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Empirical Analysis of the Mode of Payment Systems in the Nigerian Economy
(Pre-Covid-19 Era)

By

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Abstract

The study examines the contemporaneous and spill-over effects of the dominants payment system in Nigerian Economy in Pre-Covid-19 era using an excerpt of the CBN dataset on Cheque, POS and ATM value of transactions spanning through 2009 to 2019 on a monthly basis via the Vector Autoregressive Model techniques.

During the Pre-Covid-19 era, it is discovered that the value of cheque transaction declines at the increase of ATM and POS transactions. Highest transactions across the payment system are associated with December while the least attributed to February on yearly basis over the study period. A long-run dependence is observed with the values of transaction per payment system.

The value of cheque transaction is significantly related to its immediate past and its 3rd lag, there is no form of significant spillover effect of POS and ATM transaction on cheque transaction. Though there is a noticeable decrease in cheque transaction caused by ATM in the previous year as well as the 3rd year while the second year imposes a positive effect. The impact of the immediate past value of ATM transaction on the current is found to be statistically significant and positive; the values of POS transaction in the past two and three years pose negative and positive significant impacts on the value of ATM transaction respectively. Cheque transaction has no significant impact on ATM transaction. POS transaction is significantly impacted by its values in the previous year while a positive impact is associated with its immediate past. The forecast and the forecast error variance are also computed to account for the level of spill-over detected in each payment system transaction value.

Keywords: VAR model, POS, Spill-over, Payment System, Transaction.

Introduction

The mode and manner of transactions by customers to the banking sector have posed a different dimension to the smooth and efficient running of the day to day activities

in the banking sector and somewhat somehow reduce congestion in the banking service inlet. Hence, facilitate less work and reduce stress on the part of the tellers in the banking sector for they have little attention drawn towards withdrawal on the counter and a bit more of deposits: aiding proper and adequate records and account balancing at the close of a work day.

Transactions are rather done online, via USSD, the use of automated teller machine (ATM), Remita and some other modes as the operative banking system permits.

The need to monitor the trend of deposit and withdraw is of importance to see how the recent development and strategies have challenged the conventional means of deposit and withdraw on the counter. This study therefore put forward a way to investigate the spill over as well as the contemporaneous effect of the incorporated new strategies on the convectional strategy (Okifo, J. and Igbunu, R., 2015), Nakajima, M., 2017, Onalo et al, 2021 and CBN. 2019).

Research on withdrawal and deposits in the banking sector have been fully delved into. Majority of such are basically on descriptive statistics and those centered on how some economic variables affects deposit and withdrawal. The value of cheque transactions declined monthly by 12% to 240 billion naira in July, 2022 from its value in June, as the cashless economy policy emerged (Idowu, B., 2022). Over time, POS has affected other form of transaction say cheque negatively, since cheque transactions has been discovered to decline in its conventional use by the customers not highly willing withdraw money within the banking halls. The occurrence of this reached its peak during Covid-19 where all Nigeria Citizens were under lockdown and the only way out for performing transaction using POS from home (Clement P. S., 2022). In 2021, the banking system of Kazakhstan was assessed and finding shows that there is a significant relationship between the amount of non-cash transfers, POS and ATM (Kredina, A., 2021). The relationship between cash supply and the amount of ATM and POS and it is ascertained that the envisioned relationship is significant.

Data and Methods

The data for the study is an excerpt of the Central Bank of Nigeria and span through 2009 to 2019. It is a monthly data on the number of transactions attributed to the different mode of transactions which include Cheque, ATM, and POS in relation to their respective worth of transactions in billions of naira from January 2009 to December 2019 as a result of available data timeline (say, the pre Covid-19 era) where normalcy is observed by both parties in the banking sector.

The convectional payment system mode is identified as the Cheque while ATM, POS, Internet Web and the Mobile Payment are identified as the contemporaneous (Okonkwo, 2018). All the modes tend to have some impacts on one another in terms of transactions either positively or negatively as the case may be.

The method of data analysis for the study entails both descriptive statistics (which include the exploratory data analysis and preliminary analysis for conducting inferential statistics such as the test of stationarity, test of normality and the test of independency) and inferential statistical techniques.

The principal inferential technique for the research is the Vector Autoregressive Model. It is an extension of the Autoregressive distributed lag model though used for the purpose of joint investigation of effects both spill over and contemporaneous on basis of multiple equations. It is the proxy for the simultaneous equation model in the Time series domain Gourieroux, & Jasiak, 2001).

For a stationary VAR model it is of interest to have the vector of series $X_t = (x_{1t}, x_{2t}, \dots, x_{nt})'$, an $(n \times 1)$ vector of the time series observed such that the kth lag model i.e. $VAR(k)$ is given as

$$X_t = \alpha + \mathrm{B}_1 X_{t-1} + \mathrm{B}_2 X_{t-2} + \cdots + \mathrm{B}_k X_{t-k} + \varepsilon_t, \qquad t = 1,2, \dots, T \tag{1}$$

Where B_i are $(n \times n)$ coefficient matrices and ε_t implies an $(n \times 1)$ white noise process with zero mean thus are found to be serially uncorrelated (Shittu, O. I., 2008).

If there exist a $VAR(2)$ model, equation (1) becomes in matrix for as follows

$$\begin{bmatrix} x_{1t} \\ x_{2t} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \begin{bmatrix} \beta_{11}^1 & \beta_{12}^1 \\ \beta_{21}^1 & \beta_{22}^1 \end{bmatrix} \begin{bmatrix} x_{1t-1} \\ x_{2t-1} \end{bmatrix} + \begin{bmatrix} \beta_{11}^2 & \beta_{12}^2 \\ \beta_{21}^2 & \beta_{22}^2 \end{bmatrix} \begin{bmatrix} x_{1t-2} \\ x_{2t-2} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{2}$$

Alternatively,

$$x_{1t} = \alpha_1 + \beta_{11}^1 x_{1t-1} + \beta_{12}^1 x_{2t-1} + \beta_{11}^2 x_{1t-2} + \beta_{12}^2 x_{2t-2} + \varepsilon_{1t}$$

$$x_{2t} = \alpha_2 + \beta_{21}^1 x_{1t-1} + \beta_{22}^1 x_{2t-1} + \beta_{21}^2 x_{1t-2} + \beta_{22}^2 x_{2t-2} + \varepsilon_{1t}$$

With $cov(\varepsilon_{1t}, \varepsilon_{2s}) = \sigma_{12}$ for $t = s$ and zero otherwise.

The seemingly unrelated regression model is a bit similar to the VAR model for each equation has the same independent variables as lagged values of x_{1t} and x_{2t}.

Using Lag operator, the model could be specified as

$$\mathrm{B}(L)X_t = \alpha + \varepsilon_t$$

For; $\mathrm{B}(L) = I_n - \mathrm{B}_1 L - \cdots - \mathrm{B}_k L^k$. And the model becomes stable if the roots of $\det(I_n - \mathrm{B}_1 L - \cdots - \mathrm{B}_k L^k) = 0$ are found outside the complex unit circle with modulus more than one (Hamilton, J. D. 1994).

Data Analysis

Table 1: Descriptive Statistics: Value of transaction by mode of payment**.**

Statistics	**VCT**	**VATMT**	**VPOST**

Minimum	3.365900e+02	18.480000	0.040000
Maximum	3.236850e+03	670.980000	372.690000
1st Quartile	4.554975e+02	129.560000	2.340000
3rd Quartile	1.430118e+03	491.677500	105.535000
Mean	9.147249e+02	298.428182	66.524167
Median	5.746650e+02	298.570000	24.800000
Total Value of Transaction	1.207437e+05	39392.520000	8781.190000
SE Mean	6.093493e+01	16.417857	7.735871
LCL Mean	7.941811e+02	265.949744	51.220769
UCL Mean	1.035269e+03	330.906619	81.827564
Variance	4.901247e+05	35580.076267	7899.367418
Standard Deviation	7.000890e+02	188.626817	88.878386
Skewness	1.323298e+00	0.102285	1.431181
Kurtosis	4.433970e-01	-1.303324	0.953710

The highest value of transaction is attributed to cheque payment system followed by ATM then POS. Among all forms of payment system, less variability is associated with POS transaction. the value of transaction across all the payment system are non-normally distributed since they have skewness and kurtosis values other than 0 and 3 (emblem of positive skewness and kurtosis). ATM is platykurtic in nature.

Exploratory Data Analysis

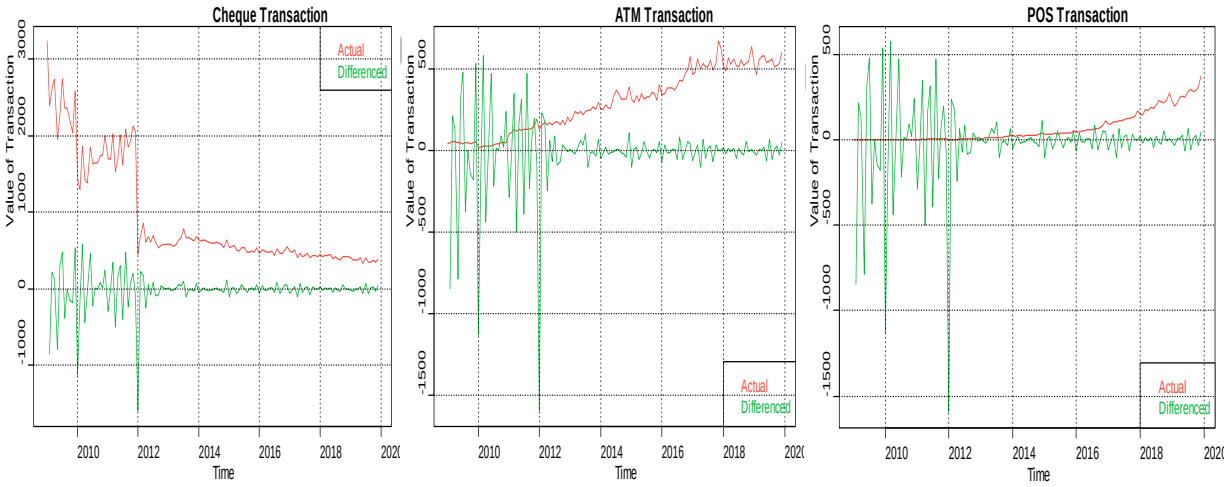


Figure 1: Time plot of the actual value of transaction by Payment System versus their differenced series.
(Source: Central Bank of Nigeria [CBN])

It is observed from figure 1 that the value of transaction via cheque declined over the period of time in the reverse direction to the growth of the value of transaction attributed to Automated Teller Machine (ATM) and Point of Sale (POS) payment system. This is an indication that the

contemporaneous payment systems have some influence on the conventional (cheque) payment system.

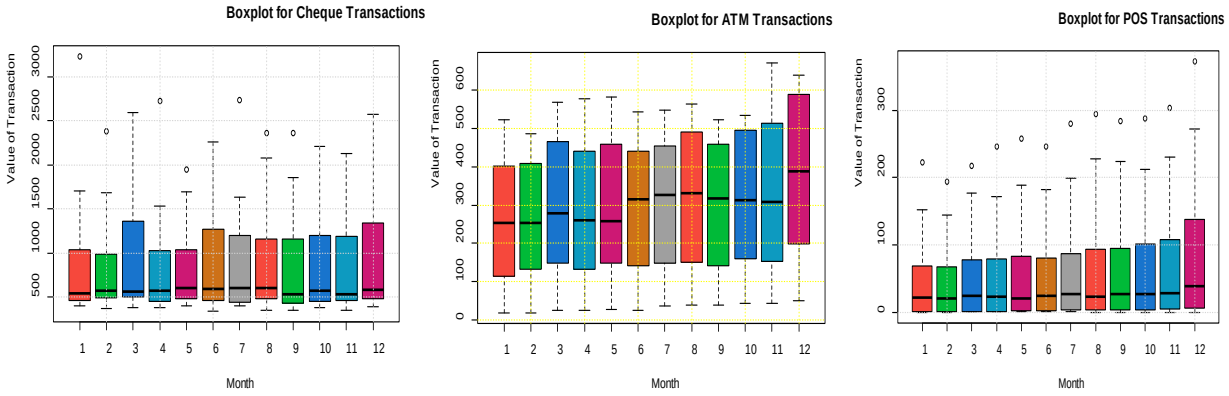


Figure 2: Monthly boxplot of the actual value of transaction by Payment.

The boxplot for the different payment system by month have different growth over the period of study. Highest value of transaction is experienced in December while the minim value of transaction is traceable to February. While there are cases of outliers for cheque and POS transaction, ATM has known on monthly basis. Thus ATM is more consistent as compared to other payment system. On quarterly basis, The first and last quarter have similar attributes while 2nd and 3rd show a different attribute with noticeable upward trend for ATM and POS payment system.

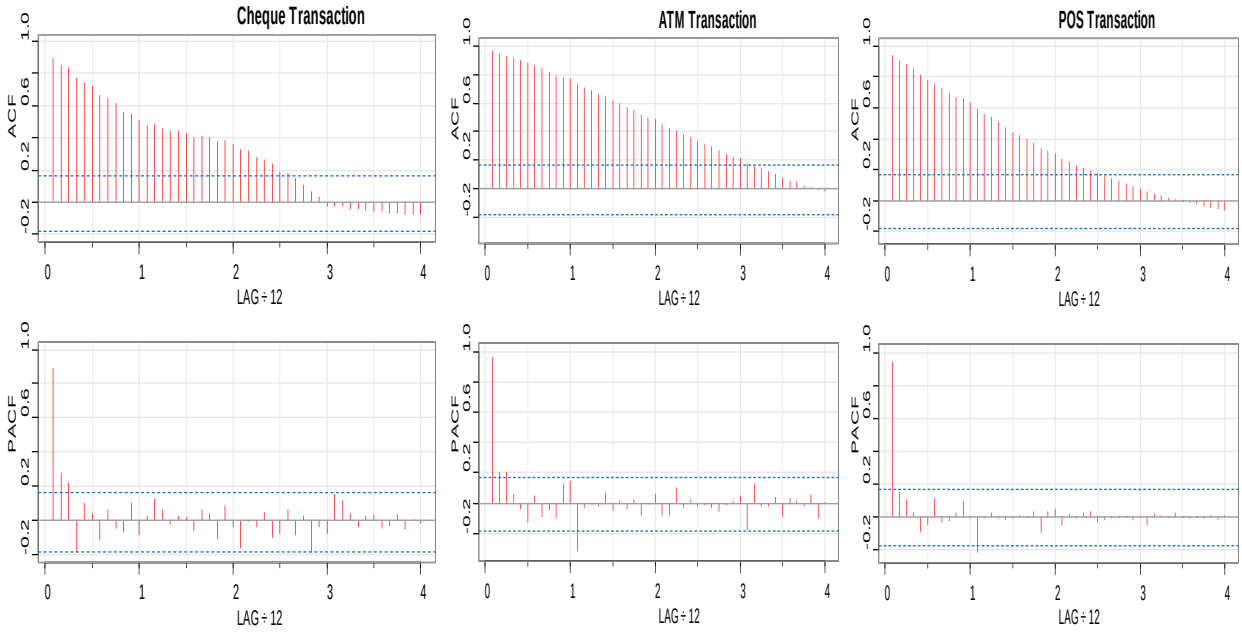


Figure 3: ACF and PACF plot for the value of transaction by payment system.

The acf plot declined slowly to zero reveals a great deal of dependency between the values of transaction given a payment system. Hence there is possibility of predicting the value of transaction at a time point using any value of transaction within the same payment system at ease. For the payment systems, the pacf declined linearly to zero after the second lag except for POS which occurred after zero lag. An autoregressive model of order 2 at maximum is somewhat of suggestion.

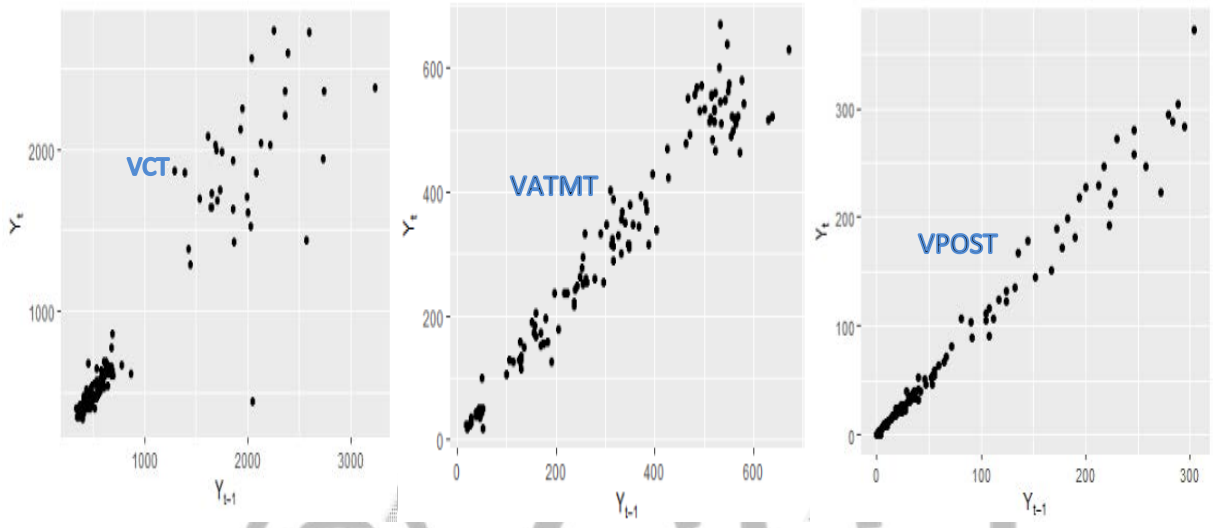


Figure 4: Lag relationship plot

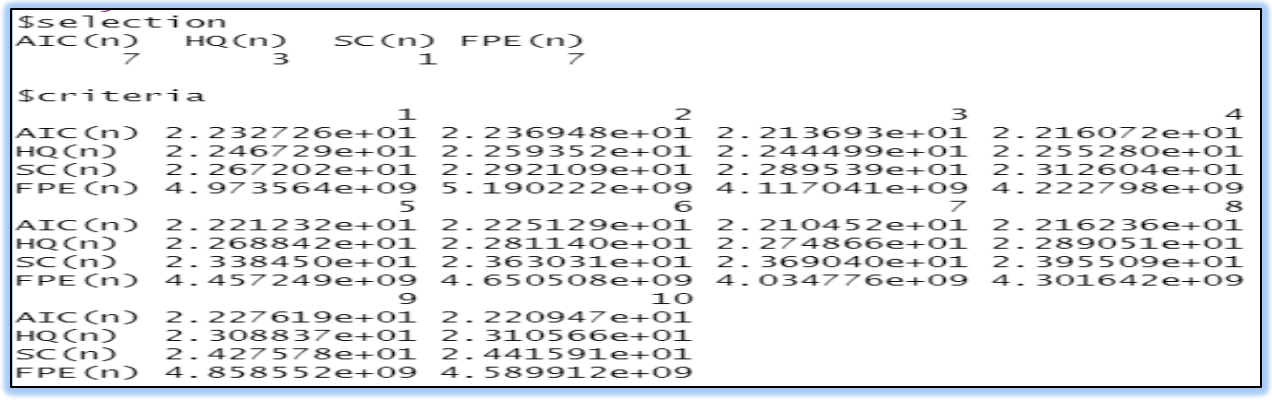
The relationship between the payment system values and their immediate lag is presented in figure 4. It is discovered that for all the form of payment, the values of transaction for given year (current) is positively related to the immediate past (previous). Hence the value of transaction shows a high sense of dependency for each payment system.

Test of Stationarity

Test of Independency

Formal Test of Vector Autoregressive Model

Model Selection



```
$selection
AIC(n)  HQ(n)  SC(n) FPE(n)
     7      3      1      7

$criteria
                 1             2             3             4
AIC(n) 2.232726e+01 2.236948e+01 2.213693e+01 2.216072e+01
HQ(n)  2.246729e+01 2.259352e+01 2.244499e+01 2.255280e+01
SC(n)  2.267202e+01 2.292109e+01 2.289539e+01 2.312604e+01
FPE(n) 4.973564e+09 5.190222e+09 4.117041e+09 4.222798e+09
                 5             6             7             8
AIC(n) 2.221232e+01 2.225129e+01 2.210452e+01 2.216236e+01
HQ(n)  2.268842e+01 2.281140e+01 2.274866e+01 2.289051e+01
SC(n)  2.338450e+01 2.363031e+01 2.369040e+01 2.395509e+01
FPE(n) 4.457249e+09 4.650508e+09 4.034776e+09 4.301642e+09
                 9            10
AIC(n) 2.227619e+01 2.220947e+01
HQ(n)  2.308837e+01 2.310566e+01
SC(n)  2.427578e+01 2.441591e+01
FPE(n) 4.858552e+09 4.589912e+09
```

Figure 5: Model selection

In order to choose the right VAR model, four selection criteria are used – AIC, HQ, SC and FPE. While both AIC and FPE select 7 as the appropriate lags for the model, HQ selects 3 and SC identified 1. To overcome the problem over-parameterization, AIC is considered not worthwhile then HQ is identified as best suited for the VAR model parameter estimation since it is relation to the order suggested by the PAC plot.

Parameter Estimation

Table 1: Model Summary

VAR Estimation Results:
==========
Endogenous variables: VCT, VATMT, VPOST
Deterministic variables: both
Sample size: 129
Log Likelihood: -1939.338
Roots of the characteristic polynomial:
1.038 0.9051 0.7914 0.7223 0.7223 0.6326 0.6326 0.5415 0.5415

The model summary is presented above to have three dependent variables which are Values of transaction for cheque payment (VCT), Value of transaction for ATM payment (VATMT) and Value of Transaction for POS payment (VPOST). 129 observations were entered into the system per variable and the estimated log-likelihood is -1939.338 associated with 9 roots of characteristics polynomial.

Table 2: Estimation results for equation VCT:
==========
VCT = VCT.l1 + VATMT.l1 + VPOST.l1 + VCT.l2 + VATMT.l2 + VPOST.l2 + VCT.l3 + VATMT.l3 + VPOST.l3 + const + trend

Variable	Estimate	Std.Error	t-value	Pr(>|t|)

VCT.l1	0.48394	0.08699	5.563	1.68e-07	***
VATMT.l1	-0.58077	0.73577	-0.789	0.431	
VPOST.l1	1.27779	2.41402	0.529	0.598	
VCT.l2	-0.01152	0.09601	-0.120	0.905	
VATMT.l2	0.34968	0.82288	0.425	0.672	
VPOST.l2	-0.72435	3.16728	-0.229	0.819	
VCT.l3	0.37359	0.08319	4.491	1.66e-05	***
VATMT.l3	-0.05638	0.68471	-0.082	0.935	
VPOST.l3	-0.05821	2.49670	-0.023	0.981	
Const	230.26746	191.18697	1.204	0.231	
Trend	-1.05217	4.32578	-0.243	0.808	

Residual standard error: 208.2 on 118 degrees of freedom
Multiple R-Squared: 0.9045, Adjusted R-squared: 0.8964
F-statistic: 111.7 on 10 and 118 DF, p-value: < 2.2e-16

Table 2 gives the estimates of the value of cheque transaction in Nigeria over the period of study. Result shows that the model explains 89.64% of the variation in the value of cheque transaction. While value of cheque transaction is significantly related to its immediate past and its 3rd lag, there is no form of significant spillover effect of POS and ATM transaction on cheque transaction. Though there is a noticeable decrease in cheque transaction caused by ATM in the previous year as well as the 3rd year while the second year imposes a positive effect. Also the trend of value of transaction becomes negative in the presence of its counterparts prevailing. This effect is not statistically significant.

Table 3: Estimation results for equation VATMT:
==========
VATMT = VCT.l1 + VATMT.l1 + VPOST.l1 + VCT.l2 + VATMT.l2 + VPOST.l2 + VCT.l3 + VATMT.l3 + VPOST.l3 + const + trend

Variable	**Estimate**	**Std.Error**	**t-value**	**Pr(>|t|)**	
VCT.l1	0.002621	0.013445	0.195	0.845765	
VATMT.l1	0.445116	0.113718	3.914	0.000152	***
VPOST.l1	-0.266038	0.373105	-0.713	0.477230	
VCT.l2	0.006897	0.014839	0.465	0.642911	
VATMT.l2	0.137418	0.127182	1.080	0.282130	
VPOST.l2	-1.042420	0.489526	-2.129	0.035295	*
VCT.l3	0.010892	0.012857	0.847	0.398619	
VATMT.l3	0.079306	0.105826	0.749	0.455112	
VPOST.l3	1.098298	0.385884	2.846	0.005219	**
Const	-61.970699	29.549380	-2.097	0.038112	*
Trend	2.446981	0.668582	3.660	0.000379	***

Residual standard error: 32.19 on 118 degrees of freedom
Multiple R-Squared: 0.9726, Adjusted R-squared: 0.9703
F-statistic: 419.2 on 10 and 118 DF, p-value: < 2.2e-16

The parameter estimates of the effect other variables on value of ATM transaction is presented in table 3. It is discovered from the model that value of ATM increase significantly over the years.

The impact of the immediate past value of ATM transaction on the current is found to be statistically significant and positive. The values of POS transaction in the past two and three years pose negative and positive significant impacts on the value of ATM transaction respectively. Cheque transaction has no significant impact on ATM transaction. 97.03% of the variation in the value of ATM transaction is attributed to the model.

Table 4: Estimation results for equation VPOST:

==========

VPOST = VCT.l1 + VATMT.l1 + VPOST.l1 + VCT.l2 + VATMT.l2 + VPOST.l2 + VCT.l3 + VATMT.l3 + VPOST.l3 + Const + Trend

Variable	**Estimate**	**Std. Error**	**t-value**	**Pr(>|t|)**	
VCT.l1	6.775e-04	4.280e-03	0.158	0.8745	
VATMT.l1	-2.323e-02	3.620e-02	-0.642	0.5222	
VPOST.l1	7.974e-01	1.188e-01	6.714	6.99e-10	***
VCT.l2	7.956e-04	4.723e-03	0.168	0.8665	
VATMT.l2	3.259e-02	4.048e-02	0.805	0.4224	
VPOST.l2	-4.058e-01	1.558e-01	-2.604	0.0104	*
VCT.l3	1.713e-03	4.092e-03	0.419	0.6763	
VATMT.l3	-6.368e-02	3.369e-02	-1.890	0.0612	.
VPOST.l3	6.429e-01	1.228e-01	5.234	7.31e-07	***
Const	-1.051e+01	9.406e+00	-1.118	0.2659	
Trend	3.848e-01	2.128e-01	1.808	0.0731	.

Residual standard error: 10.25 on 118 degrees of freedom
Multiple R-Squared: 0.9879, Adjusted R-squared: 0.9869
F-statistic: 961.6 on 10 and 118 DF, p-value: < 2.2e-16

The model for POS value of transaction is given by table 4. Findings show that, no significant impacts of cheque and ATM is found upon POS transaction. POS transaction is significantly impacted by its values in the previous year. While a positive impact is associated with its immediate past, a negative effect is accounted for by its value in past two year then followed by a positive impact in past 3 years. The model explains 98.69% variation. Also the model is generally significant with p-value less than 0.05 level of significance.

VAR Model Diagnostics

Table 5: Correlation matrix of residuals:

	VCT	VATMT	VPOST
VCT	1.00000	0.1994	0.07688
VATMT	0.19937	1.0000	0.58009
VPOST	0.07688	0.5801	1.00000

The residual correlation is shown on table 5. It is discovered that the residuals from the models are posiively correlated. Though a moderate correlation is found for ATM and POS transaction

while the relation between cheque and and either of ATM or POS is very weak. This suggests that there is a relatioship in the values of transasction between POS and ATM.

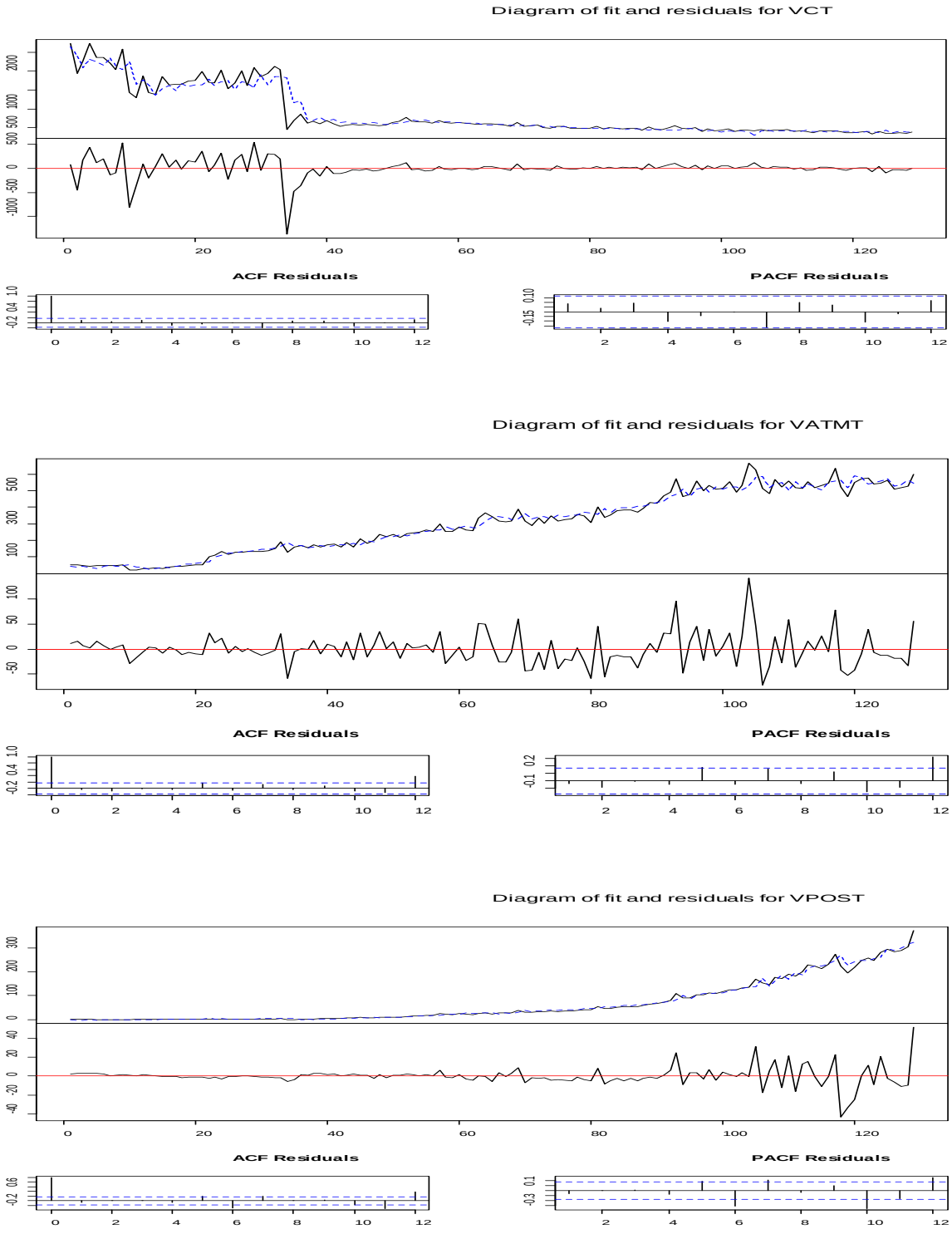


Figure 7: Fit and residual plot

The fit and residual plot indicates that there is corresponding relationship between the value of transaction for ATM and POS payment system. By the introduction of POS and ATM payment system, cheque transaction continued declining while ATM transaction has been growing together with POS transaction.

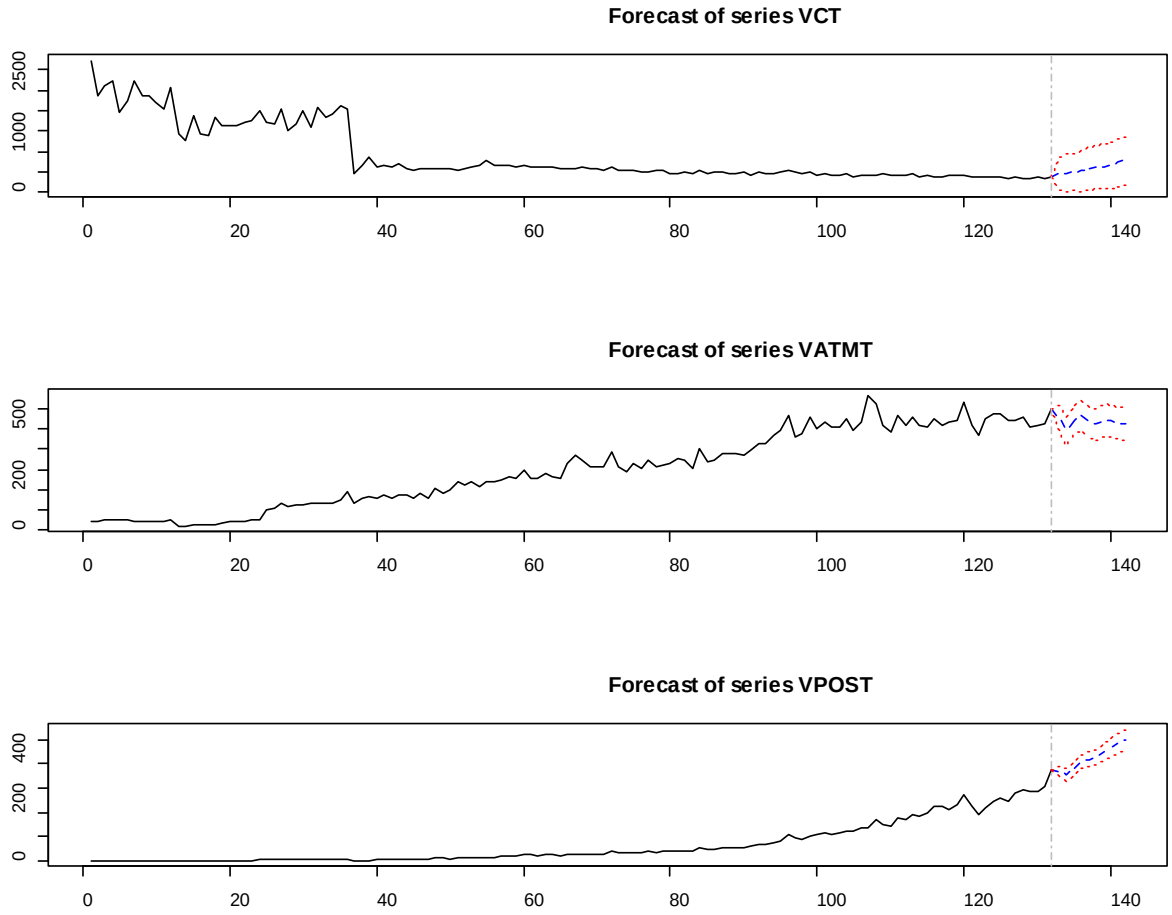


Figure 8: Forecast plot

The forecast plot shows the values of transaction for the next 10 months. Result indicates that cheque transaction would increase somewhat, ATM transaction will maintain some forms of stationarity while a significant increment will be attributed to POS transaction.

Forecast Error Variance Decomposition for 12 Month ahead Prediction

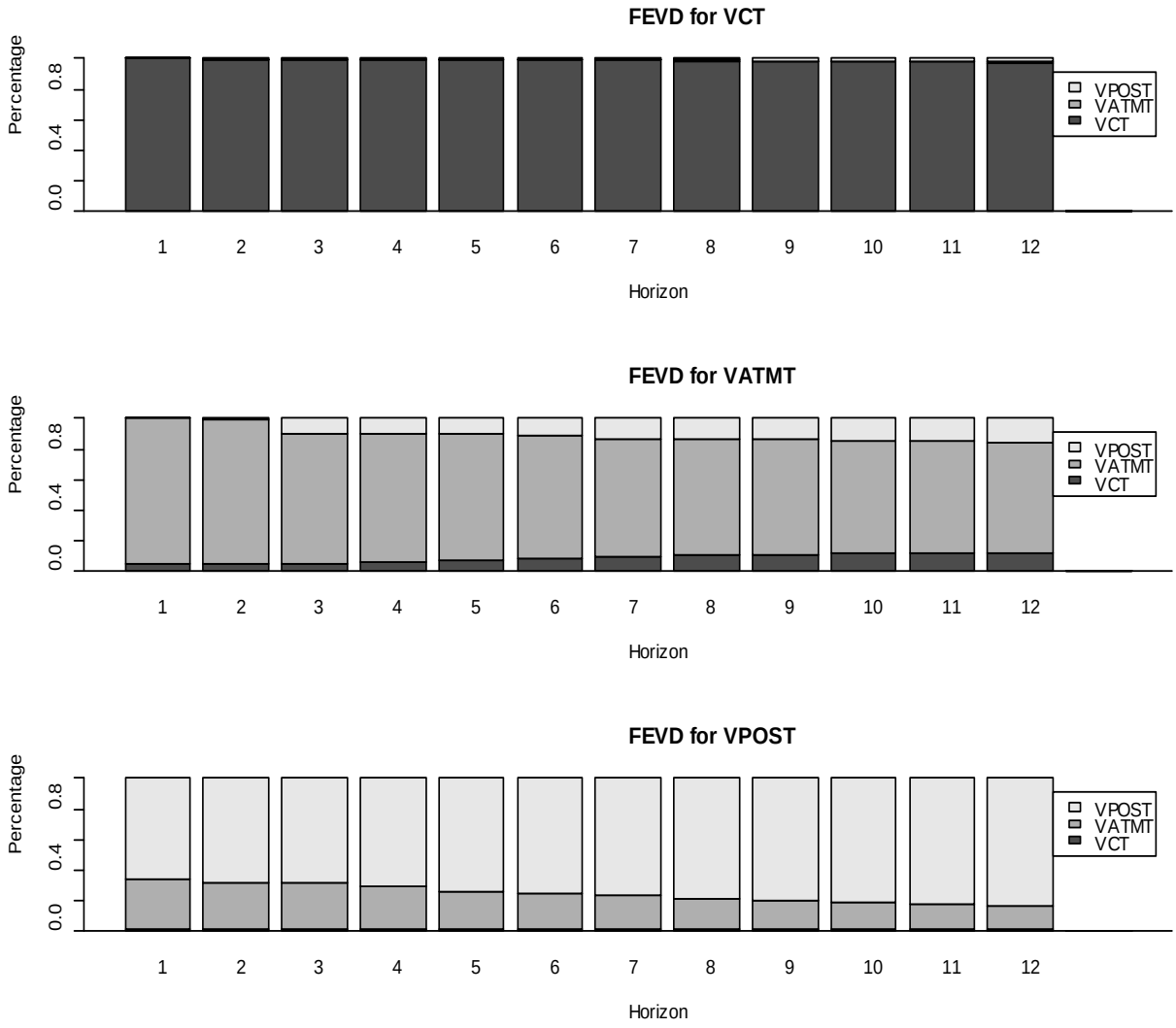


Figure 9: Forecast Error variance decomposition

The plot of the forecast error variance decomposition presents the decomposition of forecast error into the contribution of each exogenous shock. The plot suggests that at the initial time 100% of the variation in cheque transaction is from shocks to the cheque transaction.

For ATM transaction almost 90% of the variation is traceable to shocks from itself with 10% attributed to cheque transaction at the initial time. In the long run, the shock impact of ATM reduces to about 65% while shocks from POS increase gradually to about 18% that of cheque increases to almost 17%.

In terms of the variation in POS transaction, the shocks from POS itself initially is above 60% with remaining contributed by shocks from ATM transaction. In the long run the, the shocks

from POS rises gradually and converges around 80% resulting to reduction in the shocks from ATM transaction at a convergence rate of almost 20%. Cheque has no impact on POS transaction.

Table 6: Forecast Estimate and Interval

VCT	**Point Forecast**	**Lo 80**	**Hi 80**	**Lo 95**	**Hi 95**
Jan 2020	461.8421	194.9611	728.7232	53.68278	870.0015
Feb 2020	482.5809	186.9548	778.2070	30.45975	934.7021
Mar 2020	500.4884	198.9083	802.0686	39.26145	961.7154
Apr 2020	529.8734	203.0668	856.6800	30.06580	1029.6810
May 2020	576.7502	233.1946	920.3058	51.32727	1102.1732
Jun 2020	618.1483	267.0509	969.2458	81.19113	1155.1055
Jul 2020	643.6105	283.2940	1003.9271	92.55398	1194.6671
Aug 2020	680.9930	312.4674	1049.5186	117.38171	1244.6043
Sep 2020	729.7434	355.7342	1103.7525	157.74570	1301.7410
Oct 2020	770.4378	391.4323	1149.4432	190.79888	1350.0766
VATMT	**Point Forecast**	**Lo 80**	**Hi 80**	**Lo 95**	**Hi 95**
Jan 2020	553.0649	511.8165	594.3134	489.9809	616.1490
Feb 2020	491.0109	446.4961	535.5257	422.9314	559.0904
Mar 2020	547.5625	500.4246	594.7003	475.4713	619.6536
Apr 2020	570.7215	521.9572	619.4858	496.1429	645.3001
May 2020	532.5719	482.6669	582.4770	456.2487	608.8952
Jun 2020	526.2214	475.4364	577.0064	448.5524	603.8904
Jul 2020	544.4447	492.7127	596.1767	465.3274	623.5619
Aug 2020	542.4643	490.2936	594.6350	462.6761	622.2525
Sep 2020	530.4545	477.8946	583.0144	450.0711	610.8379
Oct 2020	528.8183	475.7381	581.8986	447.6391	609.9976
VPOST	**Point Forecast**	**Lo 80**	**Hi 80**	**Lo 95**	**Hi 95**
Jan 2020	370.9231	357.7934	384.0529	350.8429	391.0033
Feb 2020	355.1595	338.6812	371.6379	329.9581	380.3610
Mar 2020	383.3658	366.5683	400.1633	357.6763	409.0553
Apr 2020	411.4274	393.5276	429.3272	384.0520	438.8028
May 2020	417.9353	397.7049	438.1658	386.9955	448.8752
Jun 2020	428.3814	406.7305	450.0323	395.2693	461.4935
Jul 2020	450.0401	427.3912	472.6890	415.4016	484.6786
Aug 2020	469.5701	445.5374	493.6028	432.8152	506.3250
Sep 2020	484.6157	459.0027	510.2287	445.4439	523.7875
Oct 2020	502.1571	475.1595	529.1548	460.8678	543.4464

The estimates of the 10 months forecast are given in table 6. It is shown that cheque transaction will continue to increase alongside POS values of transaction while value of transaction for ATM will decrease over time.

Discussion/Findings/Conclusion

Findings from the study have shown that cheque transaction has the highest value of transaction in the pre-Covid-19 era. The minimum value of transaction at a time period referenced is associated with POS transaction. All contemporary form of payment system are found to possess a positive trend at the decline trait of the conventional payment system (Cheque) suggesting non-stationary series.

The highest value of transaction is usually attained in December across all forms of payment system while the minim value of transaction is traceable to February. While there are cases of outliers for cheque and POS transaction, ATM has known on monthly basis. Thus ATM is more consistent as compared to other payment system. On quarterly basis, the first and last quarter have similar attributes while 2nd and 3rd show a different attribute with noticeable upward trend for ATM and POS payment system. Also revealed from the study is high level of dependence in each of the payment system values of transaction over time as depicted the ACF and PACF plots.

The lag relationship plots indicate linear positive relationship between the series and their immediate past. Considering the VAR models, it discovered that while value of cheque transaction is significantly related to its immediate past and its 3rd lag, there is no form of significant spillover effect of POS and ATM transaction on cheque transaction. Though there is a noticeable decrease in cheque transaction caused by ATM in the previous year as well as the 3rd year while the second year imposes a positive effect. Also the trend of value of transaction becomes negative in the presence of its counterparts prevailing. This effect is not statistically significant. The impact of the immediate past value of ATM transaction on the current is found to be statistically significant and positive. The values of POS transaction in the past two and three years pose negative and positive significant impacts on the value of ATM transaction respectively. Cheque transaction has no significant impact on ATM transaction. 97.03% of the variation in the value of ATM transaction is attributed to the model.

No significant impacts of cheque and ATM are found upon POS transaction. POS transaction is significantly impacted by its values in the previous year. While a positive impact is associated with its immediate past, a negative effect is accounted for by its value in past two year then followed by a positive impact in past 3 years. The model explains 98.69% variation. Also the model is generally significant with p-value less than 0.05 level of significance.

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