Dynamics of Heteroscedasticity Modelling and Forecasting of Tax Revenue in a Developing Economy: A Review

Baba Gimba Alhassan, Fadhilah Binti Yusof, Siti Mariam Norrulashikin, Ibrahim Lawal Kane

Abstract: Tax revenue modelling and forecasting is very crucial for revenue collection and tax administration management. The dynamics of heteroscedasticity in the financial time series (tax revenue) in the domain of technique used to model and predict tax revenue in the emerging economy threw us to this investigation. The reviews are categorized into two the tax revenue and stock exchange index. Five factors were considered in this studies modelling, forecasting, linear model, nonlinear model and heteroscedasticity, it is on this note that we syntheses over 75 studies from the literature to consider the pattern of reporting tax revenue and stock market index. Thus, from the reviewed literature, we inferred that the pattern of reporting tax revenue data and the analytical techniques employed by most of these studies are responsible for the instability (volatility) in the financial time series forecasting. Also, results revealed that linear models are mostly applied to tax revenue data with fewer non-linear models, while combination and single non-linear models were mostly used for stock exchange data. Thus, we recommend the combination of linear and nonlinear models for both tax revenue and stock exchange data which can minimize the error of heteroscedasticity in the forecasting of tax revenue in a developing economy.

Keywords: Heteroscedasticity, Financial time series, Modelling, and forecasting,

I. INTRODUCTION

The challenges of heteroscedasticity persistence which is not clearly defined either from the data or the methodological approach (technique) used for the analysis, either from the angle tax revenue and stock market index data., Meanwhile, research on heteroscedasticity of the financial time series modelling and forecasting has drawn a lot of attention by the researchers in recent times. Tax revenue heteroscedasticity consists of revenue variability during the process of the business cycle [1, 2]. It has become an area of interest for fiscal administrators and policymakers working inside the framework of secured budget desires [3, 4]. It's quite challenging to make a precise forecast for prospect tax revenue for establishing long-term monetary policies for steady procedures of government programs and service areas [5, 6]. With the world economy being opened and extra firmly linked, the tax situation of governments has been progressively volatile and unclear over the previous years, for these reasons it has become difficult predominantly for countries working underneath the established control of stable budget requirements for financial planning and management [7-9]. The main effect of tax revenue volatility is the lack of sufficient monetary reserves for government finance [8, 10, 11]. Similarly, Crotty [12]it is difficult for a government that has a volatile revenue base to escape huge expenditure slashes and tax slogs in eras of a financial predicament when states experience hostage to fortune recurrent monetary actions are required particularly. Head and Alford [13] An additional effect is that pro-cyclic severity methods which touch actual economies, falling households and productions' tendency to inject and subsequently building the nasty circle of monetary depression Green, King [14]. Seizing revenue explosiveness is very vital Raddats and Zolkiewski [15]. Observing at the perception of future planning and wish to resolve the structure of the revenue sources which we depend on to make available adequate revenue for all crucial government services [16, 17], they have to reflect both the average rate of progress of the revenue bases and heteroscedasticity also on the economic growth [18, 19]. Besides, revenue instability might be utilized as an independent variable in emerging and considerate regarding the former conclusions for examples of the revenue organizations, the use of wet days' reserves, or government deriving developments amongst others Arik, Clark [20]. The research was executed on the significance of observing tax revenue portfolios plus fiscal conditions in defining the development rate and heteroscedasticity of government tax revenue [21-24]. The tax revenue and government tax portfolios were constructed using tax revenue data from 1981-2017 and graphical presentation with different proportional analysis of the short-run volatility and long-run growing in percentage variations. There's wide-range of variations among the states from the results of our findings and other results proposed that government cannot modify the principal economy structure but can allay the effects of commercial phase on their economic circumstance in the short-run by deviating from their tax portfolios [25-28].

Baba Gimba Alhassan1*, Department of Mathematical Sciences, Universiti Teknologi Malaysia (UTM), 81310 Johor Bahru, Malaysia. And Department of Statistics, School of Applied and Natural Sciences Federal Polytechnic Bida (FPB) Niger State Nigeria. Email: Baba.Alhassan@fedpolybida.edu.ng

Fadhilah Binti Yusof, Department of Mathematical Sciences, Universiti Teknologi Malaysia (UTM), 81310 Johor Bahru, Malaysia. Email: fadhilahy@utm.my

Siti Mariam Norrulashikin, Department, Name of the affiliated College or University/Industry, City, Country. Email: xyz3@blueeyesintlligence.org. Email: sitimariam@utm.my

Ibrahim Lawal Kane, Department of Mathematics and Computer Science, Umaru Musa Yar'adua University, Katsina State, Nigeria. Email: ibrahimlk131@gmail.com

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The importance of tax analysis and forecasting to provide the directions so as to augment tax revenue, improve equity and proficiency of taxes encouraging investment and subsequently observe the procedures and budget planning [29, 30]. Shravani and Kumar [31] studied the evidence on the correlation amongst financial development and economic growth of northern Indian selected states: utilising panel vector error correction model (VECM) their outcomes indicated the existence of causality and cointegration amongst indicators of growth and financial development of the economy. Their study uncovering bi-directional correlation successfully amongst them (variables). Banking sector in an emerging economy like India plays essential portion for financial sector. It also explains the resource wrapper establishing the source for efficient medium-term and long-term plan.

Macroeconomic research and multivariate time series modeling became critically interlinked after the publication [32, 33] by Sims (1980). In the public sector budgeting revenue forecasting is very vital. Hence, it becomes necessary for the government to project the tax revenue collection for future development purposes [34, 35]. In recent times uncertainties of the budget have led to economic reliance by the state on revenue forecast [36, 37]. There is numerous fiscal challenge many states are facing which has taken a central role by the policymaker [38, 39]. Examine revenue forecast and accuracy is essential, to improve on these analysts requires much data about the state of the economy including both formal and informal [40, 41].

1.0. 1.0 Tax Revenue

Similarly, Agnirup [42] examines the understanding of the short-run relationship amongst the growth in emerging economies and stock market to clarify the strong positive relationship among booms and busts of the stock market, declines and rises in real per capital growth rates in developing economies. He showed in the first scenario that, growth enhancing productivity shock increases market capitalization ratio in the short run and secondly, positive demand shock increases short-run growth. Kithure, Waititu [43] Forecasted and modeled Instability of VAT (Value Added Tax) Revenue in Kenya using ARIMA (3,0,3) and ARIMA model and found that VaR at 1.45% and 1.49% which is 95% and 99% respectively, whereas the expected shortfall (ES) at the intervals of 0.04% and 0.1%. However, there are two issues observed in this study, the model used and data which cannot capture the volatility and insufficient data to make a conclusion for the study, since there are more multivariate time series models that can achieve better.

ARIMA models performance on the VAT collection return display in Figure 1. and the model validation is also display in figure 2 for the Kithure et al., (2020) studies.prepared as per journal the template. 3. Contents of the paper are fine and satisfactory. Author (s) can make rectification in the final paper but after the final submission to the journal, rectification is not possible.
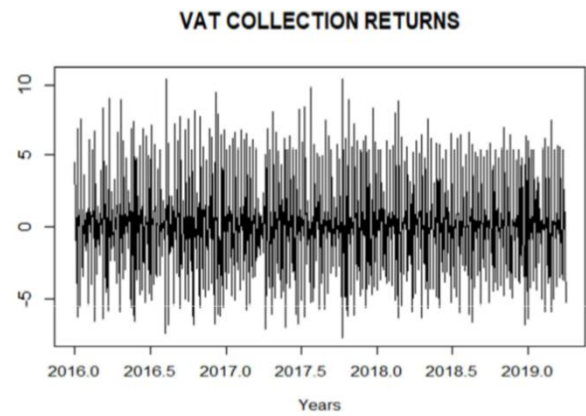
Figure 1. A plot of daily VAT returns, Kithure, Waititu [43]
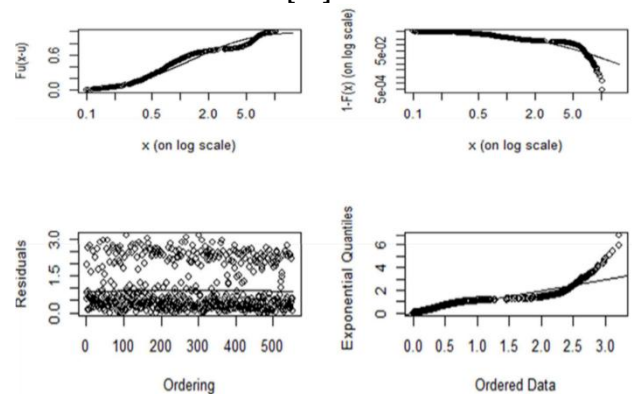
Figure 2. GPD Model Validation Plots, Kithure, Waititu [43]

Cameron, Spyropoulos [49] focus on the residential and also look at the multiplicity of revenue forecasting methods which they pointed out that there is a significant variation in "consensus forecasting" practices. Maulia, Miftahuddin [45] forecast inflation rate and tax revenue using VECM model with optimal lag and shows that this Model (VECM) with 3rd optimal lag or VECM (3) is incomparable technique for the data of inflation rate and revenue taxes in Banda Aceh City. Moreover, Moses, Afees [46] used ARIMA and AFRIMA and proposed a supply side augmented Phillips curve for an oil-dependent (Nigerian) economy and the Improvement of Nigeria's Inflation rates with Oil Price. Their studies reveal that the choice of estimator does matter for Nigeria inflation rates, whether out-of-sample or in-sample and the WN estimator is favoured, especially, when related with ordinary least squared (OLS) estimator. Besides, this study is limited to only one independent variable which is not enough to justify the research and instability was not considered at all.

López and Vasco [47] utilizing principal component analysis and transfer functions to impose parsimony and determine macro-economic indicators to execute a short-term predicting model for (VAT) revenue to shun multicollinearity challenges with least information loss, the output factors obtained from the dimension reduction technique were highly significant as explanatory variables in the transfer function. This piece considers only the multicollinearity without a proper forecast model to establish the contribution of the pre-processing model (PCA).

Streimikiene, Ahmed [48] apply Autoregressive model (AR with seasonal dummies), ARIMA, and the Vector Autoregression (VAR) model for fiscal year 2016–17 forecast for tax revenue of Pakistan revealed that among these models the ARIMA model offers better-predicted values for Pakistan total tax revenues. The study used the conventional method and did not consider instability in the data. The tax base methods for evaluating the distribution of housing price and applied tax rates to univariate time series approaches and multivariate econometric models which include Bayesian techniques, dynamic factor modeling, computable general equilibrium models, techniques to anticipate turning points and forecasting the tax take directly. The study concentrates on the ability of the forecasting model but, the study requires more than that since heteroscedasticity also exists in the data. Anderson and Johnson [50] used univariate time series model to analyze the revenue assortment of Customs, Excise and Preventive Service (CEPS) from 2008-2012 to develop a practically accurate prediction for each tax components their study reveals that both the quadratic trend model and the growth curve model have the smallest accuracy ratio as compared to the linear trend model.
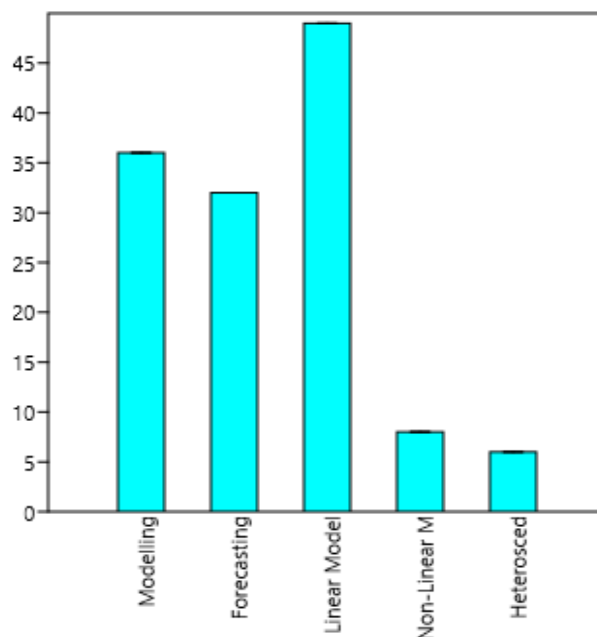
Table 1 Tax Revenue Synthesis

Parameters	No	Publication
Modelling	36	[1],[2],[3],[5],[6],[7],[9],[12],[13],[14],[16],[17],[18],[19],[20],[21],[22],[23],[24],[25],[26],[27],[28],[32],[33],[38],[39],[42],[43],[47],[49],[57],[58],[61],[62],[63]
Forecasting	32	[3],[4],[5],[8],[10],[11],[15],[16],[17],[29],[30],[34],[35],[36],[37],[40],[41],[43],[48],[49],[50],[51],[52],[53],[54],[55],[56],[57],[58],[61],[62],[63]
Linear model	49	[1],[2],[3],[4],[5],[6],[8],[10],[11],[13],[15],[17],[18],[19],19],[20],[21],[22],[23],[24],[25],[26],[27],[28],[29],[30,[31],[32],[33],[34],[35],[36],[37],[38],[39],[42],[43],[44],[45],[50].[52],[53],[57],[58],[61],[62],[63],[64]
Non-linear model	8	[6],[7],[9],[12],[14],[47],[50],[55],
Heteroscedasticity	6	[2],[12],[14],[15],[18],[19]

Figure 3. shows the bar Plots Modelled parameter

Table 1 indicates the broad view of the reviewed literatures for the tax revenue with the following factors modelling, forecasting, linear model, nonlinear model and heteroscedasticity on the recent literatures there's a clear trend that linear model is always utilized for modelling and forecasting tax revenue meanwhile nonlinear models and heteroscedasticity were not considered much. Figure 3 shows vividly with over 85% of the literatures accounted for linear models as indicated in the bar plot for modelling and forecasting and nonlinear model and heteroscedasticity has the lowest bar meaning that they are not much put into consideration. Cyril [51] Forecasted Tax Revenue and its Instability using different techniques ARMA, combined forecast, and GARCH models he found the instability to be on a steady increase over time, though with a tenacious instability they suggest the expansion of the tax base to increase the values of commercial activities. And reduced the informal sector and improve the implementation to bring more people in the tax net. Deskar-Škrbić, Šimović [52] analyzes the effects of various structural characteristics of the economies on the efficiency of government consumption in the Central Eastern and Southeastern European region (CESEE) using the panel VAR model with exogenous variables their study shows that fiscal policy plays a vital growth role in the CESEE region as the rise in government spending has a positive and relatively strong (the fiscal multiplier around 0.8) effect on economic growth. But the nature of the data requires more than that because if the past studies reveal similar challenges then there should be away forward to address the issue that is the need to process before forecasting. Firdawss and Karim [53] used the Vector error correction model (VECM) to forecast Moroccan Tax Revenues and was able to apply a co-integration approach to grip stationarity crises.

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Their research inferred that the accuracy of the forecast depends mainly on the knowledge and the proficiency of the researcher who runs the analysis. Franklin, Bourdeaux [44] reviewed the discussion on the budget practices around revenue forecasting and the diversity of the forecasting processes. They observed that every forecast faced a significant challenge, irrespective of the methodology or the process around the forecast. More so the reviews in this paragraph validate the ability model but couldn't check the dimensionality in the data.

Umar, Derashid [54] examine the problems in the collection of tax revenue in emergent nations using the carrot/stick method identify key factors that affect tax revenue, to classified the main issues under a carrot/stick method found that socioeconomic condition, civil commitment, and tax service quality has constitute the carrot approach whereas the stick aspects constitute the audit and sanction. They contend that the approach of carrot and stick can be one of the best technique to optimized the tax revenue problems in the emerging economies. Williams and Calabrese [55] assessed the extent of the up-to-date forecast literature as it correlates to public budget makeup and identifies a number of areas where forecasting literature requires attention. Nonetheless, the study did not really specify the model adopted in the literature thus, the study inferred the weaknesses of the forecasting errors that account for mostly the prediction.

Shahnazarian, Solberger [56] used a Bayesian Vector Autoregression (BVAR). to offer a background that links the decomposition of macroeconomic predictions to corporate tax revenues, through commercial incomes. Meanwhile, the quarterly predictions perform well for surplus net operations, believing that the accuracy in the annual predictions for corporate tax revenues and net business income will hangover to larger samples (tax areas). Lütkepohl and NetŠunajev [57] examines the several volatility techniques and highlights the gains and minuses with structural VAR models which reveals that restrictions were previously used in identifying the shocks which has been identified in a standard structure and properly verified contrary to the data and mostly rejected by volatility models. These also did not consider the issue of dimensionality or multicollinearity in the data.

Hassan [60] used Regression technique of Ordinary Least Square (OLS) to studies literature extensively, pondering on empirical and theoretical studies, upon the relationship amongst the VAT revenue and economic growth. He reveals that there is a strong and positive relationship indicating that VAT revenue has a strong and positive influence on the economic development (GDP) in Pakistan. However, there's an increase of 0.24% of the nominal growth of GDP whenever VAT revenue increases by at least 1% in Pakistan. Brun and Diakité [58] assessing countries with non-resource VAT's tax prospective and tax prospective individually, using a stochastic frontier model which shows that, there is always a realistic decline whenever the tax effort is high in the low income countries within the period the resource depending countries are in shamble. Conversely, these studies have a good result with a low percentage of tax avoidance but multicollinearity and heteroscedasticity were not in their consideration.

Adejare [61] applied Multiple regressions to examines the effect of VAT on the Nigeria economy and reveals that aggregate consumption effect on income is clearly negative since the rise in the VAT rate decreases people's dispensable income and suggested that the government should supervise the collection of VAT to ensure orderly, fair and equitable dealings in collecting VAT revenue and to forestall illegal deals by privilege insiders in order to raise the revenue accrued by this tax as effectively and efficiently as possible. Egbunike, Emudainohwo [62] Study revenue taxes and economic growth in Ghana and Nigeria using multiple regressions and their result shows a positive impact of tax revenue on their gross domestic product (GDP) with the recommendation that, if adequate measures were structured there will be effective tax utilization that will yield more revenue. Thus, the two studies in this paragraph shows the insufficiency of the data to be able to justify the ability of the models and also there's no model checking parameter to ascertain the efficacy of the model.

Ifere., Eugene Okoi [63] worked on revenue generation, tax innovation, and tax administration a case of Cross river state in Nigeria. Their investigation reveals an inefficiency in the administration of taxes. With a recommendation that, there should be a time lag for the updates and review of tax policy that will earn improvement and efficiency in the administration of taxes. 64] projected Philippines income tax revenue for the fiscal year 2014-2020, utilizing ARIMA model for mathematical model improvement. Their results infer that a cointegration occurs among the variables, signifying a long-run relationship. And the outcome also reveals that there exists an uni-directional relationship between the Dependent and Independent Variables.

Reviews on Stock Exchange

Chowdhury., Chakravarty [65] make a Short-Term financial time series forecast, they utilized the integration of principal component analysis PCA and independent component analysis ICA with support vector regression SVR. The results reveal that the proposed model (PCA-ICA-SVR) surpass the three other model compared with (i.e. PCA-SVR, ICA-SVR and single SVR) methods, they infer that clinching PCA and ICA can effectively explain the influential data and as well improve the SVR performance in stock price prediction. Thus, the proposed model was only used for the short-term forecast in which they did not considered the medium and long-term forecast using the proposed model. Tang, Pan [66] combined computational intellect model known as PANK model for financial time series forecasting i.e. applied PCA to reduce the redundancy information in the data, using affinity propagation clustering (APC) for breeding paradigms and consistent clusters as feature mining, and a nested reformulation of k-Nearest Neighbor for forecasting their studies revealed that the PANK model performance better compared to other KNN allied models, and results also indicates that about 0.80 success rate has also improves the novel KNN to a modified Nested KNN which has the ability to hold a bulky quantity of estimations and imbalances.

Tang and Lin [67] Hybrid Quantitative Method on Stock Selection Basis using quantum genetic algorithm RF-QGA-SVR Their studies show that the stock selection with RF feature optimization is much better than the stocks exclusive of optimization characteristic. Tealab, Hefny [68] examine the non-linear time series models forecasting employing recurrent neural network RNN model and autoregressive neural network ARNN model, their experimental results indicate the inability of these models RNN and ARNN to tackle the behavior of a non-linear time series data, there's the need for an artificial neural network model.

Grigoryan [69] applied Independent Component Analysis (ICA) and Support Vector Machines (SVM) to examine the stock market prediction based method their study shows that the hybrid of SVM and feature selection technique methods are effective technique for the stock market forecast. Besides, the application of the pre-processing technique on the data yields a better result. Gupta, Pratama [70] used Twin support vector regression (TSVR) to forecast the instability and non-stationarity in the data for stock exchange index.
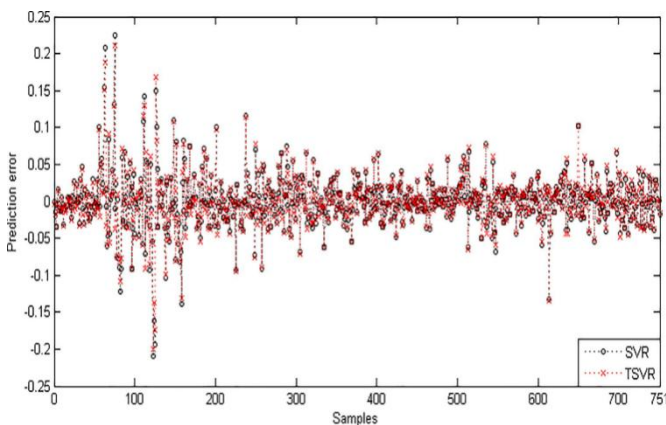
Fig 4. The plot of Prediction error using a linear kernel on the SHI dataset, Gupta, Pratama [70].

Their studies reveal that the TSVR can treat the data and make computation time four times faster in learning speed while compared to the usual SVR. Huberman [71] compares functional time series and grouped multivariate forecasting on annuity pricing using the functional time series model with Lee-Carter model their result inferred that combination of both model has improved the error performance, although they conclude that, the Lee-Carter method does not surpass functional time series method in terms of forecasting. Tran, Iosifidi [72] used neural network with a layer architecture which integrates the concept of a bilinear forecast along with an interested mechanism that aids the layer to identify and concentrate on spatial information. Their studies reveal that two-hidden-layer network with the proposed layer network surpasses most of the existing state-of-the-art network results. Nahila and Lyhyaouia [73] forecasted stock market price for short-term utilizing kernel PCA and SVM. Their study verifies the accuracy and effectiveness of the proposed techniques through the integrated model performance that utilizes KPCA and SVR which performs better significantly than the usual standard SVR model.
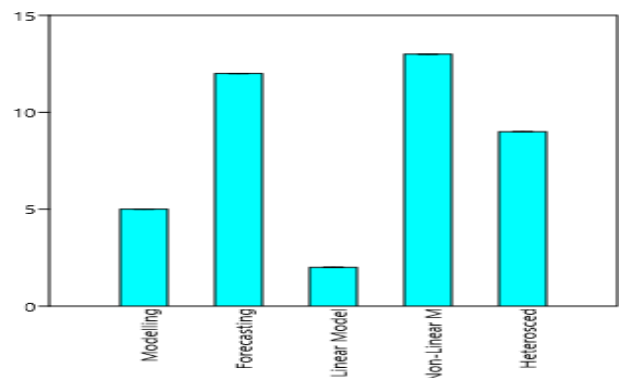
'Nahila and Lyhyaouia [73] used kernel principal component analysis and support vector machines: to make a

Short-term forecast for Casablanca stock exchange, their study reveals that the integration models of KPCA and SVR significantly performs better while compare to single model of SVR. Bezerra and Albuquerque [74] study the volatility forecast thru SVR–GARCH and a blend of Gaussian kernels models, their experimental results show that out-of-sample forecasts indicate that the model SVR–GARCH combine with Gaussian kernels improves the instability forecasts and confine the behavior of regime-switching changes. Kuang, Xu [75] hybrid KPCA and SVM with GA model for interface detection, their empirical results reveals that the classification accurateness of their proposed KPCA SVM techniques are exclusive to the forms of SVM classifiers that their parameters are selected randomly.

Zhong and Enke [76] apply PCA with kernel-based principal component analysis (KPCA) and fuzzy robust principal component analysis (FRPCA), for dimensionality reduction to predict daily stock market return, the outcome of their study shows that the hybrid of ANN with the PCA offers little different in classification accuracy compared to other hybrids under investigation. Xi, Muzhou [77] optimized generalization of neural network architecture for overfitting, their studies reveal that the real-world challenges on stock market closing price with skipping cutoff has been raised and confirmed the inaccuracy of the theory on the stock price index behavior. Dai, Wu [78] hybrid neural network and nonlinear independent component analysis to predict Asian stock market indexes in order to improves the prediction accuracy of neural network approach for the stock exchange market. On their study attention was concentrated on the model performance ability living data and forecasting accuracy unpredicted.

Table 2 Reviewed papers on stock exchange studies

Parameters	No	Publication
Modelling	5	[70],[71],[73],[[80],[82]
Forecasting	12	[65],[66],[67],[68],[69],[70] [71],[73],[76],[79],[80],[81]
Linear model	2	[62],[72]
Non-linear model	13	[65],[66],[68],[69],[70],[71], [72],[73],[76],[79],[80],[81], [82],
Heteroscedasticity	9	[69],[70],[71],[73],[76],[79], [80],[81],[82],

Figure 5: Show the bar plot for modelled factors of Stock exchange data

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Table 2 reveals the overview of the studied literature on stock exchange index. With over 80% of the literatures on stock exchange index utilized nonlinear model for forecasting stock price index with consideration for heteroscedasticity in the data. Moreover, only few literatures considered linear model and modelling the stock index data. The bar plot in figure 5 shows clearly the information in table 2 with nonlinear model having the higher bar and linear model has the lowest bar Figure 5: Show the bar plot for modelled factors of Stock exchange data Chowdhury [79] integrates PCA and SVR to forecast financial time series their empirical results showed that PCA can effectively reveal the influential data and also process the data in order to improve the predicting accuracy of SVR. Corrêa, Neto [80] propose an performance accuracy and prediction improvement by wavelet autoregressive integrated moving average with exogenous variables and generalized auto-regressive conditional heteroscedasticity (WARIMAX-GARCH) methods their experimental results inferred that the WARIMAX-GARCH technique yields a better prediction outcome compared to individual models of ANN and W-ANN approaches. Cortez, Saydama [81] focuses on the combination of chaos theory CT and machine learning ML to acquire a genuine sign of MC market behavior to forecast long-term price trends, they observed that none of the proposed innovative methods whether ML or CT could be distinctly and wholly utilized for long term MC prices forecasting. Therefore, it is important to know the model that yield a better result.

II. DISCUSSION OF RESULTS

Kithure, Waititu [43] Forecasted and modeled the instability of VAT revenue in Kenya using ARIMA. Cyril [51] forecasted tax revenue and its instability using different techniques ARMA, hybrid forecast models, and GARCH models. Streimikiene, Ahmed [48] apply Autoregressive model (AR with seasonal dummies ARIMA and VAR to forecast volatility in the tax revenue data in Tanzania. Cameron, Spyropoulos [49] reviewed tax revenue, forecasting models. Anderson and Johnson [50] used univariate time series model to analyzes the revenue assortment of the customs, excise and preventive service (CEPS) for the period 2008-2012. Firdawss and Karim [53] used the Vector error correction model (VECM) to forecast Moroccan Tax Revenues and its heteroscedastic. Gupta, Prathama [70] used Twin support vector regression (TSVR) is to forecast the instability and non-stationarity in the data. Hafner, Herwartz [84] used Structural multivariate GARCH models to proposes a loss statistic to discriminate in a data-driven way amongst different structural assumptions on the order of the transmission scheme.

Umar, Derashid [54] study the problems of tax revenue collection in emergent economies using carrot and stick method to identify the key factors that affect tax revenue. Shahnazarian, Sulzberger [56] used a Bayesian Vector Autoregression (BVAR). to offer a background that links a decomposition of corporate tax revenues to macroeconomic predictions, through corporate incomes. Hassan [60] examine extensively on literature, concentrating on theory and empirical studies, on the relationship between VAT revenue and economic growth used the Ordinary Least Square (OLS) Regression technique to. Olufemi, Jayeola [85] investigated the relationship between tax revenue and economic development in Nigeria using Auto-Regressive Distributed Lag (ARDL) Regression Benjasak and Keshab Bhattarai [86] Generalized Equilibrium Impacts on VAT and Corporate Tax in Thailand using CGE model. However, in recent times there are numerous kinds of literature reviewed which is shown above it is obvious that volatility in the financial time series data (tax revenue) still suffers a great challenge from both the data and the model that are used to capture the heteroscedasticity in the data. Meanwhile different types of vector autoregression (VAR) generalized autoregressive conditional heteroscedastic (GARCH) that are multivariate family were utilized and yet the problem still persists. More so we observed that there is low dimensionality existence in the tax revenue data which also tightening another problem in the data. Conclusively, the literatures investigated took different dimensions in financial time series analysis reviewed. The literatures on tax revenue focusses on forecasting using linear models without or fewer hybrid models on tax revenue analysis. While literatures on stock exchange index concentrates on data classification and regression applying nonlinear models and their hybrids. With these it shows that much is still required to be done in financial time series analysis which prompt our interest for this study. most of the financial time series modeling and forecasting concentrated on stock exchange data which is also hindering the study, though a lot of research has been advance in hybrid models to model and forecast short-term and long-term prediction of the stock market. Besides there are no much studies on tax revenue that has hybrid models or forecast to this effect in which if the study is undertaken to hybrid models that can address the issues of low dimensionality and volatility that are residing in the tax revenue data it will go long way to minimize tax revenue challenges.

III. CONCLUSION

Recommendations

Thus, from the reviewed literatures the results inferred that the data factors and the technique are responsible for the instability in the financial time series modelling and forecasting. Also, it reveals that linear models are mostly applied to tax revenue data with fewer non-linear models, while combination and single non-linear models were mostly used for stock exchange data. Therefore, the study recommends the combination of linear and nonlinear models for both tax revenue and stock exchange data which can minimize the error of heteroscedasticity in financial time series modelling and forecasting.

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