

Sobti, N. (2018). Domestic intermarket linkages: measuring dynamic return and volatility connectedness among Indian financial markets. Decision, 45(4), 325-344.

Yilmaz, K. (2010). Return and volatility spillovers among the East Asian equity markets. Journal of Asian Economics, 21(3), 304-313