UNIVERSITY OF CAPE COAST

PRINCIPAL COMPONENTS VECTOR ERROR CORRECTION MODEL FOR REVENUE COMPONENTS OF GHANA

EBENEZER ACQUAH-BENTIL

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BY

EBENEZER ACQUAH-BENTIL

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature................................. Date……………………..……………

Name**:** Ebenezer Acquah-Bentil

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature................................. Date……………………

Name: Prof. Bismark Kwao Nkansah

Co-Supervisor's Signature... Date……………………

Name: Prof. Nathaniel Howard

ABSTRACT

Revenue data structure has assumed a dynamic nature, and evolving methodology for their study constitutes an interesting problem. In this regard, the study examines the various revenue components that are most influential in revenue generation and attempts to obtain a suitable multivariate time series model that characterizes the contribution of each revenue component in Ghana. Data is therefore obtained on some fourteen revenue variables from Ghana Community Management System for the study. The theory of VEC modelling, which is relevant for variables expected to be related in the long run, is found appropriate for the study. An optimum lag order is determined at 8. The VEC(8) model produces more realistic performance measures than the initial VAR(8). By incorporating principal components extraction into the VEC model, five salient revenue dimensions are identified with no loss of information. The most dominant source is what is influenced by CIF, accounting for about 80% of the total variation in all revenue sources. The remaining 20% is explained by Volume (VOL), Total Revenue (TORE), Total Amount Exempt (TOAE) and Petroleum tax (PETAL), in that order. The VEC model is applied to project the original data onto the five components. The resulting PCAVEC model now provides a plausible econometric characterization of the data structure. The results suggest that CIF, in particular, should be protected to generate the requisite revenue.

KEY WORDS

Impulse Response Function

Multivariate Time series

Portmanteau Test

Principal Component Analysis

Revenue Components

Vector Error Correction Model

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DEDICATION

To The Acquah-Bentil Family

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LIST OF ABBREVIATIONS

ADF:	Augmented Dickey Fuller
AFAC:	Association Fee and Charges
AIC:	Akaike's information Criterion
ARIMA:	Auto-regressive Integrated Moving Average
AWBL:	Air Way Bill
BIC:	Bayesian information criterion
CD:	Customs Division
CEPS:	Customs, Excise and Preventive Service
CIF:	Cost, Insurance and Freight
CPC:	Customs Procedure Codes
CTSB:	Customs Technical Standard Bureau
CV:	Customs Value
DTRD:	Domestic Tax Revenue Division
ECOWAS:	Economic Community of West Africa States
ERP:	Economic Recovery Programme
EXTAX:	Export Tax
GCNet:	Ghana Community Network
GDP:	Gross Domestic Product
GRA:	Ghana Revenue Authority
GSA:	Ghana Shippers Authority
IMDAL:	Import Duty And Levies
IMVAT:	Import Value Added Tax

IRS:	Internal Revenue Service
NHIL:	National Health Insurance Levy
NNAR:	Neural Network Auto-regression
NRS:	National Revenue Secretariat
PCA:	Principal Component Analysis
PCAVEC:	Principal component analysis Vector Error Correction
PETAL:	Petroleum and Other Tax Levies
SSGDP:	Service Sector Gross Domestic Product
TOAE:	Total Amount Exempt
TORE:	Total Revenue
VAR:	Vector Auto Regression
VAT:	Value Added Tax
VECM:	Vector Error Correction Model
VOL:	Volume

CHAPTER ONE

INTRODUCTION

Background to the Study

Multivariate time series models are statistical models that capture the complex interdependence among multiple variables over time. They are used to analyze the relationships across variables, predict their future values and assess the impact of external factors such as policy changes or economic shocks. The most common multivariate time series models include the following:

1. Vector Autoregression (VAR): VAR is a linear model that describes the dependence between variables by regressing each variable on its own past lags and the past lags of every other variable in the system. It does not assume the presence of any cointegrating relationships, and is therefore primarily used for short-term forecasting and shock analysis.
2. Dynamic Factor Models (DFM): DFM represents a popular class of models that explain the variability of a large number of observed variables using a few unobserved factors. It is often used for dimensionality reduction and forecasting, and has found extensive applications in finance and macroeconomics.
3. State-Space Models: State-space models describe the dynamics of a system by decomposing observed data into unobserved state variables that follow certain stochastic processes. They are very flexible and can handle a wide range of models, making them popular for tracking and forecasting time-varying phenomena with nonlinear dynamics.

4. Bayesian Structural Time Series (BSTS): BSTS is a generalization of state-space models that uses Bayesian inference to estimate model parameters and uncertainty. It offers a flexible modeling framework and can handle missing data, outliers, and structural breaks.

It is how ever more appropriate to use the Vector Error Correction Model (VECM). VECM are a type of time-series model used in econometrics for analyzing the dynamic relationships between variables that may be integrated of different orders. VECM was first introduced by Engle and Granger (1987) as an extension of the conventional vector autoregression (VAR) model to account for cointegration among variables. Cointegration refers to a long-run equilibrium relationship between two or more variables that display a stochastic trend, which implies that they share a common stochastic trend or cointegrating vector. VECM aims to capture the short-run dynamics and long-run equilibrium relationships simultaneously by modeling the errors of the cointegrated variables as a linear combination of their deviations from their long-run equilibrium relationships. The VECM model consists of multiple regression equations, one for each variable in the system, and the lagged differences of the variables are used as explanatory variables. It is widely used to analyze the dynamics of variables that may be integrated of different orders. According to Enders (2014), VECM is a system of multiple equations in which some of the variables may be of different orders of integration, but a linear combination of these variables is stationary. VECM is commonly used to investigate the short- and long-run relationships between variables in economics and finance (De Vita & Trachanas, 2016).

VECM has become an increasingly popular technique in applied economics and finance research because it can provide valuable insights into the complex dynamic relationships between economic variables, such as interest rates, inflation, and stock prices. VECM is also well-suited for policy analysis and forecasting, as it can account for long-run equilibrium relationships and short-run adjustments.Overall, VECM is a valuable tool for analyzing the dynamic relationships between variables that may be integrated of different orders, and has numerous applications in multivariate time series data.

The focus of this study seeks to examine the short and long run relationship that exists among revenue components which have been collected over time. The VECM is therefore found relevant for the study. However, since only few most relevant revenue sources are required, there is the need to incorporate dimensionality reduction into the technique in order to determine some concise results.

Principal Component Analysis (PCA) is a dimensional reduction technique that could be applied in multivariate time series data. The objective of this approach is meant to extract few components from large dimensional data which represents total variation of the original data. One common application of PCA in time series analysis is to identify trends or patterns in financial data, such as stock prices or economic indicators. For example, PCA can be used to identify the most important factors that contribute to stock price movements, such as changes in interest rates or inflation. This can help investors make more informed decisions about which stocks to invest in and when to buy or sell them. PCA may also be used in climate science to identify patterns or trends in climate data, such as changes in temperature or precipitation over time. By reducing the dimensionality of the data, researchers can better understand the factors that contribute to climate variability and predict future climate patterns.

Some studies on the application of PCA include: Kanhere and Ghorpade, (2015) conducted a study on “Image denoising using principal component analysis”. This study used PCA for image denoising, which involves removing unwanted noise from digital images. The authors demonstrated that PCA can effectively reduce the noise in images and improve their visual quality. Another study (Liu, Huang & Yang, 2019) on the application of PCA analyzed gene expression data from a genome-wide association study. The authors demonstrated that PCA can effectively reduce the dimensionality of the data and identify the most important genes that contribute to disease risk.

Effects of Tariff Rates on Revenue

The term “tariff” refers to an official list or table that displays the duties or customs that a government has imposed on imports or exports. According to Investopedia, a tariff is a charge imposed by one country on imports of goods and services from another**.** From a report written by Assibey-Yeboah and Panford (2020), indicates that determination of the rate of duty and tax for goods is covered by Section 1 of the Customs Act, Act 891 (2015) as modified. Imported commodities are subject to customs and taxes, as stated in Section 1 (1). Then, at a tariff rate specified in the Harmonized Commodity Description and Coding System, they are exported outside the country (referred to as Harmonized

System). There are Six Thousand One Hundred and Forty (6,140) Harmonized System tariff Lines; Ghana Customs uses the ECOWAS Common External Tariff and Other Schedule, 2017. In Ghana Customs, Six (6) Import Duty Rates are applied on the Cost, Insurance and Freight (CIF) to obtain the Import Duty of the Commodity. They are Zero (0) rate, Five (5) percent rate, Exemption, Ten (10) percent rate, Twenty (20) percent rate, and Thirty-Five (35) percent rate.

Zero-rated goods are goods whose import duties are charged at zero. This is normally applied to goods the country does not have a comparative advantage on and agricultural products and machinery. An exemption is a tax rate applied on the goods whose duty could have been any of the other tax rates but has been exempted from those taxes. These exemptions are granted to Custom Procedure Codes having letters P, F, G, I, M, V, W and D07. The Ds are dutiable with the exception of D07. Another aspect of exemption that is also applied is the concessionary rate. These are rates given to manufacturers of certain products whose import duty rate could have been higher than the actual import duty applied. They are normally used for the Custom Procedure Code having the letter 'E'.

D – Permit granted by Ministry of Finance and Ministry of Trade relief on ECO/EDIF Levy

F – Statutory exemption for Head of States, Diplomatic Missions, Technical Assistants, etc.

G – Exemption for Ghana National Petroleum Corporation (PNDC Law 64,19)

I – Exemption for Ghana Investment Promotion and the Tourism Sector

M – Exemption for the Mining Sector

P – Exemption for the Various Ministries

V – VAT Exemption for the Manufacturing Companies

Governments use taxation to generate revenue and therefore introduce several policies (Haque, 1999; Asuliwonno, 2011; Ofori-Atta, 2019) to widen the tax net. This is because of some setbacks the Government of Ghana faces in revenue generation. When these challenges persist, they will influence the nation negatively in terms of the building of infrastructure, roads and other social amenities. The "Gross Domestic Product (GDP)" is a major source of revenue in every nation.

Since 1985, Ghana has undergone several tax reforms, all geared at enhancing the nation's revenue collection efforts and overall fiscal stability. The Internal Revenue Service (IRS) and two significant revenue agencies, "Customs, Excise and Preventive Service (CEPS)," were founded as independent, non-civil service institutions in 1985, along with the National Revenue Secretariat (NRS). The NRS was in charge of overseeing CEPS and IRS operations and advising the government on revenue-related policies.

Some taxes were eliminated or lowered in 1987, including the import and purchase tax on all commercial vehicles, the levy on basic raw materials and capital goods, and the corporate tax rate on manufacturing businesses, which dropped from 55% to 45%. To ensure prompt payment of excise charges and sales taxes acquired by manufacturers on behalf of the government, the sales tax clearance certificate was introduced in 1988.

The super sales tax on luxury goods was introduced in 1990. The taxes range from 50% to 500%. The following year this tax was reduced between 10% and 100%. The corporation tax rate for manufacturing, real estate, construction, services, and agriculture decreased to around 35% in the same year. Due to unpaid taxes, the Ministry of Finance established the Debt Collection Unit in 1994. The VAT bill was enacted into law in 1995 with a flat rate of 17.5%. To oversee service and consumption taxes, the VAT Service was founded in 1998. From then on, numerous reforms and the creation of new units were implemented. For instance, the Ministry of Finance's Tax Policy Unit was established in 2006 to act as a unit to compile, coordinate, and oversee the implementation of tax policies.

Several tax automation systems have been introduced to help in the mobilization processes. The Ghana Community Network (GCNet) was created in 2000 and charged with the provision of Customs clearances, and trade transactions are processed through a single platform. The "Ghana Shippers Authority (GSA)," Ghana Commercial Bank (GCB), Ecobank Ghana Limited (EBG), and the Swiss company Société Générale de Surveillance (SGS) are partners in the public-private partnership known as GCNet. It is estimated that the operation of the GCNet has led to a 30% increase in customs revenues (Owusu-Gyimah, 2015). The graph in Figure 1 represents the rise and fall of import revenue in Ghana from 1999 to 2014.

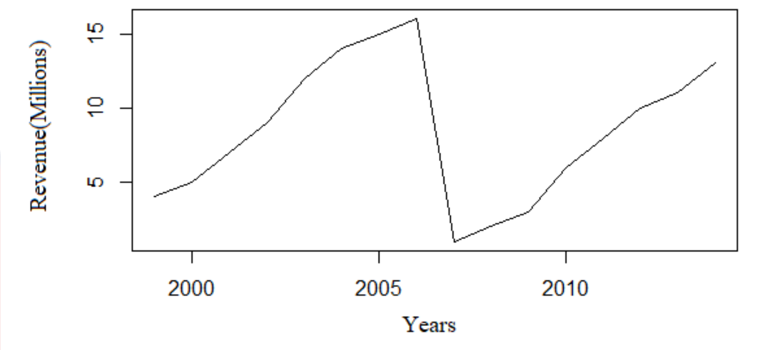

Figure 1: Tax Revenue trend, 1999 – 2014 in millions of Ghana Cedis (Owusu-Gyimah, 2015)

Despite having one of the fastest growing African economies and abundant natural resources, Ghana mainly depends on imports of products and services. Ghana now imports products and services worth an average of 976 million US dollars yearly. Most goods imported into the country are industrial supplies, capital and consumer goods and foodstuffs. These goods are mostly imported from China, the United States, Belgium, the United Kingdom and France. While the current state may not encourage industrialization and the use of indigenous products, the economy is still cushioned through import taxes.

Governments' frequent introduction of taxes into the Ghanaian economy has been a source of huge distress to residents (cite daily paper). The proliferation of taxes leaves questions about the relevance of existing fundamental revenue generation mechanisms if they exist. As seen in the literature, revenue components are extensively covered by some fourteen variables. These are GDP, Service Sector GDP, the actual Total Revenue (TORE), Volume of imports (VOL), CIF, AFAC, IMDAL, IMVAT, EXTAX, NHIL, and FEES.

Recent methodology for analyzing revenue sources such as Ghana has gone a step further from traditional methods of ARIMA models to machine learning time series modelling (Agbenyega, Andoh, Iddi, & Asiedu, 2022). The search for an alternative methodology for studying revenue data would continue. Apparently, this quest is understandable as there exists differences in revenue data structures due to availability and coverage at any point in time and the numerous gaps in revenue generation (World Bank, 2020) that must be filled. Therefore, revenue data is dynamic and requires an updated methodology for a thorough study.

Statement of The Problem

Revenue generation is one of the major challenges of every nation, especially for developing countries such as Ghana. Various governments have used taxation to generate revenue and introduced several policies to widen the tax net. Nonetheless, the 2017 budget statement of Ghana saw some taxes introduced by the earlier administration on some import commodities as nuisance taxes, whiles other taxes were introduced to cater to others, all in an attempt to lessen the burden on citizens.

Weak domestic income mobilisation targets are the main source of the country's fiscal imbalances and the biggest danger to the government's capacity to achieve its development goals, Institute for Fiscal Studies (Belfield, Britton, Dearden & Van Der Erve, 2017). Now, given that tax revenue is due to various factors acting at the same point, government and stakeholders' decisions can properly be enhanced if the nature and level of each component's contribution to the national GDP are assessed. The general notion, however, is that introducing several taxes is a burden to the citizenry. The literature has not revealed rigorous econometric characterization of Ghana's revenue generation components. There is also the need to assess the relevance of tax proliferation in the economy. The study finds it relevant to apply current multivariate statistical tools to assess the country's revenue components. Although effort has been made in this regard in recent times, the composition and coverage of the data create a dynamic data problem that could be studied from alternative perspectives using a different methodology.

Objectives of the Study

Based on the problem outlined, the main aim of the study is to obtain a general econometric characterization of the revenue components of Ghana. Specific objectives are:

1. Examine the various revenue components that are most influential in revenue generation.
2. Obtain a suitable multivariate time series model that characterizes the contribution of each revenue component.

It should be noted that, unlike various studies, the study does not focus on generating forecast values for identified revenue components. As pointed out earlier, the dynamic nature of revenue data primarily requires an understanding of their performance and their relation among themselves.

Significance of the Study

In Ghana, one of the main ways the government makes money is through imports. It is important to understand whether import revenue has a significant impact on Ghana's socio-economic development and how that has an impact on GDP growth. Furthermore, since there are several components of import revenue, it is worth studying and statistically model the components to determine the network and interactions of these components towards their performance in revenue mobilization. The study results will lead to a clearer understanding of Ghana's structure of revenue components to direct mobilization efforts.

Limitation and Delimitation of the Study

Even though the study is focused on characterizing revenue components, it obviously does not cover every possible source of revenue available. The study, therefore, concentrates on only the main components in the fourteen feasible sources in their organization. Related to this is that modelling revenue source is a dynamic study as new taxes are introduced into the economy at a very fast pace. For example, several other revenue sources have been introduced into the economy after concluding the study duration. These include:

- Network Charge on Covid-19 Health Recovery Levy (Code 39);
- Sanitation and Pollution Levy (Code 64);
- Withholding Tax on Payment made for Unprocessed Precious Mineral (Code 75);
- Covid-19 Health Recovery Levy (Code 99); and

- Anti-dumping Duty (to recycle or eliminate waste materials imported into the country, Code 100).

The frequent introduction of tax sources could thus affect the reality of the results of the situation at any point in time.

Definition of Terms

This part is concerned with definition of some terms that are saught to be significant to the understanding of the thesis

Multivariate time series: A multivariate time series is a type of time series data where there are multiple variables recorded over time. In other words, it's a collection of observations made sequentially in time that involve more than one variable or feature.

Principal Component Analysis: Is a statistical technique used to reduce the dimensionality of high-dimensional data while retaining as much of the original variation as possible. It is a widely used technique in machine learning, data science, and other fields where large datasets need to be analyzed and visualized.

Vector Error Correction model : (VECM) is a statistical model used to analyze the long-term relationships between multiple time series variables that may be non-stationary, meaning their mean and/or variance changes over time. It is a type of Vector Autoregressive (VAR) model that includes an error correction mechanism to account for any deviations from long-run equilibrium.

Forecast error: Forecast error, also known as prediction error or residual error, is the difference between the actual value of a variable and the value predicted by a forecasting model. It is a measure of the accuracy of the forecast and provides information on how much the actual value deviates from the predicted value.

Organization of the Study

Five chapters make up the study's structure: The study's introduction, which provides context for the rest of the research effort, is covered in Chapter 1. The literature evaluation of related investigations is included in Chapter 2. The research approach taken to carry out the study is reviewed in Chapter 3. Chapters Four and Five, respectively, examine data analysis, discussion, and recommendations on the other side, as well as a summary, conclusion, and recommendations.

CHAPTER TWO

LITERATURE REVIEW

Introduction

In this chapter, literature on the application of the techniques of Vector Error Correction model to multivariate time series is reviewed. Subsequently, The background of revenue mobilization and procedures for generating revenue components in Ghana is also examined.

Empirical Literature on Modelling Revenue Using Multivariate Time Series Techniques

The generating of revenue is one of a business's core functions. The revenue model explains how a company generates income by selling its goods and services. A firm must evaluate its revenue model to see whether its current strategy of appropriating revenue is optimal because earning money is critical to a corporation. The study's commissioner did pre-interviews, and it became evident that Bisnode must structurely analyse its current business model for its credit determination services to continue to be profitable and competitive. Sjögren and Isaksson (2016). The study looked into the methods and justifications for revenue model analysis. To comprehend and explain the occurrence, the study compared empirical data to accepted theory, typical of analytical or explanatory research (Collis & Hussey, 2014). The qualitative approach was used in accordance with the empirical data and was determined to be adequate to address our study concerns. However, it admits that a quantitative analysis might have helped with producing statistical data on the important factors to consider when assessing a revenue model. The business strategy has been extensively scrutinised, although the revenue model is still mostly in its infancy. (Morris, Schindehutte, Allen, Shafer, Smith & Linder, 2005; Dubosson-Torbay, Osterwalder & Pigneur, 2002; Johnson, Christensen & Kagermann, 2008; Wirtz, Pistoia, Ullrich & Göttel, 2016; Zott & Amit, 2008). Additionally, new revenue model trends are emerging, prompting businesses to assess their current revenue models to find new ways to improve sales.

Blomkvist and Hallin (2015), who agree with Morris et al. (2005) that a business model’s various components must work together harmoniously and that a revenue model is one such component, claim that this has motivated the case study being conducted by the product, business development, and sales departments in order to include all various viewpoints. A basic understanding of the issue and industry must formulate the study’s goal and aim effectively.

An iterative, analytical procedure was employed for the Bisnode model, drawing from the work of Gioia, Corley, and Hamilton (2013) and Smith (2014), in which data were carefully evaluated to arrive at theoretical interpretations. The procedure was broken down into four steps: (1) perform the case study; (2) identify important themes; (3) identify critical dimensions; and (4) create a work methodology for revenue model analysis.

Reliability, external validity, construct validity, and internal validity are all important considerations in revenue modelling (Fox & Campbell, 1975; Kenny, 1975). These standards guarantee the procedure’s reliability. The measurement’s accuracy and precision are an issue for reliability (Blomkvist & Hallin, 2015).

Therefore, the type of data-generating system affects reliability. Chetty (1996) advises that collecting data should originate from various sources to allow for triangulation and increase trustworthiness. How well the results can be applied to other contexts is known as external validity or generalizability (Gibbert et al., 2008).

By examining the construct validity of key ideas, one can establish whether the study has explored the questions it set out to answer (Gibbert et al., 2008). A thorough literature selection might ensure a high construct validity. Utilizing many data sources and data collection techniques in a triangulated fashion also improves the case study's construct validity (Yin, 1994).

Whether the stabilisation of production growth may be attributable to a decrease in output volatility, a decrease in the gap between the mean growth rates in recessions and expansions, or both has been a subject of debate. Similar inquiries have been made regarding the United States (McConnell & Perez-Quiros, 2000; Kim & Nelson, 1999a; Blanchard & Simon, 2001) and the G7 countries (Wang,Tieu,De Boer & Yuen, 2000). In each of these, output growth models are presented as a univariate autoregressive process. The method used in one of the presentations calculates a rolling regression over twenty-quarter periods and examines how the standard deviation of the residual behaves. In the second, the mean growth rate and residual variance are driven by independent state variables in a Markov switching method.

On the other hand, Kim and Nelson (1999) find evidence that the drop in the variation of US production growth is connected with a reduction in the difference between the mean growth rates in expansions and recessions. The third significant distinction between the Markov switching models estimated by McConnell and Perez-Quiros and Kim and Nelson is that McConnell and Perez-Quiros allow for global Markov switching in the variance, whereas Kim and Nelson only allow for a one-time switch.

The ability of a model to generate a credible business cycle is a crucial test. A review of various widely used models of real GDP growth reveals that, in general, they do not reflect the cyclical patterns of the collected data (Harding & Pagan, 2002; Hess & Iwata, 1997). Markov switching models outperform a straightforward AR (1) model quite poorly, according to a new set of non-parametric tools developed by Harding and Pagan for analysing business cycle characteristics and evaluating the fit of various cycle models, such as Hamilton's basic Markov switching model.

In most situations, transition countries depend on foreign corporations since they lack the necessary capital to generate and drive technical advancement and economic growth (Škare, Franc-Dąbrowska & Cvek,2020). With foreign direct investment (FDI) inflows, the country derives benefits that would create jobs, transfer new technologies and know-how, enhance the competitiveness of the domestic economy, and increase tax revenues (Paun, 2019).

Specifically, with reference to the Croatian economy, Škare et al. (2020) highlight the significance of FDI and other macroeconomic factors and their interaction. Utilizing the ADF test, stability, variance decomposition of the variable prediction error, and responses to unit orthogonal shocks, it creates and evaluates the VECM model's performance. It is discovered that FDI is a necessary but insufficient condition for growth convergence and that some of the anticipated benefits of FDI disappear.

Vector Error Correction Model (VECM) Approach

A type of VAR model utilised with co-integration constraints is the VECM. The VAR system was developed using statistical data and empirical guidelines. The VAR model was created by Mehdi and Seyyed (2013) and Sims (1980), who criticised conventional econometrics models. All variables in the VAR model are endogenous and resemble simultaneous equations. The general form of the VAR model for *k*-dimensional multivariate time series variable $\mathbf{Y}_t$ is

$$Y_t = \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \varphi_3 Y_{t-3} + \ldots + \varphi_p Y_{t-p} + U_t$$

Where p is the number of lags.

Static variables are needed for VAR models. In order to prevent erroneous regression, their differences are used for non-stationary variables. The non-stationary time series theorem was created as a result of the fact that the majority of macro time series are unit roots. Engel (1996) demonstrates the possibility of a stationary linear combination of non-stationary variables. These time series are co-integrated, and the co-integrating equation is a stationary combination that describes the long-term relationship between two variables. Cointegration should first be examined if the model contains any non-stationary time series. A approach that was first described by Johansen (1995) and later developed by Johansen and Juselius (1990) allows for the testing of many cointegrating vectors in the data as well as the creation of maximum-likelihood estimates of these vectors.

The Johansen-Juselius technique decomposes the matrix $\mathbf{\Pi} = -\left(\mathbf{I} - \sum_{i=1}^{p} \boldsymbol{\varphi}_i\right)$, where $\mathbf{I}$ is $k \times k$ identity matrix, to show information about the long-run relationships among the variables in $\mathbf{Y}_t$. Johansen and Juselius design a maximum-likelihood estimator to obtain estimates of α and β, such that $\mathbf{\Pi} = \boldsymbol{\alpha\beta}'$. This procedure also yields two test statistics of the number of statistically significant cointegrating vectors. One test is called the λ- max statistic and compares the null of $H_o(r)$ with an alternative of $H_1(r+1)$. The trace test examines the same null of $H_o(r)$ versus an alternative of H_1 Clements and Hendry (1995). Cointegration is fundamental to the VECM approach. VECM is a kind of VAR where cointegration restrictions are determined, and so is RVAR. VECM contains both long-run and short-run relations among variables set in vector $\mathbf{Y}_t$. The general form of VECM is given as

$$\Delta Y_t = \mathbf{\Pi} Y_{t-1} + A_1 \Delta Y_{t-1} + A_2 \Delta Y_{t-2} + \cdots\cdots + A_p \Delta Y_{t-p} + U_t ; \quad \mathbf{\Pi} = \boldsymbol{\alpha\beta}',$$

Where $A_j,\ j = 1, 2, \ldots, p,$ is a matrix of parameters; and $\mathbf{\Pi}$ contains long-run information. The matrix $\boldsymbol{\alpha}$ is the matrix of error correction coefficients and measures the speed at which the variables adjust to restore a long-run equilibrium. The matrix $\boldsymbol{\beta}$ is coefficients of long-run relationship.

The error correction terms $\boldsymbol{\beta}' Y_{t-1}$, are the mean reverting weighted sums of co-integrating vectors and data dated $(t-1)$. One of the VECM properties and generally VAR model is the ability to study the effects of shocks on endogenous variables. Sims (1980) suggests impulse response functions (IRF) for studying unpredictable policy shocks on macro variables. IRF shows the reaction of one variable to stochastic element in time.

In contrast to the classic VAR literature, the IRF computation is based on the VECM representation, which considers the projected long-run limitations. This enables us to investigate how a variable-specific shock affects the estimated co-integrating relationships and the individual variables (Pesaran & Shin, 1996).

An example of the application of VECM is a study by Chen and Leung, (2019) on the relationship between housing prices, housing credit, and economic growth in Hong Kong. The authors found that there is a significant long-run equilibrium relationship between the three variables and the results support the hypothesis that housing prices and credit expansion have a positive impact on economic growth. Another study that used VECM is by Sheng and Wang (2018), who examined the dynamic relationship between foreign direct investment (FDI), domestic investment, and economic growth in China. The authors found that there is a unidirectional causality from FDI to economic growth in the short run, and a bidirectional causality between FDI and domestic investment in the long run.

Application of Principal Components in Multivariate Time Series

A principal component analysis (PCA) statistical technique enables the summary of information in big data sets using a more manageable range of dimensions. In multivariate time series modelling, the PCA technique is also used to reduce variable redundancies to obtain fewer variables that can explain all or an appreciable amount of the total variation in the data. Some literature studies use principal component analysis in multivariate time series studies.

Hyndman, Wang, and Laptev (2015) did a study on the detection of large-scale anomalous time series. The study's objective was to identify abnormal time series compared to other time series on the same cluster. A multivariate point anomaly or even a univariate point anomaly is not the same as this kind of anomaly detection. Given that they originate from major internet organizations, early discovery of these aberrant time series is essential for taking preventative action to safeguard users and improve user experience. In such businesses, tens of thousands of servers power user services that give users a continuous and secure experience. Therefore, it is crucial to watch for any odd behaviour in the server metrics (such as latency and CPU), which are represented as time series. A feature vector measuring each time series's properties is computed in such a study. Lag correlation, the degree of seasonality, and spectral entropy are possible characteristics. First, m features are extracted from the k time series random vector. In order to find the patterns, PCA is then applied. The top k m outliers are then discovered using a two-dimensional outlier identification technique once the first two main components (PCs) have been chosen. A principle component decomposition is performed on the features, and then different bivariate outlier identification techniques are used on the first two principal components. The oddest series based on the feature vectors are found using this process. The highest density regions are the foundation for the bivariate outlier detection techniques.

Parmentier (2014) used seasonal trend analysis to investigate the characterization of land transition patterns from multivariate time series. STA with Principal Component Analysis (PCA). The goal was to identify surface temporal trends connected to places where there had been land change due to fire disturbances. The approach involves three steps: (1) using STA to extract amplitudes and create Theil Sen slope images; (2) creating a change/no-change area mask from the MTBS database; and (3) using PCA to describe change on slope images in the masked areas.

Characterizing change over vast areas remains a fundamental challenge in remote sensing and land change science. Remotely sensed time series are usually short and noisy, necessitating extensive pre-processing and advanced methodology to extract valuable temporal patterns. In order to advance land cover change monitoring, the paper provides a technique that combines seasonal trend analysis and principle components analysis (PCA) to uncover temporal patterns in areas of land change from multivariate picture time series. In order to define biophysical trends in Alaska, three surface state variables—normalized difference vegetation index, land surface temperature, and albedo—are employed. Burned regions are given as an example of change (ALB).

Instead of characterizing change, that is, how the process of change affects surface attributes, most research has concentrated on detecting land cover change or making up for missing observations. Much information is lost when defining change with change/no-change Boolean categories. A group of biophysical characteristics pertaining to its structure and constituent materials defines several land cover types. These characteristics control land surface-atmosphere exchanges, influencing local climate, water, carbon, and energy fluxes. Bio-geophysical feedback processes may either boost or decrease exchanges at local, regional, or global scales due to the influence that land transitions (i.e., modifications or changes in features) have on land-atmosphere fluxes. Skin temperature and surface albedo may be impacted, especially if the forest cover turns browner or greener, as shown by a drop in or rise in NDVI. According to experiments utilizing regional and global circulation models, increased radiative forcing acting as a positive response due to a decrease in albedo would arise from afforestation in high latitudes. Roughness, sensible heat, latent heat, and albedo values, dependent on the structure and makeup of different land cover types, are more widely used to describe land surfaces. Therefore, land transitions simultaneously affect a number of surface properties as part of the bio-physical repercussions of the process of land cover change. Documenting and monitoring these characteristic changes may be helpful for research aiming at understanding environmental changes in the Arctic since it may allow inference of the processes behind the land change. Many studies characterise land cover change by using a single unique time series or by establishing some typology or categorization: disturbance, revegetation, disturbance and revegetation. This is done in place of providing a clear bio-physical representation of change, such as photographs, to characterise and categorise change processes. Twenty-five transition types were proposed by (Parmentier, 2014) to establish a more thorough and general typology to track and characterise the land cover change in forested areas. As the number of variables and criteria used to define land cover change increases, the complexity of potential links and combinations of transitional categories is rising quickly. Parmentier and Eastman found that a sizable percentage of Alaska is detected as changing and summarising change in the seasonal pattern using a simple aggregation method, such as overlay. Using this strategy, the authors found that many sites have three changing STA factors, but they could not interpret and identify the most frequent combinations of variables present within the observed change areas.

Infestation outbreaks and wildfires are the primary sources of land change in the state of Alaska. Studies show that Alaska has become a net carbon sink and has an impact on the global carbon budget. As temperatures rise and climate change occurs, there are worries that the area may ultimately turn into a carbon source.

Evaluation-Analysis of Trends Using PCA and Validation Using Ancillary Information

One may assess the extraction process by combining seasonal trends and auxiliary data to understand the PCA components. The MTBS fire perimeters are used to create the Boolean variable “Burnt,” with the value “one” denoting pixels that have burned and the value “zero,” denoting pixels that have not. Further analysis is performed utilising the dNBR, a Boolean severity index, and fire size: fire intensity to determine the relationship between PC scores and the continuous validation variable of change. Land cover types created from the NLCD dataset and the evergreen forest percentage were also employed to inform and interpret

PC1 scores in accordance with the literature. The main goals involve evaluating the change component, which combines the starting variables and characterising transitions in change areas. The burned Boolean variable and the burned severity index are inputs into a general linear model (here after referred to as "LM" to avoid confusion with the Generalized Linear Model), with the dependent variable being the first main component (PC1). Both categorical and continuous variables are acceptable in the LM general regression model. The analysis of variance (ANOVA) is analogous to a linear regression with dummy variables when independent categorical variables are used. The 2D plot of loadings shows the correlation patterns between the input Fourier parameters and the principal components. The 2D loading graphic helps to identify biophysical trends in change areas as a result. Additionally, the change variable produced from the SDTC technique supports the PCA interpretation. LM is performed after the change variable is plotted along the change-designated principal component.

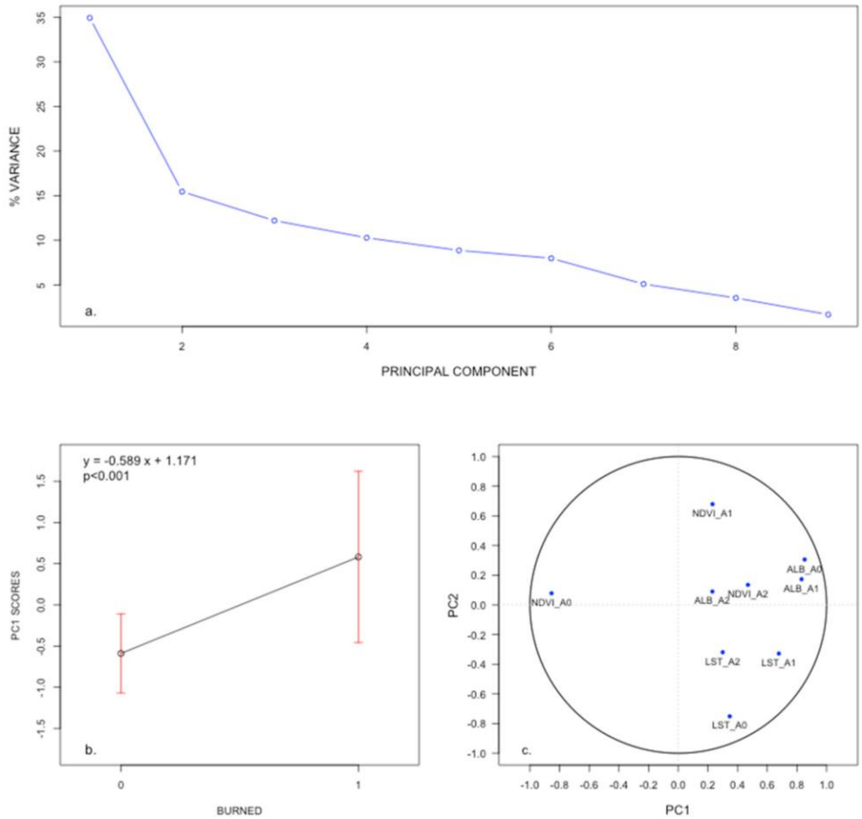

Figure 2: Component Extraction of Land Cover Change (Parmentier, 2014)

Recent research into Ghana's economy (Agbenyega, Andoh, Iddi, & Asiedu, 2022) Data on monthly revenue from January 2010 to December 2019 was taken from the Ghana Revenue Authority's Customs Division (GRA-CD). The information was gathered using historical exchange rate records from the Bank of Ghana and the GRA-CD. (BoG, 2018). Customs information is derived from a database that includes financial measures of the Customs Division's development and performance. The information includes records on the following tax variables from 2010 to 2019: Value of Imports (CIF) data, Zero and Exempt Portion of Value of Imports (ZE), Taxable or Effective Portion of Value of Imports (ECIF), Effective Duty Rate (EDR), Import Duty Revenue (IDREV), Total Customs Revenue (TOTREV), and Average Monthly Exchange Rate (XCHR). The ARIMA model and ARIMA Error Regression Model (ARIMAX), two classical time series models, the Bayesian Structural Time Series (BSTS) model and the Neural Network Auto-regression (NNAR) model, two machine learning time series models, were all used in the study. The best forecasts with reported related Mean Squared Error (MSE) and Mean Absolute Percentage Error was produced by the Neural Network Auto-regression model of the form NNAR (1, 3). (MAPE). In general, it was discovered that machine learning models performed better than conventional time series models. Forecast values from the NNAR (1, 3) suggested that immediate action be taken by the necessary authorities to increase revenue generation because they showed a potential reduction in revenue.

Background of Revenue Mobilization in Ghana

Over the years, government upon government has embarked upon developmental projects that can be financed through donations or internally generated funds (IGF). Governments in emerging and underdeveloped nations raise money in two primary ways: borrowing money from outside sources and levying taxes and other fees. External borrowing results in debt repayment, which strains the state. Additionally, some people and residents are unhappy with the imposition of taxes and levies. The government of Ghana from 2012 to 2016 was described to practice tax-based revenue mobilization, while the current administration from 2018 has proposed a production base. The fiscal performance in the first half of 2017 was concerning, according to the Institute for Fiscal

Studies (Belfield *et al*., 2017). The government was forced to reduce spending to achieve the desired fiscal deficit because domestic revenue fell short of the budget's target. However, the government committed to reducing spending in the second half of 2017 if domestic revenue remained below the budget's target

Most economies, including Ghana, import revenue accounts for a sizable portion of total government revenue (Zhu & Kotz, 2010). Import income, therefore, influences how effectively an economy develops because the quantity of revenue mobilised in a country largely determines how well that economy develops. This is why many countries and people may consider the idea and practise of import to be of the utmost importance. A country's economy may benefit from imports and exports. Governments may generate significant amounts of cash from taxes on exotic items and services thanks to imports (Othieno & Shinyekwa, 2011). In China, on average, imports and exports account for 15% of the country's governmental revenue (Lin & Li, 2011). According to reports, import income growth in Ghana from the year 2000 to the year 2010 was significant (Asuliwonno, 2011).

However, a country's ability to import depends on its trade links with other nations through international trade. A country's "balance of trade" refers to the difference between the value of its imports and exports and is the foundation of international trade in addition to export (Pan, Phillips, & Chen 2008). Additionally, the organisations effectiveness in generating import earnings determines the country's capacity for imports. The majority of nations hire particular organisations to raise import money. Whatever their methods, these organisations are granted the duty and power to impose all types of taxes on all arriving exotic goods and services (Danquah, 2008; Nour, 2011). The primary purpose of the partnership between Customs, Excise and Preventive Service (CEPS) and other agencies or institutions is to boost the effectiveness and efficiency of generating import income, which will have a favourable impact on the "Gross Domestic Product (GDP)" (Asuliwonno, 2011).

The Ghana Revenue Authority's only purpose has been to mobilize revenue in Ghana (GRA). The Internal Revenue Service (IRS), the Customs, Excise and Preventive Service (CEPS), and the Value Added Tax (VAT) all performed services before the General Accounting Office (GRA) was created in 2009 by an act of parliament (Act 791).

Service under one umbrella of revenue mobilisation. The administration of the GRA seeks to:

1. calculating and collecting the Republic's owing taxes, interest, and charges as effectively as feasible.
2. deposit the funds raised into the Consolidated Fund unless the GRA Act and other Acts provide differently.
3. Encourage tax adherence and awareness.
4. fighting tax evasion and corruption, and collaborating with other competent law enforcement and revenue entities abroad to achieve that goal.
5. give District Assemblies advice on how to assess and collect their money.
6. prepare and release reports and data concerning its revenue mobilization.

7. make suggestions to the Minister about the revenue; and
8. carry out any additional revenue-related duties outlined by the Minister or given to it by another statute. (Act 891 of 2015, Ghana Revenue Authority)

The operations of the GRA as outlined are to achieve the following objectives:

1. to administer taxes and customs, adopt a comprehensive strategy.
2. reduce the cost of administration and tax compliance while giving taxpayers greater service.
3. encourage effective revenue collection, equitable tax burden distribution, and more integrity and openness.
4. make sure that the government is held more accountable for effectively handling the tax system.
5. enhance information linking and sharing between the Authority's Divisions;
6. provide a single point of contact for the filing of returns and payment of taxes to taxpayers;
7. create standard tax practises so that a single set of rules governs taxpayers; and
8. make preparations for any additional challenges that may arise as revenue administration develops.

GRA today has undergone several reforms and adjustments in its operation and mobilisation processes geared toward increasing the country's revenue. These modifications included revisions to the taxation structure, an increase of the taxation's bases, and a thorough reorganisation of the institutions responsible for collecting and distributing the nation's taxes. Tax administration Reforms are widely acknowledged as The percentage of tax collections to GDP increased from an average of around 11 percent over the decade prior to the Economic Recovery Programme (ERP) in 1983 to about 19 percent in 1998, indicating a considerable improvement in revenue in recent years. Ghana's revenue has much capacity to increase, but as of December 2018, it only contributed 13.1% to its GDP (Ofori-Atta, 2019).

Currently, the GRA, which forms part of the service sector of the Ghanaian economy, operates with three main divisions, namely, the Domestic Tax Revenue Division (DTRD), Customs Division (CD), and the Support Services Division (SSD). DTRD Direct, DTRD Indirect, and Customs Division are responsible for tax administration. In addition to other taxes, the DTRD Direct also collects PAYE, self-employment, company, and mineral royalties taxes. The DTRD Indirect collects domestic VAT, national health insurance levy, domestic excise, and communication service tax. Due to the fact that it is a VAT on petroleum goods, the Special Petroleum Tax was included in the 2015 Budget and is collected by Customs, but it also contributes to DTRD Indirect revenue. Import VAT, National Health Insurance Levy, and Petroleum Tax are all collected by the Customs Division.

Knowledge regarding the current performance of various revenue components in revenue mobilisation in Ghana towards GDP growth is of enormous relevance. This has become necessary since, over the past years, each government has introduced policies and programmes to mobilise revenue. Therefore, since import and export duties or taxes form the major component of GDP growth of Ghana, there is a need to study the various components and their performance towards GDP.

Gross Domestic Product of Ghana

Gross Domestic Product (GDP) estimates the market value in dollars of all finished products and services produced during a specific period. The GDP is a representation of the economic worth of a country (Lepenies, 2016). It could also be outlined as the total gross value added producers in the economy, plus any applicable product taxes, less unaccounted-for subsidies. A measure of the economic worth of an individual living in a particular country is given by the GDP per capita computed as a ratio of GDP to population. Arguably, GDP per capita is used as an indicator of the standard of living in any country. It is also asserted that it gauges a nation's economic output and income. GDP is, therefore, the total cost of all finished goods and services produced in a nation at a specific point in time, and it is computed without considering the depreciation of manufactured assets or the scarcity of natural resources (Venkatesh, 2015).

The production, marginal, and speculative expenditure approaches are the three methods for calculating GDP. To calculate the total, the production approach adds the output of each type of business. The expenditure approach is based on the idea that since everyone must purchase the entire good, its overall value must match what individuals have spent on it; The income approach bases its calculation of GDP on the premise that the incomes of the productive components (sometimes known as "producers" informally) must be equal to the value of their output(World Bank, 2009). The production approach computes the GDP based on the definition and classification of Organisation for Economic Co-operation and Development (OECD). The OECD states that the gross domestic product (GDP) is calculated in light of the numerous economic activities. It also evaluates the cost of the raw materials, supplies, and labour used to produce finished goods or services. Finally, it subtracts intermediate utilisation from gross value to arrive at gross value added. The difference between the gross value of production and the value of intermediary consumption is the gross value added.

By summing the incomes that businesses pay as wages for labour, interest on capital, rent for land, and profits from entrepreneurship, the income approach estimates GDP. The "National Income and Expenditure Accounts" of the United States (US) divide incomes into five categories that add to the net domestic income. Wages, salaries, and other labour income are among the categories, along with corporate profits, interest income, other investment income, farmer earnings, and revenue from non-farm unregistered enterprises. These five income components add up to the GDP with the necessary adjustments. Thus, subsidies are subtracted from Indirect taxes and added to capital consumption allowances. GDP is, therefore, the aggregate sum of compensation of employees (*COE*), gross operating surplus (*GOS*), mixed gross income (*GMI*), and taxes (*T*) minus subsidies on production and imports $(S_{P\&M})$. Thus,

$$GDP = COE + GOS + GMI + T_{P\&M} - S_{P\&M}$$

where,

- **Compensation of employees** (COE) measures the total remuneration to employees for work done, including wages, salaries and employer's contributions to social security.
- **Gross operating surplus** (GOS) is the surplus from owners of incorporated businesses.
- **Gross mixed income** (GMI) is the surplus from owners of unincorporated businesses, including small businesses.

The expenditure method estimate GDP as the sum of the final uses of goods and services measured in purchasers' prices. This approach assumes that every production is bought and consumed by someone and that if a product is not bought, the producers buy them themselves. The expenditure approach computes GDP as

$$GDP = C + I + G + (X - M),$$

where,

- **C (consumption)** is made up of private expenditures in the economy, including food, rent, jewelry, gasoline, and medical expenses and excluding the purchase of new housing.
- **I (investment)** consist of commercial investments like building a new mine, buying software, buying a new home, or buying gear and equipment for a firm. Stocks, bonds, and other financial instruments are not considered investments in GDP since they are considered savings

that will be utilised to buy goods that will be included in the calculation of GDP.

- **G (government spending)** is the sum of government expenditures on final goods and services, including salaries of public servants, expenditure on the military and any investment expenditure by the government. This excludes transfer payments, such as social security or unemployment benefits.
- **X (exports)** includes all goods and services produced for other nations' consumption.
- **M (imports)** represents gross imports. Imports are subtracted since imported goods will be included in the terms **G**, **I**, or **C** and must be deducted to avoid counting foreign supply as domestic.

An international set of guidelines for assessing national accounts and calculating GDP, known as SNA93, was developed by the International Monetary Fund, the European Union, the OECD, the United Nations, and the World Bank (National Account, 2011). The Ghanaian government's quest for economic transformation led to the formation of the Ghanaian Panel on Economic Development (GPED) in 2011. In order to start a conversation about the structural transformation of the Ghanaian economy, the Friedrich Ebert Stiftung (FES) and the "Institute of Statistical, Social and Economic Research (ISSER)" of the University of Ghana together launched the Global Partnership for Economic Development (GPED).

The group was established to identify tactics to support Ghana's economic development and progress. "Some of the topics that were discussed in the panel from which recommendations were made to stakeholders and policy makers included the following agriculture, informal economy, banking and finance, green economy, oil and gas, social protection, industrial policy, structural transformation, Education, long term development planning, decentralization and infrastructural development being part of the panel discussed how Ghana's economy has been influenced by Neo-liberal policies over the years (Osei & Domfe, 2008)". Unlike classical organization theory, the neo-classical theory posits that an organisation is a combination of both the formal and informal forms of organisation. Thus, the economy is not only in the hands of the public sector but also considers the private sector the engine of economic growth. The neo-liberal state policies are based on a few principles, including the privatisation of state-owned businesses, the loosening of government regulations, the liberalisation of trade, the removal of import bans, the promotion of foreign investment, the withdrawal of incentives, and the scaling back of welfare programmes (Haque, 1999).

Indeed, Osei and Domfe (2008) and GLSS (2008) have demonstrated a positive correlation between poverty reduction and economic growth. Contrarily, according to Kefela and Ghirmai (2009), economic growth is not a guarantee of poverty reduction unless accompanied by a well-crafted pro-poor tax policy that creates more chances for people to earn income and allows them to work in rewarding jobs. Kefela and Ghirmai ascribed the enormous discrepancy between the tax payments mandated by law and those given to the state as the cause of emerging countries' economic problems. According to the report, developing nations in the medium-income group have tax rates ranging from 17 to 22%, whereas wealthy countries' average tax rates as a percentage of GDP range from 29 to 32%. The average tax rate ranges from 13% to 16% in the world's poorest nations. This makes taxation a prime factor of economic growth.

The Ghana Statistical Service (GSS) is the country's agency responsible for computing the national GDP. In Ghana, the economic activity is measured by supply tables and social accounting matrices in the Economic National Account (ENA) of the GSS. GDP is expressed in two ways depending on how it is calculated; Nominal and real GDP. The nominal GDP measures the total amount of finished goods and services an economy produces in a given year. It is calculated using the prices in force in the year the output is produced. In economics, a nominal value is expressed in monetary terms. For instance, a nominal value may change due to variations in quantity and price. The nominal GDP includes all adjustments for all goods and services generated over the course of a year. The nominal GDP would fluctuate even while the output stayed constant if prices changed from one period to the next. The value of all the final products and services produced by an economy in a given year, after taking inflation into account, is the real GDP. It is determined using the costs from a chosen base year. In calculating the Real GDP, inflation must first determine how much GDP has been changed by inflation since the base year. By dividing the GDP, the impact of inflation is taken into account. Therefore, real GDP considers that nominal GDP would change if prices changed, but output stayed the same. Nominal GDP, usually considered unadjusted GDP, is the market worth of all final items produced in a nation. Real GDP, in contrast, is nominal GDP that has been inflation-adjusted. It consistently captures the actual production of a nation within a specific time.

The base year plays an important role in determining a country's GDP. Rebasing an economy involves revising the methods and the based data used to calculate a country's GDP. Rebasing is necessary to ensure the GDP reflects the current prices of economic activities in the country and to adapt to the current national accounting system. Ghana's GDP was calculated using 2006 as the base year instead of 1993 in 2010. Ghana's service sector, which had previously been agriculture's largest contributor to GDP, now accounts for 60% of the GDP increase. The base year was recently changed from 2006 to 2013, resulting in a 24.3% jump in the GDP to GH¢ 279billion. The GDP has been increasing from 2008 to 2019, as indicated in Figure 3.

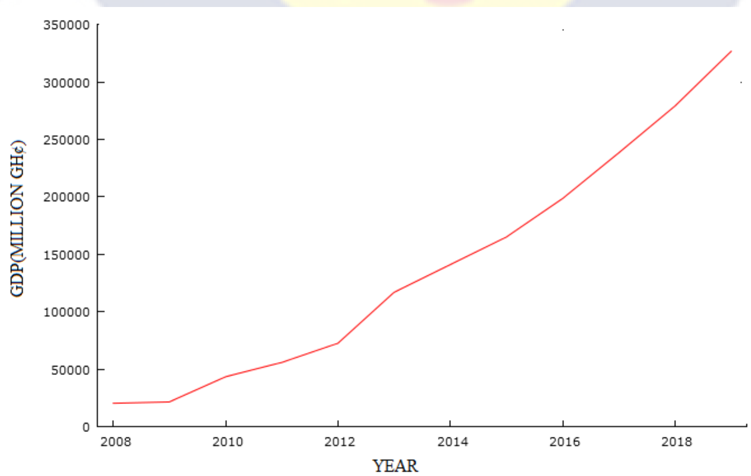

Figure 3: GDP Trend from 2008 to 2019 (Osei & Domfe, 2008)

In 2008 Ghana's GDP was GH¢20343.80 million, and agriculture contributed GH¢ 5,716 million, representing 28.10 percent of that years GDP. The service sector contributed GH¢ 10105.90 million, representing 49.68 percent of the GDP, and the industrial sector also contributed GH¢ 4521.90, representing 22.23 percent of GDP.

In general, there is an increase in GDP in the country's combined effect of the three major sources of GDP, as shown in Figure 2.

Trend observation from Figure 3 indicates domination of the service sector over the years in contribution to GDP. The agricultural sector, which used to be the major contributor, seems to be lagging in recent times (from 2011) even though there is a gradual increase in GDP.

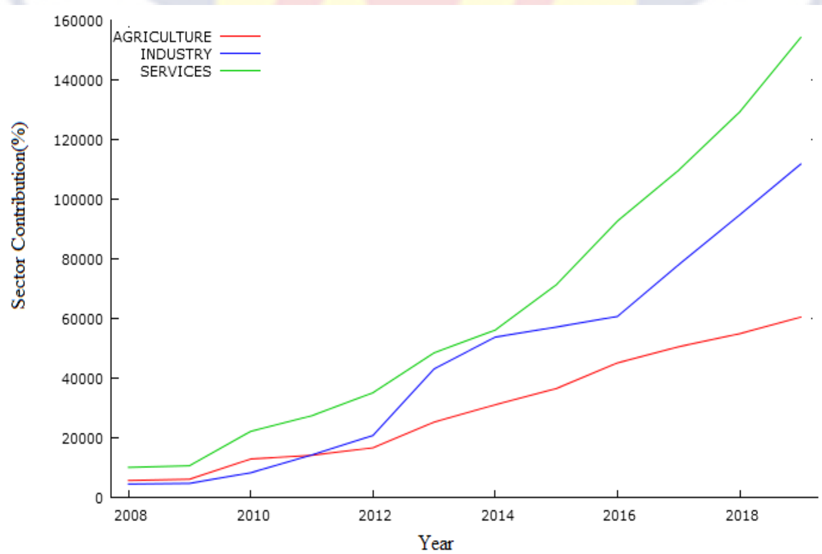

Figure 4: Trend of the Three Major Sources of GDP from 2008 to 2019 (Osei & Domfe, 2008)

Taxation in Ghana

In Ghana, levies are collected on all incomes of resident and non-resident persons, resident companies, and established bodies of persons operating in the country. If a person satisfies one of the following requirements, they are considered to be a resident for tax reasons: they must be a citizen of Ghana, except for those who maintain a permanent residence outside of Ghana for the entire year; they must also be present in Ghana for a total of 183 days or more during any 12-month period that begins or ends during the year; they must be an employee or official of the Ghanaian government who is posted abroad during the year.

In order to qualify as a resident for tax purposes, a firm must either be incorporated in Ghana or have management and control functions performed there at any time during the fiscal year.

A group of people is deemed to be a resident group of people if one or more of the following conditions are met: the group of people is established in Ghana; at any point during the assessment year, one or more resident individuals serve as the group's manager, or one or more resident individuals directly or indirectly control the group of individuals at any point during the assessment year. The levies are calculated at a flat rate each year on all incomes accumulated by the persons or bodies from their business, employment and investments. For example, a person's income from employment consists of all financial gains or profits, including any allowances or benefits received directly or on their behalf in cash or in-kind gifts. A communication company that is not resident in Ghana but engaged in Businesses that operate in Ghana and transmit communications through cable, radio, optical fiber, or satellite is subject to a final rate of tax on Ghana gross receipts of 15%. The mining industry in Ghana also contributes to revenue through mineral royalties. The royalty rate currently stands at. A mining lease, limited mining lease, or small-scale mining licence holder is entitled to 5% of the total earnings from minerals extracted through mining activities. The GRA is again given the mandate to impose taxes on the profit of some selected companies in the country. This levy, collected quarterly, is known as National Fiscal Stabilization Levy (NFSL) and is collected from companies such as;

- Banks (excluding community and rural banks);
- Non-bank financial institutions;
- Insurance companies;
- Telecommunication companies (liable to collect and pay Communications Service Tax (CST) under the CST Act 754) of 2008;
- Breweries;
- Inspection and valuation companies;
- Companies providing mining support services; and
- Shipping lines and maritime and airport terminal operators.

Certain gifts received by taxable persons in Ghana are levied at a rate of 15% on the total taxable value estimated at the value of the gift at the time of receipt and exceeding GH¢ 50.00. Taxable gifts include;

- If received as a gift, any of the assets listed below that are located in Ghana: Land; permanent or movable structures; shares, bonds, and other securities; finance, including foreign currency; Any form of transportation, whether on land, at sea, or in the air; Businesses and business assets; Additional eligible commodities or chattels; a benefit or asset located in Ghana or abroad that was given to a resident as a gift; a portion of, a right to, or an interest in any of the aforementioned assets;

- an asset, whether local or international, acquired as a gift by or for the benefit of a resident person, provided that the asset has been credited in an account, invested, accumulated, or capitalized under that person's control and;
- Any payment or other type of payment intended to secure the performance of an action or the omission of an action that benefits a resident person.

Value Added Tax (VAT) and the National Health Insurance Levy (NHIL) are fees that apply to the provision of all goods and services and the importation of goods and services in Ghana. The standard tax rates are determined by the value of the taxable supply of the goods, services, or imports, with the VAT standard rate being 15% and the NHIL standard rate being 2.5%, respectively. The only exception to this rule are shipments considered exempt on special occasions. When determining import duties or customs revenues for products, the value of the taxable supply is defined as including Cost, Insurance, and Freight (CIF). The Harmonized System and Customs Tariff Schedule 2012 ("HS Code"), which outlines the various tariffs and administrative costs that apply to imports, exports, and excise levies, has been implemented in Ghana. (description and classification) of the imported item as defined by the HS Code. Import tariffs may range from 0% to 35%, depending on the kind of import. Normally, import duties are applied to the imported good's Costs, Insurance, and Freight (CIF). Along with the NHIL inclusive of 17.5 percent, import duties and levies are calculated using the product's total value or the CIF value (used for customs purposes).

Determination of Customs Value

The assessment of the economic value of items declared for importation is known as customs valuation. The decision establishes a benchmark for taxes to be charged on all imports into the nation. This aids in properly using commercial policy measures, import and export analyses, and collecting import duties and taxes. The Customs determines the value of commodities, "Excise and Preventive Service (CEPS)," presently known as Customs Division, a subsidiary of GRA, based on "Cost, Insurance and Freight (CIF)" and the current exchange rate at that particular moment. Mathematically, CIF is given by

CIF = FOB + Freight + Insurance, where

Cost

The term "cost" in customs terminology is "Free On Board (FOB)," a condition of sale under which the amount paid or indicated by a seller comprises all charges up to boarding the ship at the port of departure chosen by the buyer. The term "FOB" initially showed up during the era of sailing ships. The ship's rail was still relevant when the International Chamber of Commerce (ICC) first issued its standards for using the term in 1936 because products were frequently transferred over the rail by hand. According to ICC, FOB is an expression used in international commercial law that describes when, in accordance with the Incoterms standard, the buyer has responsibility for all responsibilities, costs, and risks related to the delivery of goods. It might also be referred to as freight forward, or freight collect. When shipping, the term FOB denotes that the customer will not be charged for any products loaded onto a vehicle by a carrier at the point of dispatch. Free On Board (FOB) is a legal phrase that denotes the obligation that the seller transport goods at the seller's expense along a particular route to the buyer's specified destination. Only inland canal transit or non-containerized maritime freight use FOB. The point at which ownership of the products is transferred is not specified by FOB, as is the case with all Incoterms. The phrase, which is always paired with a loading port, is also used to indicate when a seller is no longer liable for shipping costs in contemporary domestic shipping.

Freight

A fee is paid for the conveyance or shipping of goods by air, land, or sea. The goods retain the consignor's property if the freight is paid for (as under C&F and CIF agreements) until the consignee accepts delivery of them after they arrive at the destination and until the consignor gets paid for their invoice. When the goods are given to the carrier against a bill of loaded, the consignee acquires ownership of them if freight is paid by the consignee (as with FOB conditions). 20% of the FOB is for freight.

Insurance

Using shipping insurance, senders may be compensated if their packages are misplaced, stolen, or destroyed while in transit. The loss or damage of ships, cargo, terminals, and any other means of transportation used to move the property between its points of origin and its destination is covered by marine insurance. Customs determines insurance as 0.875 percent of the FOB and Freight value while considering sea or land transportation. Insurance is 0.875% (FOB + Freight) in the case of sea or land transportation, and for air transportation, Insurance is 1% (FOB + Freight). The FOB and the Freight are normally stated by the importer on the Invoice covering the goods or the Bill of Laden (B/L) as in sea or land transportation and Air Way Bill (AWBL) as in air transportation. In situations where the importer does not state the Freight then, the Customs Technical Standard Bureau (CTSB) makes use of the following formula to determine the Freight:

Freight =20% of FOB ; Insurance = 0.875% (FOB + Freight)

The above calculations for Freight and Insurance are related to sea or land transportation when the Freight is not stated. In cases of air transportation, where the Freight is not stated, the computations are given by

Freight =20% of FOB ; Insurance = 1% (FOB + Freight)

These computations are done in foreign currencies to arrive at the CIF in foreign currency.

Exchange Rate

Exchange rates show the amount needed to interchange one currency for another. It is the cost at which one country's currency can be exchanged for the currency of another. The Custom Value (CV) is given by the product of CIF and the prevailing Exchange Rate. The CV, which forms the basis upon which revenue (duties, taxes, levies and fines) are imposed on imported items, is declared by the importer, its declarant, or the Assessed CIF by the CTSB. The Declared CIF in foreign currency or the Assessed CIF in foreign currency becomes the basis for imposing taxes in local currency after multiplying the value by the prevailing Exchange Rate. When customs have doubts about the Declared CIF, customs go ahead to use the Assessed CIF for further computations in determining the customs value.

How Customs Value is Determined

The transaction value or price paid or payable for the products imported into the country is defined as the customs value under Section 67 of the Customs Act, 2015 (Act 891) unless an alternative method of assessing customs value is expressly provided for. When customs value cannot be calculated based on transaction value, as required by Section 68 of the Customs Act, 2015 (Act 891), the customs value shall be evaluated by utilizing each of the subsequent secondary valuation methods. Six methods are used to determine where the transaction method cannot be used. These include transaction value, transaction method for same or similar items, transaction method for comparable goods, a deductive technique for valuing, a computed method for valuing, and residual method for valuing.

Transaction Method

When calculating the value for duty on the amount paid or payable for imported products while considering specific modifications, customs uses this approach. The majority of people employ this technique. The Transaction value is used when selling products to a buyer in Canada for export to Canada. The sum of the buyer's payments to the seller, whether directly or indirectly, is known as the Price Paid. However, the price payable is the entire amount of all payments the buyer makes to the seller, whether directly or indirectly.

Transaction Value of Identical Goods

Customs uses a predetermined value for duty on identical products when it cannot utilise transaction value. In all ways, identical products are regarded as the same as the goods being appraised. However, there is one exception, and that is for slight variations in appearance. These variations cannot impact the worth of the commodities. Products would need to be produced in the same nation as the identical commodities to qualify.

When customs use identical and transactional items, they base their assessment of similar commodities' duties on an established value. Goods must have a value that must be:

- Closely resembling similar goods,
- Capable of performing the same function,
- Commercially interchangeable, produced in the same country and by the same manufacturer as the similar goods

Deductive Value Method

By comparing the cost of similar imported items to those sold to non-sellers in the country's largest aggregate amount at the time of importation, the deductive value is calculated by;

- Commissions
- Additions for profit and general expenses
- Cost of transportation and insurance from the port of arrival in the country to the place of delivery
- Duties payable on importation.

Computed Value Method

The calculated value included the imports' production costs, profits, and other costs. Producers in the exporting nation must be aware of these while selling the same goods to Canadian importers.

Residual Value Method

The residual technique does not specify any particular standards for figuring out a number for duty. The value is instead based on one of the alternate techniques (considered in sequence). The least amount of adjustment is also needed. The price must be fair market and accurate to current business conditions. Finally, the following factors may have an impact on the ultimate value of the duty:

- The relation between the parties involved (i.e., a related buyer and seller)
- Condition where the goods were provided to the consignee at no charge (i.e., consignment)

- Allowable additions or deductions to the value of the goods
- Used goods
- Goods not sold in the home country (i.e., for rent or lease)

Customs Regimes

Customs regimes show the intensions or the purposes for which the goods were imported. Table 1 presents the main custom regions and are Nine (9) which are used by Customs worldwide Chalfin, (2006).

Table 1: The Main Customs Regimes

Code	Description
10	Direct Export
20	Direct Temporary Export
30	Direct Re-export for goods landed but not entered
40	Import into Home Consumption
50	Temporary Admission
60	Re-import
70	Direct entry into Bonded Warehouse
80	Transit, Transshipment and Coastwise Trade
90	Direct Entry into Free Zones, Duty Free Shops and ship Stores

(Chalfin, 2006)

Direct Export means the goods or raw materials produced in a country and exported to a different country. These include traditional and non-traditional goods. These goods and raw materials are exported for Foreign exchange, mainly agro-based goods. Direct Temporary Export means the goods are semi-produced in the country and sent to another country to be put into finished products, goods, or trade fairs to bring the goods back to the country. These include goods for trade fairs or exhibitions, repairs, constructions, personal use, and further processing in other countries.

Direct Re-export are goods imported into the country, landed but not entered and sent back. The goods may be re-exported back to the originating country or a different country.Goods imported into a country with the intention to be used in the importing country are termed Home Consumption. This regime is the main source of revenue for the country, although other regimes also contribute some form of revenue. Most under-developed or developing countries revenue and hence GDP depends much on this type of regime and its associate regimes.

Temporary admissions are goods imported into a country intending to send the goods back to the originating country after use in a destination country. These include goods for repairs, construction, further processing, personal use and trade fair or exhibitions. Re-imports are goods imported into a country and sent back to the originating country with the intention of importing the goods back to the importing country for which the goods were sent to the originating country. This includes vehicles for repairs, goods for further processing, construction equipment and goods for exhibitions sent back to the importing country.

Direct entry into the bonded warehouse is meant for goods for which duties, taxes and other levies are deferred for future payment, and the goods are admissible into Custom Bonded Warehouse. This allows the Government or the Customs Division to secure the deferred revenue on behalf of the country in the form of an Insurance Bond as a guarantee for the deferred revenue. The Insurance Bond comprises the Premises. The Premises Bond covers the facility or the warehouse, with the Removal Bond covering the conveyance of the goods from the port to the customs bonded warehouse whiles whereas the particular bond covers a particular transaction.

Customs Transit (from the European Union website) is a customs procedure used to move goods between two points of Custom territory via another or two different Customs territories. In Customs, transit means goods that are meant for another country and are allowed to pass through another country and the goods are sent by road to the destination country. This happens when the destination country is a land lock country. It is termed transshipment when the goods are sent by sea to the other country.

According to Yasui, (2010) a free zone is an area of a contracting party's territory where import duties and taxes on commodities are treated as though they were beyond the country's customs jurisdiction. Free Zone companies must export at least 70 percent of their produce by law. The ultimate aim of a Free Zone Company is to boost the country's balance of trade. A duty-free business sells items free of local taxes and duties since they are sold to travellers who will take them out of the nation rather than use them in the country.Other twenty-four (24) regimes show the combination of two different regimes. This means that one regime can be converted into different regimes depending on the goods' intentions,The regime combinations are presented in Table 2.

Table 2: Various Combinations of Regimes

Regime Code	Description
19	Export following Free Zone
27	Temporary Export following Warehousing
34	Re-export following Home Consumption
35	Re-export following Temporary Admission
37	Re-export following Warehousing
39	Re-export following Free Zone
45	Home Consumption following Temporary Admission
47	Home Consumption following Warehousing
48	Home Consumption following Coastwise Transshipment or Transit
49	Home Consumption following Free Zone or Duty-Free Shop
57	Temporary Admission following Warehousing
59	Temporary Admission following Free Zone
61	Re-Import Following Direct Export
62	Re-Import following Temporary Export
72	Warehousing following Temporary Export
75	Warehousing following Temporary Admission
77	Bond to Bond
79	Bonded Warehouse following Free Zone
88	Transit or Transshipment following Transit or Transshipment
89	Transit from Bond
94	Free Zone following Home Consumption
95	Free Zone following Temporary Admission
97	Free Zone following Warehousing
99	Free Zone or Duty-Free Shop following Free Zone or Duty-Free Shop

(Yasui, 2010)

Temporary Admission following Warehousing is used in a situation where goods which were warehoused are temporarily used locally. This is mostly used for trade fairs or exhibitions, further processing, repairs, construction or institutional use. Temporary Admission following Free Zone or Duty-Free Shop or Ship Stores is used when goods in Free Zone or Duty-Free Shop or Ship Store are temporarily used locally. This is mostly used for trade fairs or exhibitions, further processing, repairs, construction or institutional use.

Re-import Following Direct Export refers to a situation where the goods produced locally and exported abroad are sent back to the country. This mostly happens when the importing country rejects the goods.Re-import following Temporary Export is used when the goods after temporary exporting are brought back into the originating country. Goods for repairs are brought back into the country using this regime. With this regime, duties have already been paid, but duties will be calculated only on the cost of the changes made to the goods.

Warehousing following Temporary Export refers to a situation where the temporary goods set out of the country are brought back but administered into the warehouse. This is mostly used for construction, further processing, trade fair, or exhibition works carried outside the country, and when coming back, they are taken into Bonded Warehouse. Warehousing following Temporary Admission refers to a situation where the goods came into the country to be used temporarily, and after the use, they are administered into Custom Bonded Warehouse. Goods that came into the country for trade fair or exhibition purposes and expect to get a local buyer mostly use this regime.

Bond to Bond is a situation where goods admitted into Custom Bonded Warehouse are sent to other Custom Bonded Warehouse within the same Customs territory or country. This mostly happens where the warehouse which used to take the goods is too small to carry the goods when there are additions to the goods.Bonded Warehouse following Free Zone or ship Store or Duty-Free Shop is where goods admitted into Free Zone, or ship Store or Duty-Free Shop are sent to a bonded warehouse. This mostly happens when the Free Zone Company is not having enough space to keep its goods. Following Transit or Transshipment is where goods meant for transit in a country are transited or transshipped into another country. This mostly happens when a transistor has a market for its goods outside his or her transiting country or where transit rejected goods are transited to another country.

Customs Procedure Codes

The Customs regimes into which items are being brought and removed from them are identified using Customs Procedure Codes (CPC). The CPC informs the system whether the declaration is for an import, export, transit, or any other situation that may be feasible in the Customs environment. The Code specifies to the system how the statement is to be processed and how the data input from the declaration is to be handled.

The CPC is constructed from left to right using a succession of numeric and alpha characters. The General Procedure, or first number, denotes the generally accepted international standard. These agreed standards are Export, Temporary Export, Re-export, Imports, Temporary Imports, Re-imports

Warehousing, Transit and Transshipment, and Free Zones, ship Stores and Duty-Free Shops. The second number is called Previous Procedure, which signifies the last procedure to which the goods on the declaration were subjected.

In Ghana, we use the five alpha-numeric characters, while some countries use seven to represent the Custom Procedure Codes. The characters are described as follows:

D – Dutiables for Home Consumption and permits granted by Ministry of Finance and Ministry of Trade relief on ECO/ EDIF Levy

F – For Head of States, Diplomatic Missions, Technical Assistants, etc.

E – For Raw materials for the Manufacturing Companies

G – Exemption for Ghana National Petroleum Corporation (PNDC Law 64, 19)

I – For Ghana Investment Promotion and the Tourism Sector

M – For the Mining Sector

N – Fishes caught in the Ghanaian Sea, Vehicles for Customs Operational use and Container transfer from port to off-dock Terminals

P – For the Various Ministries

R – For Petroleum Activities

X – For Export

V – VAT Exemption for the Manufacturing Companies

W – Special ECOWAS Exemptions

In Ghana, there are ninety-eight (98) tax codes that the Ghana Customs administer. Tax Codes 39, 64, 75 and 80 have been reserved for future use. The tax codes are grouped under Import Duty, Import Vat, Export tax, National Health Insurance Levy, Petroleum Taxes and Levies, Fees, Fines and Agencies and charges. The list of duty tax codes is presented in Appendix **A**.

Import Duties and Levies

Import duties and levies constitute the chunk of the Import taxes administered by Ghana Customs under the Customs Act, 891 (2015) as amended. Thirty-six (36) out of the ninety-four representing 38.3%, contribute to the total Import taxes in Ghana. The following tax codes fall under import duty taxes. Import Duty is computed by multiplying CIF by the Exchange Rate. Appendix **B** presents the Import Duties and Levies tax codes and descriptions.

Import Vat Tax and Export Tax

The Import VAT tax is the second highest generating tax for the import taxes in Ghana. All stages of the production and distribution cycle are taxed on the value contributed to products and services. It is part of the total cost of the product or service that the customer receives. Some nations (such as Spain, France, Germany, the United Kingdom, etc.) use the term 'Goods and Service Tax' to refer to this tax. In addition to CIF and import duty, the GET fund, the NHIL levy, and import excise are included in the tax base for Import VAT. The tax code for Import VAT is 02. On the other hand, the Export Tax (with duty tax code 08) is the tax exerted on export commodities.

National Health Insurance Levy (NHIL)

The National Health Insurance Levy (the Import NHIL) is a tax levied for products and services sold or imported into Ghana. Without an exemption, the tax applies to all goods and services. The fee is levied at a 2.50 percent rate.

Petroleum Taxes and Levies

Petroleum Taxes and Levies (PETAL) are duties paid on petroleum products. Seventeen (17) of the Ninety-four tax codes administered in Ghana are petroleum taxes representing 18.06 percent. Table 3 is the duty tax codes and description for petroleum taxes and levies Malik, Ross, Abrokwah, Conron, Kamara and Nuer, (2021).

Table 3: Petroleum Taxes and Levies and Descriptions

Duty Tax Code	Duty Tax Description
34	Excise Duty from OMC
35	Exploration Levy
36	Stock Fund Levy
37	Energy Fund
38	Interest on Petroleum Payments
52	Road Levy
53	Debt Recovery
57	Social Impact Mitigation Levy
58	Cross Subsidy Levy
59	Excise Duty (M)
62	Penalty on Petroleum Payments.
66	Road Fund
79	Special Petroleum tax
86	Energy Debt Recovery Levy
95	EDRL (Foreign Exch under Recv)
96	EDRL (Power Gen. & Infra Acct)
97	EDRL (TOR Debt Recovery)

(Malik *et al.*, 2021).

Fees

Fees are charges that Ghana Customs charges on services rendered. Table4 presents the duty tax codes and description for Fees.

Table 4: Shows the various Fees Tax Codes and Descriptions

Duty Tax Code	Duty Tax Description
16	Vehicle Certification
26	Manufacturer Renewal License
27	Official Publication
28	Certification Fee

(Malik *et al*., 2021).

Fines and Other Charges

Fines (with code 14) and other charges, which comprise Overtime Charges (with code 13) and Forfeited Money (with code 22). They constitute three out of the ninety-four tax codes.

Agencies Fees and Charges

Agencies Fees and Charges are charges administered by the Ghana Customs for other governmental and non-governmental agencies. Thirty out of the Ninety-Four Tax Codes are Tax Codes for Agencies and Charges. The list of duty tax codes and descriptions for Agency Fees and Charges are presented in Appendix **C**.

Harmonized Commodity Description and Coding System

"Harmonized Commodity Description and Coding System (HS Code)" is used to classify commodities in shipment. Wikipedia states that the Harmonized Code is an international standard for describing and classifying commodities.

There are a total of 99 chapters and 21 parts in this book. Chapters may be added to any section at any time. The first two digits of each chapter identify the heading and subheading, while the next four digits identify the chapter number. Additional numbers are added based on the country's system. Headings and subheadings in the 99 HS chapters are further broken down into 1,244 and 5,224, respectively.

HS International usage by the parties is reserved for Chapter 77. Chapters 77 and 98, and 99 are set aside for future international and national use, respectively. Special categorization provisions are found in Chapter 98, while temporary changes made in accordance with the parties' national direction or law are found in Chapter 99. Since its inception, HS has undergone a number of revisions, either to get rid of headings and subheadings that described commodities that were no longer traded or to add headings that dealt with new technology and environmental issues. On January 1st, 2017, the most recent iteration of the HS went into effect. These guidelines control how things are classified in the nomenclature (Maine & Scala, 2017).

To make referencing easier, the titles of the sections, chapters, and sub-chapters are given first. The headings and any relevant category or chapter notes are used to categorise the content.Secondly, if an article is included in a heading, it is assumed that any mention of that item also refers to it as incomplete or unfinished, provided that the way it is presented retains all of the fundamental characteristics of the complete or finished article. It also includes a mention of the article being presented unassembled or dismantled, complete or finished, or failing to be categorised as complete under this rule. Any reference to a material or substance in a heading is interpreted to include any mention of the material or substance in any mixtures or combinations with other materials or substances. Any reference to goods made of a certain material or substance is interpreted to include references to goods made entirely or partially of that material or substance.

Thirdly, when the second rule is applied or any other reason, goods are prima facie, classifiable under two headings, and classification is administered by

(a) The heading which provides the most specific description. Nevertheless, even if one of the headings provides a more thorough or accurate description of the goods, it is acceptable for two or more headings to each refer to a portion of the materials or substances present in mixed or composite goods or a portion of the items in a set offered for retail sale.

(b) As far as this criterion is applicable, mixtures, composite goods made up of various materials or components, and goods displayed in sets for retail sale that cannot be classified according to to reference A are classified as if they were made up of the material or component that gives them their distinctive character.

(c) When products cannot be categorised using (a) or (b), they are categorised under the heading that appears last among those that equally merit attention in numerical order.

(d) Fourthly, products that cannot be categorised using the first three rules are categorised under the topic that corresponds to the items that they are most similar to. In addition to the guidelines mentioned above, the following ones also apply to the commodities mentioned there:

(a) cases for cameras, musical instruments, and weapons. Drawing instrument cases, necklace cases, and other similar containers that are designed to hold a specific item or group of items suitable for long-term usage and are sold alongside the items for which they are intended are included in this category. However, containers that give the entire distinctive character are exempt from this requirement.

(b) As long as they are of the type typically used for packaging such products, packing containers delivered with the goods inside are classified with the goods, subject to the limitations in (a). This condition is not applicable when packing material containers are suited for repeated use.

For lawful reasons, the categorisation of goods in the subheadings shall be in accordance with the terms of the subheadings in question, any pertinent subheading notes, and the rules as mentioned above, with the knowledge that only subheadings at the same level are similar to this rule. The relevant section and chapter notes shall apply unless the context dictates otherwise.

Tax Revenue and Economic Growth

Moraa and Gathege (2013) state that a rise in a nation's output of goods and services is a common definition of economic growth. However, improving average earnings and living standards can also define economic progress (Baumol & Blinder, 2005). Gross domestic product (GDP), which represents the entire value of goods and services generated over a specified period, is a typical indicator of economic growth.

Several limitations have been pointed out by a great number of people and institutions that matter on the concept of GDP: what it measures, how it is applied, measured for what etc. For instance, according to Stiglitz, Sen, and Stiglitz (2009), GDP is a subpar indicator of social progress since it ignores environmental damage. Nussbaum (2013) proposes the incorporation of household labour and unpaid work since, according to her, they serve as a substitute for goods and services that would otherwise be purchased for value. Blades *et al*. (2006) suggests that unpaid labour constitutes about 50% of Australian GDP. Many scholars disagree that a country's GDP per capita is a reliable indicator of its citizens' living standards. A higher GDP or GDP growth does not always translate into a higher standard of living, particularly in sectors like healthcare and education, as noted by Elistia and Syahzuni (2018).

It has been the concern of every country to grow its economy. They do so by tackling certain economic variables which have growth relationships. Many researchers have proposed growth models that measure existing and future economic growth with other macro and microeconomic variables.

According to Solow and Swan (1956) neoclassical growth model, long-term steady-state economic development is not impacted by tax policy. On the other hand, Romer (1990) has produced growth models with government spending and tax policies having long-term or permanent economic growth effects. The endogenous growth model also models tax policies as having a positive correlation with the economic growth rate over time.

The Keynesian theory (Keynes, 1924) of economic growth postulates that government intervention is necessary to ensure economic growth. The government can intervene to correct market failures that lead to budget deficits by adjusting taxes and government expenditures. A budget deficit is usually avoided by exploring new areas of taxation or cutting down government expenditure.

In a study on the connection between tax policies and government deficit in Kenya, Onyango(2013) found that there were still many untapped potential areas for tax policy and that the country's tax policy was primarily to blame for the ongoing budget deficit. Furthermore, the tax system was held responsible for the ongoing budget deficit, with most voters placing the primary blame on the limited tax base and compliance problems. The researcher also looked into possible strategies for reducing and ultimately doing away with the nation's poor tax compliance rates. It was discovered that an astounding 81 percent of respondents thought that lowering the various tax rates would guarantee greater tax compliance in the nation.

Takumah and Njindan (2015) have studied the link between tax revenue and economic growth through empirical investigation. They undertook a causality analysis performed in a multivariate set up to establish the nexus between tax revenue and economic growth and found strong evidence of a unidirectional causal flow from tax revenue to economic growth in Ghana.

Data on 10 high-tax nations, such as Zambia, Britain, Chile, and Zaire, and 10 low-tax nations, such as Singapore, Korea, Uruguay, and Japan, were gathered in a study by Skinner (1987). Marsden determined that a one percentage point rise in the tax to GDP ratio reduces economic growth by 0.36 percentage points when comparing the 20 countries and calculating the differences in productivity growth rates.

Owusu-Gyimah (2015) studied the impact of tax revenue on the economic development of Ghana and the Gross Domestic Product using the Least Squares Multiple Regression. The study explored sources of revenue leakages, tax reforms, the impact of automation on tax revenue performance, and strategies for increasing tax collection. The study found a significant positive link between tax revenue and GDP. Thus, though neo-classical economic growth models depict lack of positive correlation between economic growth and taxation, Ghana seems to be an exception. This is partly as a result of the fact that majority of the country's revenue rest on taxation due to lack of production. Again, since the country is an import-based economy, import taxes are very heavy.

Gaps in Ghana's Taxes

The Ghana Tax Gap Analysis (The World Bank, 2020) presents, among others, the share of the contribution of tax revenue to GDP (1983-2019), the tax gap by region, corporate tax gap by sectors, import revenue gap estimation for 2012 to 2016, import tax revenue gap as a percentage of the potential for a number of countries and their respective contribution to revenue gap, and the import revenue gap by top 10 contributing commodities. The report shows that, unlike the developed nations, Ghana suffers hugely from large revenue gaps.

Chapter Summary

The literature review provides background to revenue mobilization in Ghana. It is highlighted that the import revenue has overarching importance for economic development as it forms a significant part of government total revenue. It is acknowledged that the potential of import revenue depends on the structure of its trade relations with the international community through international trade and the efficiency of agencies responsible for its mobilization. It, therefore, outlines the partnership that exists among the revenue mobilization agencies, such as the "Customs," "Excise and Preventive Service (CEPS)," "Internal Revenue Service (IRS)" and the "Value Added Tax (VAT)" Service, whose activities are coordinated by the Ghana Revenue Authority (GRA). The GRA undergone various reforms with the main aim of ensuring efficiency in revenue generation with the enactment of relevant Acts.

A review is made on the performance of various revenue components in revenue generation. These involve the "Gross Domestic Product (GDP)." The derivation of the GDP is extensively reviewed, and it comes to light that the tax revenue component is quite low (13 to 16%) among developing nations compared to the developed. It is clear from the literature that taxation is a prime factor in economic growth. Components and computations of GDP have been presented. In particular, the relevance of GDP is seen to be influenced by periodic rebasing, the recent one occurring in 2013. Therefore, such activity has implications for data coverage for studies on economic variables.

Taxation in Ghana is presented to cover all activities that attract taxes. The National Health Insurance Levy (NHIL), Import duty, VAT, and Petroleum and Agency Levy (PETAL) are such taxes. The Cost, Insurance and Freight (CIF) are included in the definition of the value of taxable amount for imports of goods. There is an extensive presentation on the "Harmonized System and Customs Tariff Schedule" 2012 ("HS Code''), which specifies various duties and administrative charges for imports, exports and excise duties. The CIF forms the basis on which the customs value of goods is determined. Several alternative procedures are presented for determining the customs value of imported goods.

Presentation is made on two practices that help with the appropriate classification of goods. These include the custom regimes that involve the main regimes and a combination of regimes; the other is the assignment of HS Codes.

Research has examined the relationship between tax revenue and countries' economic growth. Results appear divergent on the correlation that exists between the two. However, in Ghana, tax revenue contributes positively to GDP. The Ghanaian exception is attributable to the large composition of import revenue to GDP. It is documented that a good understanding of the problem and the industry is necessary for a clear specification of revenue modeling procedure. It is seen that for revenue modelling, processes such as the identification of key themes and key dimensions are useful. What ensures the robustness of the revenue model has also been of concern in the literature. These broadly cover issues of reliability and validity that guarantee data quality and results' accuracy and generalizability. Avenues for ensuring these are the availability of multiple sources of data collection and consistency of data measurements, and rigour of techniques.

The review clearly shows that some fourteen sources cover Ghana's revenue components extensively. These are GDP, Service Sector GDP, Total Revenue (TORE), Volume of imports (VOL), CIF, AFAC, IMDAL, IMVAT, EXTAX, NHIL, and FEES.

A univariate auto-regressive process has been used to obtain output growth models in various developed countries such as the USA. A Markov switching approach has also been used in the process, though the AR(1) model has been identified as more appropriate. The review identifies the use of the VEC model to examine the impact of foreign direct investment (FDI) on economic growth. In particular, the principal components vector error correction (PCAVEC) model for multivariate times series has been used in a couple of research that boarder, for example, on unusual time series detection and multivariate image time series in land-cover-change monitoring. In some cases, the application of the PCAVEC has combined the seasonal trend analysis and PCA.

Finally, the theoretical background of the VEC model is briefly described. The theory shows that the VEC model directly estimates the rate at which the dependent variable returns to equilibrium after a change in other variables. Since the variables under study are expected to be related in the long run, the technique is appropriate for studying the data problem.

Apart from the PCAVEC model, recent studies on the case of Ghana's revenue, which are sparing, have made use of machine learning times series modelling, which includes Bayesian Structural Time Series (BSTS) and the Neural Network Auto-regression (NNAR) in addition to traditional methods of ARIMA modelling.

CHAPTER THREE

RESEARCH METHODS

Introduction

There are two key techniques on which the study is based. These are the vector error correction model and principal component extraction. Since the data constitutes a multivariate time series with an expected long-run relationship in their contribution to GDP and Total Revenue, the vector error correction (VEC) model is most appropriate for the study. As described in the introductory chapter, revenue components are highly correlated. It is therefore expedient to identify salient dimensions of revenue components. The chapter will thus establish the methodology that incorporates the extracted principal components into the VEC model. First, a description of the data collection procedure is presented.

Data Collection

The data for the study is a secondary one that covers some fourteen (14) salient revenue sources. These revenue variables with their abbreviations are:

Gross Domestic Product (GDP);

Service Sector GDP (SSGDP);

Total Revenue (TORE);

Volume of imports (VOL);

Cost, Insurance and Freight (CIF);

Association Fee and Charges (AFAC);

Import Duty And Levies (IMDAL);

Import Value Added Tax (IMVAT);

Export Tax (EXTAX);

National Health Insurance Levy (NHIL);

Total Amount Exempt (TOAE);

Fine And other Charges (FAOC)

Petroleum Tax And Levies (PETAL), and

FEES.

The data on all transactions covering imports and exports from 2008 to 2019 are pulled from the Ghana Community Management System of the Ghana Community Network (GCNet). The data collection process is facilitated using software such as IMPROMPTU and Business Intelligence (BI) Tool.

The Vector Error Correction Model

The VAR(p) model with first-order stationary variables $\mathbf{X}_t = (X_{1t}, X_{2t}, \ldots, X_{kt})$, i.e., $I(1)$ X s, is written as

$$X_t = \varphi_1 X_{t-1} + \varphi_2 X_{t-2} + \ldots + \varphi_p X_{t-p} + Z_t \quad (3.1)$$

By Equation (**3.1**), the assumption is that the variables are stationary and ergodic. As seen in the data problem, numerous variables may have shared underlying stochastic trends along which they move together. Individually non-stationary variables can nevertheless be co-integrated (Akbar, Khan, & Khan 2012). An error-correction model is the proper econometric characterisation in this situation. In such a model, the equation is differentiated, and an error-correction term that gauges the departure from long-run equilibrium over the preceding period is included. Noting that

$$X_t - X_{t-1} = \Delta X_t \tag{3.2}$$

$$\begin{aligned}
X_t - X_{t-1} &= \Delta X_t & \Rightarrow\ & X_t = X_{t-1} + \Delta X_t \\
X_{t-1} - X_{t-2} &= \Delta X_{t-1} & \Rightarrow\ & X_{t-2} = X_{t-1} - \Delta X_{t-1} \\
X_{t-2} - X_{t-3} &= \Delta X_{t-2} & \Rightarrow\ & X_{t-3} = X_{t-1} - \Delta X_{t-1} - \Delta X_{t-2} \\
&\vdots & \vdots\ & \vdots \\
X_{t-i} - X_{t-(i+1)} &= \Delta X_{t-i} & \Rightarrow\ & X_{t-(i+1)} = X_{t-1} - \Delta X_{t-1} - \Delta X_{t-2} - \ldots - \Delta X_{t-i} \\
&\vdots & \vdots\ & \vdots \\
X_{t-(p-1)} - X_{t-p} &= \Delta X_{t-(p-1} & \Rightarrow\ & X_{t-p} = X_{t-1} - \Delta X_{t-1} - \Delta X_{t-2} - \ldots - \Delta X_{t-i} - \ldots - \Delta X_{t-(p-1}
\end{aligned}$$

Thus, in terms of the difference ΔX_t, Equation (**3.1**) may be expressed as

$$\begin{aligned}
X_t - X_{t-1} = \varphi_1 X_{t-1} - X_{t-1} &+ \varphi_2(X_{t-1} - \Delta X_{t-1}) + \varphi_3(X_{t-1} - \Delta X_{t-1} - \Delta X_{t-2}) \\
&+ \varphi_4(X_{t-1} - \Delta X_{t-1} - \Delta X_{t-2} - \Delta X_{t-3}) \\
&+ \varphi_5(X_{t-1} - \Delta X_{t-1} - \Delta X_{t-2} - \Delta X_{t-3} - \Delta X_{t-4}) + \\
&\ldots + \varphi_{p-1}(X_{t-1} - \Delta X_{t-1} - \Delta X_{t-2} - \ldots - \Delta X_{t-(p-2)}) + \\
&\ldots + \varphi_p(X_{t-1} - \Delta X_{t-1} - \Delta X_{t-2} - \ldots - \Delta X_{t-(p-1)})
\end{aligned}$$

Simplifying gives

$$\begin{aligned}
\Delta X_t = -(1 - \varphi_1 - \varphi_2 - \ldots - \varphi_p)X_{t-1} &- (\varphi_2 + \varphi_3 + \ldots + \varphi_{p-1} + \varphi_p)\Delta X_{t-1} \\
&- (\varphi_3 + \varphi_4 + \ldots + \varphi_{p-1} + \varphi_p)\Delta X_{t-2} - (\varphi_4 + \varphi_5 + \ldots + \varphi_{p-1} + \varphi_p)\Delta X_{t-3} \\
&\vdots \\
&- (\varphi_{p-1} + \varphi_p)\Delta X_{t-(p-2)} - \varphi_p \Delta X_{t-(p-1)}
\end{aligned}$$

Further still, we have

$$\Delta X_t = -\left(\mathbf{I} - \sum_{i=1}^{p} \boldsymbol{\varphi}_i\right) X_{t-1} - \left(\sum_{i=2}^{p} \boldsymbol{\varphi}_i\right) \Delta X_{t-1} - \left(\sum_{i=3}^{p} \boldsymbol{\varphi}_i\right) \Delta X_{t-2} - \left(\sum_{i=4}^{p} \boldsymbol{\varphi}_i\right) \Delta X_{t-3}$$
$$- \left(\sum_{i=j+1}^{p} \boldsymbol{\varphi}_i\right) \Delta X_{t-j} - \ldots - \left(\sum_{i=p-1}^{p} \boldsymbol{\varphi}_i\right) \Delta X_{t-(p-2)} - \boldsymbol{\varphi}_p \, \Delta X_{t-(p-1)} \quad (3.3)$$

A further representation of Equation (6) is given as

$$\Delta X_t = \boldsymbol{\Pi} X_{t-1} + \boldsymbol{\varphi}_1^* \Delta X_{t-1} + \boldsymbol{\varphi}_2^* \Delta X_{t-2} + \boldsymbol{\varphi}_3^* \Delta X_{t-3} + \ldots + \boldsymbol{\varphi}_j^* \Delta X_{t-j}$$
$$+ \boldsymbol{\varphi}_{p-2}^* \Delta X_{t-(p-2)} + \boldsymbol{\varphi}_{p-1}^* \Delta X_{t-(p-1)} + Z_t \quad (3.4)$$
$$= \boldsymbol{\Pi} X_{t-1} + \sum_{i=1}^{p-1} \boldsymbol{\varphi}_i^* \Delta X_{t-i} + Z_t$$

where

$$\boldsymbol{\varphi}_j^* = -\sum_{i=j+1}^{p} \boldsymbol{\varphi}_i \quad \text{and} \quad \boldsymbol{\Pi} = -\left(\mathbf{I} - \sum_{i=1}^{p} \boldsymbol{\varphi}_i\right) = \boldsymbol{\Phi}(1)$$

and

$$\boldsymbol{\Phi}(s) = 1 - \sum_{r=0}^{p} \phi_r . s^r \quad \text{is a characteristic polynomial.}$$

The model for X_t is then derived from Equation (6).

It is noted that

1. if the model cannot be expressed in terms of lag 1 of the series, i.e., X_{t-1}, then $\boldsymbol{\Pi} = \mathbf{0}$. In this case, there is no co-integration.
2. If $\boldsymbol{\Pi}$ it is of full rank, then Xs cannot be $I(1)$ but are stationary.
3. If $rank(\boldsymbol{\Pi}) = m < k$, then there is a case of co-integration.

The vector Z_t is considered to have a multinomial normal distribution and therefore have the following assumptions:

1. $\mathrm{E}(\mathbf{Z_t}) = 0$
2. $\mathrm{E}(\mathbf{Z_t Z'_t}) = 0$, which is a contemporaneous matrix of error term and a $(p \times p)$ positive definite matrix.
3. $\mathrm{E}(\mathbf{Z_t, Z_{t\text{-}k}}) = 0.$ That is, for any non-zero *k*, there is no correlation across time.

The Long-term relationship

"There is an adjustment to the equilibrium X^* or long term relation described by cointegration relation $\Delta X = 0$ we obtain the long term relation i.e. $\prod X^* = 0$. This may be further written as $\prod X^* = \alpha(\beta' X^*) = 0$

In the case 0 <Rank$(\prod)$= Rank(α)= m<k, the number of systems of linear equations which are different from zero is *m*, and is given by"

$$\beta' X^* = \mathbf{O}_{m \times 1}$$

"The long run relation does not hold perfectly in $(t-1)$. There will be some deviation error, expressed as $\beta' X_{t-1} = \xi_{t-1} \neq 0$ which represents induce adjustment. They determine ΔX_t, so that the *X*'s move in the right direction in order to ensure that the system is kept in equilibrium".

Principal Components Vector Error Correction Model

As pointed out earlier, the VEC model enables the determination of common trends in the behavior of the component series in the multivariate time series. Another usefulness of the VEC is that it helps to overcome the incidence of multi-collinearity in the series. When multicollinearity is severe, as is the case of this study's data problem, some of the problems are still captured in the VEC model from the VAR model. Therefore, the need to further incorporate methods that could filter out this problem to provide a true picture of the relationship among the variables. To ensure this, the study first extracts principal components of the lag zero variance-covariance matrix of the time series data.

This study's dimension ($k = 14$) of the time series data is quite large. In addition, Chapter One explains that the variables are highly correlated in practice. Since PCA converts a set of correlated variables into one of an uncorrelated set through orthogonal transformation. Therefore, it is expected that a much smaller subset of the original set of variables would carry all the information in the original data. The linear combination

$$y_i = \sum_{j=1}^{k} a_{ij} X_j \ ; \qquad i = 1, 2, \ldots, k \tag{3.5}$$

constitutes principal components extracted from $\mathbf{X}_t = (X_1, X_2, \ldots, X_k)'$ such that the matrix of coefficients

$$\mathbf{P}' = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1k} \\ a_{21} & a_{22} & \cdots & a_{2k} \\ \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ik} \\ \vdots & \vdots & \vdots & \vdots \\ a_{k1} & a_{k2} & \cdots & a_{kk} \end{pmatrix} \tag{3.6}$$

is orthonormal. That is, if $\mathbf{Y} = \mathbf{P}'\mathbf{X}$, then $\mathbf{P}'\mathbf{P} = \mathbf{P}\mathbf{P}' = \mathbf{I}$. Now, if the variance-covariance matrix of $\mathbf{X}$ is $\boldsymbol{\Sigma}_{\mathbf{X}}$, then

$$V(\mathbf{Y}) = \mathbf{P}'\boldsymbol{\Sigma}_{\mathbf{X}}\mathbf{P} = \boldsymbol{\Lambda}$$

where $\boldsymbol{\Lambda} = diag(\lambda_1, \lambda_2, \ldots, \lambda_k)$.

Since a number of the variables are dependent on others, it is expected that reduced dimension obtained from the transformation $y_i = \mathbf{P}'\mathbf{X};\ i = 1, 2, \ldots, r;\ \ r < k$ will lead to no information loss. As a result, the matrix of PCs which are eigenvectors $\boldsymbol{\Sigma}_{\mathbf{X}}$ given by the columns of, $\mathbf{P}$ may be partitioned into two parts such that the first r columns preserve all information $\mathbf{X}_t$ Thus, the partitioned eigenvector matrix

$$\mathbf{P} = \left(\begin{array}{cccc|ccc} a_{11} & a_{21} & \cdots & a_{r1} & a_{r+1,1} & \cdots & a_{k1} \\ a_{12} & a_{22} & \cdots & a_{r2} & a_{r+1,2} & \cdots & a_{k2} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ a_{1j} & a_{2j} & \cdots & a_{rj} & a_{r+1,j} & \cdots & a_{kj} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \ddots & \\ a_{1k} & a_{2k} & \cdots & a_{rk} & a_{r+1,k} & \cdots & a_{kk} \end{array}\right) \tag{3.7}$$

shows that $\mathbf{P} = (\mathbf{P}_T \,\vdots\, \mathbf{P}_o)$ yields a matrix with the last $(k-r)$ columns constituting a redundant matrix $\mathbf{P}_o$, and the first r columns constitute a matrix along which all information $\mathbf{X}_t$ could be captured. The $(k \times r)$ reduced matrix of PCs $\mathbf{P}_T$ will then be used in place of the full transformation matrix, $\mathbf{P}$. Thus,

$$\begin{aligned} V(\mathbf{Y}) &= \mathbf{P}_T' \boldsymbol{\Sigma}_{\mathbf{X}} \mathbf{P}_T = \boldsymbol{\Lambda} \\ &= diag(\lambda_1, \lambda_2, \ldots, \lambda_r, 0, 0, \ldots, 0) \end{aligned} \tag{3.8}$$

It can therefore be noted that the total information in $\mathbf{X}_t$ given by

$$\sum_{i=1}^{k} Var(X_i) = tr(\boldsymbol{\Sigma}_{\mathbf{X}}) = tr(\mathbf{P}_T' \boldsymbol{\Lambda} \mathbf{P}_T) = tr(\boldsymbol{\Lambda}) = \sum_{i=1}^{r} Var(Y_i) \tag{3.9}$$

will be completely accounted for by the r few PCs.

Thus, the proportion of total variance in $\mathbf{X}_t$ explained by the ith PC is

$$\frac{\lambda_i}{\sum_{j=1}^{r} \lambda_j}, \quad i = 1, 2, \ldots, r$$

Denote $\mathbf{P}_{Ti}'$ the ith row of $\mathbf{P}_T'$, and define $u_i = (0, 0, \ldots, 0, 1_i, 0, 0, \ldots, 0)_k$, a k-dimensional unit vector with ith element being 1 and 0 otherwise. Thus, $u_1 = (1, 0, 0, \ldots, 0)'$ and $u_2 = (0, 1, 0, \ldots, 0)'$. Thus, for the vector $\mathbf{X}_t = (X_1, X_2, \ldots, X_k)'$, the ith component may be expressed in terms of u_i as $X_1 = \mathbf{X}_t'\mathbf{u}_1$; $X_2 = \mathbf{X}_t'\mathbf{u}_2$ and $X_i = \mathbf{X}_t'\mathbf{u}_i$. Then

$$\begin{aligned} \text{cov}(Y_i, X_j) &= \text{cov}(\mathbf{P}'_{Ti}\mathbf{X}_t, \mathbf{u}'_j\mathbf{X}_t) \\ &= \mathbf{P}'_{Ti}\Sigma_{\mathbf{X}}\mathbf{u}_j \\ &= \mathbf{P}'_{Ti}(\mathbf{P}_{Ti}\mathbf{\Lambda}\mathbf{P}'_{Ti})\mathbf{u}_j \\ &= \lambda_i a_{ij} \end{aligned} \tag{3.10}$$

Thus, the correlation coefficient between Y_i and X_j is given as

$$\rho_{(Y_i, X_j)} = \frac{\text{cov}(Y_i, X_j)}{\sqrt{Var(Y_i) \times Var(X_j)}} = \frac{\sqrt{\lambda_i}\, a_{ij}}{S_j} \tag{3.11}$$

where $Var(X_j) = S_j$.

Thus, the coefficient a_{ij} may be used as a measure of the importance of X_j in the formation of Y_i

Accordingly, by the projection $\underset{n \times r}{Y'} = \mathbf{P}'_T\mathbf{X}'$, the original data is transformed based on the reduced PCs. The VEC model in Equation (**3.4**) is then generated for the projected data to obtain the PCAVEC model.

There is a need to identify the form of the variance-covariance (VC) matrix $\mathbf{\Sigma_X}$ of a time-dependent multivariate random vector $\mathbf{X}_t$. In developing multivariate VECM, the VC matrix is given by $V(Y_t) = \mathbf{\Gamma}_o = E[(Y_t - u)(Y_t - u)']$, which is a $(k \times k)$ structure given at lag zero and is of the form

$$\boldsymbol{\Gamma}_o = \begin{pmatrix} \text{var}(y_{1t,}) & \text{cov}(y_{1t,}y_{2t}) & \cdots & \text{cov}(y_{1t,}y_{kt}) \\ \text{cov}(y_{2t,}y_{1t}) & \text{var}(y_{2t}) & \cdots & \text{cov}(y_{2t,}y_{kt}) \\ \vdots & \vdots & \ddots & \vdots \\ \text{cov}(y_{kt,}y_{1t}) & \text{cov}(y_{kt,}y_{2t}) & \cdots & \text{var}(y_{kt}) \end{pmatrix} \quad (3.12)$$

"The corresponding correlation matrix is derived as $\mathbf{R}_o = \mathbf{D}^{-1}\boldsymbol{\Gamma}_o\mathbf{D}^{-1}$, where D is a $(k \times k)$ diagonal matrix with j^{th} diagonal element given by the univariate standard deviation of the *j*th variable and given by $\left(\gamma_{jj}^{o}\right)^{\frac{1}{2}} = \left(\text{var}(y_{jt})\right)^{\frac{1}{2}}$," and the parameters u, Γ_o, R_o are estimated from data using sample moments

$$E(X) = \bar{X} = \frac{1}{T}\sum_{t=1}^{T} X_t \quad (3.13)$$

$$\hat{\Gamma}_o = \frac{1}{T}\sum_{t=1}^{T}(X_t - \bar{X})(X_t - \bar{X})'$$

All the "lag *h* cross-variance and correlations are summarized in the $(k \times k)$" matrix

$\boldsymbol{\Gamma}_h = (\Gamma_{ij})$ Where $\Gamma_{ij} = \text{cov}(X_{t+h,\, i}, X_{tj})$ the covariance between X_{ti} and X_{tj} at lag *h*.

Interpretation of VECM

If $\boldsymbol{\Pi} = \mathbf{0}$, $\left(\lambda\left(\prod\right) = 0\right)$ then there is no co integration. Non-stationarity of L(1) type vanishes by taking differences. If $\boldsymbol{\Pi}$ has full rank *k*, then the *X*'s cannot be L(1) but are stationary.

The interesting case is $Rank(\mathbf{\Pi}) = m < k$, which is the case of co-integration, with the expression represented as $\underset{k \times k}{\mathbf{\Pi}} = \underset{k \times m}{\boldsymbol{\alpha}} \underset{m \times k}{\boldsymbol{\beta}'}$

where the columns $\boldsymbol{\beta}$ contains the *m* co-integrating vectors and the columns of $\boldsymbol{\alpha}$ are the *m* adjustment vectors.

VAR Representation

When anticipating and analyzing the impacts of structural shocks, vector autoregressive (VAR) models are frequently used. The choice of the VAR's lag duration is an important consideration in the specification of VAR models. By showing that impulse response functions, variance decompositions created from estimated VARs, and estimations of a VAR whose lag length differs from the true lag length are inconsistent, Braun and Mittnik (1993) give evidence for the importance of lag length determination. According to Lütkepohl (1993), adopting a larger order lag length than the actual lag length increases the mean-square forecast errors of the VAR and overfitting the lag length frequently causes auto-correlated errors. According to Hafer and Sheehan, the accuracy of forecasts from VAR models varies dramatically for various lag durations (1989). As synchronous lags are used to build most VAR models, all variables in all of the model's equations have the same lag length. Many explicit statistical criteria are used to determine this lag time, including Schwarz's information criterion (SIC, Neath & Cavanaugh, 1997), the Bayesian information criterion (BIC), and Akaike's information criterion (AIC), and others (Hurvich & Tsai, 1993).

The Portmanteau Approach to Lag selection

The diagnosis phase of model construction is one of the most crucial phases. We are particularly interested in determining if the model's residuals are white noise or follow a process with no serial correlation and homoscedastic distribution. The statistic that Box and Pierce proposed is the traditional portmanteau test statistic.

$$Q_{BP} = n\sum_{k=1}^{m} \hat{\rho}_k \tag{3.14}$$

and "$\hat{\rho}_k$ is the sample auto-correlation of order k of the errors. Under the null hypothesis that the ARMA model is adequate, Q_{BP} is distributed as a χ^2 with $(m - p - q)$ degrees of freedom".

Ljung-Box

This approach is a modification of Box and Pierce, and its test statistic is given as

$$Q_M = n(n+2)\sum_{k=1}^{m} \frac{\hat{\rho}^2}{n-k} \tag{3.15}$$

This test statistic has a finite sample distribution that is much closer to that of the $\chi^2_{(m-p-q)}$. The aim is that $\hat{\rho}_k$ in the Q_{BP} Statistic by its asymptotic variance. However, there is some opposition to this adjustment because it has been demonstrated that its variance may be significantly more than its asymptotic distribution. Performance of Q_M is as good as the Q_{LM} and is more improved if the order of the autoregressive is understated.

Mcleod – Li Approach

This approach uses squaring error of auto-correlations for diagnostic checking and possible deviation from the ARMA linearity assumption. A lag order *p* of residual of the auto-correlation is defined as

$$\hat{\rho}_{ee} = \frac{\sum_{t=p+1}^{n}\left(\hat{e}_t - \hat{\sigma}^2\right)\left(\hat{e}_t - \hat{\sigma}^2\right)}{\sum_{t=p+1}^{n}\left(\hat{e}_t - \sigma^2\right)^2} \tag{3.16}$$

where $\hat{\sigma} = \frac{\sum \hat{e}^2}{n}$. Mcleod –Li equation for testing auto-correlation also follows a Chi-square distribution and is represented as $Q_{ML} = n(n+2)\sum_{i=1}^{m}\frac{\hat{\rho}_{ee}(i)}{n-i}$ (3.17)

Error Measures

Error measures in a model are used to quantify the performance of the model and to compare it with other models. The study would consider the following measure of error: Mean Error (ME), Mean Absolute Error (MAE), Mean Square Error (MSE), Root Mean Square Error (RMSE), Mean Percentage Error (MPE) and Mean Absolute Percentage Error (MAPE).

$$ME = \frac{\sum_{i=1}^{n}\left(y_i - \hat{y}_i\right)}{n} \tag{3.18}$$

$$MAE = \frac{\sum_{i=1}^{n}\left|y_i - \hat{y}_i\right|}{n} \tag{3.19}$$

$$MSE = \frac{\sum_{i=1}^{n}\left(y_i - \hat{y}_i\right)^2}{n} \quad (3.20)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(y_i - \hat{y}_i\right)^2}{n}} \quad (3.21)$$

$$MPE = \frac{\sum_{i=1}^{n}\left(y_i - \hat{y}_i\right)}{y_i} \times 100 \quad (3.22)$$

$$MAPE = \sum_{i=1}^{n}\left|\frac{\left(y_i - \hat{y}_i\right)}{y_i}\right| \times 100 \quad (3.23)$$

Chapter Summary

The methodology describes the revenue variables on which data is obtained for the study. Some fourteen (14) of such variables are initially identified. The chapter also reviews relevant techniques that are intended to be used for the study. The proposed principal components vector error correction (PCAVEC) model is informed by the high dependency structure of the data. Therefore, the study's design is guided by a motivation to isolate this dependency. The methodology, therefore, begins with a review of the vector auto-regressive (VAR) model, which provides the basis for further developments. For the data problem of the study, The VAR model is flawed by high multi-collinearity and would yield spurious regression with extremely high R-square values. The VEC model is then reviewed and shows a modification of the VAR by expressing the VAR in terms of lagged differences $X_t - X_{t-1} = \Delta X_t$ and lag 1 of the series, X_{t-1}. This means that for a meaningful model, the effect of the one time period is expected to significantly influence the model. Since one time-period apart differences could have traces of effects of dependencies, the VEC model could further be improved. The design reviews how the extraction of principal components could be used to provide an improvement to the VEC model. The principal components extraction is expected to achieve a dimensionality reduction from the k original series variables $\mathbf{X}_t$ to r $(r < k)$ principal components $\{\mathbf{Y}_t\}$ with no loss of information. A projection of the original data on the reduced components would produce a transformed data dimension $n \times r$ The PCAVEC model would be generated by obtaining a VEC model of the transformed data.

A necessary step in the procedure is choosing the optimal lag p for obtaining the most suitable model. The chapter, therefore, reviews the Portmanteau lag selection test. Further methods for model performance assessment are also presented. These include the forecast error variance decomposition (FECD), impulse response functions and diagnostic measures for checking underlying model assumptions.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter uses the combined techniques of principal components and vector autoregressive model to characterize revenue sources. The variables used include GDP, SSGDP, TORE, IMDAL, IMVAT, AFAC, NHIL, PETAL, CIF, VOL and FEES. As described in the introductory chapter, the data structure is such that measurements on all variables are collected every month between the periods of January, 2008 to December, 2019 making a total of 144 data points for a single variable making a total of 1584 data points to be considered for the study based on these 11 variables.

The software used are the R Studio, Gretl and Matlab. The study examines essential components of revenue generation activities to identify the fundamental revenue sources. As pointed out earlier, since these revenue components are interrelated, there would be a long-term relationship among them. As a result, the Vector Error Correction (VEC) model would ordinarily be the most appropriate to characterize the variables. The chapter will therefore proceed to identify this model. The inadequacies of this model will then be examined, and the Principal Components (PC) will be incorporated into the VEC model. It is anticipated that using the PC instead of the original variables would present a more reasonable econometric representation of the revenue sources.

The Series of Original Variables

The variables are time series in nature; therefore, there is a need to plot them to check the level of stationarity among these variables.

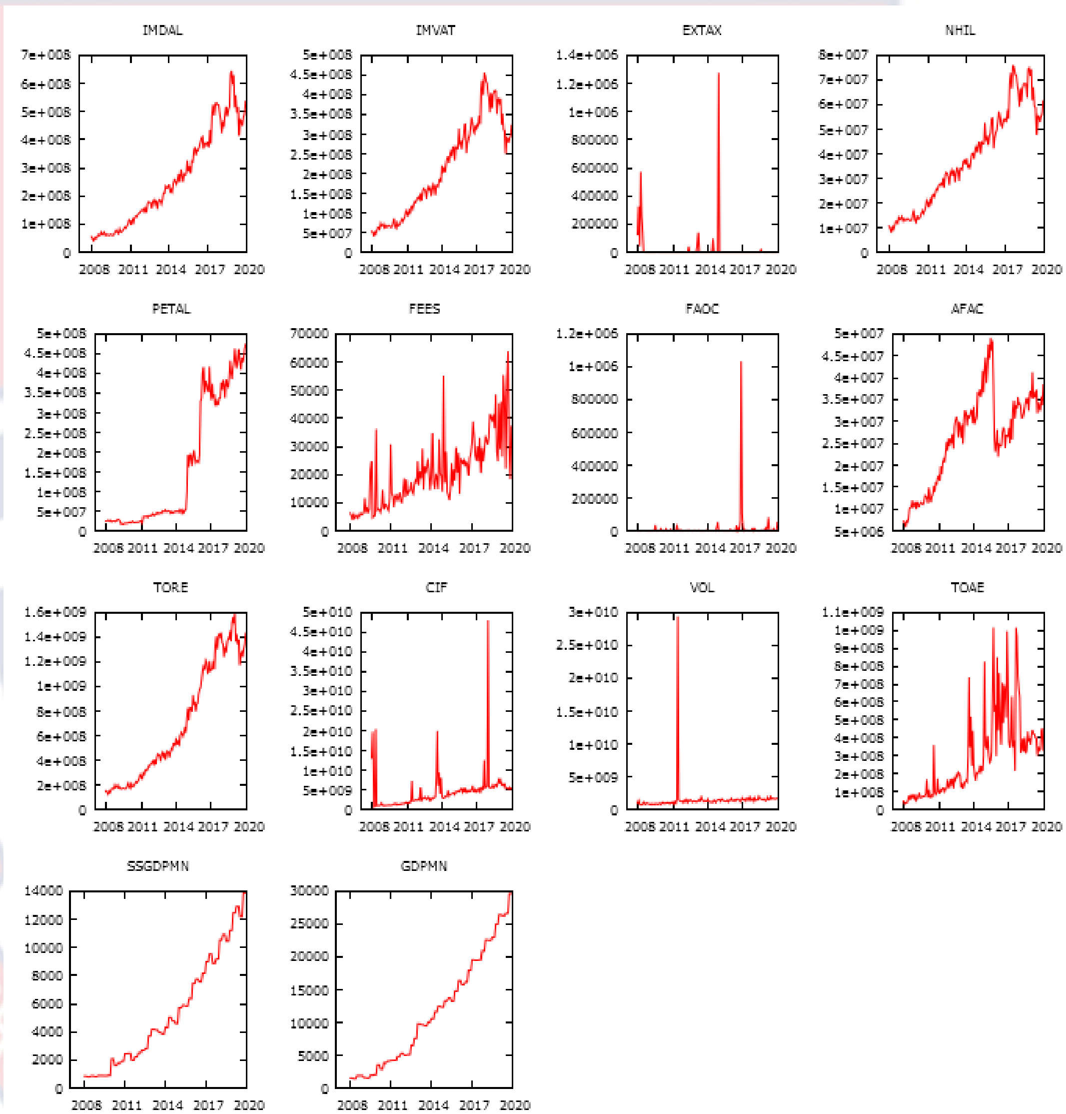

Figure 5: Time Series Plot of Original Variables with Order-Zero Differencing (Author's Construct)

The series plot indicates that some variables may not be stable or stationary. This would be confirmed after performing an ADF test on the variables. Table 5 provides details of the ADF test of the variables.

Table 5: ADF Test of Variables after first Differencing

Variable	Adf Test at zero-order differencing	Adf test at first differencing
IMDAL	0.4643	3.003e-006
IMVAT	0.6687	0.002182
EXTAX	1.32e-015	4.096e-016
NHIL	0.8028	1.291e-005
PETAL	0.7397	0.1103
FEES	0.6965	4.849e-008
FAOC	1.351e-014	4.251e-019
AFAC	0.5203	0.02226
TORE	0.6455	0.008853
CIF	0.0008636	1.777e-033
VOL	8.166e-017	1.801e-012
TOAE	0.7379	6.935e-007
GDPMN	0.9639	0.02253
SSGDPMN	1	0.037

Author's Construct

Table 5 shows that except for PETAL, all the variables are stationary after the first differencing. The plots of the variables after the first difference are shown in Figure 6

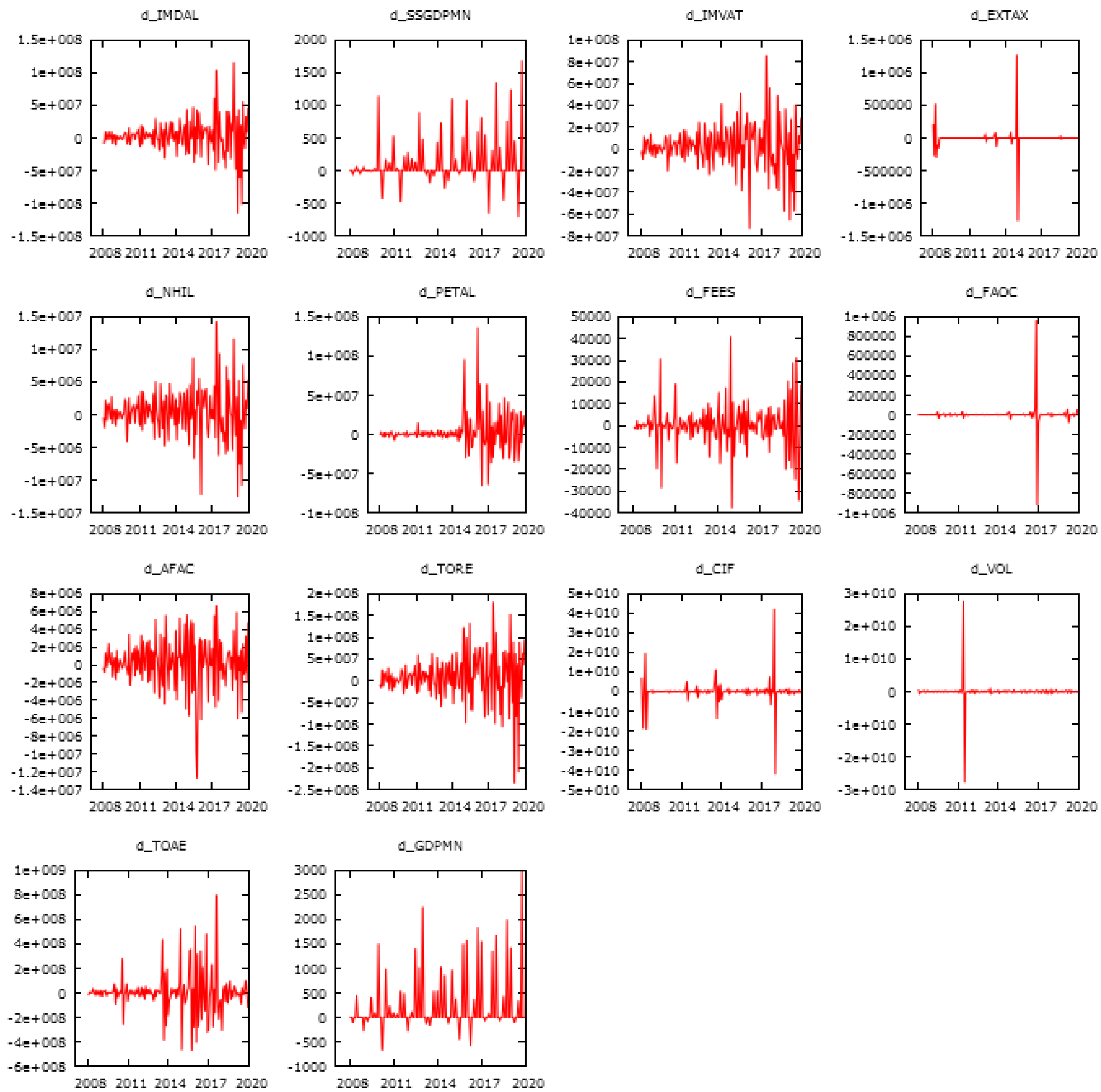

Figure 6: Plot of the Series after the First Difference (Author's Construct)

Lag Selection Criteria

Earlier on discussed in chapter three, about the approaches in lag selection criteria, the nature of our data uses the portmanteau approach since this approach, in particular, ensures that serial correction is checked for in the residuals.

It is our expectation that there is an absence of serial correlations among the residuals in the data. This is a necessary condition to be met so far as the model building is concerned. Test results of the portmanteau test are presented in Table 6

Table 6: Portmanteau Test of Lag selection

Lag	Variable	R- Square	Standard error	Portmanteau test
1	GDPMN	0.004807	547.0731	Chi- Squared = 4012 , df = 4719 *p*= 0.0197
	SSGDPMN	0.003127	331.573	
	TORE	0.029626	56196653	
	VOL	0.002279	3.32E+09	
	CIF	0.317122	5.09E+09	
	AFAC	0.02916	2937108	
	IMDAL	0.006444	28302825	
	IMVAT	0.008126	21942195	
	IMDAL	0.008126	21942195	
	EXTAX	0.131634	1.53E+05	
	NHIL	0.010329	3.82E+06	
	FEES	0.003355	10804.25	
2				
	GDPMN	0.139858	531.4871	Chi-squared = 4599 df = 4598, *p* = 0.4943
	SSGDPMN	0.120488	325.5203	
	TORE	0.3882	46633121	
	VOL	0.261814	2.98E+09	
	CIF	0.484929	4.61E+09	
	AFAC	0.240115	2716260	
	IMDAL	0.450241	22001150	
	IMVAT	0.39111	17970783	
	IMDAL	0.39111	1347862	
	EXTAX	0.35956	137072.9	
	NHIL	0.414482	3.07E+06	
	FEES	0.371494	8969.679	
3				
	GDPMN	0.219217	531.4632	
	SSGDPMN	0.31671	301.1919	
	TORE	0.481208	45055663	
	VOL	0.346924	2.95E+09	
	CIF	0.528098	4.47E+09	Chi-squared = 4510.5,
	AFAC	0.305624	2725041	
	IMDAL	0.501191	21995243	df = 4477, *p*-value = 0.3593
	IMVAT	0.470897	17571286	

	IMDAL	0.390757	138923.9	
	EXTAX	0.390757	138923.9	
	NHIL	0.493134	3.00E+06	
	FEES	0.47643	8595.602	
4				
	GDPMN	0.376019	500.9434	
	SSGDPMN	0.538287	261.1768	
	TORE	0.605207	41477110	
	VOL	0.401032	2.98E+09	
	CIF	0.562697	4.54E+09	Chi-squared = 4275.6,
	AFAC	0.417432	2633335	
	IMDAL	0.636043	19828481	df = 4356, *p*-value = 0.805
	IMVAT	0.574407	16623985	
	IMDAL	0.492671	128659.5	
	EXTAX	0.591721	2836903	
	NHIL	0.541721	2.99E+07	
	FEES	0.589291	8035.136	
5				
	GDPMN	0.419053	513.3514	Chi-squared= 4216.9,
	SSGDPMN	0.546786	274.8719	
	TORE	0.685163	39335638	df = 4235, *p* = 0.5752
	VOL	0.486317	2.93E+09	
	CIF	0.554592	4.68E+09	
	AFAC	0.522934	2531782	
	IMDAL	0.731455	18093451	
	IMVAT	0.691951	15023045	
	EXTAX	0.509478	132559.8	
	NHIL	0.714006	2.52E+06	
	FEES	0.660302	7763.783	
6				
	GDPMN	0.547583	485.1787	
	SSGDPMN	0.601243	276.1894	
	TORE	0.739359	38348724	
	VOL	0.508805	3.07E+09	
	CIF	0.601172	4.54E+09	Chi-squared = 4205.4
	AFAC	0.57997	2545243	
	IMDAL	0.751068	18666028	, df = 4235, *p*-value = 0.1562
	IMVAT	0.739763	14793160	
	EXTAX	0.598485	128314	

	NHIL	0.748655	2.53E+06	
	FEES	0.71947	7559.874	
7				
	GDPMN	0.685329	438.0777	Chi-squared = 4231.4, df = 4238, p = 0.00000262
	SSGDPMN	0.72942	246.4963	
	TORE	0.766895	39288737	
	VOL	0.539574	3.22E+09	
	CIF	0.695883	4.30E+09	
	AFAC	0.682245	2393895	
	IMDAL	0.761977	19771775	
	IMVAT	0.800421	14030754	
	EXTAX	0.624998	133868.9	
	NHIL	0.795762	2.47E+06	
	FEES	0.736336	7940.845	
8				
	GDPMN	0.80124	481.06	Chi-squared = 4269.3, df = 4238, p = 0.6223
	SSGDPMN	0.832136	230.24	
	TORE	0.596842	36679227	
	VOL	0.740231	3.36E+09	
	CIF	0.792314	4.41E+09	
	AFAC	0.82021	2134238	
	IMDAL	0.830214	19094042	
	IMVAT	0.660326	1387961	
	EXTAX	0.830214	140008.8	
	NHIL	0.772364	2461367	
	FEES	0.73421	8078.13	

Author's Construct

The results of the portmanteau test in Table 6 give the significance level at each lag of the test. The hypothesis that is being tested is given as:

H_o: autocorrelation of the residual time series is zero

H_1: autocorrelation of the residual time series is not zero

The test results at lag 7 indicate that p < 0.05 is significant. This further means that for the test results at lag 7, there is the presence of autocorrelation, and therefore, residual time series are not zero in the model at lag 7. This would not be a part of the options of lags to select from in deciding the optimum lag. The remaining results of the test that have *p*-values more than 0.05 indicate that the autocorrelation of the time series of residuals is zero; therefore, we fail to reject the null hypothesis. The results further indicate a study improvement of R-squares within the variables and a corresponding decline in standard errors. The optimal lag to consider, therefore, would be lag 8. This lag yields the best of R- squares and a major decline in the standard errors.

In generating the model, two issues have to be noted. The first observation is the system-selected variables in the model. The system, by default, selects eleven (11) out of the 14 variables. The exclusion of the three variables, PETAL, FAOC and TOAE, are ascribed to high multi-collinearity and small values of measurements on some of the items compared to measurements on others. The second is the notation representing the variables at the various lags. At the current time *t*, the variables are as follows:

X_{1t} — GDP; X_{2t} — SSGDP; X_{3t} — TORE; X_{4t} — VOL; X_{5t} — CIF; X_{6t} — AFAC; X_{7t} — IMDAL; X_{8t} — IMVAT; X_{9t} — EXTAX; X_{10t} — NHIL X_{11t} — FEES

The following vector representations are subsequently observed:

$$\mathbf{X}_{t-1} = \begin{pmatrix} \mathbf{X}_{1t-1} \\ \mathbf{X}_{2t-1} \\ \mathbf{X}_{3t-1} \\ \mathbf{X}_{4t-1} \\ \mathbf{X}_{5t-1} \\ \mathbf{X}_{6t-1} \\ \mathbf{X}_{7t-1} \\ \mathbf{X}_{8t-1} \\ \mathbf{X}_{9t-1} \\ \mathbf{X}_{10t-1} \\ \mathbf{X}_{11t-1} \end{pmatrix}, \quad \Delta\mathbf{X}_{t-1} = \begin{pmatrix} \Delta\mathbf{X}_{1t-1} \\ \Delta\mathbf{X}_{2t-1} \\ \Delta\mathbf{X}_{3t-1} \\ \Delta\mathbf{X}_{4t-1} \\ \Delta\mathbf{X}_{5t-1} \\ \Delta\mathbf{X}_{6t-1} \\ \Delta\mathbf{X}_{7t-1} \\ \Delta\mathbf{X}_{8t-1} \\ \Delta\mathbf{X}_{9t-1} \\ \Delta\mathbf{X}_{10t-1} \\ \Delta\mathbf{X}_{11t-1} \end{pmatrix}, \quad \cdots \quad \Delta\mathbf{X}_{t-7} = \begin{pmatrix} \Delta\mathbf{X}_{1t-7} \\ \Delta\mathbf{X}_{2t-7} \\ \Delta\mathbf{X}_{3t-7} \\ \Delta\mathbf{X}_{4t-7} \\ \Delta\mathbf{X}_{5t-7} \\ \Delta\mathbf{X}_{6t-7} \\ \Delta\mathbf{X}_{7t-7} \\ \Delta\mathbf{X}_{8t-7} \\ \Delta\mathbf{X}_{9t-7} \\ \Delta\mathbf{X}_{10t-7} \\ \Delta\mathbf{X}_{11t-7} \end{pmatrix}$$

In line with the VEC representation in Chapter Three, these vectors are the lag 1 of the series $\{\mathbf{X}_t\}$ of all variables in the model and $\Delta\mathbf{X}_{t-j}$ the lag *j*, $j = 1, 2, \ldots, 7$, of the differenced series $\{\Delta\mathbf{X}_t\}$ of all variables. The VEC(8) model is as shown.

The VEC Model in terms of original variables

GDPMN		132.91	
SSGDPMN		42.95	
TORE		0.0000	
VOL		-0.0000	
CIF		0.0000	
AFAC	=	791721	+
IMDAL		-283506	
IMVAT		0.0000	
EXTAX		1179.63	
NHIL		122740	
FEES		2795.57	

-0.23435	0.46844	0.00000	-0.00000	0.00000	0.00004	-0.00000	0.00000	-0.00085	-0.00005	-0.00339
-0.11807	0.23601	0.00000	-0.00000	0.00000	0.00002	-0.00000	0.00000	-0.00043	-0.00002	-0.00171
14917.0	-29817.6	-0.15896	0.00357	-0.00064	-2.34391	0.20384	-0.10420	54.11291	2.94087	215.730
-0.00008	0.00016	0.00000	-0.00000	0.00000	0.00000	-0.00000	0.00000	-0.00000	-0.00000	-0.00000
-0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	-0.00000	0.00000	-0.00000	-0.00000	-0.00000
2410.90	-4819.13	-0.02569	0.00058	-0.00010	-0.37882	0.03294	-0.01684	8.74578	0.47531	34.8664
1037.10	-2073.06	-0.01105	0.00025	-0.00004	-0.16296	0.01417	-0.00724	3.76218	0.20446	14.9985
1311.40	-2621.36	-0.01397	0.00031	-0.00006	-0.20606	0.01792	-0.00916	4.75723	0.25854	18.9655
-0.49888	0.99721	0.00001	-0.00000	0.00000	0.00008	-0.00001	0.00000	-0.00181	-0.00010	-0.00721
62.1550	-124.242	-0.00066	0.00001	-0.00000	-0.00977	0.00085	-0.00043	0.22547	0.01225	0.89889
-1.18410	2.36690	0.00001	-0.00000	0.00000	0.00019	-0.00002	0.00001	-0.00430	-0.00023	-0.01712

$\mathbf{x}_{t-1}$

+

0.28873	-0.40417	0.00000	0.00000	-0.00000	-0.00010	-0.00001	-0.00003	0.00136	0.00016	0.01216
0.05842	0.02415	0.00000	0.00000	-0.00000	-0.00003	-0.00000	-0.00000	0.00068	0.00006	0.01025
-51099.9	104814	-0.64765	-0.00380	-0.00087	-2.98731	-0.64334	-2.18962	72.1826	20.5298	-2022.41
1030490	313385	1.32511	-0.71011	-0.02177	33.9029	-26.4451	-67.0483	1071.53	517.683	-38441
2009300	-3611780	32.7798	0.22840	-0.82871	-187.315	4.97156	-209.201	2177.38	761.77	-66830.5
-3113.18	7868.17	0.01677	-0.00068	0.00016	-0.04653	-0.10069	-0.16057	-1.43022	1.29003	-112.294
-18021.2	34766.4	-0.15932	-0.00041	-0.00063	-2.59953	-0.55946	-2.04318	18.1816	15.7104	-624.536
-16883.5	22950.9	-0.2249	-0.00086	-0.00032	-1.12755	-0.17582	-0.35432	30.2681	5.55957	-728.335
-4.14139	18.2418	-0.00082	0.00000	0.00000	-0.00284	0.00041	-0.00263	-0.66967	0.02719	-2.29347
-2685.72	3523.51	-0.03447	-0.00012	-0.00008	-0.22532	-0.02051	-0.14365	5.88793	1.22403	-124.311
3.01765	-11.9954	-0.00004	0.00000	-0.00000	-0.00034	0.00012	0.00005	-0.00028	-0.00016	-0.94534

$\Delta\mathbf{x}_{t-1}$

+

0.02093	-0.43174	-0.00000	0.00000	0.00000	0.00000	-0.00000	-0.00003	0.00115	0.00026	0.00523
0.02306	-0.24055	0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00002	0.00058	0.00014	0.00311
-17730.9	33596.8	0.20006	-0.00202	-0.00129	-5.62789	0.71857	0.60654	26.3098	-6.69832	-1998.04
325503	382232	-32.0533	-0.56922	-0.00795	68.2803	41.996	84.2653	-288.805	-264.774	-61787.8
1655800	-2968910	-15.7948	0.22770	-0.57093	288.012	15.9439	115.661	670.051	-664.988	-134306
-1487.28	6470.55	0.01229	-0.00052	0.00015	0.27937	-0.04062	0.02534	-8.35612	-0.10553	-81.5831
-4190.53	11953.3	0.05657	0.00022	-0.00059	-1.58917	0.36811	0.96724	-14.6941	-6.84264	-263.694
-457.745	12923.2	0.05069	0.00044	-0.00063	-1.7512	0.37747	0.16221	-9.0412	-3.16318	-420.031
41.0994	-211.066	0.00015	0.00000	0.00000	0.00600	-0.00000	0.00581	-0.56706	-0.03268	-0.15900
-201.361	2218.1	0.01233	0.00006	-0.00009	-0.29207	0.06019	0.06801	-0.12864	-0.79542	-67.8866
-1.3366	-7.7481	-0.00006	0.00000	0.00000	-0.00012	-0.00000	0.00000	0.01495	0.00053	-0.8203

$\Delta \mathbf{x}_{t-2}$

+

0.46916	-0.17090	-0.00000	0.00000	-0.00000	0.00001	0.00000	0.00003	-0.00017	-0.00021	0.01194
0.39076	-0.42545	-0.00000	0.00000	-0.00000	-0.00001	0.00000	0.00002	-0.00020	-0.00014	0.00884
22273.9	-31544.9	0.72075	-0.00111	-0.00036	-3.87888	-0.84143	-0.38109	29.7308	6.81577	-1305.67
489168	-1357460	-5.30158	-0.39370	-0.04324	110.626	9.40616	16.2842	390.184	-85.2164	-30156.7
837104	-3088740	-31.8135	0.27882	-0.64194	-77.8954	34.2905	12.0929	184.413	362.729	-111002
1463.14	-339.294	0.00617	-0.00027	0.00006	0.00229	-0.04897	0.02889	-7.28736	0.35315	-72.7093
18272.3	-25500.1	0.17764	0.00082	-0.00032	-1.04088	-0.18319	0.26166	-33.147	0.87324	183.029
7060.3	-15894.2	0.10529	0.00019	0.00023	-1.34973	-0.02795	0.35131	20.706	0.23568	-472.622
-16.4345	-24.4997	0.00007	0.00000	0.00000	-0.00697	-0.00030	-0.00051	-0.50572	0.00726	2.62515
1766.54	-3116.67	0.02175	0.00008	0.00002	-0.27003	-0.01162	0.03646	2.13287	0.19737	-57.7817
1.53952	-2.21483	-0.00005	0.00000	-0.00000	-0.00061	-0.00034	-0.00029	0.02390	0.00388	-0.76266

$\Delta \mathbf{x}_{t-3}$

+

0.41974	-1.34124	-0.00000	0.00000	-0.00000	-0.00003	0.00001	-0.00000	0.00110	0.00004	0.00046	
0.18528	-0.54468	-0.00000	0.00000	-0.00000	-0.00001	0.00000	-0.00000	0.00065	0.00004	0.00194	
-16097	35142.3	0.83863	-0.00136	0.00057	2.27927	-1.6627	0.51666	-45.2369	-1.59537	997.521	
-686843	0.00000	-6.69458	-0.35464	0.01343	-159.19	-5.50189	-40.555	658.8	423.701	45079.8	
103728	0.00000	9.93427	0.21879	-0.32653	-515.995	-63.4221	-23.6395	4565.68	876.362	-48475.6	
-2838.72	4170.46	0.03325	-0.00037	0.00006	0.40447	-0.06009	0.04636	-3.82902	-0.59543	52.6458	$\Delta \mathbf{x}_{t-4}$
-5686.46	919.341	0.31304	0.00040	0.00043	1.21501	-0.26466	0.81538	-50.0122	-5.74581	1376.27	
-3796.74	4165.57	0.30542	0.00010	-0.00022	3.3017	-0.36666	0.37132	-26.1697	-5.54248	420.511	
-31.8967	48.8489	-0.00104	0.00000	0.00000	0.00453	0.00092	-0.00329	-0.33521	0.01177	6.04492	
-615.892	302.169	0.05161	0.00004	-0.00000	0.54478	-0.05277	0.08760	-5.11855	-1.03553	118.352	
0.26259	-0.59110	-0.00004	0.00000	-0.00000	-0.00015	0.00002	-0.00027	0.00718	0.00140	-0.37971	

+

-0.40780	0.17928	-0.00000	0.00000	-0.00000	0.00002	0.00002	0.00005	0.00138	-0.00041	0.01511	
-0.14881	-0.03264	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00001	0.00046	-0.00015	0.00858	
1796.34	8809.3	-0.32107	0.00007	0.00177	0.58458	-0.07868	2.48561	-82.0465	-11.8957	1262.0	
-2364870	4818590	-7.09185	-0.31147	0.02526	40.0253	4.30516	-20.5445	-2247.07	96.9281	187744	
-408922	-1506240	-13.3708	0.13772	-0.32392	471.534	-26.0682	-125.008	-371.002	540.398	119549	
-2402.29	4173.48	-0.00782	-0.00022	0.00010	0.20623	-0.02259	-0.06400	-3.51947	0.2861	18.0773	$\Delta \mathbf{x}_{t-5}$
-1029.34	11120.4	-0.16382	0.00050	0.000904	2.00018	0.32820	1.30318	-49.2083	-9.14571	1562.84	
-1396.25	5449.58	-0.30244	0.00025	0.00094	0.03841	0.32185	0.62648	-10.0747	-2.05493	173.792	
152.419	-177.681	-0.00135	0.00000	-0.00000	0.00191	0.00193	0.00436	-0.30923	-0.02759	3.56090	
-410.412	1328.4	-0.04516	0.00007	0.00014	0.15353	0.04537	0.11341	-3.58167	-0.49234	98.9692	
3.86734	-2.74713	-0.00005	0.00000	-0.00000	-0.00015	0.00014	0.00008	-0.00151	-0.00100	-0.40284	

+

0.04238	-0.03100	-0.00000	0.00000	-0.00000	0.00003	0.00000	-0.00001	0.00141	-0.00000	0.00616	
0.23941	-0.52166	-0.00000	0.00000	-0.00000	-0.00000	0.00000	-0.00002	0.00029	0.00005	0.00731	
14207	-637.457	-0.62458	-0.00078	0.00126	0.72411	-0.00070	-0.29694	59.5039	5.50592	855.4	
967990	-723965	-22.9137	-0.14847	0.01344	-32.4319	27.0112	-42.271	-4622.44	498.059	138004	
2175480	-698451	-33.4101	0.08496	-0.14643	-62.1292	79.4818	-36.6754	-365.551	580.198	93497	
-526.455	3872.38	0.00498	-0.00022	0.00005	-0.16813	-0.06740	-0.04329	-0.84813	0.58465	82.6491	$\Delta \mathbf{x}_{t-6}$
4735.27	-3135.39	-0.31380	0.00006	0.00130	1.52629	0.26827	-0.02895	1.78598	0.54896	1181.19	
8499.64	-2630.89	-0.06388	0.00012	0.00053	0.44272	0.02071	0.20945	32.276	-1.53594	412.639	
6.18981	49.541	-0.00043	-0.00000	0.00000	-0.01819	0.00339	0.00152	-0.03182	-0.00645	-1.78495	
1466.45	-507.632	-0.02476	0.00004	0.00008	0.14013	0.03114	0.03710	3.97743	-0.29424	118.309	
6.86286	-15.3644	-0.00001	0.00000	-0.00000	-0.00140	-0.00000	-0.00014	0.00531	0.00199	-0.41475	

+

0.08019	-0.39642	0.00000	0.00000	0.00000	-0.00003	0.00001	0.00001	0.00037	-0.00009	0.02384	
-0.01029	-0.06931	-0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00031	-0.00006	0.01456	
-37162	106921	0.12889	-0.00173	0.00194	-2.81216	-0.82291	-1.06128	82.7198	8.6895	380.864	
885465	-645716	-12.38	-0.05607	0.00008	-186.991	48.2635	93.487	-5307.43	-375.93	100270	
4568370	-2362510	-9.63742	0.07581	-0.1296	-184.607	94.9251	276.318	-4528.37	-1244.26	85117.1	
-2769.95	6053.63	0.00424	-0.00019	0.00009	-0.18666	-0.04254	-0.06722	-0.06722	0.71629	44.9912	$\Delta \mathbf{x}_{t-7}$
-8559.33	39756.5	-0.00416	-0.00048	0.00108	-0.97855	-0.14519	0.00042	6.61418	0.88994	888.33	
-6348.01	18232.9	0.00102	-0.00056	0.00126	-0.69416	-0.23280	-0.08586	24.9872	1.63253	-262.655	
-14.1858	-47.073	0.00156	-0.00000	0.00000	0.00657	0.00070	0.00143	-0.00211	-0.03346	0.11265	
-991.758	3641.77	0.00072	-0.00009	0.00019	-0.11505	-0.03288	0.01411	3.68127	0.08484	18.0786	
0.95657	-0.78397	0.00008	-0.00000	-0.00000	-0.00044	0.00002	0.00040	0.00722	-0.00267	-0.07223	

It should be noted again that the representation of the coefficient matrices is as follows:

Row Label:

1 — GDPMN; 2 — SSGDPMN; 3 — TORE; 4 — VOL; 5 — CIF;

6 — AFAC; 7 — IMDAL; 8 — IMVAT; 9 — EXTAX; 10 — NHIL;

11 — FEES

Model Interpretation

Clearly, the study's main objective is to investigate how some revenue components affect the total revenue. Detail results from the model summary indicate that the model explains 59.69% of total variations in TORE. Components such as GDPMN, SSGDPMN, and IMDAL have a greater variety of 80% and are more explained by their respective models, indicating that such components could be reliably mobilized than what constitutes Total Revenue.

In the coefficient matrices, the model for a component is influenced by those other components for whose generation they form the basis. **At lag 1**, for example, no item is significant in the formation of GDP (Row 1 of the coefficient matrix $\Delta \mathbf{x}_{t-1}$). This possibly indicates that GDP does not form the basis for the generation of all the other components; it is rather the converse. Row 4 of that matrix shows that no item is significant in determining VOL, indicating that volume does not influence the formation of any component except itself. Similarly, CIF (Row 5) is influenced by itself. We observe that AFAC (Row 6) is significantly influenced by as many as eight items influencing the formation of the largest number (8) of items as these are significant. These include VOL and CIF. It, however, does not influence itself.

At lag 4, GDP influences seven (7) components while AFAC influences the formation of five (5) components. Components that significantly influence other components do so largely at lags 1 and 4. This means that the effect of components on the generation of other components is visible only after one month and after four months.

The influence of a component on itself is one of interest. The phenomenon occurs mostly at Lag 1 for TORE, VOL and CIF. For the VOL model, for example, the variable is significant by itself at lags 1 and 2 of the difference $\Delta\mathbf{x}_t$ but only influenced significantly by SSGDP at lag 5. Similarly, for the CIF model, the variable is significant at lags 1 and 2 of the difference $\Delta\mathbf{x}_t$ but only influenced significantly by GDP at lag 7.

Drawbacks of the model

Even though several variables in the model have a greater coefficient of variations and indication that their lag values could be used to predict future values of those variables, it still has some setbacks. The observation in the original model would therefore guide improvement in the model:

1. It contains less number of original variables that are system-selected and influenced by multicollinearity among the variables.
2. There is a need to control the selection of the variables and the effect of high collinearity among the variables.

3. There is the need to investigate the phenomenon of a component that 'significantly influences itself.'

To resolve the drawbacks identified, principal components extraction of the data is obtained as shown in Table **7**

Table 7: Principal Components Extraction

Item	1	2	3	4	5	6	7	8	9	10	11	12	13
IMDAL	0.0124	-0.0002	0.2987	-0.1097	-0.2528	0.7394	-0.2880	-0.1936	-0.1712	-0.1181	-0.1146	0.0076	0.0000
IMVAT	0.0088	-0.0002	0.2068	0.0020	-0.4889	-0.6471	-0.2875	-0.2215	-0.1713	-0.1182	-0.1145	0.0077	0.0000
EXTAX	0.0000	-0.0000	-0.0000	0.0002	-0.0000	0.0003	0.0002	-0.0214	0.9093	-0.2069	-0.1369	0.0099	0.0002
NHIL	0.0015	0.0000	0.0343	-0.0047	-0.0748	-0.0081	0.0427	0.9102	-0.1476	-0.1287	-0.1155	0.0080	-0.0000
PETAL	0.0104	-0.0006	0.2818	-0.1431	0.8191	-0.1674	-0.1393	-0.1200	-0.1694	-0.1194	-0.1146	0.0076	0.0000
FEES	0.0000	0.0000	0.0000	-0.0000	-0.0000	0.0001	0.0002	0.0004	0.0192	-0.0043	0.9404	-0.0639	-0.0010
FAOC	0.0000	-0.0000	0.0000	0.0002	0.0003	-0.0003	0.0002	0.0070	0.0729	0.9329	-0.1149	0.0080	0.0005
AFAC	0.0005	0.0001	0.0130	0.0027	-0.0890	0.0195	0.8778	-0.2302	-0.1721	-0.1182	-0.1147	0.0075	0.0000
TORE	0.0336	-0.0010	0.8346	-0.2525	-0.0862	-0.0636	0.2063	0.1309	0.1698	0.1190	0.1146	-0.0077	-0.0000
CIF	0.9978	-0.0510	-0.0418	-0.0052	0.0007	-0.0003	0.0001	-0.0000	-0.0000	0.0000	0.0000	-0.0000	0.0000
VOL	0.0511	0.9987	-0.0003	0.0018	0.0005	-0.0001	-0.0001	-0.0000	0.0000	-0.0000	-0.0000	0.0000	-0.0000
TOAE	0.0172	-0.0026	0.2981	0.9506	0.0721	0.0445	-0.0011	-0.0000	-0.0002	-0.0002	0.0000	0.0000	0.0000
SSGDP	0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000	0.0001	-0.0001	-0.0004	-0.0004	0.0280	0.3986	0.9167
GDP	0.0000	-0.0000	0.0000	-0.0000	0.0000	0.0000	0.0001	-0.0003	-0.0005	0.0000	0.0618	0.9146	-0.3995
% Contr	0.8029	0.1871	0.0092	0.0007	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cum	**0.8029**	**0.9900**	**0.9992**	**0.9999**	**1.0000**								

Author’s Construct

Interpretation of the Principal Components and Discussion

It is observed that the transformation of the original data automatically achieves dimensionality reduction in Table 7. This means that very few components account for all information. It also shows that the practice, and the revenue sources are interdependent. In addition, the last (14th) component (see Appendix **E**) completely lacks interpretability. Thus, there is a reduction not only in terms of information explained but also in the required number of transformed components that are theoretically required.

CIF almost exclusively influences the first component. The component may therefore be labelled as a CIF-Revenue source. Thus, CIF alone contributes over 80% of all revenue sources. This means that the CIF is an overwhelming source of revenue generation in Ghana. The second component is similarly exclusively influenced by the VOL. Thus, the second component may also be labelled as a VOL-revenue source. Thus, the volume of goods alone constitutes 18.71% of all revenue sources. The first and second components together, therefore, account for 99% of revenue generation.

The remaining 1% is shared among the next three components. The third component is mainly influenced by total revenue (TORE). The third component may therefore be labelled as the Total Revenue source. Thus, the TORE contributes just 0.92% of all revenue sources. Other revenue sources that contribute to some small extent are IMDAL, IMVAT, PETAL and TOAE. Thus, Import Duty, Import VAT, Petroleum Charges and Total Amount Exempt are four sources that support total revenue generation. The fourth component is highly influenced by TOAE. The fourth component may therefore be labelled as TOAE-revenue sources. This accounts for 0.07% of revenue sources. The TORE contributes negatively to this component to a small extent. Thus, what increases the TOAE is likely to affect TORE to some extent. The first four components account for 99.99% of revenue generation sources. PETAL, the petroleum tax, highly influences the fifth component. It may therefore be labeled as a PETAL-revenue source. The fifth component contributes the last 0.01% of all revenue sources. The IMDAL and IMVAT contribute negatively to this component to some extent. Thus, what increases the PETAL is likely to affect IMDAL and IMVAT appreciably.

Some three observations may be made from the data transformation. The first is that beyond the fifth component, all other sources are redundant as they do not contribute to the information in the revenue sources. That is, all other sources are derived from the first five.

Intriguingly, total revenue emerges as one of the revenue sources, as though it constitutes a source of its own. Only IMDAL and IMVAT appear to be substantial contributors to the total revenue. This means that other major sources of total revenue are not accounted for in the revenue data. CIF, the major revenue source, is expected to make a noticeable direct contribution to TORE. This is, however, not the case.

The third observation worth identifying is that all the transformed components are one-item components. This means that major revenue sources are identified as single policies or activities.

The extracted PCs in Table **7** are based on combined data for the entire period.

Since PCs are extracted from the variance-covariance matrix, it is important to check the consistency with extraction from the separate data on individual years. Figure **7** represents the information explained by the components extracted from segmented data for each year within the study period.

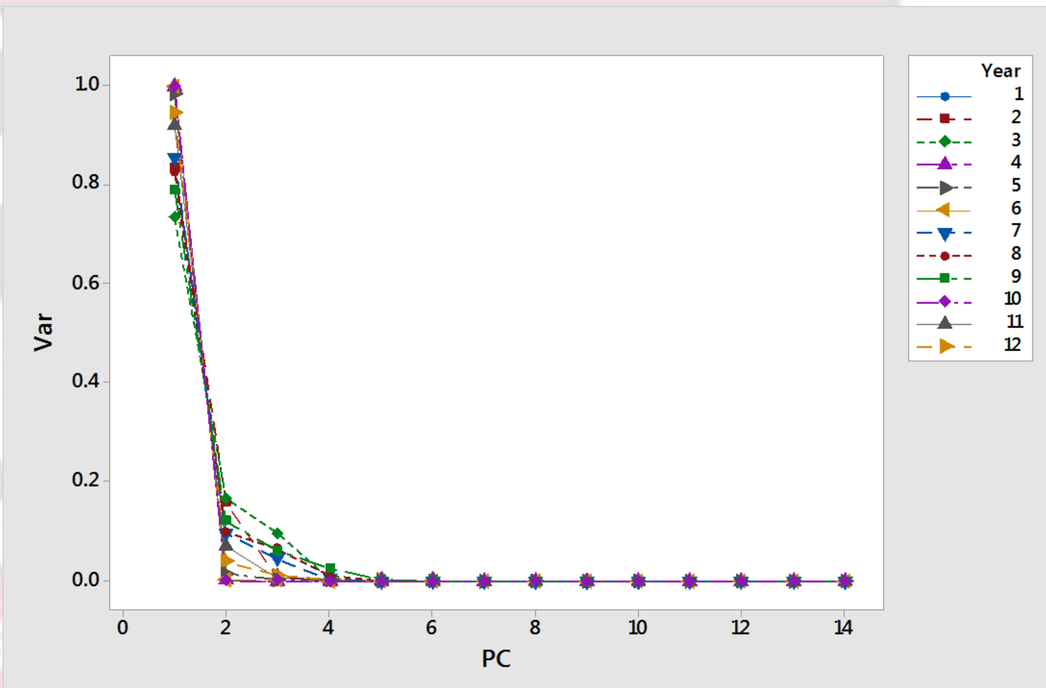

Figure 7: Component Information Extracted For Each Year (Author's Construct)

Figure **7** shows that corresponding components in each year do not account for the same amount of information. For a number of years, PC1 accounts for almost all information in the data, and for each of the remaining years, the first

PC account for close to 80% (See Appendix **F**). Clearly, the first five PCs almost completely account for all information each year. This shows that the structure of the data as a composite is not too different from that observed in the separate years.

Principal Component VEC Model

A noteworthy observation is that all the transformed components are one-item components. This means that major revenue sources are quite clearly defined as single policies or activities. We obtain a projection of the data on the five PCs and generate the PCAVEC model as presented in Appendix **E**. The final reduced model is generated with the same lag selection order of 8 using the results of the Portmanteau test.

In the model, we observe that for the CIF model, only TOAE and PETAL are significant at lag 3 and lag 7, respectively. For the VOL model, it is significant only by itself at all lags except at lag 7. Thus, volumes of items are largely influenced by (recent) past volumes. For the TORE model, it is significantly influenced only by TOAE at lags 3 and 4. This means that Total Revenue is only influenced by total exemptions within 3 and 4 months. The portion of the model for PETAL in Appendix E is presented here in Table 8 for special mention. For PETAL, all other variables are significant at lag 1, which is itself significant at lag 4.

Table 8: PCAVEC Model for PETAL

Variable	*Coefficient*	*Std. Error*	*t-ratio*	*p-value*	
const	-1.7404e+06	2.74667e+06	-0.6336	0.52778	
d_CIF_1	0.00753647	0.00209064	3.6049	0.00049	***
d_CIF_2	-0.0011692	0.00225313	-0.5189	0.60497	
d_CIF_3	0.00216992	0.0021681	1.0008	0.31934	
d_CIF_4	0.000574478	0.00218865	-0.2625	0.79350	
d_CIF_5	0.000578435	0.00202271	0.2860	0.77550	
d_CIF_6	0.000132334	0.00201872	0.0656	0.94787	
d_CIF_7	0.00217952	0.00207012	1.0528	0.29497	
d_VOL_1	0.000577728	0.00099172	0.5826	0.56152	
d_VOL_2	0.000527626	0.00123412	0.4275	0.66992	
d_VOL_3	0.000309996	0.00135639	0.2285	0.81969	
d_VOL_4	0.000287239	0.00137493	0.2089	0.83495	
d_VOL_5	-0.000106749	0.00132068	-0.0808	0.93574	
d_VOL_6	-6.80384e-05	0.00118136	-0.0576	0.95419	
d_VOL_7	-1.44353e-05	0.00091643	-0.0158	0.98746	
d_TORE_1	0.159995	0.0460291	3.4760	0.00076	***
d_TORE_2	-0.0698744	0.0513716	-1.3602	0.17686	
d_TORE_3	0.029939	0.0511793	0.5850	0.55989	
d_TORE_4	-0.0586451	0.0526055	-1.1148	0.26763	
d_TORE_5	0.000667565	0.0510603	0.0131	0.98960	
d_TORE_6	0.0145482	0.0518234	0.2807	0.77951	
d_TORE_7	0.0683983	0.0529938	1.2907	0.19982	
d_TOAE_1	-0.0893144	0.0260437	-3.4294	0.00088	***
d_TOAE_2	0.0114339	0.0287988	0.3970	0.69220	
d_TOAE_3	-0.0159637	0.0290293	-0.5499	0.00362	**
d_TOAE_4	0.0222168	0.0307804	0.7218	0.47213	
d_TOAE_5	0.0479348	0.0290304	1.6512	0.10187	
d_TOAE_6	-0.00923215	0.0289888	-0.3185	0.75080	
d_TOAE_7	-0.0492988	0.0262172	-1.8804	0.06299	*
d_PETAL_1	0.142231	0.11042	1.2881	0.20072	
d_PETAL_2	-0.0137716	0.111903	-0.1231	0.90230	
d_PETAL_3	-0.0794932	0.110986	-0.7162	0.47552	
d_PETAL_4	-0.234303	0.114715	-2.0425	0.04376	**
d_PETAL_5	0.0962077	0.113198	0.8499	0.39743	
d_PETAL_6	-0.00463246	0.115014	-0.0403	0.96795	
d_PETAL_7	0.147008	0.109816	1.3387	0.18374	
EC1	-0.00220144	0.00138392	-1.5907	0.11486	

Author's Construct

It can be noticed in particular that PETAL is influenced at multiple lags of TOAE. Thus, total exemptions are very influential on the PETAL within a quarter of the year and beyond.

Performance of the PCAVEC Model

Although five components from the principal component extraction explained 100% of the total variation in the 14 multivariate time-series data, it does not necessarily mean that model summary statistics of the transformed model should be the same as those of the original. Reasons accounting for the inequality that exists between these two models include:

1. Level of stationarity of the original data with 13 variables in the first model would not be the same as that of the transformed model.
2. Data pattern and linearity with each variable over time would differ within each dataset.
3. No loss of information in original data means no loss in information in the regression based on the transformation.

The third point is paramount as in regression based on fewer variables; The degree of freedom lost impacts how much data the model can explain.

In Table 9, the summary statistics of the three models are provided. These are the Vector Auto-regressive (VAR) model, the Vector Error Correction (VEC) model and the Principal Components Vector Error Correction (PCAVEC) model. In the VAR model, almost 100% of the variation in some seven variables is accounted for. This is precisely the situation that was anticipated right from the beginning as a result of the structure of the data. This is a spurious model. It, however, performs poorly for VOL. This is because OL naturally is not influenced by any revenue component, so its series is not prone to p. The VEC model presents an improvement in the representation of the VOL and EXTAX, which are poorly represented by the VAR. The VEC also achieves a reduced R-square value compared to those in VAR, and this performance is more feasible. From the ratio of the standard error regression of the two models, the error in the VEC is not markedly different from that of the VAR for all variables. However, as already observed, the plausibility of the VEC representation could still be flawed due to a clear pattern of dependence in interpretation. The PCAVEC model presents rather much reduced R-square values, which is more plausible. Interestingly, it produces smaller error regression values for some components (VOL and CIF).

Table 9: Model Statistics at lag 8 for VAR, VEC and PCAVEC

	VAR Model					VEC Model			SER EC/
Variable	R-sq	SS Res	SE Reg.	*F*	*p*-value	R-sq	SS Res	SE Reg.	SER VAR
GDPMN	0.999302	6303147	366.2097	764.3319	3.88e-57	0.772645	9558159	409.4960	1.1182
SSGDPMN	0.998940	2071869	209.9579	503.2830	6.97e-53	0.804872	3021617	230.2408	1.0966
TORE	0.997955	5.83e+16	35207344	260.6651	3.39e-46	0.832125	7.67e+16	36679227	1.0418
VOL	**0.353436**	5.13e+20	3.31e+09	0.291954	1.000000	**0.586551**	6.43e+20	3.36e+09	1.0151
CIF	0.706910	8.07e+20	4.14e+09	1.288187	0.171621	**0.735949**	1.11e+21	4.41e+09	1.0652
AFAC	0.983262	2.13e+14	2126369	31.37547	5.26e-25	0.791362	2.60e+14	2134238	1.0037
IMDAL	0.996437	1.33e+16	16794340	149.3685	1.48e-40	0.816550	2.08e+16	19094042	1.1369
IMVAT	0.995314	8.59e+15	13520685	113.4481	8.83e-38	0.838651	1.10e+16	13879761	1.0266
EXTAX	**0.511477**	7.99e+11	130408.4	0.559186	0.990484	**0.661146**	1.12e+12	140008.8	1.0736
NHIL	0.994780	2.56e+14	2332682	101.7814	1.09e-36	0.832766	3.45e+14	2461367	1.0552
FEES	0.853677	2.83e+09	7764.716	3.115996	0.000022	0.774573	3.72e+09	8078.130	1.0404

Author's Construct

Table 9 Continued

Variable	VEC Model			PCAVEC Model			SER PCAVEC/ SER VEC
	R-sq	SE Reg.	*F*	R-sq	SE Reg	*p*-value	
GDP	0.772645	409.4960	764.3319				
SSGDP	0.804872	230.2408	503.2830				
TORE	0.832125	36679227	260.6651	0.6630	1.69e+08	0.00347	4.6075
VOL	0.586551	3.36e+09	0.291954	0.4403	2.95e+09	0.41157	0.8780
CIF	0.735949	4.41e+09	1.288187	0.6925	3.68e+09	0.00008	0.8345
AFAC	0.791362	2134238	31.37547				
IMDAL	0.816550	19094042	149.3685				
IMVAT	0.838651	13879761	113.4481				
EXTAX	0.661146	140008.8	0.559186				
NHIL	0.832766	2461367	101.7814				
FEES	0.774573	8078.130	3.115996				
TOAE				0.6175	1.27e+08	0.11121	
PETAL				0.4741	37869794	0.11486	

Author’s Construct

In order to check the reliability of the PCAVEC model, three different graphs are generated. These graphs are the original dataset, its predicted graph based on the model generated by the original multivariate time series (VEC model) and the predicted graph based on the PCAVEC model. The graphs in Figures 8 to 12 show that all three graphs have the same pattern over time, with very few deviations from each other. This is a significant observation that indicates model validity and reliability of the reduced PCAVEC model even with the disadvantage of a loss of degrees of freedom. In the graphs, the PCAVEC model is preceded by P. For example, the new model for

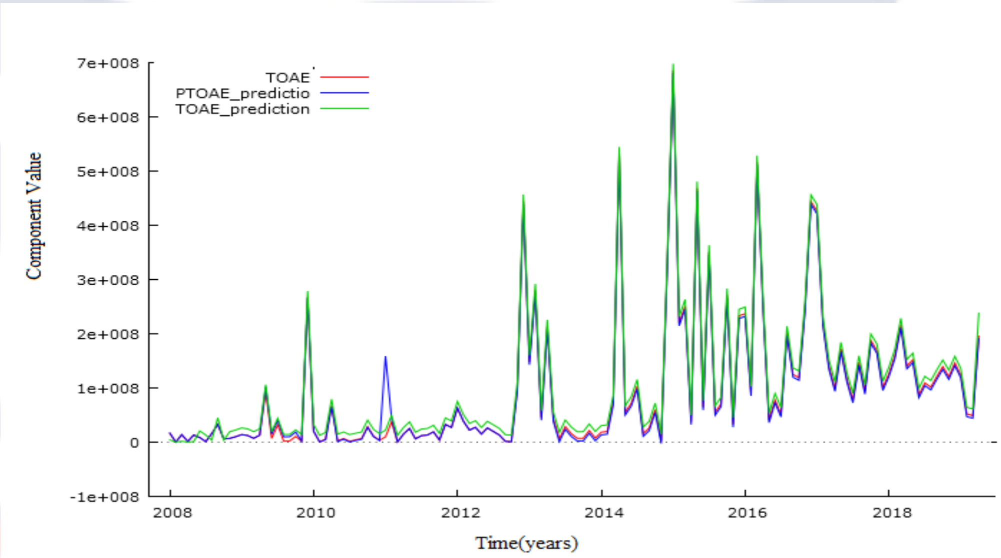

Figure 8: PCAVEC Model for TOAE Overlaid on the Original series and Predicted Series Based on The Full Model (Author's Construct)

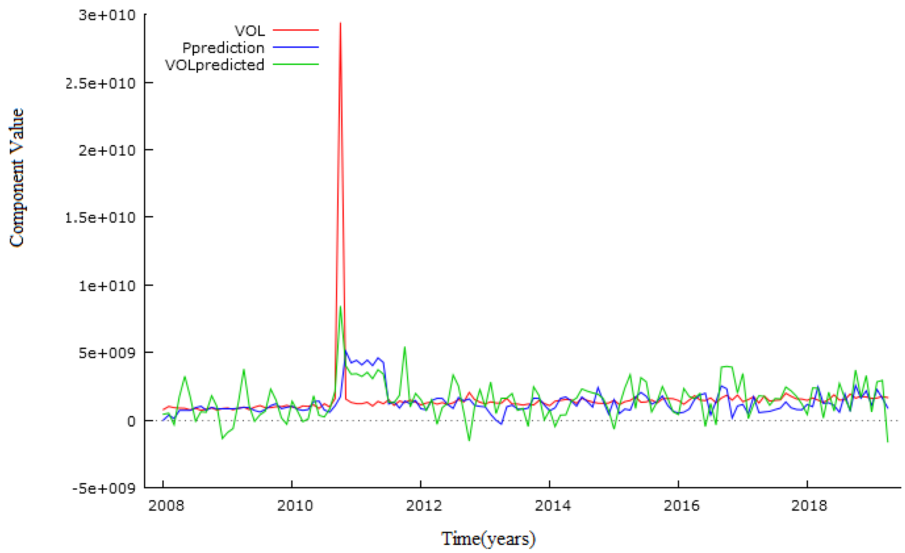

Figure 9: PCAVEC model for CIF Overlaid on the Original series and Predicted Series Based on the Full Model (Author’s Construct)

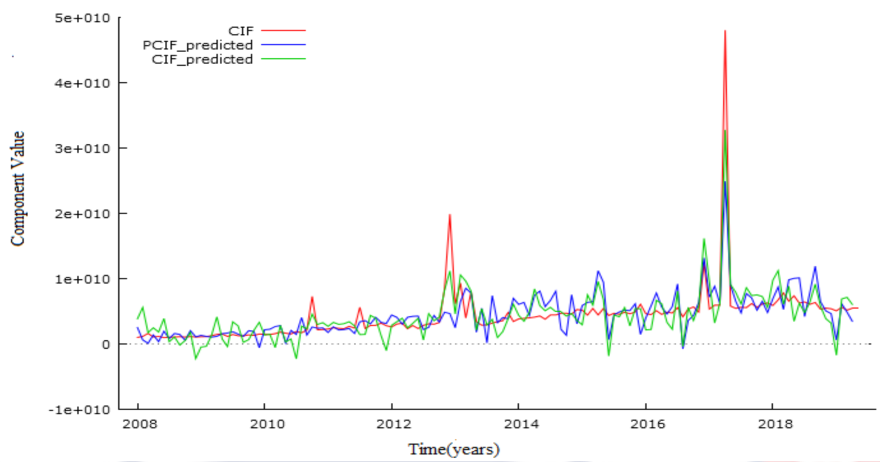

Figure 10: PCAVEC model for VOL Overlaid on the Original Series and Predicted Series Based on The Full Model (Authors Construct)

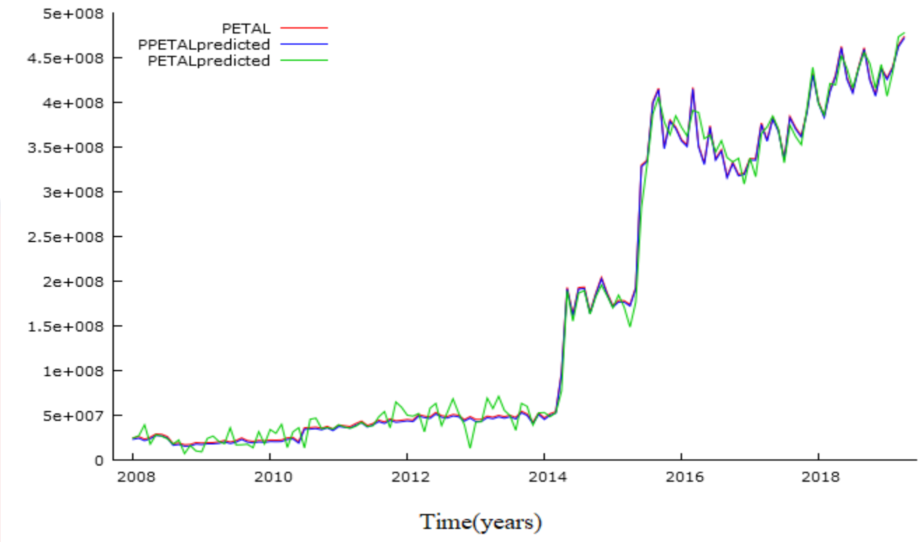

Figure 11: PCAVEC model for PETAL Overlaid on the Original Series and Predicted Series Based on the Full Model (Authors Construct)

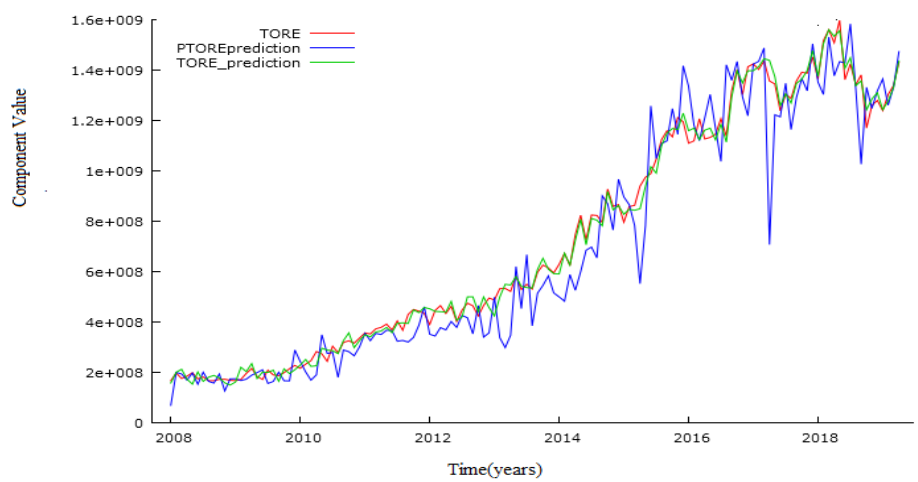

Figure 12: PCAVEC Model for TORE Overlaid on the Original Series and Predicted Series Based on the Full Model (Author's Construct)

It can be seen from the graphs that, with the exception of TORE, the proposed model closely approximates the original series. The deviations are apparent at periods where there are spikes in the original series.

Model Validation

The primary procedures for assessing and establishing the reliability of numerical models are model validation and model verification (Salamanca et al., 2010). For this study, the following procedure is carried out for validation: The model is generated with 80% of the transformed data. The resulting model is then used to predict the remaining 20%. The graphs generated for this procedure are presented in Figures 13,14,15,16 and 17

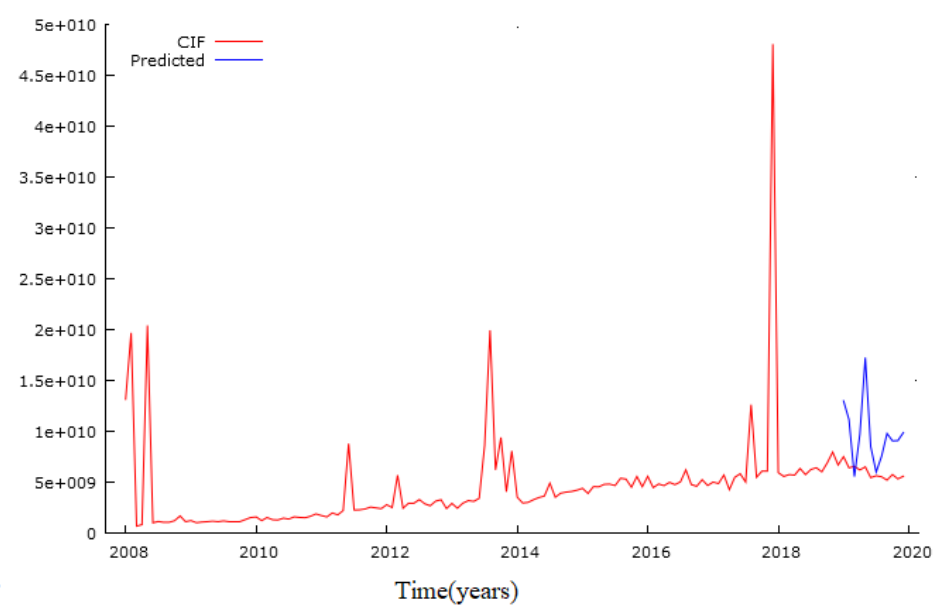

Figure 13: Generated graphs From out of Sample Model used to Predict For The Remaining Periods for CIF (Author's Construct)

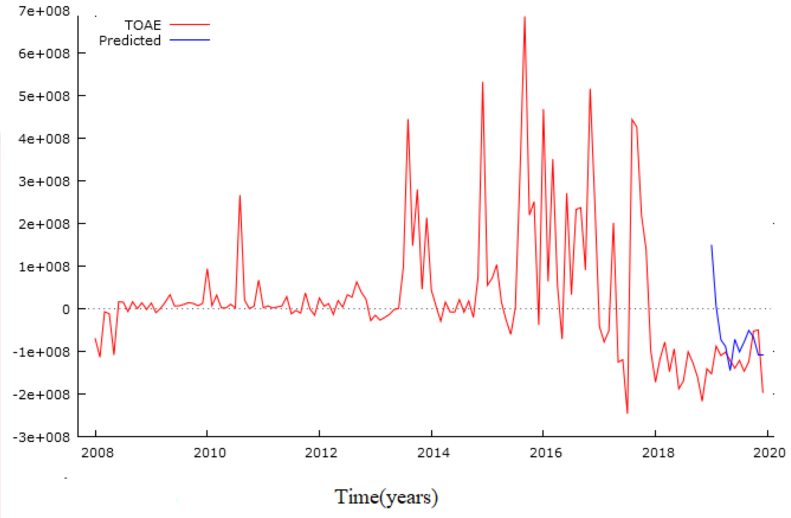

Figure 14: Generated graphs from out of Sample Model used to Predict for the Remaining Periods for TORE (Author's Construct)

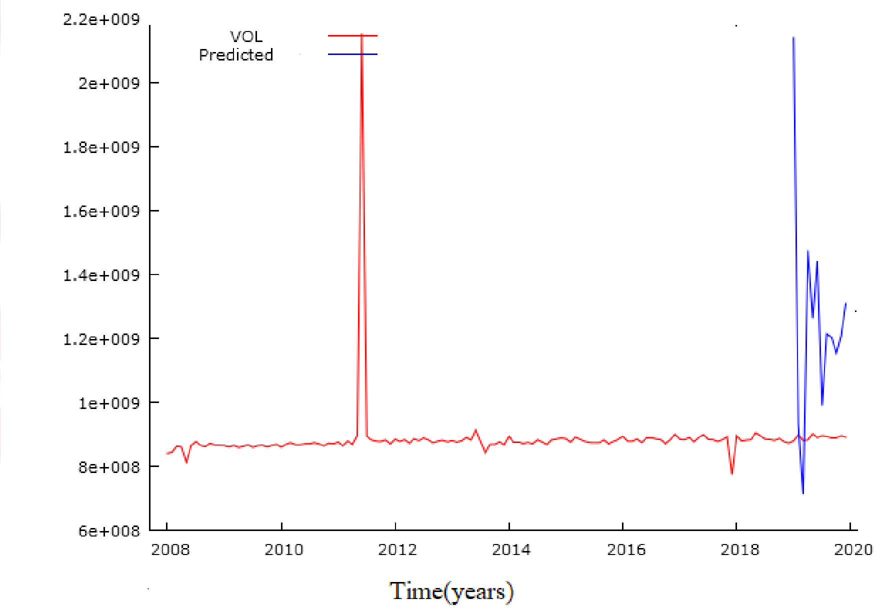

Figure 15: Generated Graphs From Out of sample model used to Predict for the Remaining Periods for VOL (Author's Construct)

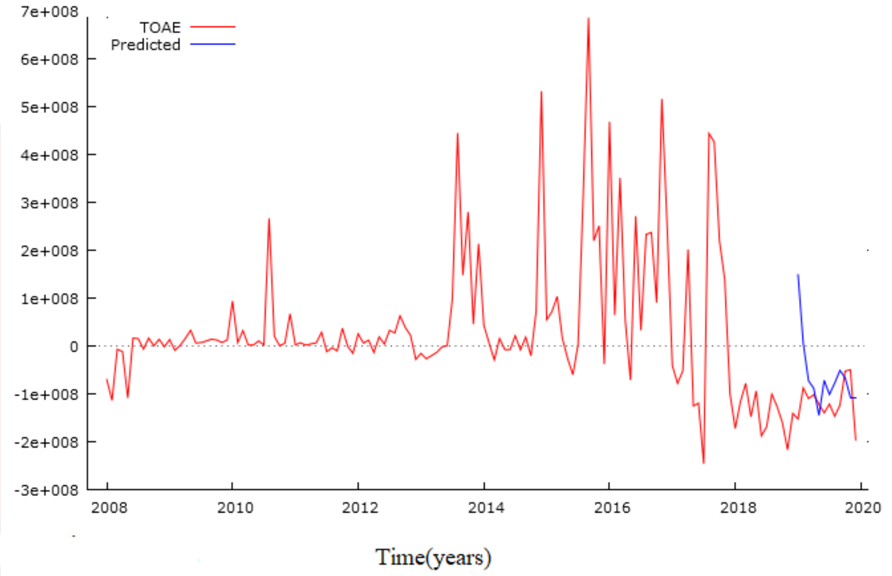

Figure 16: Generated Graphs from Out of Sample Model used to Predict for the remaining periods for TOAE (Author's Construct)

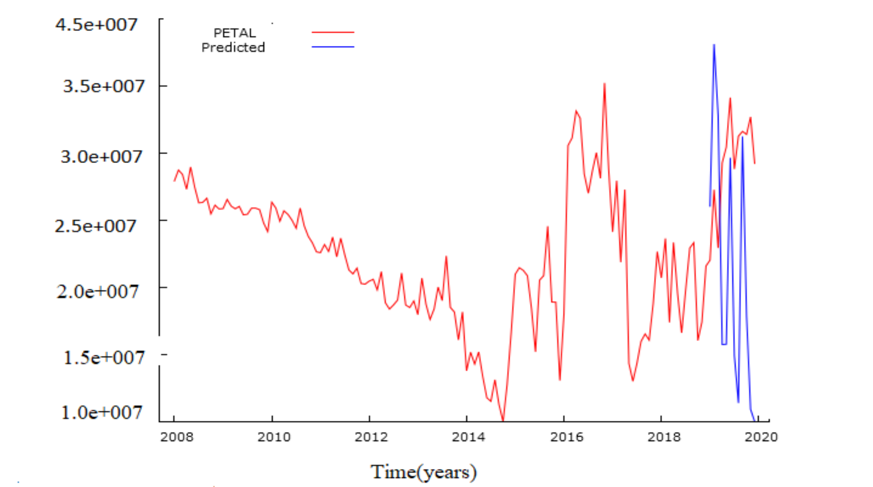

Figure 17: Generated Graphs from Out of-sample model used to Predict for the remaining periods for PETAL (Author's Construct)

From the graphs, it is clear that generally, the recent values follow the pattern of the distant past values for all revenue sources. Fluctuations in the forecast appears quite pronounced for CIF and VOL. It means that for these two sources, predictions from recent past values could be prone to errors. The error measures associated with the validated forecast and defined in Chapter Three are given in Table 10.

Table 10: Forecast Evaluation Statistics

Error Measures	PCIF	PVOL	PTORE	PTOAE	PPETAL
ME	1.3578e+11	9.4368e+08	1.7122e+09	1.164e+10	5.6224e+07
MSE	9.2509e+23	1.6328e+21	2.0457e+20	1.3552e+22	3.3102e+18
RMSE	9.6182e+11	4.0408e+10	1.4303e+10	1.1641e+11	1.8194e+09
MAE	5.5527e+11	2.4898e+10	8.3316e+09	6.796e+10	1.0435e+09
MPE	-2511.9	-251.7	124.29	503.69	12.663
MAPE	9832	1796.7	625.62	2329.5	236.46

Author's Construct

In the table, the abbreviated error measures are explained as follows:

ME — Mean Error

MSE — Mean Square Error

RMSE — Root mean Squared Error

MAE — Mean Absolute error

MPE — Mean Percentage Error

MAPE — Mean Absolute Percentage Error

The results show that error measures are consistently lower for PETAL than any other variable. Another stage of the validation process is to use the new model to obtain prediction for the variables. This is to assess the level of precision at which the model could mimic the behaviour of the original variables. These are presented in Figures 18,19,20,21,22 and 23

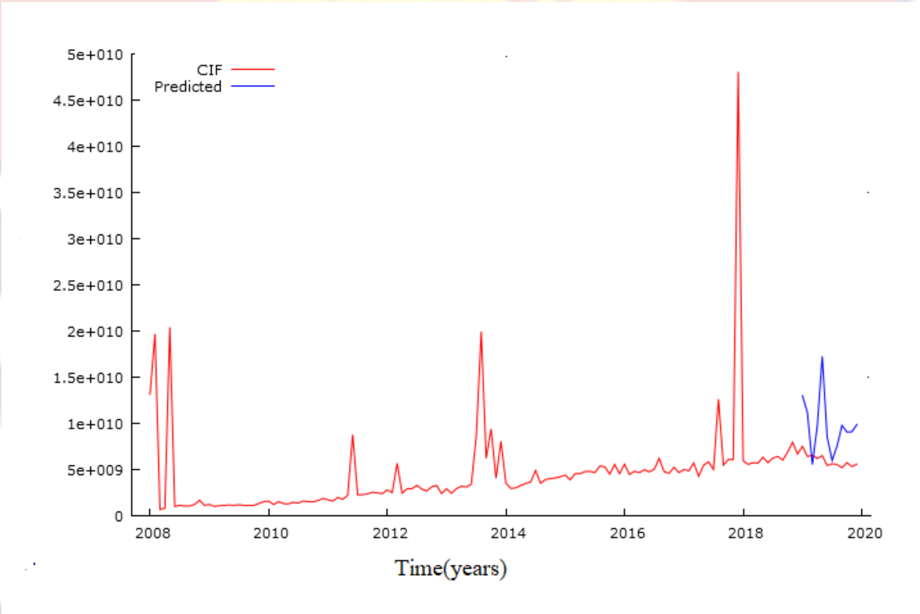

Figure 18: Graph of The actual and Predicted Variable for CIF (Author's Construct)

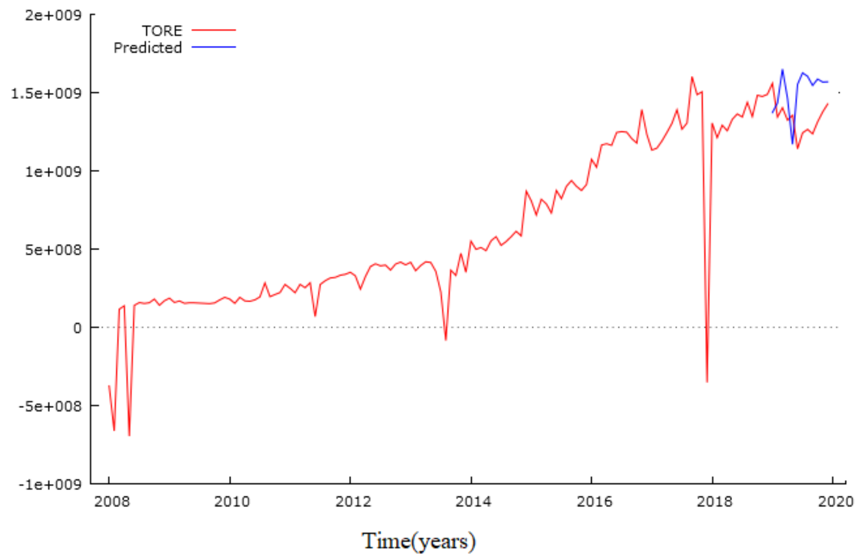

Figure 19: Graph of the Actual and Predicted variable for TORE (Author's Construct)

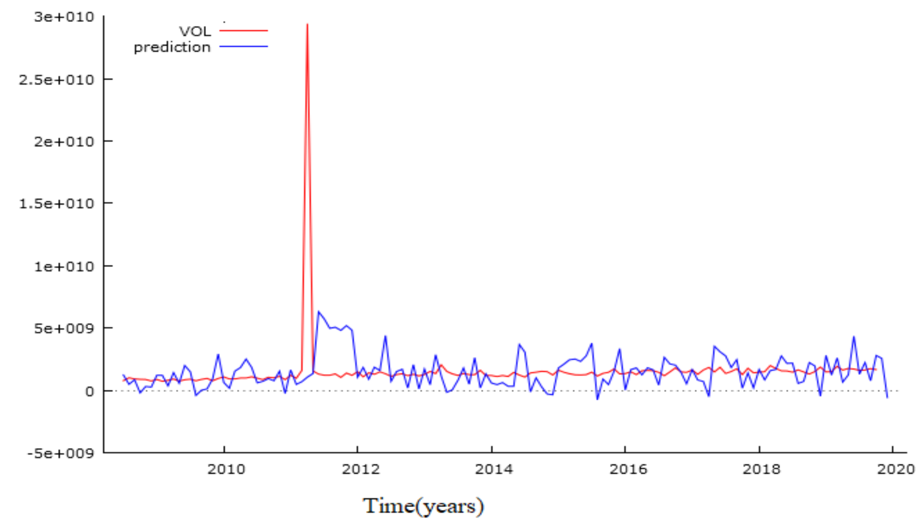

Figure 20: Graph of the Actual and Predicted Variable for VOL (Author's Construct)

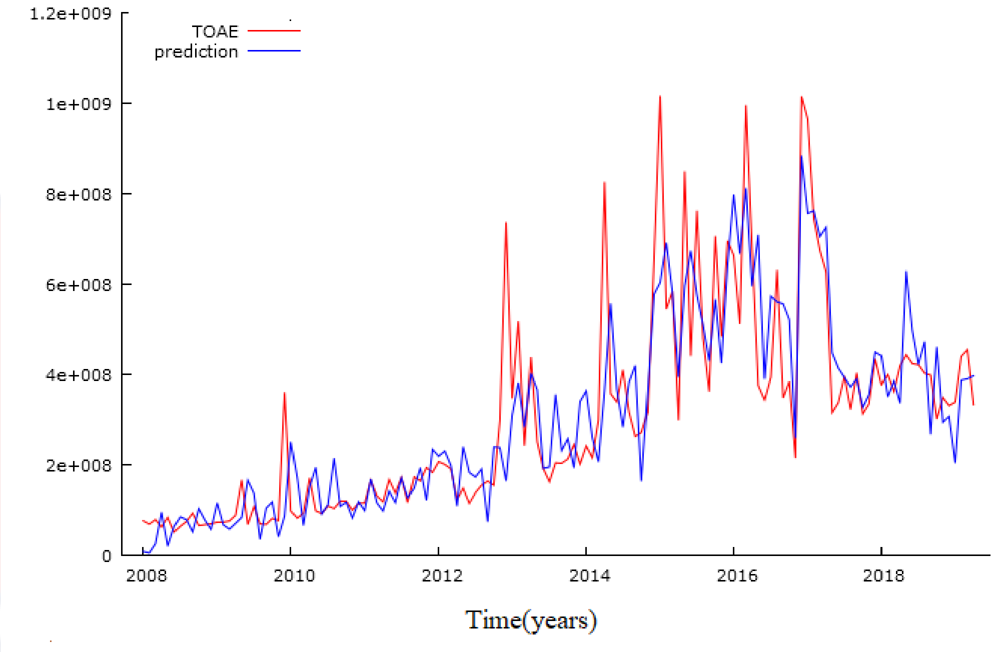

Figure 21: Graph of The Actual and Predicted Variable for TOAE (Author's Construct)

Figure 22: Graph of the Act
ual and Predicted Variable for PETAL
(Author's Construct)

The graphs show that using the new model to make predictions is said to have very little deviations from the original plot of the variables. This observation of the graphs indicates that the validated model is efficient in predicting. This also shows some level of reliability for future forecasts.

Model Diagnosis and Checking

The new model is subjected to a test that would be the basis for determining the model's efficacy. These are normality tests, impulse response functions, heteroscedasticity, granger causality, and variance decomposition.

Normality Test

This test is undertaken in order to determine if the data set used for the VECM model estimation is normally distributed and conforms to an assumption of normality. The hypothesis for this test is given as follows:

H_o: The variables in the data are normally distributed

H_1: The variables in the data are not normally distributed

Table 11 shows detail results for the normality test .

Table 11: Jarque Bera Test for Normality (Multivariate only)

Parameter	Chi-square	D.F	P
Skewness	1.218	8	0.768
Kurtosis	2.2179	8	0.842

Author's Construct

For the test, a significance level greater than 0.05 would mean that there is confirmation that residuals from the model are normally distributed and independent. From the results in Table 11, since *p*-values are greater than 0.05, there is an indication that residuals of the model are normally distributed and independent and therefore satisfy the assumption of independence and normality of the residuals.

Heteroscedasticity

When heteroscedasticity occurs, the error variance does not remain constant over the range of factors used to forecast it. We hope that the VECM(8) model would not experience heteroscedasticity, indicating that the model is strong and trustworthy for predicting the various response variables. Table 12 presents results of heteroscedasticity.

Table 12: Test For Heteroscedasticity

Chi-squared	D.F	P
8641	43214	0.789

Author's Construct

The test results indicate greater evidence of the absence of heteroscedasticity since the significance level is more than 0.05.

Granger Causality

A statistical notion or hypothesis called Granger Causality can be used to assess whether one-time series can be used to forecast subsequent series. It can also establish the relationship between two variables in a time series. Investigating if the response variables in this study exhibit some degree of granger causality with one another over time is interesting. The result is expected to put into perspective results in the derived model. Table 13 presents the results of the causality among variables in the PCAVEC model.

H_o: There is no Granger causality between the variables

H_a: There is granger causality between the variables

Table 13 : Causality Among Variables from the PCAVEC Model

Causality	F Test	Pvalue	Conclusion
CIF granger cause VOL	1.3425	0.0321	Reject Ho
CIF granger cause TORE	1.9872	0.0023	Reject Ho
CIF do not granger cause TOAE	1.883	0.2431	Fail to Reject Ho
CIF granger cause PETAL	1.332	0.0420	Reject Ho
VOL granger cause CIF	2.3421	0.0214	Reject Ho
VOL granger cause TORE	1.3424	0.0321	Reject Ho
VOL does not granger cause PETAL	1.4360	0.0531	Fail to Reject Ho
TORE granger cause CIF	1.0982	0.0213	Reject Ho
TORE does not granger cause VOL	1.5820	0.3420	Fail to Reject Ho
PETAL does not granger cause TOAE	1.009	0.2131	Fail to Reject Ho

Author's Construct

Table 13 indicates that 60% of causality within the variables. The results show that only these could be used in indicating that one time series could be used in predicting the other as a result of the occurrence of the other.

Impulse Response Functions

The impulse response is a method for determining how model variables react over time to a shock in another variable. Figures 23,24,25,26 and 27 presents impulse response graphs that are generated for the response of TORE to a shock in CIF, VOL, TORE, TOAE and PETAL over 24 time period.

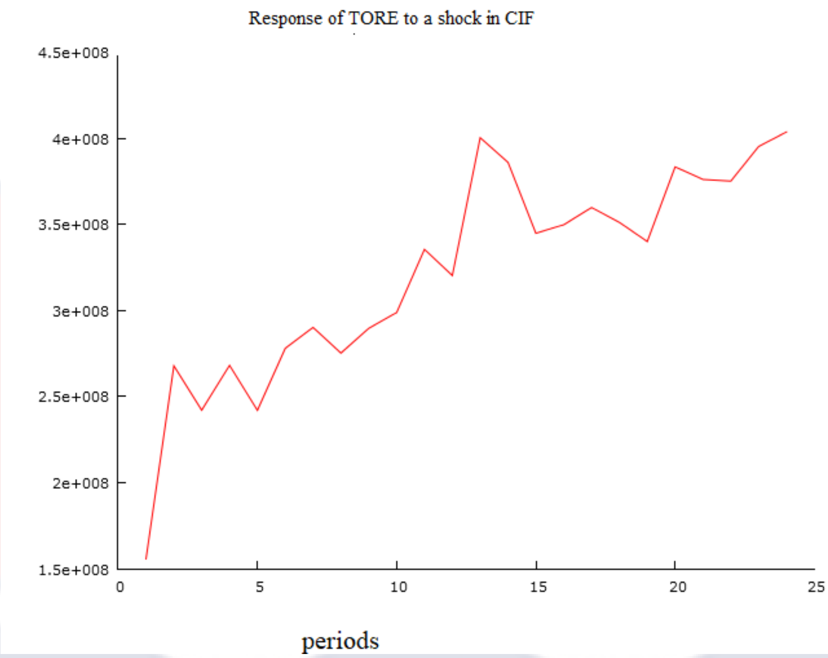

Figure 23: Impulse Response for TORE to Shocks in CIF (Author's Construct)

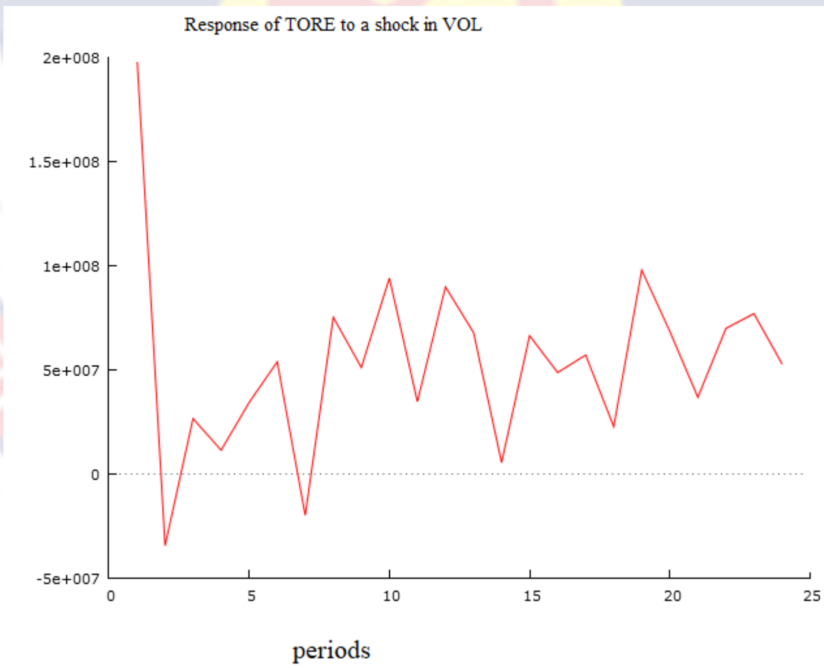

Figure 24: Impulse Response for TORE to Shocks in VOL (Author's Construct)

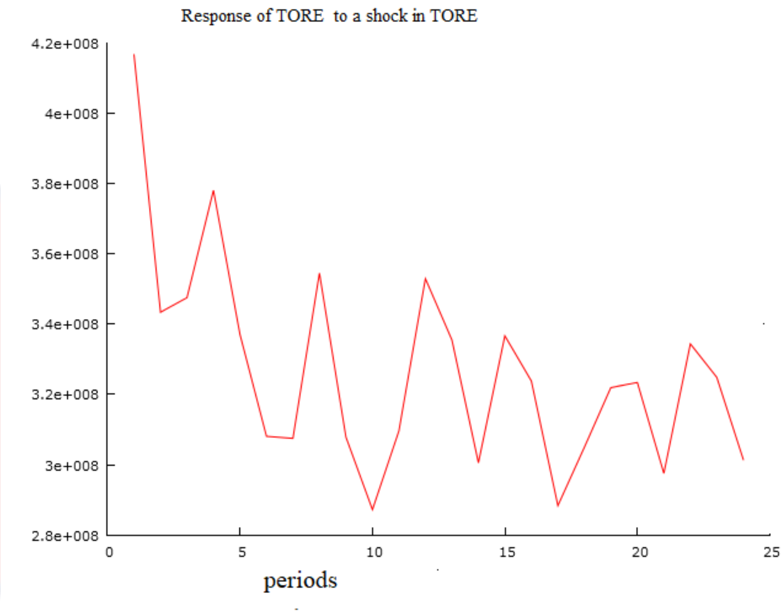

Figure 25: Impulse Response for TORE to Shocks in TORE (Author's Construct)

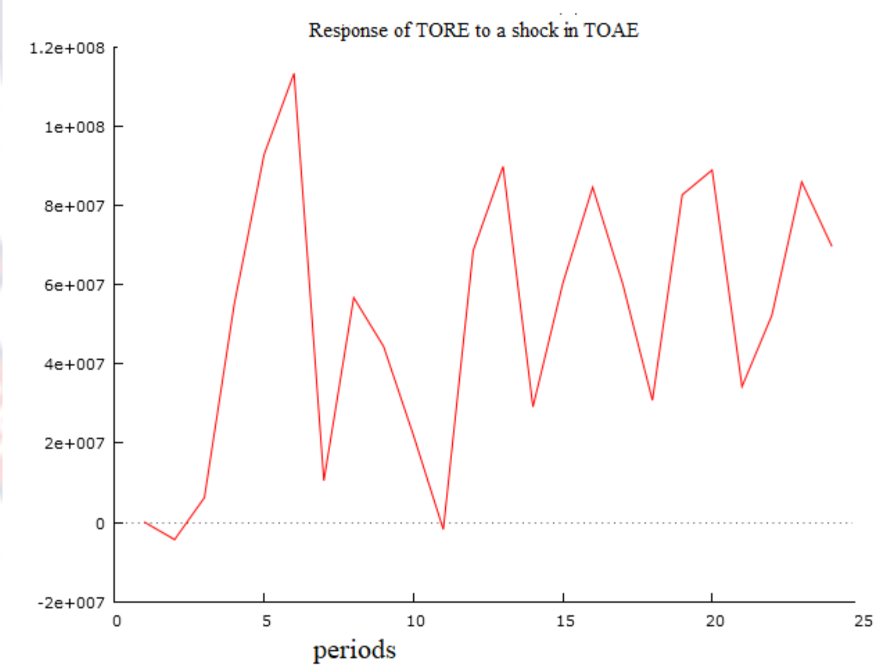

Figure 26: Impulse Response for TORE to Shocks in TOAE (Author's Construct)

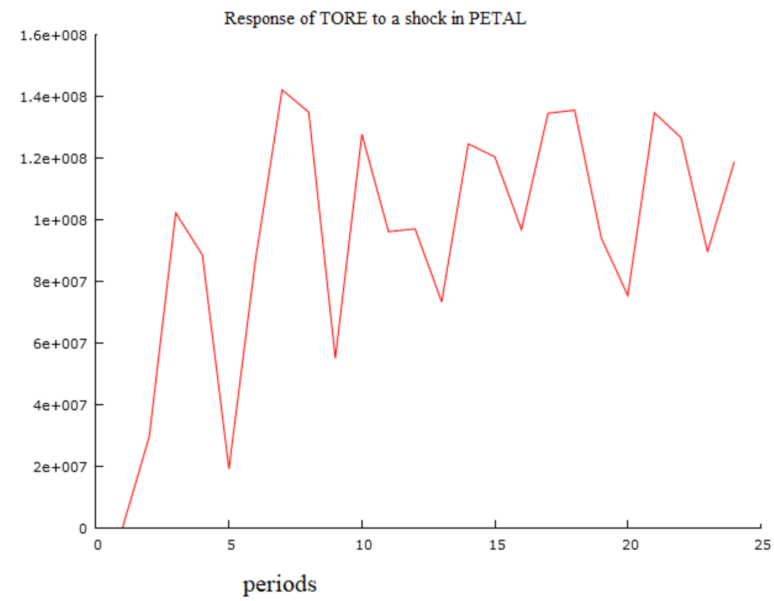

Figure 27 : Impulse Response for TORE to socks in PETAL (Author's Construct)

There is generally positive response to TORE as a shock outcome in CIF. It shows a sharp increase in TORE from the first to the second period. This response on TORE increased continuously with time but with little fluctuations over the period of two years. However, TORE has a peak response at about the 14th time point. In general, CIF influence on the performance of TORE shows that within the first two months, TORE would experience a sharp increase.

Response of TORE as a result of a shock in VOL shows that TORE is influenced greatly by VOL only in the short term of one or two months. There appears to be a stability of influence from VOL in the long term but with fluctuations. The response of TORE to a shock in TORE indicates a rather declining trend throughout the first 12 months and remains stable with fluctuations after that. TORE does not have a positive influence on itself with time. TOAE negatively influences TORE in the first three months, but the effect causes TORE to increase to its peak in about 6 months. TORE generally experiences stability with high fluctuations over time due to one standard deviation shock from TOAE.

TORE response to a shock in PETAL is one of the severe fluctuations throughout the period but with a general increasing trend likely to be curvilinear in the long term. Thus, in the long term, possibly after two years, the effect of PETAL would cause a decline in the total revenue.

Forecast Error Variance Decomposition (FEVD)

Using the widely used statistical technique of forecast error variance decomposition, one can explain the degree of unpredictability in dependent variables that are lagged by their own. It also indicates the probability or percentage forecast error associated with the forecast of a particular variable with respect to other variables over time. Figures 28,29,30,31 and 32 presents graphs of variance decomposition starting with period zero for the variables within the model.

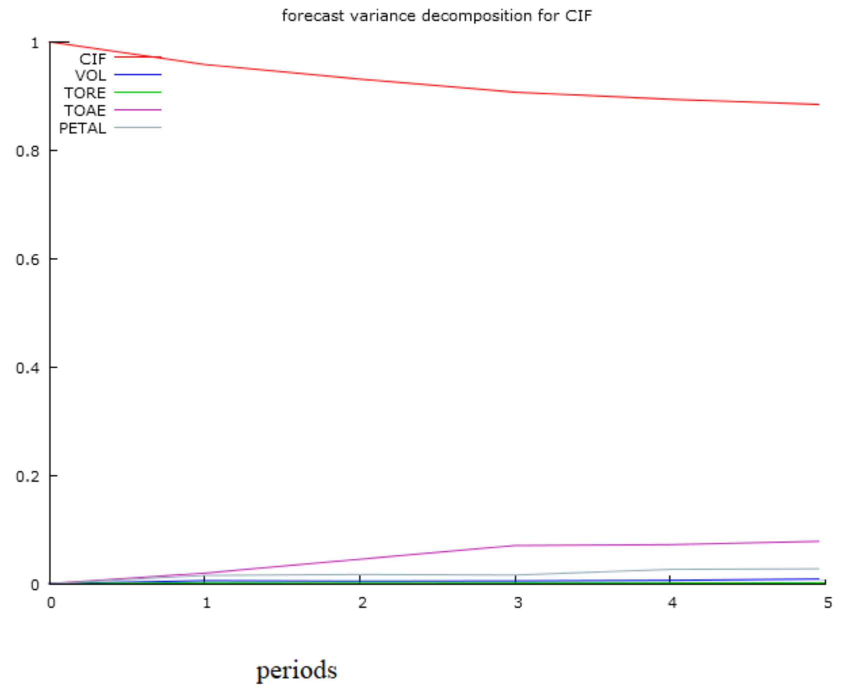

Figure 28: Error Variance Decomposition of CIF in the Final model (Author's Construct)

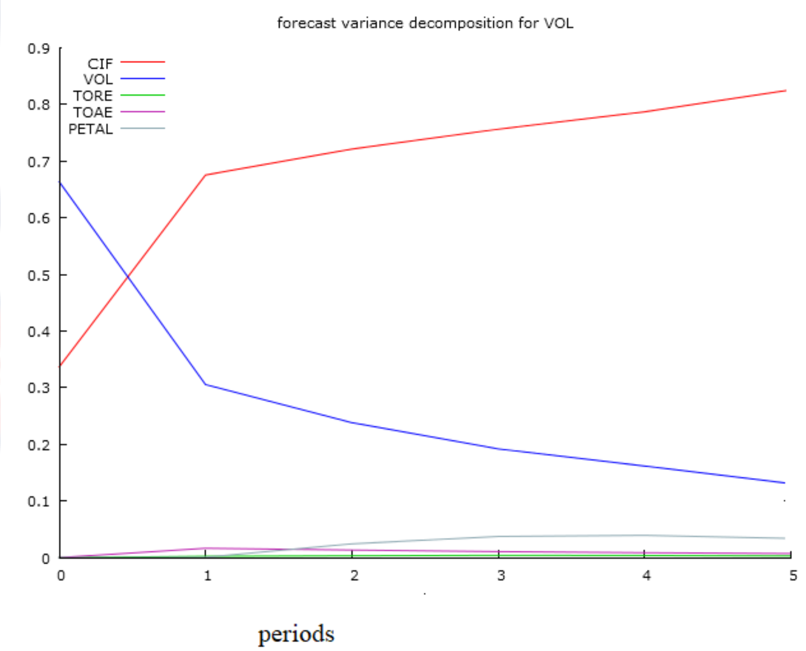

Figure 29 : Error variance decomposition of VOL in the Final Model (Author's Construct)

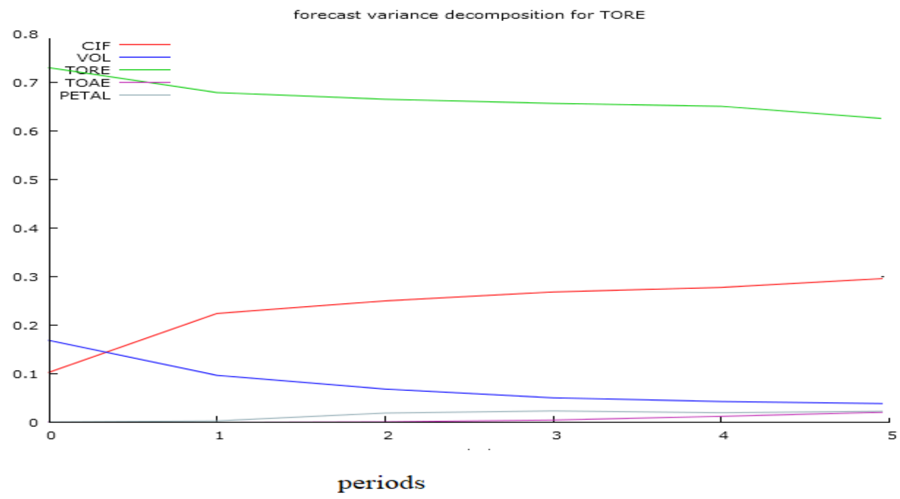

Figure 30: Error Variance Decomposition of TORE in the Final Model (Author's Construct)

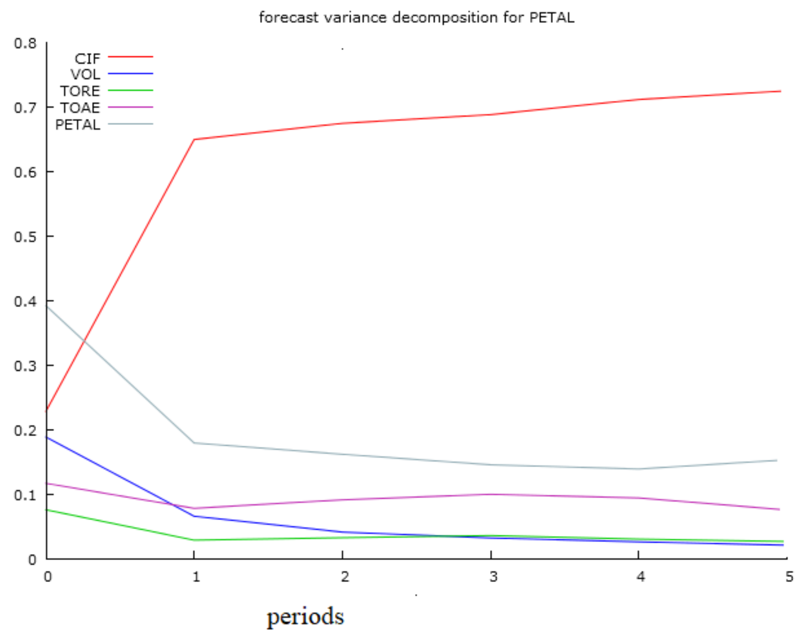

Figure 31: Error Variance Decomposition of PETAL in the Final Model (Author's Construct)

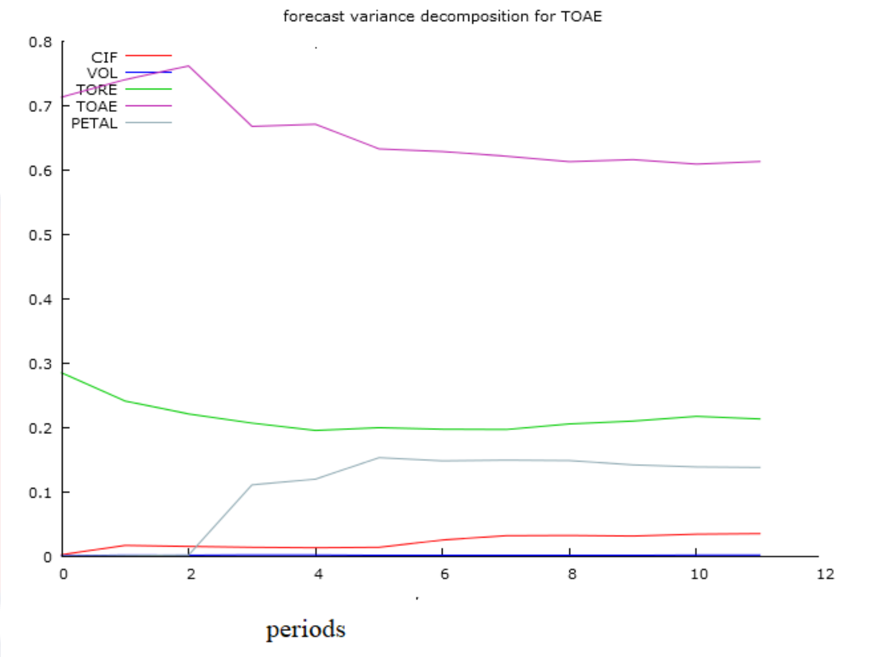

Figure 32: Error Variance Decomposition of TOAE in the Final Model (Author's Construct)

The graphs of the forecast errors generally indicate an increase in forecast errors of each variable decomposition in relation to the others. There is generally stability in errors after period 1, and no visible changes are observed after period 5, which explains why the graphs are generated up to period 5. Thus, after one month, there is stability in the effect of all other variables on the variation in the particular source of revenue. This is seen in the leveling off of all other variables after period 1 in relation to the graph of the variable of interest. The CIF has the smallest long-run forecast error of about 10%. Thus, forecast estimates for CIF show the highest reliability, even in the short run. VOL has the highest forecast error of about 87% in the long run. Thus, forecast estimates of VOL have the lowest reliability, which is realized in the medium term of just after five months. In the long term, TORE has the second smallest forecast error of about 38%. This means that forecast estimates for TORE show some high reliability. TOAE has about 45% forecast error in the long run. PETAL has the second largest forecast error of about 72% in the long term. Thus, the forecast estimates of PETAL have the second lowest reliability.

Discussion

The results have shown that the PCAVEC model gives a more plausible representation of the revenue sources as the pattern obtained by the model mimics the pattern in the original data with little deviation and yields more reasonable R-square values. The plausibility of the model is also seen in the interpretation of the models themselves. For example, the model for VOL is significantly influenced only by its lags. Again, the TORE model is influenced only by total exceptions within 3 and 4 months. These are more realistic representations of the revenue items. The interpretation of the PCAVEC model is apt and reveals that the results based on the original model are a kind of an inverted notion of the PCAVEC model. In the VEC model, it is realized that an item is significantly influenced by those items that it is influential in their generation. For example, TORE in the VEC model is influenced by GDP, SSGDP, AFAC, NHIL, FEES and by itself at various lags. All these items are rather influenced by TORE. For CIF, apart from itself, it is influenced only by GDP at lag 7. However, it is rather CIF that determines the GDP.

A notable finding is the influence of TOAE on total revenue (TORE). This result is evident in the PCAVEC model. This result buttresses the popular assertion in the literature that tax exemptions remain an essential drain on the country's total revenue.It is noticed that the proposed model is associated with a large error for TORE. The composition of total revenue may not be complete for the data studied. It indicates that other sources that could add to the total revenue are yet to be identified. However, based on the derived model, it is noted that fluctuations characterise TORE over the years.

Chapter Summary

In this chapter, the procedures for a proposed model for characterizing revenue sources have been implemented. The chapter systematically examines three techniques in the process. First, lag selection criteria are assessed that obtain an optimum lag of 8 for building the models. At the optimum lag, the performance measures of R-squares and standard errors of the models are at their highest and lowest, respectively. The development of the proposed model begins by first examining the initial Vector Auto-regressive (8) model. As expected, this model explains almost 100% variation in several series variables. Such a model is thus spurious since structural dependencies with severe multi-collinearity characterize the data. However, the model incidentally provides a poor fit for some items, such as the CIF and VOL, with R-squares of just about 35%.

An improvement over the VAR(8) model applies the Vector Error Correction (VEC) at lag 8 VEC(8) model to the same data. The model produces a more realistic characterization with a more reasonable performance in all variables. It yields a reasonable reduction in all R-squares that are initially more than 90%. There is an improvement in R-square values for VOL and EXTAX in which the VAR performs poorly. In spite of the more plausible performance in the

VEC model, some drawbacks of the VAR model remain: (1) It contains less number of original variables that are system-selected; (2) There is still the incidence of dependency structure in interpretation. In order to resolve this challenge, the study incorporates principal components extraction into the VEC model. Five salient dimensions constitute the main contributions to general revenue mobilization. The first and the dominant source is that which is influenced by CIF and accounts for about 80% of the total variation in all revenue sources. The remaining 20% of revenue information is influenced predominantly by Volume (VOL), accounting for 18.7% of the variation. The small percentage remains are explained by Total Revenue (TORE) (about 0.92%). What further remains is accounted for by Total Amount Exempt (TOAE) and Petroleum tax (PETAL). Thus, like the original data structure, all five major components are one-item and are now orthogonal. It follows that the remaining nine components are redundant and could therefore be discarded as they contain no information.

By projecting the original data onto the five components, a new dataset is obtained that is a linear transformation of the original in a five-dimensional space. Applying the VEC model to the transformed data yields the principal component Vector Error Correction (PCAVEC) model. The model now explains 66.3% variation in TORE, 44.03% variation in VOL, 69.25% variation in CIF, 61.75% variation in TOAE, and 47.41% variation in PETAL. These performance measures are more plausible for the data structure. The standard errors associated with the model for some variables are even smaller than those produced in the VEC model, which has the advantage of a higher number of variables and is associated with higher degrees of freedom. Out of the five components, the model is found to be significant for CIF and TORE.

Further assessment of the PCAVEC model is carried out using the forecast error variance decomposition (FEVD), impulse response functions (IRF), model validation and diagnostics. The FEVD shows that the effect of other revenue sources on a given one becomes stable after just one period. This means there is very little further impact of any variable on others in the long run after just one month. CIF remains the revenue source with the least forecast error (of 10%) and hence would produce the most reliable forecast estimates. The second list of reliability is TORE.

On the other hand, it is observed that the PETAL model has the highest forecast error in the long run. Except for CIF, shocks in each variable cause severe fluctuations in TORE. For all the five items, the validation of the models shows that the immediate future revenue values are consistent with the pattern of values for the recent past. This pattern is less prone to errors for the PETAL, suggesting that piecewise regression modelling could be more suitable for this variable. The PCAVEC model, therefore, provides a plausible econometric characterization of revenue sources.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

Overview

In this chapter, the summary of the entire study is presented. It covers the summary of the introductory chapter through to the results and discussion. Conclusion of the study will be drawn from the summary. Subsequently, relevant recommendations from the results will be put forward for effective mobilization of revenue.

Summary

The study has examined various activities that generate revenue, such as tariffs and item categorization procedures for imposing tariffs, and the role of taxation in revenue mobilization has been extensively explained. Restructuring in revenue mobilization agencies has taken place in the country's history to engender efficiency in revenue generation. Efficiency in revenue mobilization has been sought by introducing new taxes, the complete abolition of existing taxes and substantial reduction in others. The reforms have introduced automation systems such as the Ghana Community Network (GCNet), which provides a single window platform for processing trade transactions and customs clearance. Importing foreign goods has been identified as a key supporter of the Ghanaian economy, despite its injurious repercussions for local industrialization.

The study has been motivated by a number of prevailing economic issues. The first is the proliferation of taxes in the economy and the need to investigate the relevance of multiple taxes. Another motivation is the methodology for studying a dynamic data problem such as revenue. It is noted that recent methodology for studying Ghana's revenue data has made use of traditional Auto-regressive Integrated Moving Average (ARIMA) and ARIMA Error regression model. There are, however, applications of machine learning time series methods that include the Bayesian time series and Neural Network Auto-regression (NNAR) modelling. The dynamic nature of revenue data structure, evolving methodology for studies in the area, and different coverage of revenue data in related studies constitute this research's problem. Two main specific objectives are therefore identified to guide the study. The first is to examine the various revenue components that are most influential in revenue generation; the second is to obtain a suitable multivariate time series model that characterizes the contribution of each revenue component. The study is expected to deepen our understanding of the structure of revenue components guiding revenue mobilization efforts.

The literature on the subject highlights the importance of import revenue for economic development as it forms a significant part of government total revenue. It is observed that the potential of import revenue depends on the efficiency of revenue mobilization. The Ghana Revenue Authority (GRA) oversees the work of the revenue mobilisation agencies, including the Customs, Excise and Preventive Service (CEPS), Internal Revenue Service (IRS), and Value Added Tax (VAT) Service, which describes the relationship that exists among these organisations. It is evident that the GRA has undergone various reforms to ensure efficiency in revenue generation, with the enactment of relevant Acts.

The derivation of the GDP is extensively reviewed and shows that the tax revenue component is quite low (13 to 16%) among developing nations compared to developed. It is clear from the literature that taxation is a prime factor in economic growth. Components and computations of GDP have been presented, and the relevance of GDP is seen to be influenced by periodic rebasing of the economy. Therefore, such activity has implications for data coverage for studies on economic variables.

Taxation activities involve the National Health Insurance Levy (NHIL), Import duty, VAT, and Petroleum and Agency Levy (PETAL). The Cost, Insurance and Freight (CIF) play a crucial role in determining revenue. An extensive presentation on the Harmonized System and Customs Tariff Schedule 2012 ("HS Code'') specifies various duties and administrative charges for imports, exports and excise duties. The CIF forms the basis on which the customs value of goods is determined. Several alternative procedures are presented on the CIF to determine the customs value of imported goods.

In addition to the HS Codes, a practice that helps with an appropriate classification of goods is the custom regimes that involve the main regimes and a combination of regimes. Research has also examined the relationship between tax revenue and countries' economic growth. Results appear divergent on the correlation that exists between the two. However, in Ghana, tax revenue contributes positively to GDP. The Ghanaian exception is attributed to the large composition of import revenue to GDP. It is documented that a good understanding of the problem and the industry is necessary for a clear specification of revenue modeling procedure. It is seen that for revenue modelling, processes such as the identification of key themes and key dimensions are useful. The robustness of the revenue model is of concern in the literature.

The review clearly shows that some fourteen sources cover Ghana's revenue components extensively. These are GDP, Service Sector GDP, Total Revenue (TORE), Volume of imports (VOL), CIF, AFAC, IMDAL, IMVAT, EXTAX, NHIL and FEES. Methodology used in the area includes a univariate auto-regressive process for output growth models. The Markov switching approach has also been used in the process, though the AR(1) model has been identified as more appropriate. The Vector Error Correction (VEC) model for the examination of the foreign direct investment (FDI) on economic growth has been sighted. In particular, the principal components vector error correction (PCAVEC) model for multivariate times series has been used, for example, on unusual time series detection and multivariate image time series in land-cover-change monitoring.

The review of the theory of the VEC model, which is relevant for variables that are expected to be related in the long run, shows that the technique is appropriate as a part of procedures for studying the data problem. Besides the PCAVEC model, recent studies on Ghana's revenue have used machine learning times series modelling, including Bayesian Structural Time Series (BSTS) and the

Neural Network Auto-regression (NNAR), in addition to traditional methods of ARIMA modelling.

The methodology, therefore, explains the proposed principal components vector error correction (PCAVEC) model within the context of the structure of the data problem, which is characterized by high dependencies. Therefore, the study's design is guided by a motivation to isolate this dependency. The methodology, therefore, begins with the vector auto-regressive (VAR) model, which provides the basis for further developments. Since the VAR model is flawed by high multi-collinearity, with extremely high R-square values, a model expressed in terms of lagged differences $X_t - X_{t-1} = \Delta X_t$ and lagged 1 of the series X_{t-1} could prove more adequate. This means that for a meaningful model, the effect of the one time period is expected to significantly influence the model. Since one time-period apart differences could have traces of effects of dependencies, the VEC model could further be improved. The methodology, therefore, proposes extracting principal components that are expected to achieve a dimensionality reduction from the k original series variables $\mathbf{X}_t$ to r $(r < k)$ principal components $\{\mathbf{Y}_t\}$ with no loss of information. A projection of the original data on the reduced components would produce a transformed data dimension $n \times r$. The PCAVEC model would be generated by obtaining a VEC model of the transformed data. The Portmanteau lag selection test is prescribed for selecting the optimal lag at which the most suitable model would be obtained. Further methods for a model performance assessment that are prescribed are the forecast error variance decomposition (FECD), impulse response functions and diagnostic measures for checking underlying model assumptions.

The implementation of the procedures for the proposed model has been carried out. The procedure systematically examines three techniques in the process. First, a lag selection criteria are assessed that obtains an optimum lag of 8 for building the models. At the optimum lag, the performance measures of R-squares and standard errors of the models are at their highest and lowest, respectively. The development of the proposed model first examines the initial VAR(8). As expected, this model explains almost 100% of the variation in several series variables. Such a model is thus spurious since structural dependencies with severe multi-collinearity characterize the data. However, the model incidentally provides a poor fit for some items, such as the EXTAX and VOL, with R-squares of just about 35%.

An improvement over the VAR(8) model applies the VECM(8) at lag 8 VEC(8) model to the same data. The model produces a more realistic characterization with a more reasonable performance in all variables. It yields a reasonable reduction in all R-squares that are initially more than 90%. There is an improvement in R-square values for VOL and EXTAX in which the VAR performs poorly. In spite of the more plausible performance in the VEC model, some drawbacks of the VAR model remain: (1) It contains less number of original variables that are system-selected; (2) There is still the incidence of dependency structure in interpretation. In order to resolve this challenge, the study incorporates principal components extraction into the VEC model. Five salient dimensions constitute the main contributions to general revenue mobilization. The first and the dominant source is that which is influenced by CIF and accounts for about 80% of the total variation in all revenue sources. The remaining 20% of revenue information is influenced predominantly by Volume (VOL), accounting for 18.7% of the variation. The small percentage remains are explained by Total Revenue (TORE) (about 0.92%). What further remains is accounted for by Total Amount Exempt (TOAE) and Petroleum tax (PETAL). Thus, like the original data structure, all five major components are one-item and are now orthogonal. It follows that the remaining nine components are redundant and could therefore be discarded.

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Further assessment of the PCAVEC model is carried out using the FEVD, the IRF, model validation and diagnostics. The FEVD shows that the effect of other revenue sources on a given one becomes stable after just one period. This means there is very little further impact of any variable on others in the long run after just one month. CIF remains the revenue source with the least forecast error (10%) and hence would produce the most reliable forecast estimates. The second most reliable source is TORE.

On the other hand, it is observed that the PETAL model has the highest forecast error in the long run. Except for CIF, shocks in each variable cause severe fluctuations in TORE. For all the five items, the validation of the models shows that the immediate future revenue values are consistent with the pattern of values for the recent past. This pattern is less prone to errors for the PETAL, suggesting that piecewise regression modelling could be more suitable for this variable. The PCAVEC model, therefore, provides a plausible econometric characterization of the identified major revenue sources.

Conclusion

The proliferation of taxes in the Ghanaian economy poses a tax burden generally acknowledged by the citizenry. The revenue data structure has assumed a dynamic nature and evolving methodology for studies in the area, and varying coverage of revenue data in related studies constitutes the problem for this research. Therefore, the specific objectives that guide the study are to examine the various revenue components that are most influential in revenue generation; and to obtain a suitable multivariate time series model that characterizes the contribution of each revenue component.

The literature on the subject highlights the overarching importance of import revenue for economic development as it forms a significant part of government total revenue. It is observed that the potential of import revenue depends on the efficiency of revenue mobilization. This explains why numerous reforms have taken place in Ghana Revenue Authority and its partnership with revenue mobilization agencies, such as the Customs, Excise and Preventive Service (CEPS) and the Value Added Tax (VAT) Service, with the sole aim of ensuring efficiency in revenue generation. Harmonized System and Customs Tariff Schedule 2012 ("HS Code''), application of custom regimes, and the CIF have greatly contributed to revenue generation.

It has been highlighted that taxation remains a prime factor for economic growth. Importing foreign goods, on which duties are charged, has been identified to be key support of the Ghanaian economy, despite its injurious repercussions for local industrialization.

The review clearly shows that some fourteen (14) sources cover Ghana's revenue components extensively. These are GDP, Service Sector GDP (SSGDP), Total Revenue itself (TORE), Volume of imports (VOL), CIF, AFAC, IMDAL, IMVAT, EXTAX, NHIL and FEES. Data is therefore collected on these variables from the database of the GCNet of CEPS for the study.

Recent methodology for studying aspects of Ghana's revenue data has used traditional Auto-regressive Integrated Moving Average (ARIMA) and ARIMA Error regression model in addition to machine learning time series methods that include the Bayesian time series and Neural Network Auto-regression (NNAR) modelling. Related areas of study have used the univariate auto-regressive (AR) process and Markov switching approach, though AR(1) model has been identified to be more appropriate. The Vector Error Correction (VEC) model and the principal components vector error correction (PCAVEC) model for unusual time series detection and multivariate image time series in related areas.

The theory of the VEC model, which is relevant for variables that are expected to be related in the long run, shows that the technique is appropriate as a part of procedures for studying the data problem. The methodology, therefore, explains the PCAVEC model within the context of the structure of the data problem, which is characterized by high dependencies. Therefore, the study's design is guided by a motivation to isolate this dependency. The methodology begins with the vector auto-regressive (VAR) model, which provides the basis for improvement. Since the VAR model is flawed by high multi-collinearity, with extremely high R-square values, a VEC model, expressed in terms of one time-period difference and lag 1 of the series, X_{t-1}, could prove more adequate. This means that for a meaningful model, the effect of one time period is expected to significantly influence the model. However, since one time-period apart differences could have traces of effects of dependencies, the VEC model could further be improved. The methodology, therefore, proposes extracting principal components that are expected to achieve a dimensionality reduction with no loss of information. A projection of the original data on the reduced components would produce transformed data on which the VEC model could be applied to obtain the proposed PCAVEC model. The Portmanteau lag selection test is prescribed for selecting the optimal lag at which the most suitable model would be obtained. Further methods for a model performance assessment that are prescribed are the forecast error variance decomposition (FECD), impulse response functions and diagnostic measures for checking underlying model assumptions.

The implementation of the procedures for the PCAVEC model has been carried out. According to the prescribed theory, the procedure systematically examines three techniques in the process. First, lag selection criteria are assessed that obtain an optimum lag of 8 for building the models. The initial VAR(8) is examined. As expected, this model explains almost 100% of the variation in several series variables, which is quite spurious. However, the model provides a poor fit for some items, such as the EXTAX and VOL, with R-squares of just about 35%.

An improvement over the VAR(8) model applies the VECM(8) to the same data. The model produces a more realistic characterization with more reasonable performance statistics in all variables. It yields a reasonable reduction in all R-squares that are initially more than 90%. There is an improvement in R-square values for VOL and EXTAX in which the VAR performs poorly. Despite the more plausible performance in the VEC model, some drawbacks of the VAR model remain: It contains less number of original variables due to system selection, and there is still the incidence of dependency structure in interpretation. In order to resolve this challenge, the study incorporates principal components extraction into the VEC model. Five salient dimensions constitute the main contributions to general revenue mobilization. The first and the dominant source is that which is influenced by CIF and accounts for about 80% of the total variation in all revenue sources. The remaining 20% of revenue information is influenced predominantly by Volume (VOL), accounting for 18.7% of the variation. The small percentage that remains is explained by Total Revenue (TORE) (about 0.92%), Total Amount Exempt (TOAE) and Petroleum tax (PETAL), in that order. Thus, like the original data structure, all five major components are one-item but are now orthogonal. The remaining nine components could then be discarded as they are redundant.

By projecting the original data onto the five components, a new dataset is obtained that is a linear transformation of the original in a five-dimensional space. The VEC model is applied to the transformed data, which yields the Principal Component Vector Error Correction (PCAVEC) model. The model now explains 66.3% variation in TORE, 44.03% variation in VOL, 69.25% variation in CIF, 61.75% variation in TOAE and 47.41% variation in PETAL. These and other performance measures are found more plausible for the data structure of the five components; the model is significant for CIF and TORE.

Further assessment of the PCAVEC model is carried out using the FEVD, the IRF, model validation and diagnostics. The FEVD shows that the effect of other revenue sources on a given one becomes stable after just one period. This means there is very little further impact of any variable on others in the long run after just one month. CIF remains the revenue source with the least forecast error (10%) and hence would produce the most reliable forecast estimates. The second most reliable source is TORE.

On the other hand, the model for PETAL has the highest forecast error in the long run. With the exception of CIF, shocks in each of the variables cause severe fluctuations in TORE. For all the five items, the validation of the models shows that immediate future revenue values are consistent with the pattern of values for the recent past. This pattern is less prone to errors for the PETAL, suggesting that piecewise regression modelling could be more suitable for this variable. The PCAVEC model, therefore, provides a plausible econometric characterization of the identified major revenue sources.

Recommendation

A notable observation in the study is the dominant influence of CIF as a source of revenue generation. The CIF should therefore be protected from any manipulation that could affect its usefulness. Under-declaration of values (FOB, Freight, Insurance) will affect the computations based on the CIF that reduce the total revenue, and hence the economy's GDP. Apart from the under-declaration of values, what could undermine revenue generation is the improper assignment of the tax rate, a tax that is applied only on import duty (Code 01). When an item is zero-rated, it does not attract input duty which eventually reduces tax revenue on such items. In order to increase revenue, there is the need to reduce the incidence of zero-rated items. This is only possible if such items are produced locally or if local substitutes should be found. The study shows that the proliferation of taxes may not be the way to achieve efficient resource mobilization. A focus is required on deriving the optimum benefit from the key sources of revenue identified in this study. Proper valuation of items is required to enable an efficient determination of the CIF. In addition, proper item classification would enable applying the right tax rates. Implementing these measures would almost surely lead to optimal revenue generation.

This study also found that Total Revenue is affected by the amount of tax exemptions (TOAE). For efficient revenue mobilization, TOAE must be controlled. Government must impose a ceiling on exemptions that could control their impact on TORE. In addition, exemptions should largely generate other sources of revenue; they should be strategically targeted at institutions and individuals whose activities would further add value to the economy.

Since revenue mobilization is dependent to a large extent on the quantity of commodities that are generated either by import or local production, a complete characterization of revenue sources could be achieved by incorporating variables of commodities into the revenue model. Therefore, future work in the area could consider commodities as exogenous variables in the PCAVEC model.

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APPENDIX A

DUTY TAX CODES AND THEIR DESCRIPTIONS

Duty Tax Code	Duty Tax Description
01	Import Duty
02	Import VAT
03	Import Special Tax
04	Import Excise Duty
05	Processing Fee
06	ECOWAS Levy
07	Export Dev. Levy
08	Export Tax
09	Mining Levy
10	Cassette Levy
11	Rent Charges
12	Customs Penalty
13	Overtime Charges
14	Fines
15	Manifest Amendment
16	Vehicle Certification
17	Auction Sales
18	Seized & Forfeited Sales
19	Destination Inspection Fee
20	Miscellaneous Penalty/Charges
21	Bonded Warehouse Renewal Licence.
22	Forfeited Money
23	Temporary Importation Fee
24	Registration Fee
25	Manufacturer Licence
26	Manufacturer Renewal Licence
27	Official Publication

28	Certification Fee
29	Rent, Warehouse
30	Interest Charges
31	Vehicle Examination
32	Network Charge
33	Net Charge VAT
34	Excise Duty From OMC
35	Exploration Levy
36	Stock Fund Levy
37	Energy Fund
38	Interest on Petroleum Payments
40	DIS Fee (GSL)
41	DIS Fee (ICS)
42	DIS Fee (GL)
43	DIS Fee (BV)
44	Customs Inspection Fee
45	Ghana Shippers Council SNF Fee
46	GIFF Levy
47	Import NHIL
48	Net Charge NHIL
49	Vehicle Over-aged Penalty
50	Bonded Warehouse Licensing
51	Transit Admin Fee
52	Road Levy
53	Debt Recovery
54	CUBAG Levy
55	Ghana Shippers Council SNF-Exp
56	IRS Tax Deposit

57	Social Impact Mitigation Levy
58	Cross Subsidy Levy
59	Excise Duty (m)
60	Transit Infrastructure Fee
61	SIC E-Transit Bond Premium
62	Penalty on Petroleum Payments.
63	GHS Disinfection Fee
65	TVI (c59) Fee
66	Road Fund
67	Mini Bus-Bus Road Fund
68	Non Articulated Trucks Road Fund
69	Articulated trucks road Fund
70	TVI Extend Overstay Penalty
71	TVI Close Overstay Penalty
72	MOTI E-IDF Fee
73	Import Levy
74	DIC Fee (WEBF)
76	Environmental Excise Tax
77	Special Import Levy 1%
78	Special Import Levy
79	Special Petroluem Tax
81	Warehouse Reg Licence Fee
82	Warehouse Renewal Licence Fee
83	Tax Stamp - Cigar & Tobacco
84	Tax Stamp - Soda,Beer & Water
85	Tax Stamp - Spirit and Wines
86	Energy Debt Recovery Levy
87	Ghana Export-Import Bank Exim

88	Getfund Levy
89	Network Charge Getfund
90	Freight Forwarder Levy
91	Freight Forwarder Levy
92	Freight Forwarder Levy
93	CCVR Processing Fee
94	Association of Customs House Agents
95	EDRL (Foreign Exchange under Recovery)
96	EDRL (Power Gen. & infra. acct)
97	EDRL (TOR Debt Recovery)
98	African Union Import Levy

APPENDIX B

IMPORT DUTIES, LEVIES TAX CODES AND DESCRIPTIONS

Duty Tax Code	Duty Tax Description
01	Import Duty
03	Import Special Tax
04	Import Excise Duty
05	Processing Fee
06	ECOWAS Levy
07	Export Dev. Levy
09	Mining Levy
11	Rent Charges
12	Customs Penalty
15	Manifest Amendment
17	Auction Sales
18	Seized & Forfeited Sales
20	Miscellaneous Penalty/Charges
21	Bonded Warehouse Renewal Licence.
23	Temporary Importation Fee
24	Registration Fee
25	Manufacturer Licence
29	Rent, Warehouse
30	Interest Charges
31	Vehicle Examination
44	Customs Inspection Fee
49	Vehicle Overaged Penalty
50	Bonded Warehouse Licensing
51	Transit Administration Fee
65	TVI (C59) Fee
70	TVI Extend Overstay Penalty
71	TVI Close Overstay Penalty
73	Import Levy
76	Environmental Excise Tax
77	Special Import Levy 1%
78	Special Import levy
81	Warehouse Registration Licence Fee
82	Warehouse Renewal Licence Fee
87	Ghana Export-Import Bank Exim
88	Getfund Levy
93	CCVR Processing Fee
98	African Union Import Levy

APPENDIX C

AGENCIES FEES AND OTHER CHARGES AND DESCRIPTIONS

Duty Tax Code	Duty Tax Description
10	Cassette Levy
19	Destination Inspection Fee
32	Network Charge
33	Net Charge VAT
40	DIS Fee (GSL)
41	DIS Fee (ICS)
42	DIS Fee (GL)
43	DIS Fee (BV)
45	Ghana Shippers Council SNF Fee
46	GIFF Levy
48	Net Charge NHIL
54	CUBAG Levy
55	Ghana Shippers Council SNF-Exp
56	IRS Tax Deposit
60	Transit Infrastructure Fee
61	SIC E-Transit Bond Premium
63	GHS Disinfection Fee
67	Mini Bus-Bus Road Fund
68	Non Articulated Trucks Road Fund
69	Articulated Trucks Road Fund
72	MOTI E-IDF Fee
74	DIC Fee (WEBF)
83	Tax Stamp - Cigar & Tobacco
84	Tax Stamp - Soda, Beer & Water
85	Tax Stamp - Spirit and Wines
89	Network Charge Getfund
90	Freight Forwarder Levy
91	Freight Forwarder Levy
92	Freight Forwarder Levy
94	Association of Customs House Agents

APPENDIX D

COMPLETE PRINCIPAL COMPONENTS EXTRACTION

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
0.0124	-0.0002	0.2987	-0.1097	-0.2528	0.7394	-0.2880	-0.1936	-0.1712	-0.1181	-0.1146	0.0076	0.0000	0.3333
0.0088	-0.0002	0.2068	0.0020	-0.4889	-0.6471	-0.2875	-0.2215	-0.1713	-0.1182	-0.1145	0.0077	0.0000	0.3333
0.0000	-0.0000	-0.0000	0.0002	-0.0000	0.0003	0.0002	-0.0214	0.9093	-0.2069	-0.1369	0.0099	0.0002	0.3333
0.0015	0.0000	0.0343	-0.0047	-0.0748	-0.0081	0.0427	0.9102	-0.1476	-0.1287	-0.1155	0.0080	-0.0000	0.3333
0.0104	-0.0006	0.2818	-0.1431	0.8191	-0.1674	-0.1393	-0.1200	-0.1694	-0.1194	-0.1146	0.0076	0.0000	0.3333
0.0000	0.0000	0.0000	-0.0000	-0.0000	0.0001	0.0002	0.0004	0.0192	-0.0043	0.9404	-0.0639	-0.0010	0.3333
0.0000	-0.0000	0.0000	0.0002	0.0003	-0.0003	0.0002	0.0070	0.0729	0.9329	-0.1149	0.0080	0.0005	0.3333
0.0005	0.0001	0.0130	0.0027	-0.0890	0.0195	0.8778	-0.2302	-0.1721	-0.1182	-0.1147	0.0075	0.0000	0.3333
0.0336	-0.0010	0.8346	-0.2525	-0.0862	-0.0636	0.2063	0.1309	0.1698	0.1190	0.1146	- 0.0077	-0.0000	-0.3333
0.9978	-0.0510	-0.0418	-0.0052	0.0007	-0.0003	0.0001	-0.0000	-0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000
0.0511	0.9987	-0.0003	0.0018	0.0005	-0.0001	-0.0001	-0.0000	0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000
0.0172	-0.0026	0.2981	0.9506	0.0721	0.0445	-0.0011	-0.0000	-0.0002	-0.0002	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.0000	-0.0000	0.0000	0.0000	0.0001	-0.0001	-0.0004	-0.0004	0.0280	0.3986	0.9167	0.0000
0.0000	-0.0000	0.0000	-0.0000	0.0000	0.0000	0.0001	-0.0003	-0.0005	0.0000	0.0618	0.9146	-0.3995	-0.0000
0.8029	**0.1871**	**0.0092**	**0.0008**	**0.0001**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**

Row Labels:

1 — IMDAL; 2 — IMVAT; 3 — EXTA; 4 — NHIL; 5 — PETAL; 6 — FEES; 7 — FAOC; 8 — AFAC; 9 — TORE; 10 — CIF; 11 — VOL; 12 — TOAE; 13 — SSGDPMN; 14 — GDPMN.

APPENDIX E

THE PRINCIPAL COMPONENTS VECTOR ERROR CORRECTION MODEL

VECM system, lag order 8

Maximum likelihood estimates, observations 2008:09-2019:12 (T = 136)

Cointegration rank = 1

Case 3: Unrestricted constant

beta (cointegrating vectors, standard errors in parentheses)

CIF 1.0000 (0.00000)

VOL 0.27806 (0.43549)

TORE -4.5326 (0.84155)

TOAE 0.63753 (4.7312)

PETAL 22.943 (9.2453)

alpha (adjustment vectors)

CIF -0.77157

VOL -0.12330

TORE 0.025070

TOAE -0.010396

PETAL -0.0022014

Log-likelihood = -14114.452

Determinant of covariance matrix = 9.5976457e+083

AIC = 210.5802

BIC = 214.9706

HQC = 212.3643

Equation 1: d_CIF

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-1.06813e+08	3.7098e+08	-0.2879	0.77401	
d_CIF_1	-0.0777074	0.282373	-0.2752	0.78374	
d_CIF_2	-0.230692	0.30432	-0.7581	0.45022	
d_CIF_3	-0.150392	0.292836	-0.5136	0.60870	
d_CIF_4	0.532547	0.295612	1.8015	0.07467	*
d_CIF_5	-0.284198	0.273198	-1.0403	0.30075	
d_CIF_6	0.329087	0.27266	1.2069	0.23033	
d_CIF_7	0.351996	0.279602	1.2589	0.21102	
d_VOL_1	0.181484	0.133947	1.3549	0.17853	
d_VOL_2	0.193773	0.166687	1.1625	0.24783	
d_VOL_3	0.155961	0.183202	0.8513	0.39665	
d_VOL_4	0.0938929	0.185705	0.5056	0.61426	
d_VOL_5	0.128067	0.178379	0.7179	0.47448	
d_VOL_6	0.0579098	0.159561	0.3629	0.71743	
d_VOL_7	0.049036	0.123779	0.3962	0.69284	
d_TORE_1	-0.331836	6.21695	-0.0534	0.95754	
d_TORE_2	-5.64906	6.93854	-0.8142	0.41751	
d_TORE_3	-4.40789	6.91256	-0.6377	0.52516	
d_TORE_4	10.3491	7.10519	1.4566	0.14840	
d_TORE_5	-10.3212	6.89649	-1.4966	0.13768	
d_TORE_6	7.58267	6.99955	1.0833	0.28130	
d_TORE_7	6.46379	7.15764	0.9031	0.36869	
d_TOAE_1	-0.249866	3.5176	-0.0710	0.94351	
d_TOAE_2	0.480657	3.88973	0.1236	0.90191	
d_TOAE_3	8.55463	3.92086	2.1818	0.03149	**
d_TOAE_4	5.15215	4.15737	1.2393	0.21817	
d_TOAE_5	5.14676	3.92101	1.3126	0.19235	
d_TOAE_6	-3.05203	3.91539	-0.7795	0.43755	
d_TOAE_7	-4.81528	3.54104	-1.3598	0.17697	
d_PETAL_1	21.2799	14.9139	1.4268	0.15677	
d_PETAL_2	26.0586	15.1142	1.7241	0.08781	*
d_PETAL_3	-30.3041	14.9903	-2.0216	0.04592	**
d_PETAL_4	13.2821	15.494	0.8572	0.39338	
d_PETAL_5	-5.94742	15.2891	-0.3890	0.69811	
d_PETAL_6	15.7409	15.5345	1.0133	0.31339	
d_PETAL_7	-34.5609	14.8323	-2.3301	0.02183	**
EC1	-0.771567	0.186919	-4.1278	0.00008	***

Mean dependent var	33364525	S.D. dependent var	5.58e+09
Sum squared resid	1.34e+21	S.E. of regression	3.68e+09
R-squared	0.692533	Adjusted R-squared	0.592364
rho	0.057961	Durbin-Watson	1.857523

Equation 2: d_VOL

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	4.95554e+07	2.96755e+08	0.1670	0.86772	
d_CIF_1	0.190471	0.225876	0.8433	0.40112	
d_CIF_2	0.104188	0.243432	0.4280	0.66958	
d_CIF_3	0.0928158	0.234245	0.3962	0.69279	
d_CIF_4	-0.195665	0.236466	-0.8275	0.40997	
d_CIF_5	-0.127629	0.218537	-0.5840	0.56054	
d_CIF_6	0.0428844	0.218106	0.1966	0.84453	
d_CIF_7	0.0784666	0.22366	0.3508	0.72646	
d_VOL_1	-0.81839	0.107147	-7.6380	<0.00001	***
d_VOL_2	-0.689996	0.133337	-5.1748	<0.00001	***
d_VOL_3	-0.562715	0.146547	-3.8398	0.00022	***
d_VOL_4	-0.444196	0.148549	-2.9902	0.00352	***
d_VOL_5	-0.334102	0.142689	-2.3415	0.02121	**
d_VOL_6	-0.238244	0.127636	-1.8666	0.06492	*
d_VOL_7	-0.113631	0.099013	-1.1476	0.25388	
d_TORE_1	1.14782	4.97307	0.2308	0.81794	
d_TORE_2	0.297211	5.55028	0.0535	0.95740	
d_TORE_3	1.01007	5.5295	0.1827	0.85543	
d_TORE_4	-5.61203	5.68359	-0.9874	0.32585	
d_TORE_5	-4.10005	5.51665	-0.7432	0.45911	
d_TORE_6	0.600361	5.59909	0.1072	0.91483	
d_TORE_7	1.66147	5.72555	0.2902	0.77228	
d_TOAE_1	-0.486954	2.8138	-0.1731	0.86296	
d_TOAE_2	-0.713987	3.11147	-0.2295	0.81898	
d_TOAE_3	-1.59994	3.13638	-0.5101	0.61110	
d_TOAE_4	0.15231	3.32557	0.0458	0.96356	
d_TOAE_5	1.01267	3.1365	0.3229	0.74748	

d_TOAE_6	1.24869	3.132	0.3987	0.69098
d_TOAE_7	0.430765	2.83255	0.1521	0.87944
d_PETAL_1	1.51787	11.93	0.1272	0.89902
d_PETAL_2	3.97939	12.0902	0.3291	0.74274
d_PETAL_3	7.65047	11.9911	0.6380	0.52494
d_PETAL_4	5.12623	12.394	0.4136	0.68006
d_PETAL_5	-2.58135	12.2301	-0.2111	0.83327
d_PETAL_6	-3.26875	12.4263	-0.2631	0.79306
d_PETAL_7	1.32303	11.8647	0.1115	0.91144
EC1	-0.123299	0.149521	-0.8246	0.41157

Mean dependent var	4144380	S.D. dependent var	3.37e+09
Sum squared resid	8.59e+20	S.E. of regression	2.95e+09
R-squared	0.440331	Adjusted R-squared	0.236815
Rho	-0.013534	Durbin-Watson	2.026169

Equation 3: d_TORE

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	1.90591e+07	1.66138e+07	1.1472	0.25407
d_CIF_1	-0.0145905	0.0126457	-1.1538	0.25136
d_CIF_2	0.0134448	0.0136285	0.9865	0.32628
d_CIF_3	0.0206031	0.0131142	1.5710	0.11936
d_CIF_4	-0.0151189	0.0132385	-1.1420	0.25619
d_CIF_5	0.00480031	0.0122348	0.3923	0.69564
d_CIF_6	-0.0165487	0.0122107	-1.3553	0.17842
d_CIF_7	-0.0135142	0.0125216	-1.0793	0.28309
d_VOL_1	-0.00691786	0.00599861	-1.1532	0.25159
d_VOL_2	-0.00786191	0.00746485	-1.0532	0.29482
d_VOL_3	-0.00541361	0.00820441	-0.6598	0.51089
d_VOL_4	-0.00239335	0.00831653	-0.2878	0.77411
d_VOL_5	-0.0035316	0.00798843	-0.4421	0.65939
d_VOL_6	-0.00100983	0.0071457	-0.1413	0.88790

d_VOL_7	-0.000491575	0.00554324	-0.0887	0.92952	
d_TORE_1	-0.549363	0.278417	-1.9732	0.05126	*
d_TORE_2	0.269827	0.310732	0.8684	0.38730	
d_TORE_3	0.466881	0.309569	1.5082	0.13470	
d_TORE_4	-0.28443	0.318196	-0.8939	0.37355	
d_TORE_5	0.161081	0.308849	0.5216	0.60315	
d_TORE_6	-0.425841	0.313465	-1.3585	0.17739	
d_TORE_7	-0.267429	0.320544	-0.8343	0.40612	
d_TOAE_1	0.0944938	0.157531	0.5998	0.54998	
d_TOAE_2	-0.137345	0.174196	-0.7885	0.43232	
d_TOAE_3	-0.563466	0.17559	-3.2090	0.00180	***
d_TOAE_4	-0.394996	0.186182	-2.1216	0.03637	**
d_TOAE_5	-0.169263	0.175597	-0.9639	0.33743	
d_TOAE_6	0.10188	0.175345	0.5810	0.56254	
d_TOAE_7	0.143723	0.15858	0.9063	0.36697	
d_PETAL_1	-1.15714	0.667899	-1.7325	0.08630	*
d_PETAL_2	-1.06258	0.676867	-1.5699	0.11964	
d_PETAL_3	0.863457	0.67132	1.2862	0.20137	
d_PETAL_4	-0.00210366	0.693877	-0.0030	0.99759	
d_PETAL_5	-0.443693	0.6847	-0.6480	0.51848	
d_PETAL_6	-0.634173	0.695688	-0.9116	0.36421	
d_PETAL_7	1.49809	0.664244	2.2553	0.02631	**
EC1	0.0250702	0.00837091	2.9949	0.00347	***

Mean dependent var	9377576	S.D. dependent var	2.36e+08
Sum squared resid	2.69e+18	S.E. of regression	1.69e+08
R-squared	0.663013	Adjusted R-squared	0.540967
Rho	0.032070	Durbin-Watson	1.933301

Equation 4: d_TOAE

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-201379	1.28385e+07	-0.0157	0.98752	
d_CIF_1	-0.00511873	0.00977211	-0.5238	0.60158	
d_CIF_2	-0.0024336	0.0105316	-0.2311	0.81773	
d_CIF_3	0.0112222	0.0101342	1.1074	0.27082	
d_CIF_4	0.0149036	0.0102303	1.4568	0.14833	
d_CIF_5	0.00271925	0.0094546	0.2876	0.77425	
d_CIF_6	0.0109063	0.00943597	1.1558	0.25054	
d_CIF_7	-0.000640734	0.00967622	-0.0662	0.94734	
d_VOL_1	0.00441371	0.00463551	0.9522	0.34334	
d_VOL_2	0.00232883	0.00576856	0.4037	0.68730	
d_VOL_3	0.000855663	0.00634007	0.1350	0.89292	
d_VOL_4	0.00235597	0.00642671	0.3666	0.71471	
d_VOL_5	0.000749855	0.00617317	0.1215	0.90356	
d_VOL_6	0.000444109	0.00552193	0.0804	0.93606	
d_VOL_7	0.00132969	0.00428361	0.3104	0.75690	
d_TORE_1	-0.292266	0.215151	-1.3584	0.17742	
d_TORE_2	-0.253245	0.240123	-1.0546	0.29415	
d_TORE_3	-0.0113145	0.239223	-0.0473	0.96237	
d_TORE_4	0.178402	0.24589	0.7255	0.46984	
d_TORE_5	-0.107864	0.238668	-0.4519	0.65230	
d_TORE_6	0.249628	0.242234	1.0305	0.30528	
d_TORE_7	-0.0481234	0.247705	-0.1943	0.84636	
d_TOAE_1	-0.46016	0.121734	-3.7800	0.00027	***
d_TOAE_2	-0.214833	0.134612	-1.5959	0.11369	
d_TOAE_3	-0.374967	0.13569	-2.7634	0.00682	***
d_TOAE_4	-0.349542	0.143875	-2.4295	0.01692	**
d_TOAE_5	0.031172	0.135695	0.2297	0.81878	
d_TOAE_6	-0.336101	0.1355	-2.4804	0.01481	**
d_TOAE_7	-0.361495	0.122545	-2.9499	0.00397	***
d_PETAL_1	0.417768	0.516128	0.8094	0.42021	

d_PETAL_2	0.209317	0.523058	0.4002	0.68989	
d_PETAL_3	-2.12904	0.518772	-4.1040	0.00008	***
d_PETAL_4	0.374769	0.536203	0.6989	0.04123	**
d_PETAL_5	-0.586997	0.529111	-1.1094	0.04794	**
d_PETAL_6	0.33494	0.537603	0.6230	0.53470	
d_PETAL_7	0.842959	0.513304	1.6422	0.10372	
EC1	-0.0103962	0.00646873	-1.6071	0.11121	

Mean dependent var	2364132	S.D. dependent var	1.62e+08
Sum squared resid	1.61e+16	S.E. of regression	1.24e+07
R-squared	0.617518	Adjusted R-squared	0.474979
Rho	0.210002	Durbin-Watson	2.209014

Equation 5: d_PETAL

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-1.7404e+06	2.74667e+06	-0.6336	0.52778	
d_CIF_1	0.00753647	0.00209064	3.6049	0.00049	***
d_CIF_2	-0.0011692	0.00225313	-0.5189	0.60497	
d_CIF_3	0.00216992	0.0021681	1.0008	0.31934	
d_CIF_4	-0.000574478	0.00218865	-0.2625	0.79350	
d_CIF_5	0.000578435	0.00202271	0.2860	0.77550	
d_CIF_6	0.000132334	0.00201872	0.0656	0.94787	
d_CIF_7	0.00217952	0.00207012	1.0528	0.29497	
d_VOL_1	0.000577728	0.000991716	0.5826	0.56152	
d_VOL_2	0.000527626	0.00123412	0.4275	0.66992	
d_VOL_3	0.000309996	0.00135639	0.2285	0.81969	
d_VOL_4	0.000287239	0.00137493	0.2089	0.83495	
d_VOL_5	-0.000106749	0.00132068	-0.0808	0.93574	
d_VOL_6	-6.80384e-05	0.00118136	-0.0576	0.95419	
d_VOL_7	-1.44353e-05	0.000916433	-0.0158	0.98746	

d_TORE_1	0.159995	0.0460291	3.4760	0.00076	***
d_TORE_2	-0.0698744	0.0513716	-1.3602	0.17686	
d_TORE_3	0.029939	0.0511793	0.5850	0.55989	
d_TORE_4	-0.0586451	0.0526055	-1.1148	0.26763	
d_TORE_5	0.000667565	0.0510603	0.0131	0.98960	
d_TORE_6	0.0145482	0.0518234	0.2807	0.77951	
d_TORE_7	0.0683983	0.0529938	1.2907	0.19982	
d_TOAE_1	-0.0893144	0.0260437	-3.4294	0.00088	***
d_TOAE_2	0.0114339	0.0287988	0.3970	0.69220	
d_TOAE_3	-0.0159637	0.0290293	-0.5499	0.00362	**
d_TOAE_4	0.0222168	0.0307804	0.7218	0.47213	
d_TOAE_5	0.0479348	0.0290304	1.6512	0.10187	
d_TOAE_6	-0.00923215	0.0289888	-0.3185	0.75080	
d_TOAE_7	-0.0492988	0.0262172	-1.8804	0.06299	*
d_PETAL_1	0.142231	0.11042	1.2881	0.20072	
d_PETAL_2	-0.0137716	0.111903	-0.1231	0.90230	
d_PETAL_3	-0.0794932	0.110986	-0.7162	0.47552	
d_PETAL_4	-0.234303	0.114715	-2.0425	0.04376	**
d_PETAL_5	0.0962077	0.113198	0.8499	0.39743	
d_PETAL_6	-0.00463246	0.115014	-0.0403	0.96795	
d_PETAL_7	0.147008	0.109816	1.3387	0.18374	
EC1	-0.00220144	0.00138392	-1.5907	0.11486	

Mean dependent var	213247.0	S.D. dependent var	30505739
Sum squared resid	7.36e+16	S.E. of regression	37869794
R-squared	0.474123	Adjusted R-squared	0.201077
Rho	0.017426	Durbin-Watson	1.751672

APPENDIX F

INFORMATION EXPLAINED BY PIECEWISE PRINCIPAL COMPONENTS

PC	Percentage of information explained											
	Year											
	1	2	3	4	5	6	7	8	9	10	11	12
1	0.9994	0.83342	0.73279	0.99878	0.98424	0.99757	0.85525	0.82441	0.79084	0.99922	0.91930	0.94636
2	0.00051	0.15907	0.16620	0.00121	0.01345	0.00223	0.09627	0.09875	0.12048	0.00048	0.06996	0.03875
3	0.00001	0.00493	0.09591	0.00000	0.00164	0.00017	0.04527	0.06464	0.06048	0.00025	0.00601	0.01093
4	0.00000	0.00239	0.00505	0.00000	0.00066	0.00002	0.00317	0.01103	0.02604	0.00005	0.00277	0.00337
5	0.00000	0.00015	0.00003	0.00000	0.00001	0.00000	0.00003	0.00098	0.00206	0.00000	0.00116	0.00056
6	0.00000	0.00004	0.00002	0.00000	0.00000	0.00000	0.00001	0.00017	0.00010	0.00000	0.00080	0.00002
7	0.00000	0.00001	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
11	0	0.00000	0.00000	0	0.00000	0.00000	0.00000	0.00000	0.00000	0	0.00000	0.00000
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

APPENDIX G

THE VECTOR AUTO-REGRESSIVE MODEL AT LAG 8

VAR system, lag order 8

OLS estimates, observations 2008:09-2019:12 (T = 136)

Log-likelihood = -21971.416

Determinant of covariance matrix = 5.851483e+126

AIC = 337.5061

BIC = 358.4730

HQC = 346.0265

Portmanteau test: LB(34) = 4473.98, df = 3146 [0.0000]

For the system as a whole

Null hypothesis: the longest lag is 7

Alternative hypothesis: the longest lag is 8

Likelihood ratio test: Chi-square(121) = 441.909 [0.0000]

Equation 1: GDPMN

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-663.546	235.427	-2.8185	0.00704	***
GDPMN_1	0.823428	0.189435	4.3467	0.00007	***
GDPMN_2	-0.273063	0.236444	-1.1549	0.25398	
GDPMN_3	0.446598	0.208419	2.1428	0.03734	**
GDPMN_4	0.181567	0.228657	0.7941	0.43115	
GDPMN_5	-0.808236	0.231945	-3.4846	0.00108	***
GDPMN_6	0.331386	0.233294	1.4205	0.16207	

GDPMN_7	0.0273559	0.225841	0.1211	0.90410	
GDPMN_8	-0.285146	0.199146	-1.4318	0.15881	
SSGDPMN_1	-0.0990264	0.341853	-0.2897	0.77334	
SSGDPMN_2	0.222168	0.452785	0.4907	0.62594	
SSGDPMN_3	0.309337	0.403315	0.7670	0.44693	
SSGDPMN_4	-1.29922	0.426333	-3.0474	0.00378	***
SSGDPMN_5	1.3239	0.424542	3.1184	0.00310	***
SSGDPMN_6	-0.181582	0.363544	-0.4995	0.61977	
SSGDPMN_7	-0.368987	0.39141	-0.9427	0.35065	
SSGDPMN_8	0.827804	0.361735	2.2884	0.02665	**
TORE_1	4.21636e-06	3.26319e-06	1.2921	0.20264	
TORE_2	-1.73134e-06	3.45651e-06	-0.5009	0.61878	
TORE_3	3.23582e-08	3.49477e-06	0.0093	0.99265	
TORE_4	-3.21123e-06	3.95736e-06	-0.8115	0.42119	
TORE_5	4.45174e-06	3.33957e-06	1.3330	0.18895	
TORE_6	-9.07983e-07	3.8397e-06	-0.2365	0.81409	
TORE_7	2.61096e-06	3.79091e-06	0.6887	0.49437	
TORE_8	-1.03089e-06	2.74475e-06	-0.3756	0.70891	
VOL_1	-1.02186e-08	1.56706e-08	-0.6521	0.51752	
VOL_2	-2.37711e-08	1.72528e-08	-1.3778	0.17479	
VOL_3	5.70323e-09	1.81079e-08	0.3150	0.75419	
VOL_4	4.73241e-09	1.67189e-08	0.2831	0.77838	
VOL_5	-4.22215e-08	1.70653e-08	-2.4741	0.01702	**
VOL_6	2.34285e-09	1.66915e-08	0.1404	0.88897	
VOL_7	-4.17426e-08	1.62862e-08	-2.5631	0.01364	**
VOL_8	-2.1389e-08	1.66032e-08	-1.2882	0.20397	
CIF_1	1.20821e-08	1.30518e-08	0.9257	0.35933	
CIF_2	1.76034e-08	1.25682e-08	1.4006	0.16789	
CIF_3	-7.5502e-09	1.19304e-08	-0.6329	0.52990	
CIF_4	-5.95273e-09	1.30017e-08	-0.4578	0.64917	
CIF_5	1.6859e-08	1.22638e-08	1.3747	0.17574	

CIF_6	2.08054e-08	1.22798e-08	1.6943	0.09683	*
CIF_7	2.86722e-08	1.10408e-08	2.5969	0.01252	**
CIF_8	1.37563e-08	1.08945e-08	1.2627	0.21293	
AFAC_1	-7.96195e-05	3.13096e-05	-2.5430	0.01434	**
AFAC_2	8.30627e-05	3.96682e-05	2.0939	0.04169	**
AFAC_3	8.28352e-06	3.68294e-05	0.2249	0.82302	
AFAC_4	-3.21959e-05	3.50108e-05	-0.9196	0.36248	
AFAC_5	4.80486e-05	3.52276e-05	1.3639	0.17908	
AFAC_6	1.98394e-05	3.34647e-05	0.5928	0.55613	
AFAC_7	-3.00291e-05	3.36998e-05	-0.8911	0.37743	
AFAC_8	4.78226e-05	3.06197e-05	1.5618	0.12504	
IMDAL_1	-1.67549e-05	6.48284e-06	-2.5845	0.01292	**
IMDAL_2	-5.8962e-06	6.9572e-06	-0.8475	0.40101	
IMDAL_3	8.26619e-06	7.38064e-06	1.1200	0.26841	
IMDAL_4	9.38782e-06	7.56364e-06	1.2412	0.22070	
IMDAL_5	1.41165e-05	7.3745e-06	1.9142	0.06169	*
IMDAL_6	-4.84571e-06	7.77745e-06	-0.6230	0.53627	
IMDAL_7	2.33965e-06	7.66785e-06	0.3051	0.76162	
IMDAL_8	-5.80456e-06	7.44542e-06	-0.7796	0.43953	
IMVAT_1	-3.19572e-05	1.40301e-05	-2.2778	0.02733	**
IMVAT_2	-4.07628e-06	2.01292e-05	-0.2025	0.84040	
IMVAT_3	4.33418e-05	2.2226e-05	1.9500	0.05715	*
IMVAT_4	-1.62982e-05	2.05861e-05	-0.7917	0.43251	
IMVAT_5	5.09274e-05	1.76543e-05	2.8847	0.00590	***
IMVAT_6	-3.60127e-05	1.8308e-05	-1.9671	0.05510	*
IMVAT_7	2.26677e-05	1.73754e-05	1.3046	0.19839	
IMVAT_8	-2.70763e-05	1.33243e-05	-2.0321	0.04782	**
EXTAX_1	0.000587652	0.000455134	1.2912	0.20296	
EXTAX_2	-9.80685e-05	0.000519309	-0.1888	0.85103	
EXTAX_3	-0.00125918	0.000550653	-2.2867	0.02676	**
EXTAX_4	0.000479872	0.000584735	0.8207	0.41598	

EXTAX_5	0.000138901	0.000564192	0.2462	0.80660	
EXTAX_6	0.000122586	0.00050817	0.2412	0.81043	
EXTAX_7	-0.000934693	0.000477245	-1.9585	0.05612	*
EXTAX_8	-0.000280517	0.000510073	-0.5500	0.58496	
NHIL_1	0.000218238	9.32691e-05	2.3399	0.02359	**
NHIL_2	0.000126533	0.000122589	1.0322	0.30727	
NHIL_3	-0.000339744	0.000140836	-2.4123	0.01981	**
NHIL_4	0.000101801	0.000134018	0.7596	0.45128	
NHIL_5	-0.000463967	0.000127896	-3.6277	0.00070	***
NHIL_6	0.000219304	0.000133816	1.6389	0.10792	
NHIL_7	-8.70784e-05	0.000122726	-0.7095	0.48150	
NHIL_8	0.000119921	9.54036e-05	1.2570	0.21497	
FEES_1	0.0113691	0.00762338	1.4914	0.14255	
FEES_2	0.00783173	0.00875067	0.8950	0.37535	
FEES_3	0.013398	0.00842733	1.5898	0.11858	
FEES_4	0.00173123	0.00827226	0.2093	0.83513	
FEES_5	0.0276172	0.00840723	3.2849	0.00193	***
FEES_6	0.0055321	0.00884126	0.6257	0.53453	
FEES_7	0.035038	0.00988854	3.5433	0.00091	***
FEES_8	-0.00267018	0.00973174	-0.2744	0.78500	

Mean dependent var	12251.01	S.D. dependent var	8177.055
Sum squared resid	6303147	S.E. of regression	366.2097
R-squared	0.999302	Adjusted R-squared	0.997994
F(88, 47)	764.3319	P-value(F)	3.88e-57
Rho	-0.083087	Durbin-Watson	2.163125

Equation 2: SSGDPMN

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-270.062	134.977	-2.0008	0.05121	*
GDPMN_1	-0.110016	0.108608	-1.0130	0.31627	
GDPMN_2	-0.0887314	0.13556	-0.6546	0.51594	
GDPMN_3	0.347698	0.119492	2.9098	0.00551	***
GDPMN_4	-0.0765066	0.131095	-0.5836	0.56228	
GDPMN_5	-0.344407	0.13298	-2.5899	0.01274	**
GDPMN_6	0.380777	0.133754	2.8468	0.00653	***
GDPMN_7	-0.242298	0.129481	-1.8713	0.06753	*
GDPMN_8	-0.118458	0.114176	-1.0375	0.30481	
SSGDPMN_1	1.10049	0.195994	5.6149	<0.00001	***
SSGDPMN_2	-0.0584512	0.259594	-0.2252	0.82283	
SSGDPMN_3	-0.168313	0.231231	-0.7279	0.47029	
SSGDPMN_4	-0.228482	0.244428	-0.9348	0.35469	
SSGDPMN_5	0.494321	0.243401	2.0309	0.04794	**
SSGDPMN_6	-0.523035	0.20843	-2.5094	0.01560	**
SSGDPMN_7	0.393038	0.224406	1.7515	0.08639	*
SSGDPMN_8	0.323252	0.207392	1.5587	0.12579	
TORE_1	1.33508e-06	1.87088e-06	0.7136	0.47899	
TORE_2	-3.33716e-07	1.98171e-06	-0.1684	0.86699	
TORE_3	-1.18787e-06	2.00365e-06	-0.5929	0.55612	
TORE_4	6.02662e-07	2.26886e-06	0.2656	0.79169	

TORE_5	4.33665e-06	1.91466e-06	2.2650	0.02817	**
TORE_6	-2.16164e-06	2.2014e-06	-0.9819	0.33116	
TORE_7	-8.3924e-07	2.17343e-06	-0.3861	0.70114	
TORE_8	6.27339e-07	1.57364e-06	0.3987	0.69195	
VOL_1	-2.36677e-08	8.98435e-09	-2.6343	0.01138	**
VOL_2	-6.85135e-09	9.89151e-09	-0.6926	0.49194	
VOL_3	6.19795e-09	1.03818e-08	0.5970	0.55337	
VOL_4	-9.25752e-09	9.5854e-09	-0.9658	0.33909	
VOL_5	-1.55064e-08	9.78398e-09	-1.5849	0.11970	
VOL_6	4.30287e-09	9.56969e-09	0.4496	0.65504	
VOL_7	-1.83051e-08	9.33733e-09	-1.9604	0.05589	*
VOL_8	-9.04668e-09	9.51906e-09	-0.9504	0.34678	
CIF_1	7.66335e-09	7.48297e-09	1.0241	0.31103	
CIF_2	4.81552e-09	7.20569e-09	0.6683	0.50721	
CIF_3	-3.7797e-09	6.84004e-09	-0.5526	0.58317	
CIF_4	4.12799e-09	7.4542e-09	0.5538	0.58235	
CIF_5	1.35663e-08	7.03116e-09	1.9295	0.05972	*
CIF_6	6.19174e-09	7.04032e-09	0.8795	0.38362	
CIF_7	1.58743e-08	6.32999e-09	2.5078	0.01566	**
CIF_8	7.82091e-09	6.24612e-09	1.2521	0.21672	
AFAC_1	-2.21429e-05	1.79506e-05	-1.2335	0.22351	
AFAC_2	3.35935e-05	2.27428e-05	1.4771	0.14632	
AFAC_3	-2.14065e-05	2.11153e-05	-1.0138	0.31587	

AFAC_4	-2.43972e-06	2.00727e-05	-0.1215	0.90378	
AFAC_5	2.58095e-05	2.01969e-05	1.2779	0.20756	
AFAC_6	-8.71046e-06	1.91862e-05	-0.4540	0.65192	
AFAC_7	5.98975e-06	1.9321e-05	0.3100	0.75792	
AFAC_8	2.77135e-05	1.75551e-05	1.5787	0.12112	
IMDAL_1	-9.01696e-06	3.71679e-06	-2.4260	0.01916	**
IMDAL_2	-4.74303e-06	3.98875e-06	-1.1891	0.24037	
IMDAL_3	1.04077e-05	4.23152e-06	2.4596	0.01765	**
IMDAL_4	-9.87333e-07	4.33644e-06	-0.2277	0.82088	
IMDAL_5	1.86347e-06	4.228e-06	0.4407	0.66142	
IMDAL_6	2.71778e-06	4.45902e-06	0.6095	0.54513	
IMDAL_7	4.11371e-06	4.39618e-06	0.9357	0.35419	
IMDAL_8	-3.99598e-06	4.26866e-06	-0.9361	0.35400	
IMVAT_1	-1.18959e-05	8.04383e-06	-1.4789	0.14584	
IMVAT_2	-1.17656e-05	1.15406e-05	-1.0195	0.31319	
IMVAT_3	3.38576e-05	1.27428e-05	2.6570	0.01074	**
IMVAT_4	-1.77794e-05	1.18026e-05	-1.5064	0.13866	
IMVAT_5	2.03171e-05	1.01217e-05	2.0073	0.05049	*
IMVAT_6	-1.78332e-05	1.04964e-05	-1.6990	0.09593	*
IMVAT_7	2.37584e-05	9.96179e-06	2.3850	0.02117	**
IMVAT_8	-1.39978e-05	7.63919e-06	-1.8324	0.07324	*
EXTAX_1	0.00020775	0.000260941	0.7962	0.42994	
EXTAX_2	-9.42468e-05	0.000297734	-0.3165	0.75299	

EXTAX_3	-0.000788176	0.000315704	-2.4966	0.01610	**
EXTAX_4	0.000451358	0.000335245	1.3464	0.18465	
EXTAX_5	-0.000310021	0.000323466	-0.9584	0.34275	
EXTAX_6	-0.000265078	0.000291347	-0.9098	0.36755	
EXTAX_7	4.28628e-05	0.000273617	0.1567	0.87619	
EXTAX_8	-0.000218973	0.000292439	-0.7488	0.45772	
NHIL_1	9.12141e-05	5.34737e-05	1.7058	0.09465	*
NHIL_2	0.000101872	7.02839e-05	1.4494	0.15386	
NHIL_3	-0.00022932	8.07449e-05	-2.8401	0.00665	***
NHIL_4	0.000103719	7.68359e-05	1.3499	0.18352	
NHIL_5	-0.00018865	7.33261e-05	-2.5728	0.01331	**
NHIL_6	9.92936e-05	7.67202e-05	1.2942	0.20191	
NHIL_7	-0.000114993	7.03619e-05	-1.6343	0.10888	
NHIL_8	4.558e-05	5.46975e-05	0.8333	0.40888	
FEES_1	0.0113362	0.00437069	2.5937	0.01262	**
FEES_2	0.00133219	0.00501699	0.2655	0.79176	
FEES_3	0.0104368	0.00483162	2.1601	0.03590	**
FEES_4	0.000840122	0.00474271	0.1771	0.86016	
FEES_5	0.0144811	0.00482009	3.0043	0.00426	***
FEES_6	0.00734234	0.00506894	1.4485	0.15412	
FEES_7	0.0158131	0.00566937	2.7892	0.00761	***
FEES_8	-0.00338119	0.00557947	-0.6060	0.54743	

Mean dependent var	5593.233	S.D. dependent var	3804.899
Sum squared resid	2071869	S.E. of regression	209.9579
R-squared	0.998940	Adjusted R-squared	0.996955
F(88, 47)	503.2830	P-value(F)	6.97e-53
rho	0.014304	Durbin-Watson	1.967263

Equation 3: TORE

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	3.85501e+06	2.26339e+07	0.1703	0.86549	
GDPMN_1	-24248.7	18212.3	-1.3314	0.18946	
GDPMN_2	16346.6	22731.7	0.7191	0.47563	
GDPMN_3	33495.4	20037.4	1.6716	0.10124	
GDPMN_4	-38911.2	21983	-1.7701	0.08320	*
GDPMN_5	17000.7	22299.1	0.7624	0.44963	
GDPMN_6	29830.9	22428.9	1.3300	0.18993	
GDPMN_7	-55575.1	21712.3	-2.5596	0.01376	**
GDPMN_8	49332.7	19145.8	2.5767	0.01318	**
SSGDPMN_1	80735.3	32865.7	2.4565	0.01778	**
SSGDPMN_2	-52637.8	43530.7	-1.2092	0.23263	
SSGDPMN_3	-68924.9	38774.6	-1.7776	0.08194	*
SSGDPMN_4	62852.2	40987.6	1.5334	0.13187	
SSGDPMN_5	-10963.1	40815.4	-0.2686	0.78941	
SSGDPMN_6	-26028.3	34951.1	-0.7447	0.46016	
SSGDPMN_7	104000	37630.1	2.7637	0.00813	***
SSGDPMN_8	-109561	34777.1	-3.1504	0.00283	***
TORE_1	-0.0133961	0.313723	-0.0427	0.96612	
TORE_2	0.559501	0.332308	1.6837	0.09887	*
TORE_3	0.421829	0.335987	1.2555	0.21551	

TORE_4	0.364564	0.38046	0.9582	0.34286	
TORE_5	-0.815338	0.321066	-2.5395	0.01447	**
TORE_6	-0.127822	0.369148	-0.3463	0.73069	
TORE_7	0.558757	0.364458	1.5331	0.13195	
TORE_8	-0.04437	0.26388	-0.1681	0.86719	
VOL_1	-0.000175831	0.00150657	-0.1167	0.90759	
VOL_2	0.0028083	0.00165868	1.6931	0.09706	*
VOL_3	0.0023733	0.00174089	1.3633	0.17929	
VOL_4	0.000440446	0.00160735	0.2740	0.78527	
VOL_5	0.0023561	0.00164065	1.4361	0.15760	
VOL_6	0.000923485	0.00160472	0.5755	0.56771	
VOL_7	0.000268053	0.00156576	0.1712	0.86480	
VOL_8	0.00339067	0.00159623	2.1242	0.03895	**
CIF_1	-0.00116298	0.0012548	-0.9268	0.35875	
CIF_2	-0.000794789	0.0012083	-0.6578	0.51389	
CIF_3	-0.000365074	0.00114699	-0.3183	0.75168	
CIF_4	0.000186614	0.00124998	0.1493	0.88196	
CIF_5	0.0017684	0.00117904	1.4999	0.14034	
CIF_6	-0.000753944	0.00118058	-0.6386	0.52617	
CIF_7	0.00125927	0.00106146	1.1864	0.24144	
CIF_8	-0.0022587	0.0010474	-2.1565	0.03619	**
AFAC_1	-2.37674	3.0101	-0.7896	0.43373	
AFAC_2	-2.17303	3.81369	-0.5698	0.57153	
AFAC_3	-0.611983	3.54077	-0.1728	0.86352	
AFAC_4	4.15547	3.36594	1.2346	0.22313	
AFAC_5	-2.96054	3.38678	-0.8741	0.38648	
AFAC_6	-0.577575	3.21729	-0.1795	0.85830	
AFAC_7	-3.15539	3.23989	-0.9739	0.33508	
AFAC_8	4.49171	2.94377	1.5258	0.13375	
IMDAL_1	-0.938213	0.623259	-1.5053	0.13893	
IMDAL_2	1.5591	0.668864	2.3310	0.02410	**

IMDAL_3	-0.869814	0.709574	-1.2258	0.22637	
IMDAL_4	-0.894826	0.727167	-1.2306	0.22461	
IMDAL_5	0.91229	0.708983	1.2868	0.20448	
IMDAL_6	-0.223668	0.747723	-0.2991	0.76616	
IMDAL_7	-0.704725	0.737186	-0.9560	0.34398	
IMDAL_8	-0.243192	0.715801	-0.3397	0.73556	
IMVAT_1	-1.92865	1.34885	-1.4298	0.15938	
IMVAT_2	1.90365	1.93522	0.9837	0.33031	
IMVAT_3	0.661859	2.1368	0.3097	0.75813	
IMVAT_4	-0.805138	1.97915	-0.4068	0.68599	
IMVAT_5	2.55614	1.69729	1.5060	0.13876	
IMVAT_6	-2.00789	1.76012	-1.1408	0.25975	
IMVAT_7	-0.778175	1.67047	-0.4658	0.64348	
IMVAT_8	0.936625	1.281	0.7312	0.46831	
EXTAX_1	131.475	43.7565	3.0047	0.00425	***
EXTAX_2	-22.3528	49.9263	-0.4477	0.65642	
EXTAX_3	12.4888	52.9397	0.2359	0.81453	
EXTAX_4	-41.8032	56.2164	-0.7436	0.46081	
EXTAX_5	-21.121	54.2413	-0.3894	0.69875	
EXTAX_6	106.207	48.8554	2.1739	0.03478	**
EXTAX_7	40.9396	45.8822	0.8923	0.37679	
EXTAX_8	-41.8956	49.0384	-0.8543	0.39725	
NHIL_1	23.1541	8.96687	2.5822	0.01299	**
NHIL_2	-21.9214	11.7857	-1.8600	0.06915	*
NHIL_3	1.7079	13.5399	0.1261	0.90016	
NHIL_4	-0.0662881	12.8844	-0.0051	0.99592	
NHIL_5	-11.067	12.2959	-0.9001	0.37268	
NHIL_6	13.9381	12.865	1.0834	0.28415	
NHIL_7	5.52198	11.7988	0.4680	0.64194	
NHIL_8	-6.73846	9.17209	-0.7347	0.46619	
FEES_1	-1256.91	732.91	-1.7150	0.09294	*

FEES_2	-90.8553	841.288	-0.1080	0.91446	
FEES_3	1131.39	810.203	1.3964	0.16914	
FEES_4	2339.4	795.294	2.9416	0.00506	***
FEES_5	157.848	808.27	0.1953	0.84601	
FEES_6	27.8432	849.998	0.0328	0.97401	
FEES_7	-800.464	950.683	-0.8420	0.40406	
FEES_8	-477.807	935.608	-0.5107	0.61196	

Mean dependent var	7.31e+08	S.D. dependent var	4.59e+08
Sum squared resid	5.83e+16	S.E. of regression	35207344
R-squared	0.997955	Adjusted R-squared	0.994127
F(88, 47)	260.6651	P-value(F)	3.39e-46
rho	0.134470	Durbin-Watson	1.726688

Equation 4: VOL

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	4.99179e+08	2.12472e+09	0.2349	0.81528	
GDPMN_1	849672	1.70964e+06	0.4970	0.62151	
GDPMN_2	-1.77906e+06	2.13389e+06	-0.8337	0.40866	
GDPMN_3	-209960	1.88097e+06	-0.1116	0.91160	
GDPMN_4	-944221	2.06361e+06	-0.4576	0.64938	
GDPMN_5	-2.21588e+06	2.09329e+06	-1.0586	0.29521	
GDPMN_6	3.64893e+06	2.10547e+06	1.7331	0.08964	*
GDPMN_7	137912	2.0382e+06	0.0677	0.94634	
GDPMN_8	-2.82621e+06	1.79728e+06	-1.5725	0.12254	
SSGDPMN_1	689017	3.08521e+06	0.2233	0.82425	
SSGDPMN_2	2.59514e+06	4.08636e+06	0.6351	0.52846	
SSGDPMN_3	-1.20441e+06	3.6399e+06	-0.3309	0.74220	
SSGDPMN_4	-938412	3.84764e+06	-0.2439	0.80838	
SSGDPMN_5	8.24758e+06	3.83147e+06	2.1526	0.03652	**

SSGDPMN_6	-5.45797e+06	3.28096e+06	-1.6635	0.10286
SSGDPMN_7	-683126	3.53246e+06	-0.1934	0.84749
SSGDPMN_8	3.81049e+06	3.26464e+06	1.1672	0.24902
TORE_1	-5.16615	29.4501	-0.1754	0.86150
TORE_2	-41.5276	31.1948	-1.3312	0.18953
TORE_3	34.0138	31.5401	1.0784	0.28635
TORE_4	15.9423	35.715	0.4464	0.65738
TORE_5	0.348499	30.1394	0.0116	0.99082
TORE_6	-15.0268	34.6531	-0.4336	0.66654
TORE_7	-1.04203	34.2128	-0.0305	0.97583
TORE_8	-1.99716	24.7713	-0.0806	0.93608
VOL_1	-0.0575396	0.141426	-0.4069	0.68596
VOL_2	-0.02687	0.155706	-0.1726	0.86373
VOL_3	0.0231621	0.163423	0.1417	0.88790
VOL_4	-0.10113	0.150887	-0.6702	0.50599
VOL_5	-0.113184	0.154013	-0.7349	0.46605
VOL_6	0.0690506	0.15064	0.4584	0.64879
VOL_7	0.00516189	0.146982	0.0351	0.97213
VOL_8	-0.0427731	0.149843	-0.2855	0.77655
CIF_1	0.104969	0.117792	0.8911	0.37739
CIF_2	0.0747316	0.113427	0.6589	0.51321
CIF_3	0.00784832	0.107672	0.0729	0.94220
CIF_4	0.141185	0.117339	1.2032	0.23492
CIF_5	0.100248	0.11068	0.9057	0.36969
CIF_6	0.0754146	0.110824	0.6805	0.49953
CIF_7	0.0156384	0.0996427	0.1569	0.87596
CIF_8	0.0516267	0.0983225	0.5251	0.60200
AFAC_1	188.737	282.567	0.6679	0.50744
AFAC_2	212.823	358.003	0.5945	0.55505
AFAC_3	-95.0814	332.383	-0.2861	0.77609
AFAC_4	-376.99	315.971	-1.1931	0.23881

AFAC_5	281.066	317.927	0.8841	0.38117
AFAC_6	-123.559	302.017	-0.4091	0.68432
AFAC_7	-104.308	304.139	-0.3430	0.73316
AFAC_8	433.765	276.341	1.5697	0.12320
IMDAL_1	-19.0295	58.5073	-0.3253	0.74644
IMDAL_2	66.2376	62.7883	1.0549	0.29685
IMDAL_3	-45.2971	66.6099	-0.6800	0.49982
IMDAL_4	-12.4588	68.2615	-0.1825	0.85596
IMDAL_5	15.4809	66.5545	0.2326	0.81708
IMDAL_6	8.33059	70.191	0.1187	0.90603
IMDAL_7	46.8055	69.2019	0.6764	0.50213
IMDAL_8	15.5236	67.1945	0.2310	0.81830
IMVAT_1	-63.7692	126.621	-0.5036	0.61688
IMVAT_2	225.946	181.665	1.2438	0.21976
IMVAT_3	-153.744	200.588	-0.7665	0.44723
IMVAT_4	-17.1048	185.789	-0.0921	0.92704
IMVAT_5	-17.9242	159.329	-0.1125	0.91091
IMVAT_6	15.9951	165.228	0.0968	0.92329
IMVAT_7	168.154	156.812	1.0723	0.28905
IMVAT_8	-22.2478	120.251	-0.1850	0.85402
EXTAX_1	-2668.89	4107.56	-0.6497	0.51902
EXTAX_2	-2652.64	4686.74	-0.5660	0.57409
EXTAX_3	1367.02	4969.61	0.2751	0.78446
EXTAX_4	501.477	5277.2	0.0950	0.92470
EXTAX_5	-4845.52	5091.8	-0.9516	0.34615
EXTAX_6	-4641.81	4586.2	-1.0121	0.31666
EXTAX_7	-2647.79	4307.11	-0.6147	0.54168
EXTAX_8	5725.95	4603.38	1.2439	0.21972
NHIL_1	506.168	841.748	0.6013	0.55051
NHIL_2	-1188.9	1106.36	-1.0746	0.28804
NHIL_3	620.112	1271.03	0.4879	0.62790

NHIL_4	139.582	1209.5	0.1154	0.90862	
NHIL_5	-155.902	1154.25	-0.1351	0.89314	
NHIL_6	319.573	1207.68	0.2646	0.79246	
NHIL_7	-1145.32	1107.59	-1.0341	0.30640	
NHIL_8	-485.645	861.013	-0.5640	0.57541	
FEES_1	-39000.2	68800.6	-0.5669	0.57351	
FEES_2	26644.7	78974.3	0.3374	0.73733	
FEES_3	33038.1	76056.2	0.4344	0.66599	
FEES_4	86296.1	74656.7	1.1559	0.25356	
FEES_5	181036	75874.8	2.3860	0.02111	**
FEES_6	-26056.9	79791.9	-0.3266	0.74545	
FEES_7	-6334.32	89243.6	-0.0710	0.94372	
FEES_8	-79977.2	87828.4	-0.9106	0.36715	

Mean dependent var	1.53e+09	S.D. dependent var	2.43e+09
Sum squared resid	5.13e+20	S.E. of regression	3.31e+09
R-squared	0.353436	Adjusted R-squared	-0.857152
F(88, 47)	0.291954	P-value(F)	1.000000
rho	-0.005344	Durbin-Watson	2.003045

Equation 5: CIF

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
Const	-8.01897e+08	2.66376e+09	-0.3010	0.76471
GDPMN_1	1.02737e+06	2.14338e+06	0.4793	0.63393
GDPMN_2	-5381.56	2.67526e+06	-0.0020	0.99840
GDPMN_3	-707023	2.35817e+06	-0.2998	0.76564
GDPMN_4	-58742.9	2.58715e+06	-0.0227	0.98198
GDPMN_5	-795545	2.62436e+06	-0.3031	0.76312

GDPMN_6	2.312e+06	2.63962e+06	0.8759	0.38555	
GDPMN_7	2.81892e+06	2.55529e+06	1.1032	0.27557	
GDPMN_8	-1.8526e+06	2.25325e+06	-0.8222	0.41512	
SSGDPMN_1	-1.61104e+06	3.86793e+06	-0.4165	0.67893	
SSGDPMN_2	587108	5.12307e+06	0.1146	0.90925	
SSGDPMN_3	-1.29321e+06	4.56334e+06	-0.2834	0.77812	
SSGDPMN_4	-2.40964e+06	4.82378e+06	-0.4995	0.61973	
SSGDPMN_5	1.38976e+06	4.80351e+06	0.2893	0.77361	
SSGDPMN_6	-28304.6	4.11335e+06	-0.0069	0.99454	
SSGDPMN_7	-1.1164e+06	4.42864e+06	-0.2521	0.80207	
SSGDPMN_8	1.45952e+06	4.09287e+06	0.3566	0.72299	
TORE_1	48.0462	36.9216	1.3013	0.19950	
TORE_2	-36.571	39.1089	-0.9351	0.35451	
TORE_3	-33.3882	39.5418	-0.8444	0.40274	
TORE_4	12.0427	44.7759	0.2690	0.78914	
TORE_5	-17.1529	37.7858	-0.4540	0.65195	
TORE_6	0.287369	43.4446	0.0066	0.99475	
TORE_7	3.43331	42.8925	0.0800	0.93654	
TORE_8	12.2927	31.0557	0.3958	0.69402	
VOL_1	0.0181924	0.177306	0.1026	0.91871	
VOL_2	0.045059	0.195208	0.2308	0.81845	
VOL_3	0.0676001	0.204883	0.3299	0.74291	
VOL_4	0.00795627	0.189167	0.0421	0.96663	
VOL_5	-0.0773756	0.193086	-0.4007	0.69043	
VOL_6	-0.0520533	0.188857	-0.2756	0.78405	
VOL_7	-0.0440445	0.184272	-0.2390	0.81213	
VOL_8	-0.102136	0.187858	-0.5437	0.58923	
CIF_1	-0.15485	0.147676	-1.0486	0.29973	
CIF_2	-0.043603	0.142204	-0.3066	0.76048	
CIF_3	-0.288017	0.134988	-2.1337	0.03812	**
CIF_4	-0.0180517	0.147108	-0.1227	0.90286	

CIF_5	-0.174488	0.13876	-1.2575	0.21479
CIF_6	-0.117993	0.13894	-0.8492	0.40006
CIF_7	-0.133316	0.124922	-1.0672	0.29133
CIF_8	-0.0555824	0.123267	-0.4509	0.65413
AFAC_1	-194.764	354.255	-0.5498	0.58507
AFAC_2	322.989	448.829	0.7196	0.47532
AFAC_3	-63.9959	416.709	-0.1536	0.87860
AFAC_4	-504.6	396.133	-1.2738	0.20899
AFAC_5	630.011	398.586	1.5806	0.12067
AFAC_6	-285.044	378.639	-0.7528	0.45532
AFAC_7	-382.589	381.299	-1.0034	0.32081
AFAC_8	-37.7381	346.448	-0.1089	0.91372
IMDAL_1	-28.8495	73.3506	-0.3933	0.69587
IMDAL_2	21.2366	78.7177	0.2698	0.78851
IMDAL_3	13.3057	83.5089	0.1593	0.87409
IMDAL_4	-88.6687	85.5794	-1.0361	0.30546
IMDAL_5	-16.5964	83.4393	-0.1989	0.84320
IMDAL_6	57.0478	87.9985	0.6483	0.51996
IMDAL_7	29.2507	86.7584	0.3372	0.73750
IMDAL_8	-129.048	84.2417	-1.5319	0.13226
IMVAT_1	-75.1413	158.745	-0.4733	0.63816
IMVAT_2	112.221	227.753	0.4927	0.62450
IMVAT_3	30.7053	251.478	0.1221	0.90334
IMVAT_4	-108.853	232.923	-0.4673	0.64242
IMVAT_5	-107.215	199.751	-0.5367	0.59398
IMVAT_6	-13.0384	207.147	-0.0629	0.95008
IMVAT_7	234.799	196.595	1.1943	0.23834
IMVAT_8	-189.47	150.759	-1.2568	0.21505
EXTAX_1	-3590.51	5149.65	-0.6972	0.48909
EXTAX_2	-2227.61	5875.76	-0.3791	0.70631
EXTAX_3	-1125.43	6230.4	-0.1806	0.85743

EXTAX_4	2978.82	6616.03	0.4502	0.65461
EXTAX_5	3022.9	6383.59	0.4735	0.63802
EXTAX_6	1114.99	5749.72	0.1939	0.84707
EXTAX_7	-1510.36	5399.82	-0.2797	0.78093
EXTAX_8	6717.66	5771.26	1.1640	0.25031
NHIL_1	-5.99946	1055.3	-0.0057	0.99549
NHIL_2	-494.594	1387.05	-0.3566	0.72300
NHIL_3	437.113	1593.5	0.2743	0.78505
NHIL_4	1261.88	1516.35	0.8322	0.40952
NHIL_5	240.357	1447.09	0.1661	0.86879
NHIL_6	350.963	1514.07	0.2318	0.81770
NHIL_7	-902.825	1388.59	-0.6502	0.51875
NHIL_8	1387.38	1079.45	1.2853	0.20500
FEES_1	-93105.5	86255.3	-1.0794	0.28591
FEES_2	-143614	99010.1	-1.4505	0.15356
FEES_3	-74559	95351.7	-0.7819	0.43817
FEES_4	-32302.7	93597.1	-0.3451	0.73154
FEES_5	47075.5	95124.2	0.4949	0.62299
FEES_6	-23493.6	100035	-0.2349	0.81534
FEES_7	-48364	111885	-0.4323	0.66752
FEES_8	-71989.4	110111	-0.6538	0.51643

Mean dependent var	4.34e+09	S.D. dependent var	4.52e+09
Sum squared resid	8.07e+20	S.E. of regression	4.14e+09
R-squared	0.706910	Adjusted R-squared	0.158147
F(88, 47)	1.288187	P-value(F)	0.171621
Rho	0.034890	Durbin-Watson	1.929875

Equation 6: AFAC

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	-384114	1.36699e+06	-0.2810	0.77995	
GDPMN_1	-471.484	1099.94	-0.4286	0.67014	
GDPMN_2	1390.96	1372.89	1.0132	0.31617	
GDPMN_3	2778.48	1210.17	2.2959	0.02619	**
GDPMN_4	-3584.01	1327.68	-2.6995	0.00962	***
GDPMN_5	245.414	1346.77	0.1822	0.85619	
GDPMN_6	1657.03	1354.6	1.2233	0.22733	
GDPMN_7	-2184.51	1311.33	-1.6659	0.10239	
GDPMN_8	3583.68	1156.32	3.0992	0.00327	***
SSGDPMN_1	2263.78	1984.95	1.1405	0.25987	
SSGDPMN_2	-545.743	2629.06	-0.2076	0.83645	
SSGDPMN_3	-6759.12	2341.82	-2.8863	0.00587	***
SSGDPMN_4	3776.05	2475.47	1.5254	0.13386	
SSGDPMN_5	-645.34	2465.07	-0.2618	0.79462	
SSGDPMN_6	-585.066	2110.89	-0.2772	0.78287	
SSGDPMN_7	2306.96	2272.7	1.0151	0.31527	
SSGDPMN_8	-6202.02	2100.38	-2.9528	0.00490	***
TORE_1	0.000710397	0.0189475	0.0375	0.97025	
TORE_2	0.00149576	0.0200699	0.0745	0.94091	
TORE_3	-0.0147224	0.0202921	-0.7255	0.47173	
TORE_4	0.0130765	0.0229781	0.5691	0.57201	
TORE_5	-0.0367058	0.0193909	-1.8929	0.06453	*
TORE_6	0.0239547	0.0222949	1.0744	0.28811	
TORE_7	-0.0093379	0.0220116	-0.4242	0.67334	
TORE_8	-0.00346659	0.0159372	-0.2175	0.82875	
VOL_1	-7.78967e-05	9.09899e-05	-0.8561	0.39628	
VOL_2	0.000161306	0.000100177	1.6102	0.11405	
VOL_3	0.000258072	0.000105142	2.4545	0.01787	**

VOL_4	-3.19919e-05	9.7077e-05	-0.3296	0.74320	
VOL_5	0.000185055	9.90882e-05	1.8676	0.06806	*
VOL_6	3.63231e-05	9.6918e-05	0.3748	0.70951	
VOL_7	4.35375e-05	9.45647e-05	0.4604	0.64735	
VOL_8	0.000206222	9.64052e-05	2.1391	0.03765	**
CIF_1	-3.48097e-05	7.57845e-05	-0.4593	0.64812	
CIF_2	-8.3303e-05	7.29763e-05	-1.1415	0.25944	
CIF_3	-0.000159209	6.92732e-05	-2.2983	0.02604	**
CIF_4	-9.96427e-05	7.54931e-05	-1.3199	0.19326	
CIF_5	3.66895e-06	7.12088e-05	0.0515	0.95913	
CIF_6	-0.000124237	7.13015e-05	-1.7424	0.08798	*
CIF_7	3.89931e-05	6.41076e-05	0.6082	0.54595	
CIF_8	-0.000122924	6.32582e-05	-1.9432	0.05799	*
AFAC_1	0.459706	0.181797	2.5287	0.01487	**
AFAC_2	0.227278	0.23033	0.9868	0.32882	
AFAC_3	-0.146831	0.213847	-0.6866	0.49570	
AFAC_4	0.368895	0.203288	1.8146	0.07596	*
AFAC_5	-0.272308	0.204547	-1.3313	0.18952	
AFAC_6	-0.241442	0.19431	-1.2426	0.22019	
AFAC_7	-0.0924064	0.195675	-0.4722	0.63894	
AFAC_8	0.0796859	0.177791	0.4482	0.65607	
IMDAL_1	-0.102205	0.0376421	-2.7152	0.00924	***
IMDAL_2	0.0413627	0.0403964	1.0239	0.31111	
IMDAL_3	-0.00704214	0.0428552	-0.1643	0.87018	
IMDAL_4	0.00508895	0.0439177	0.1159	0.90825	
IMDAL_5	0.0236349	0.0428195	0.5520	0.58359	
IMDAL_6	-0.0500144	0.0451592	-1.1075	0.27371	
IMDAL_7	0.0311039	0.0445228	0.6986	0.48824	
IMDAL_8	0.0173037	0.0432313	0.4003	0.69078	
IMVAT_1	-0.139766	0.0814647	-1.7157	0.09281	*
IMVAT_2	0.0598182	0.116879	0.5118	0.61119	

IMVAT_3	0.0727298	0.129054	0.5636	0.57573	
IMVAT_4	0.013619	0.119532	0.1139	0.90977	
IMVAT_5	-0.0879052	0.102509	-0.8575	0.39550	
IMVAT_6	0.0195378	0.106304	0.1838	0.85497	
IMVAT_7	-0.0672869	0.100889	-0.6669	0.50807	
IMVAT_8	0.0935551	0.0773666	1.2092	0.23262	
EXTAX_1	6.39592	2.6427	2.4202	0.01943	**
EXTAX_2	-7.28223	3.01533	-2.4151	0.01968	**
EXTAX_3	-0.876637	3.19732	-0.2742	0.78515	
EXTAX_4	0.508196	3.39522	0.1497	0.88166	
EXTAX_5	2.54422	3.27594	0.7766	0.44126	
EXTAX_6	2.18819	2.95065	0.7416	0.46202	
EXTAX_7	-0.544145	2.77108	-0.1964	0.84517	
EXTAX_8	2.83214	2.9617	0.9563	0.34384	
NHIL_1	1.62454	0.54156	2.9997	0.00431	***
NHIL_2	-0.68915	0.711806	-0.9682	0.33791	
NHIL_3	0.155003	0.817752	0.1895	0.85048	
NHIL_4	-0.80868	0.778163	-1.0392	0.30402	
NHIL_5	0.89339	0.742617	1.2030	0.23499	
NHIL_6	0.0819248	0.776991	0.1054	0.91648	
NHIL_7	0.518735	0.712597	0.7279	0.47026	
NHIL_8	-0.616374	0.553954	-1.1127	0.27150	
FEES_1	-60.4178	44.2646	-1.3649	0.17878	
FEES_2	22.4592	50.8101	0.4420	0.66050	
FEES_3	11.3955	48.9327	0.2329	0.81686	
FEES_4	135.008	48.0323	2.8108	0.00718	***
FEES_5	-34.7727	48.816	-0.7123	0.47979	
FEES_6	113.812	51.3361	2.2170	0.03150	**
FEES_7	-8.66331	57.4171	-0.1509	0.88071	
FEES_8	5.77793	56.5066	0.1023	0.91899	

Mean dependent var	27406350	S.D. dependent var	9697805
Sum squared resid	2.13e+14	S.E. of regression	2126369
R-squared	0.983262	Adjusted R-squared	0.951924
F(88, 47)	31.37547	P-value(F)	5.26e-25
rho	0.098571	Durbin-Watson	1.800766

Equation 7: IMDAL

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	-8.04436e+06	1.07967e+07	-0.7451	0.45993	
GDPMN_1	-9896.75	8687.49	-1.1392	0.26039	
GDPMN_2	5395.51	10843.3	0.4976	0.62109	
GDPMN_3	18843.3	9558.07	1.9715	0.05457	*
GDPMN_4	-23224.5	10486.2	-2.2148	0.03166	**
GDPMN_5	4708.69	10637	0.4427	0.66003	
GDPMN_6	13531.9	10698.8	1.2648	0.21218	
GDPMN_7	-15957.5	10357	-1.5407	0.13009	
GDPMN_8	20048.7	9132.8	2.1952	0.03312	**
SSGDPMN_1	36222.9	15677.4	2.3105	0.02530	**
SSGDPMN_2	-14462.3	20764.7	-0.6965	0.48956	
SSGDPMN_3	-36835.7	18496	-1.9916	0.05225	*
SSGDPMN_4	23458.6	19551.6	1.1998	0.23622	
SSGDPMN_5	14047.6	19469.4	0.7215	0.47416	
SSGDPMN_6	-22870.3	16672.1	-1.3718	0.17665	
SSGDPMN_7	42423.1	17950	2.3634	0.02230	**
SSGDPMN_8	-46789.9	16589.1	-2.8205	0.00700	***
TORE_1	-0.199029	0.14965	-1.3300	0.18995	
TORE_2	0.0789104	0.158515	0.4978	0.62094	
TORE_3	0.0262958	0.16027	0.1641	0.87038	
TORE_4	0.193196	0.181484	1.0645	0.29253	

TORE_5	-0.261853	0.153152	-1.7098	0.09391	*
TORE_6	-0.0401621	0.176088	-0.2281	0.82057	
TORE_7	0.214948	0.173851	1.2364	0.22246	
TORE_8	0.041844	0.125874	0.3324	0.74104	
VOL_1	6.28338e-05	0.00071865	0.0874	0.93070	
VOL_2	0.00129056	0.000791213	1.6311	0.10955	
VOL_3	0.00156144	0.000830427	1.8803	0.06627	*
VOL_4	0.000241323	0.000766727	0.3147	0.75435	
VOL_5	0.00091452	0.000782612	1.1685	0.24848	
VOL_6	0.000692347	0.000765471	0.9045	0.37036	
VOL_7	0.0002899	0.000746885	0.3881	0.69966	
VOL_8	0.00156993	0.000761421	2.0618	0.04478	**
CIF_1	-0.000717301	0.000598556	-1.1984	0.23678	
CIF_2	-0.000320229	0.000576376	-0.5556	0.58113	
CIF_3	-0.000603689	0.000547129	-1.1034	0.27548	
CIF_4	0.000100734	0.000596255	0.1689	0.86656	
CIF_5	0.000599531	0.000562416	1.0660	0.29187	
CIF_6	7.3594e-05	0.000563149	0.1307	0.89658	
CIF_7	0.000126857	0.00050633	0.2505	0.80326	
CIF_8	-0.00131977	0.000499622	-2.6415	0.01117	**
AFAC_1	-1.5768	1.43585	-1.0982	0.27773	
AFAC_2	0.68683	1.81918	0.3775	0.70747	
AFAC_3	-0.174631	1.68899	-0.1034	0.91809	
AFAC_4	1.29953	1.60559	0.8094	0.42238	
AFAC_5	0.0205364	1.61554	0.0127	0.98991	
AFAC_6	-0.472198	1.53469	-0.3077	0.75968	
AFAC_7	-2.46952	1.54547	-1.5979	0.11677	
AFAC_8	0.926588	1.40421	0.6599	0.51256	
IMDAL_1	0.0275054	0.297302	0.0925	0.92668	
IMDAL_2	0.978751	0.319056	3.0676	0.00357	***
IMDAL_3	-0.144515	0.338476	-0.4270	0.67136	

IMDAL_4	-0.094997	0.346868	-0.2739	0.78538	
IMDAL_5	0.18167	0.338194	0.5372	0.59368	
IMDAL_6	-0.217269	0.356673	-0.6092	0.54536	
IMDAL_7	-0.416142	0.351647	-1.1834	0.24260	
IMDAL_8	-0.564412	0.341446	-1.6530	0.10500	
IMVAT_1	-1.84805	0.643419	-2.8722	0.00610	***
IMVAT_2	2.14545	0.923122	2.3241	0.02449	**
IMVAT_3	0.471145	1.01928	0.4622	0.64605	
IMVAT_4	-0.393614	0.944077	-0.4169	0.67863	
IMVAT_5	0.965013	0.809626	1.1919	0.23927	
IMVAT_6	-1.06392	0.839601	-1.2672	0.21134	
IMVAT_7	-0.107508	0.796834	-0.1349	0.89325	
IMVAT_8	-0.0799264	0.611052	-0.1308	0.89649	
EXTAX_1	25.8195	20.8724	1.2370	0.22223	
EXTAX_2	-18.6941	23.8155	-0.7850	0.43642	
EXTAX_3	-20.8003	25.2529	-0.8237	0.41428	
EXTAX_4	-6.47187	26.8159	-0.2413	0.81034	
EXTAX_5	13.0274	25.8738	0.5035	0.61697	
EXTAX_6	33.6869	23.3046	1.4455	0.15495	
EXTAX_7	14.0156	21.8864	0.6404	0.52504	
EXTAX_8	12.3409	23.3919	0.5276	0.60028	
NHIL_1	15.3488	4.27731	3.5884	0.00079	***
NHIL_2	-17.223	5.62194	-3.0635	0.00362	***
NHIL_3	-0.0381817	6.45871	-0.0059	0.99531	
NHIL_4	-1.0934	6.14604	-0.1779	0.85956	
NHIL_5	-4.68536	5.86529	-0.7988	0.42841	
NHIL_6	8.14852	6.13678	1.3278	0.19065	
NHIL_7	2.70431	5.62819	0.4805	0.63311	
NHIL_8	1.70541	4.3752	0.3898	0.69845	
FEES_1	-302.842	349.607	-0.8662	0.39076	
FEES_2	141.461	401.305	0.3525	0.72604	

FEES_3	639.053	386.477	1.6535	0.10489	
FEES_4	1157.26	379.365	3.0505	0.00375	***
FEES_5	87.3357	385.555	0.2265	0.82178	
FEES_6	-92.4309	405.46	-0.2280	0.82066	
FEES_7	-388.213	453.488	-0.8561	0.39631	
FEES_8	-854.431	446.297	-1.9145	0.06166	*

Mean dependent var	2.71e+08	S.D. dependent var	1.66e+08
Sum squared resid	1.33e+16	S.E. of regression	16794340
R-squared	0.996437	Adjusted R-squared	0.989766
F(88, 47)	149.3685	P-value(F)	1.48e-40
rho	0.059315	Durbin-Watson	1.870326

Equation 8: IMVAT

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	9.65609e+06	8.69211e+06	1.1109	0.27226	
GDPMN_1	-10547.1	6994.07	-1.5080	0.13825	
GDPMN_2	17643.9	8729.65	2.0211	0.04898	**
GDPMN_3	7359.94	7694.95	0.9565	0.34373	
GDPMN_4	-13307.9	8442.14	-1.5764	0.12165	
GDPMN_5	4139.21	8563.54	0.4834	0.63109	
GDPMN_6	11618.6	8613.36	1.3489	0.18383	
GDPMN_7	-15263.9	8338.17	-1.8306	0.07350	*
GDPMN_8	12541.3	7352.58	1.7057	0.09467	*
SSGDPMN_1	21316.8	12621.4	1.6889	0.09786	*
SSGDPMN_2	-18701	16717.1	-1.1187	0.26896	
SSGDPMN_3	-25917.9	14890.6	-1.7405	0.08831	*
SSGDPMN_4	20886.5	15740.5	1.3269	0.19094	
SSGDPMN_5	1206.88	15674.3	0.0770	0.93895	
SSGDPMN_6	-8261.87	13422.3	-0.6155	0.54117	

SSGDPMN_7	18625.6	14451.1	1.2889	0.20375	
SSGDPMN_8	-34873.6	13355.5	-2.6112	0.01207	**
TORE_1	-0.133416	0.120479	-1.1074	0.27377	
TORE_2	0.244574	0.127616	1.9165	0.06140	*
TORE_3	0.0081923	0.129029	0.0635	0.94964	
TORE_4	0.166226	0.146108	1.1377	0.26102	
TORE_5	-0.54286	0.123299	-4.4028	0.00006	***
TORE_6	0.217237	0.141764	1.5324	0.13213	
TORE_7	0.164074	0.139963	1.1723	0.24700	
TORE_8	0.0221785	0.101338	0.2189	0.82771	
VOL_1	-0.000301851	0.000578567	-0.5217	0.60431	
VOL_2	0.00165167	0.000636985	2.5930	0.01264	**
VOL_3	0.000330824	0.000668555	0.4948	0.62302	
VOL_4	0.000165553	0.000617272	0.2682	0.78972	
VOL_5	0.000595077	0.00063006	0.9445	0.34976	
VOL_6	0.000212342	0.000616261	0.3446	0.73196	
VOL_7	-0.000281544	0.000601297	-0.4682	0.64179	
VOL_8	0.00104173	0.000613	1.6994	0.09586	*
CIF_1	-7.99241e-05	0.000481882	-0.1659	0.86898	
CIF_2	-6.06193e-05	0.000464026	-0.1306	0.89662	
CIF_3	0.000766436	0.000440479	1.7400	0.08840	*
CIF_4	-0.000314912	0.000480029	-0.6560	0.51501	
CIF_5	0.00108649	0.000452787	2.3996	0.02043	**
CIF_6	-0.000365811	0.000453377	-0.8069	0.42381	
CIF_7	0.000845031	0.000407633	2.0730	0.04368	**
CIF_8	-0.00130312	0.000402232	-3.2397	0.00220	***
AFAC_1	-0.915597	1.15597	-0.7921	0.43230	
AFAC_2	-0.93599	1.46457	-0.6391	0.52587	
AFAC_3	0.437476	1.35976	0.3217	0.74908	
AFAC_4	4.69893	1.29262	3.6352	0.00069	***
AFAC_5	-2.76273	1.30063	-2.1242	0.03895	**

AFAC_6	0.0927823	1.23554	0.0751	0.94046	
AFAC_7	-1.29943	1.24422	-1.0444	0.30165	
AFAC_8	-0.116227	1.1305	-0.1028	0.91855	
IMDAL_1	-0.327635	0.23935	-1.3689	0.17755	
IMDAL_2	0.580652	0.256864	2.2605	0.02846	**
IMDAL_3	-0.209369	0.272498	-0.7683	0.44613	
IMDAL_4	-0.370919	0.279254	-1.3282	0.19051	
IMDAL_5	0.572502	0.272271	2.1027	0.04088	**
IMDAL_6	-0.264106	0.287148	-0.9198	0.36240	
IMDAL_7	-0.399551	0.283102	-1.4113	0.16473	
IMDAL_8	-0.0830749	0.274889	-0.3022	0.76382	
IMVAT_1	0.30805	0.518	0.5947	0.55490	
IMVAT_2	0.495804	0.743182	0.6671	0.50795	
IMVAT_3	0.65236	0.820597	0.7950	0.43062	
IMVAT_4	-0.307258	0.760052	-0.4043	0.68786	
IMVAT_5	0.49899	0.651809	0.7655	0.44777	
IMVAT_6	-0.610355	0.675941	-0.9030	0.37115	
IMVAT_7	-0.333978	0.641511	-0.5206	0.60508	
IMVAT_8	-0.0921656	0.491942	-0.1874	0.85219	
EXTAX_1	40.9685	16.8038	2.4380	0.01860	**
EXTAX_2	-31.5496	19.1732	-1.6455	0.10654	
EXTAX_3	21.8908	20.3304	1.0767	0.28709	
EXTAX_4	-38.9739	21.5888	-1.8053	0.07744	*
EXTAX_5	11.2477	20.8303	0.5400	0.59177	
EXTAX_6	41.9852	18.7619	2.2378	0.03001	**
EXTAX_7	-10.4901	17.6202	-0.5953	0.55447	
EXTAX_8	-32.4316	18.8322	-1.7221	0.09162	*
NHIL_1	6.25693	3.44355	1.8170	0.07560	*
NHIL_2	-7.79636	4.52608	-1.7225	0.09155	*
NHIL_3	0.0822078	5.19974	0.0158	0.98745	
NHIL_4	-3.41052	4.94801	-0.6893	0.49404	

NHIL_5	1.42828	4.72199	0.3025	0.76363	
NHIL_6	2.12968	4.94056	0.4311	0.66840	
NHIL_7	3.28993	4.53111	0.7261	0.47139	
NHIL_8	0.573208	3.52236	0.1627	0.87143	
FEES_1	-677.338	281.46	-2.4065	0.02009	**
FEES_2	45.5236	323.08	0.1409	0.88855	
FEES_3	68.1829	311.142	0.2191	0.82749	
FEES_4	858.118	305.417	2.8097	0.00721	***
FEES_5	-283.791	310.4	-0.9143	0.36524	
FEES_6	81.2463	326.425	0.2489	0.80452	
FEES_7	-815.606	365.091	-2.2340	0.03028	**
FEES_8	49.8811	359.302	0.1388	0.89018	

Mean dependent var	2.21e+08	S.D. dependent var	1.17e+08
Sum squared resid	8.59e+15	S.E. of regression	13520685
R-squared	0.995314	Adjusted R-squared	0.986541
F(88, 47)	113.4481	P-value(F)	8.83e-38
rho	-0.068751	Durbin-Watson	2.131117

Equation 9: EXTAX

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	69103.2	83836.3	0.8243	0.41395	
GDPMN_1	14.6345	67.4585	0.2169	0.82919	
GDPMN_2	50.8881	84.1984	0.6044	0.54850	
GDPMN_3	-46.0363	74.2186	-0.6203	0.53807	
GDPMN_4	-6.19701	81.4253	-0.0761	0.93966	
GDPMN_5	148.128	82.5963	1.7934	0.07934	*
GDPMN_6	-104.55	83.0768	-1.2585	0.21444	
GDPMN_7	0.135193	80.4225	0.0017	0.99867	
GDPMN_8	4.19261	70.9164	0.0591	0.95311	

SSGDPMN_1	-13.491	121.735	-0.1108	0.91223
SSGDPMN_2	-212.16	161.238	-1.3158	0.19462
SSGDPMN_3	134.93	143.622	0.9395	0.35229
SSGDPMN_4	20.6819	151.819	0.1362	0.89222
SSGDPMN_5	-202.303	151.181	-1.3382	0.18728
SSGDPMN_6	178.972	129.459	1.3825	0.17337
SSGDPMN_7	-110.688	139.382	-0.7941	0.43111
SSGDPMN_8	39.5948	128.815	0.3074	0.75991
TORE_1	3.96147e-05	0.00116203	0.0341	0.97295
TORE_2	0.00126644	0.00123087	1.0289	0.30879
TORE_3	-8.50331e-05	0.0012445	-0.0683	0.94582
TORE_4	-0.00152348	0.00140923	-1.0811	0.28518
TORE_5	-0.000936918	0.00118923	-0.7878	0.43475
TORE_6	0.00014871	0.00136733	0.1088	0.91386
TORE_7	0.00206336	0.00134996	1.5285	0.13310
TORE_8	-0.0015218	0.000977416	-1.5570	0.12619
VOL_1	2.37733e-06	5.58034e-06	0.4260	0.67204
VOL_2	2.13696e-06	6.14379e-06	0.3478	0.72953
VOL_3	-2.8258e-06	6.44828e-06	-0.4382	0.66323
VOL_4	-1.1989e-06	5.95365e-06	-0.2014	0.84128
VOL_5	-2.93106e-07	6.077e-06	-0.0482	0.96174
VOL_6	-6.77755e-06	5.9439e-06	-1.1403	0.25996
VOL_7	-2.48929e-06	5.79958e-06	-0.4292	0.66973
VOL_8	-9.39142e-07	5.91245e-06	-0.1588	0.87447
CIF_1	2.65615e-06	4.6478e-06	0.5715	0.57039
CIF_2	-1.00051e-06	4.47558e-06	-0.2235	0.82408
CIF_3	-4.01735e-07	4.24847e-06	-0.0946	0.92507
CIF_4	1.14625e-06	4.62993e-06	0.2476	0.80554
CIF_5	-2.89375e-06	4.36717e-06	-0.6626	0.51081
CIF_6	5.94566e-07	4.37286e-06	0.1360	0.89243
CIF_7	1.59502e-06	3.93167e-06	0.4057	0.68681

CIF_8	2.22769e-06	3.87957e-06	0.5742	0.56856
AFAC_1	-0.00802215	0.0111494	-0.7195	0.47539
AFAC_2	0.0110697	0.014126	0.7836	0.43718
AFAC_3	-0.00786154	0.0131151	-0.5994	0.55177
AFAC_4	0.0112671	0.0124675	0.9037	0.37075
AFAC_5	-7.89395e-05	0.0125447	-0.0063	0.99501
AFAC_6	-0.0185467	0.0119169	-1.5563	0.12634
AFAC_7	0.0174327	0.0120006	1.4527	0.15296
AFAC_8	-0.00296549	0.0109038	-0.2720	0.78684
IMDAL_1	-0.00132127	0.00230856	-0.5723	0.56982
IMDAL_2	-0.00175452	0.00247748	-0.7082	0.48233
IMDAL_3	-0.00113295	0.00262827	-0.4311	0.66839
IMDAL_4	0.00141318	0.00269344	0.5247	0.60228
IMDAL_5	0.00213526	0.00262608	0.8131	0.42026
IMDAL_6	0.00275038	0.00276957	0.9931	0.32576
IMDAL_7	-0.0016796	0.00273054	-0.6151	0.54145
IMDAL_8	0.00274273	0.00265134	1.0345	0.30621
IMVAT_1	-0.00718487	0.00499616	-1.4381	0.15704
IMVAT_2	0.00830569	0.00716807	1.1587	0.25243
IMVAT_3	-0.00676716	0.00791474	-0.8550	0.39689
IMVAT_4	0.000714743	0.00733078	0.0975	0.92274
IMVAT_5	0.0055758	0.00628676	0.8869	0.37964
IMVAT_6	-0.00205985	0.00651952	-0.3160	0.75344
IMVAT_7	0.000359267	0.00618744	0.0581	0.95394
IMVAT_8	0.00305215	0.00474483	0.6433	0.52318
EXTAX_1	0.0147492	0.162075	0.0910	0.92788
EXTAX_2	-0.263657	0.184928	-1.4257	0.16055
EXTAX_3	-0.300921	0.196089	-1.5346	0.13158
EXTAX_4	-0.156459	0.208226	-0.7514	0.45616
EXTAX_5	-0.178146	0.200911	-0.8867	0.37976
EXTAX_6	0.112869	0.180961	0.6237	0.53583

EXTAX_7	-0.0799048	0.169948	-0.4702	0.64041	
EXTAX_8	-0.167029	0.181639	-0.9196	0.36249	
NHIL_1	0.0582732	0.0332134	1.7545	0.08586	*
NHIL_2	-0.0501579	0.0436545	-1.1490	0.25638	
NHIL_3	0.0467934	0.050152	0.9330	0.35557	
NHIL_4	-0.0127353	0.0477241	-0.2669	0.79075	
NHIL_5	-0.0338747	0.0455441	-0.7438	0.46071	
NHIL_6	0.01308	0.0476522	0.2745	0.78491	
NHIL_7	-0.0294053	0.043703	-0.6728	0.50434	
NHIL_8	-0.0141464	0.0339735	-0.4164	0.67902	
FEES_1	-3.10876	2.71471	-1.1452	0.25794	
FEES_2	1.74459	3.11614	0.5599	0.57824	
FEES_3	2.02357	3.001	0.6743	0.50343	
FEES_4	4.02381	2.94578	1.3660	0.17845	
FEES_5	-0.251426	2.99384	-0.0840	0.93343	
FEES_6	-4.38915	3.1484	-1.3941	0.16985	
FEES_7	1.78383	3.52134	0.5066	0.61482	
FEES_8	0.281833	3.4655	0.0813	0.93553	

Mean dependent var	11995.62	S.D. dependent var	110089.3
Sum squared resid	7.99e+11	S.E. of regression	130408.4
R-squared	0.511477	Adjusted R-squared	-0.403205
F(88, 47)	0.559186	P-value(F)	0.990484
rho	-0.011568	Durbin-Watson	2.011683

Equation 10: NHIL

	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	1.18641e+06	1.49962e+06	0.7911	0.43284
GDPMN_1	-1614.82	1206.67	-1.3383	0.18725
GDPMN_2	2288.22	1506.1	1.5193	0.13539

GDPMN_3	1761.23	1327.59	1.3266	0.19104	
GDPMN_4	-2839.82	1456.5	-1.9498	0.05718	*
GDPMN_5	410.323	1477.44	0.2777	0.78244	
GDPMN_6	2241.88	1486.04	1.5086	0.13809	
GDPMN_7	-2642.48	1438.56	-1.8369	0.07255	*
GDPMN_8	2334.4	1268.52	1.8403	0.07205	*
SSGDPMN_1	3763.32	2177.54	1.7282	0.09051	*
SSGDPMN_2	-2150.02	2884.15	-0.7455	0.45971	
SSGDPMN_3	-4931.8	2569.04	-1.9197	0.06098	*
SSGDPMN_4	3686.16	2715.66	1.3574	0.18115	
SSGDPMN_5	1286.75	2704.25	0.4758	0.63640	
SSGDPMN_6	-1981.5	2315.7	-0.8557	0.39652	
SSGDPMN_7	4017.57	2493.21	1.6114	0.11379	
SSGDPMN_8	-6177.87	2304.18	-2.6812	0.01009	**
TORE_1	-0.0228699	0.0207859	-1.1003	0.27682	
TORE_2	0.0375683	0.0220173	1.7063	0.09455	*
TORE_3	-0.00369187	0.022261	-0.1658	0.86899	
TORE_4	0.0235088	0.0252076	0.9326	0.35579	
TORE_5	-0.078549	0.0212724	-3.6925	0.00058	***
TORE_6	0.0248144	0.0244581	1.0146	0.31551	
TORE_7	0.0341632	0.0241473	1.4148	0.16372	
TORE_8	0.00272601	0.0174835	0.1559	0.87676	
VOL_1	-5.8064e-05	9.98183e-05	-0.5817	0.56355	
VOL_2	0.000250028	0.000109897	2.2751	0.02750	**
VOL_3	0.000140703	0.000115344	1.2199	0.22860	
VOL_4	1.90123e-05	0.000106496	0.1785	0.85908	
VOL_5	0.000124412	0.000108702	1.1445	0.25820	
VOL_6	8.25122e-05	0.000106322	0.7761	0.44160	
VOL_7	-2.53606e-05	0.00010374	-0.2445	0.80794	
VOL_8	0.000215698	0.000105759	2.0395	0.04704	**
CIF_1	-6.13582e-05	8.31376e-05	-0.7380	0.46416	

CIF_2	-5.70869e-06	8.00569e-05	-0.0713	0.94346	
CIF_3	5.92078e-05	7.59945e-05	0.7791	0.43982	
CIF_4	-5.24167e-05	8.28179e-05	-0.6329	0.52986	
CIF_5	0.00011936	7.81179e-05	1.5279	0.13323	
CIF_6	-9.03647e-05	7.82197e-05	-1.1553	0.25382	
CIF_7	0.000102964	7.03277e-05	1.4641	0.14983	
CIF_8	-0.000232387	6.93959e-05	-3.3487	0.00161	***
AFAC_1	-0.139168	0.199436	-0.6978	0.48874	
AFAC_2	-0.109056	0.252678	-0.4316	0.66801	
AFAC_3	0.0205076	0.234596	0.0874	0.93071	
AFAC_4	0.778487	0.223012	3.4908	0.00106	***
AFAC_5	-0.363796	0.224393	-1.6212	0.11166	
AFAC_6	-0.0397613	0.213163	-0.1865	0.85283	
AFAC_7	-0.30403	0.214661	-1.4163	0.16327	
AFAC_8	-0.0278254	0.195041	-0.1427	0.88717	
IMDAL_1	-0.0453883	0.0412944	-1.0991	0.27731	
IMDAL_2	0.0970201	0.044316	2.1893	0.03358	**
IMDAL_3	-0.0263367	0.0470132	-0.5602	0.57800	
IMDAL_4	-0.0443613	0.0481789	-0.9208	0.36188	
IMDAL_5	0.0599258	0.0469741	1.2757	0.20832	
IMDAL_6	-0.0264808	0.0495408	-0.5345	0.59550	
IMDAL_7	-0.0814123	0.0488426	-1.6668	0.10220	
IMDAL_8	-0.0438332	0.0474258	-0.9242	0.36008	
IMVAT_1	-0.134735	0.0893689	-1.5076	0.13834	
IMVAT_2	0.16324	0.128219	1.2731	0.20923	
IMVAT_3	0.0894776	0.141575	0.6320	0.53044	
IMVAT_4	-0.04586	0.131129	-0.3497	0.72810	
IMVAT_5	0.0718462	0.112455	0.6389	0.52600	
IMVAT_6	-0.118941	0.116618	-1.0199	0.31299	
IMVAT_7	-0.0362758	0.110678	-0.3278	0.74455	
IMVAT_8	-0.0228901	0.0848732	-0.2697	0.78857	

EXTAX_1	7.38935	2.89911	2.5488	0.01413	**
EXTAX_2	-4.00572	3.3079	-1.2110	0.23197	
EXTAX_3	1.80703	3.50755	0.5152	0.60884	
EXTAX_4	-4.78936	3.72465	-1.2859	0.20479	
EXTAX_5	2.52178	3.59379	0.7017	0.48632	
EXTAX_6	7.22398	3.23694	2.2317	0.03044	**
EXTAX_7	-0.0279514	3.03995	-0.0092	0.99270	
EXTAX_8	-3.34329	3.24906	-1.0290	0.30875	
NHIL_1	1.94995	0.594105	3.2822	0.00195	***
NHIL_2	-1.70268	0.78087	-2.1805	0.03426	**
NHIL_3	0.164566	0.897095	0.1834	0.85524	
NHIL_4	-0.566732	0.853665	-0.6639	0.51001	
NHIL_5	0.282653	0.814671	0.3470	0.73017	
NHIL_6	0.532212	0.852379	0.6244	0.53540	
NHIL_7	0.538948	0.781738	0.6894	0.49395	
NHIL_8	0.327604	0.607702	0.5391	0.59237	
FEES_1	-107.491	48.5594	-2.2136	0.03175	**
FEES_2	6.02108	55.74	0.1080	0.91444	
FEES_3	30.9172	53.6804	0.5759	0.56740	
FEES_4	162.95	52.6926	3.0925	0.00334	***
FEES_5	-43.7285	53.5524	-0.8166	0.41830	
FEES_6	2.51776	56.3171	0.0447	0.96453	
FEES_7	-133.456	62.988	-2.1187	0.03943	**
FEES_8	-58.9298	61.9892	-0.9506	0.34665	

Mean dependent var	39616524	S.D. dependent var	19050253
Sum squared resid	2.56e+14	S.E. of regression	2332682
R-squared	0.994780	Adjusted R-squared	0.985006
F(88, 47)	101.7814	P-value(F)	1.09e-36
rho	-0.034035	Durbin-Watson	2.065356

Equation 11: FEES

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	10290.6	4991.74	2.0615	0.04481	**
GDPMN_1	1.96776	4.01658	0.4899	0.62648	
GDPMN_2	-0.906509	5.0133	-0.1808	0.85729	
GDPMN_3	3.69249	4.41909	0.8356	0.40762	
GDPMN_4	-2.56174	4.84819	-0.5284	0.59971	
GDPMN_5	3.09844	4.91791	0.6300	0.53172	
GDPMN_6	3.00975	4.94652	0.6085	0.54581	
GDPMN_7	-3.96721	4.78848	-0.8285	0.41158	
GDPMN_8	2.01103	4.22247	0.4763	0.63609	
SSGDPMN_1	-7.31209	7.24829	-1.0088	0.31824	
SSGDPMN_2	-3.41762	9.60037	-0.3560	0.72344	
SSGDPMN_3	3.91866	8.55146	0.4582	0.64889	
SSGDPMN_4	1.71361	9.03952	0.1896	0.85046	
SSGDPMN_5	-3.55223	9.00153	-0.3946	0.69490	
SSGDPMN_6	-9.8954	7.7082	-1.2838	0.20552	
SSGDPMN_7	12.1341	8.29905	1.4621	0.15036	
SSGDPMN_8	-5.54318	7.66983	-0.7227	0.47343	
TORE_1	3.95411e-05	6.91892e-05	0.5715	0.57039	
TORE_2	-5.81305e-06	7.32881e-05	-0.0793	0.93712	
TORE_3	-2.73741e-05	7.40994e-05	-0.3694	0.71347	
TORE_4	-3.87974e-05	8.39077e-05	-0.4624	0.64594	
TORE_5	-2.01071e-05	7.08086e-05	-0.2840	0.77769	
TORE_6	-1.5015e-05	8.14129e-05	-0.1844	0.85447	
TORE_7	0.000150249	8.03784e-05	1.8693	0.06782	*
TORE_8	-6.26108e-05	5.81968e-05	-1.0758	0.28749	
VOL_1	2.17759e-07	3.32262e-07	0.6554	0.51542	
VOL_2	-3.21444e-07	3.6581e-07	-0.8787	0.38402	
VOL_3	4.58217e-08	3.83941e-07	0.1193	0.90551	
VOL_4	-9.94141e-08	3.5449e-07	-0.2804	0.78037	
VOL_5	-1.37653e-07	3.61834e-07	-0.3804	0.70534	

VOL_6	-1.88668e-07	3.53909e-07	-0.5331	0.59648	
VOL_7	-3.34074e-07	3.45316e-07	-0.9674	0.33827	
VOL_8	1.00874e-08	3.52036e-07	0.0287	0.97726	
CIF_1	-8.14672e-08	2.76737e-07	-0.2944	0.76976	
CIF_2	1.85193e-07	2.66483e-07	0.6950	0.49051	
CIF_3	-1.9614e-07	2.5296e-07	-0.7754	0.44200	
CIF_4	-1.72341e-07	2.75673e-07	-0.6252	0.53489	
CIF_5	-2.35705e-07	2.60028e-07	-0.9065	0.36932	
CIF_6	-6.98623e-010	2.60367e-07	-0.0027	0.99787	
CIF_7	4.72117e-07	2.34097e-07	2.0168	0.04945	**
CIF_8	1.84677e-07	2.30996e-07	0.7995	0.42803	
AFAC_1	-0.000265171	0.000663855	-0.3994	0.69138	
AFAC_2	0.000199805	0.000841082	0.2376	0.81326	
AFAC_3	-0.000112679	0.000780891	-0.1443	0.88588	
AFAC_4	0.00067343	0.000742332	0.9072	0.36894	
AFAC_5	5.64294e-05	0.000746929	0.0755	0.94010	
AFAC_6	-0.00153827	0.00070955	-2.1680	0.03526	**
AFAC_7	0.000565259	0.000714535	0.7911	0.43287	
AFAC_8	0.000182735	0.000649226	0.2815	0.77959	
IMDAL_1	3.5342e-05	0.000137455	0.2571	0.79821	
IMDAL_2	-0.000135794	0.000147513	-0.9206	0.36198	
IMDAL_3	-0.000306168	0.000156491	-1.9565	0.05637	*
IMDAL_4	0.000281867	0.000160371	1.7576	0.08533	*
IMDAL_5	0.000166915	0.000156361	1.0675	0.29120	
IMDAL_6	-7.81588e-05	0.000164905	-0.4740	0.63772	
IMDAL_7	-5.47343e-05	0.000162581	-0.3367	0.73787	
IMDAL_8	2.12189e-05	0.000157865	0.1344	0.89365	
IMVAT_1	-0.000239624	0.000297479	-0.8055	0.42458	
IMVAT_2	6.12663e-05	0.000426798	0.1435	0.88647	
IMVAT_3	-0.000220887	0.000471256	-0.4687	0.64144	

IMVAT_4	2.88007e-05	0.000436486	0.0660	0.94767	
IMVAT_5	0.000270499	0.000374324	0.7226	0.47349	
IMVAT_6	-0.000379721	0.000388182	-0.9782	0.33298	
IMVAT_7	0.000515033	0.000368409	1.3980	0.16868	
IMVAT_8	-0.000208391	0.000282514	-0.7376	0.46441	
EXTAX_1	-0.00661981	0.00965017	-0.6860	0.49610	
EXTAX_2	0.00682998	0.0110109	0.6203	0.53806	
EXTAX_3	-0.00155122	0.0116754	-0.1329	0.89487	
EXTAX_4	-0.0169406	0.0123981	-1.3664	0.17832	
EXTAX_5	-0.0176243	0.0119625	-1.4733	0.14734	
EXTAX_6	0.0048587	0.0107747	0.4509	0.65411	
EXTAX_7	-0.00438903	0.010119	-0.4337	0.66646	
EXTAX_8	-0.0213357	0.010815	-1.9728	0.05442	*
NHIL_1	0.00101706	0.00197758	0.5143	0.60945	
NHIL_2	0.000552144	0.00259926	0.2124	0.83269	
NHIL_3	0.00296685	0.00298613	0.9935	0.32553	
NHIL_4	-0.00191535	0.00284157	-0.6740	0.50358	
NHIL_5	-0.00260417	0.00271177	-0.9603	0.34181	
NHIL_6	0.00408462	0.00283728	1.4396	0.15660	
NHIL_7	-0.00413803	0.00260214	-1.5902	0.11849	
NHIL_8	0.00161725	0.00202284	0.7995	0.42803	
FEES_1	-0.233292	0.161638	-1.4433	0.15557	
FEES_2	-0.160141	0.18554	-0.8631	0.39246	
FEES_3	-0.101342	0.178684	-0.5672	0.57331	
FEES_4	0.200824	0.175396	1.1450	0.25802	
FEES_5	-0.0763553	0.178258	-0.4283	0.67036	
FEES_6	-0.160197	0.187461	-0.8546	0.39713	
FEES_7	0.192853	0.209666	0.9198	0.36237	
FEES_8	-0.0631999	0.206341	-0.3063	0.76074	

Mean dependent var	21452.51	S.D. dependent var	11977.10
Sum squared resid	2.83e+09	S.E. of regression	7764.716
R-squared	0.853677	Adjusted R-squared	0.579711
F(88, 47)	3.115996	P-value(F)	0.000022
rho	0.042140	Durbin-Watson	1.907781