Impact of Petroleum on National Debt as a Decomposed General Macroeconomic Theory Non Linear Stationary Markov Switch Process

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Abstract

National debt has been identified as a major economic problem affecting the developing world in general where vital national resources are diverted from developmental functions to meeting debt obligations in interest and principal repayments. A multiplicity of literature portraying the causes of the debt build up have tended to bring out petroleum imports as one key contributor to third world indebtedness. The study reanalyzes this proposition by studying the relative impact of the Zambian petroleum imports on its national debt as a decomposed General Macroeconomic Theoretical process utilizing a time-varying two state multivariate Markov-Switching Autoregressive Model (MSAR) with Zambian National Debt as the dependent variable and Petroleum imports, Non Petroleum imports, Government Expenditures, Gross capital formation, Exports, Private Final Consumption and GDP as the regressors, using annual time series data from the early 1980's to 2019. The study established national debt reducing effects to have run from Petroleum imports, GDP, Gross capital formation and private consumption expenditures in both the dormant and expansive states of the model. Debt increasing effects were brought out to have run from Government expenditures and national exports in both states of the model. It was only from non-petroleum imports that results were inconclusive.

Keywords
National Debt, Petroleum Imports, GDP, Government Expenditures and National Exports.

1. Introduction
National indebtedness for the third world countries is a persistent economic problem. The Zambian case had seen the national debt increasing from around US$2.3 Billion in 1980 to around US$19.7 Billion in 2019 (COMSTAT, 2020). A number of writers have alluded this problem to petroleum production, imports and oil price shocks. Oils shocks are believed to have contributed to a considerable balance of payment deficits among oil importing countries thus creating the need for borrowing (Swaray, 2005). Bacon (2005) claimed that the impact of oil price rises was felt through the net position of the Balance of Payments and the subsequent contraction required in the economy to restore the equilibrium. However petroleum remains a key driver of industry not only in Zambia but world over. The importation of petroleum oil dominates all other single commodity import expenditures forming a major part of Zambia's import bill. The petroleum imports rose from around US$197 Million in 1980 to US$2.07 Billion in 2019 (COMSTAT, 2020). Additionally, however, other general macroeconomic variables, as determined in the study, equally continued to rise in the Zambian case with Government Expenditures rising from US$514.8 Million to US$2.5 Billion, GDP rising from US$4.3 to US$27.2 Billion, Gross Capital Formation rising from US$443.3 Million to US$ 9.7 Billion, Exports rising from US$ 942 Million to US$10.2 Billion, Non- Petroleum Imports rising from US$746.4 Million to

US$7.6 Billion and Private Consumption Expenditure rising from US$2,1 Billion to US$ 12.6 Billion in the period under study. From the General Macroeconomic point of view, the motivation for the study arose to query as to whether it was accurate, then, that petroleum imports could be the sole national debt increasing variable, in the Zambian case, as had been generally claimed by multiple other studies.

Hasanli & Ismayilo (2018) using Log linear data applied OLS, and concluded that a rise in oil prices results into the growth of the world national debt, where they found that a 1% growth in oil prices increased the volume of foreign debt to World GDP by 3.17. But they fell short of isolating any particular country. Kretzmann & Nooruddin (2009) used a cross-national time-series analysis using a Generalized Method of Moments (GMM) and a comparative Least Squares Dummy Variable (LSDV) estimator model to examine the relationship between oil and debt where they found that increasing oil production led to increasing debt for the countries in their sample. Their study is not country specific and did not in any way apply the nonlinear approach Markov Switch approach. Nkomo (2006) using the Bacon and Mattar (2005) methodology established that SADC countries were heavily reliant on imported crude oil such that there could just be a relationship between the extreme dependence on crude oil imports and the debt burden that the SADC countries are currently carrying. We do not see a country specific approach even in Nkomo's approach and equally no orientation toward a decomposition of General Macroeconomic variables as a nonlinear model. The preceding review makes a clear gap in the literature concerning the analysis of the process of the petroleum to debt relationship in the Zambian case. Additionally available studies do not account for the petroleum to debt relationship as a nonlinear stationary process of decomposed General Macroeconomic variables. This is a significant shortcoming in an economy that has experienced at a continued buildup of national debt despite the debt relief it obtained during the HIPC/MDRI intervention and consequently, then, the timeliness of the study as it captures how some significant macroeconomic variables as captured in the study have been impacting the national debt.

1.1 Objectives

The main aim of this study's was the determination the *relative* impact of petroleum imports on long term Zambian national debt.

The specific objectives were then outlined as:
i) Evaluate the extent to which crude petroleum imports impacted Zambian national debt in the period of the study.
ii) To evaluate the extent to which non - petroleum imports impacted the Zambian national debt in the period of the study.
iii) To determine the impact that exports had on the Zambian national debt in the period of the study.
iv) To evaluate the effect of gross domestic product [GDP], on the Zambian national debt in the period of the study.
v) To investigate the impact of gross capital formation on the Zambian national debt in the period of the study.
vi) To evaluate the effect of government expenditure on the Zambian national debt in the period of study.
vii) To investigate the impact of private domestic consumption on the Zambian national debt in the period of study.

2. Theoretical framework

2.1 Decomposition of the General Macroeconomic Theory

The study decomposed the General Macroeconomic Theory identity as follows;
$Y = C + I + G + NX$
Where Y is the national income (GDP), C is Private Consumption Expenditure, I is Gross Capital formation, G is Government expenditure and NX are the net exports (X – M); whereby relating net exports to total national income less absorption we have the net exports identity;
$NX = Y - (C + G + I)$
Since Y- (C + G + I) represents the national savings we have the relationship
$NX = S_N$
Using the assumptions that the real interest rate (r) equals the world real interest rate (r*), we obtain our net exports identity as being;
$NX = [\overline{Y} - \overline{C} - G - I(r^*)]$
Letting national savings (S_N) be represented by $\overline{S}$
Hence $\overline{S} = NX$
Where $NX = [\overline{Y} - c(\overline{Y} - \overline{T}) - G] - I(r^*)$
Hence our net exports can equally be represented as;
$NX = \overline{S}$

Since net exports are governed by real exchange rates (ϵ); (Mankiw, 1992). Hence we rewrite this relationship between net exports and real exchange rates as;
$NX = NX(\epsilon)$
Then $\bar{S} = NX(\epsilon)$
Hence with a balance of payments
$\bar{S} - NX(\epsilon) = 0$
But with a balance of payments deficit
$\bar{S} - NX(\epsilon) = \delta$
Hence (δ) represent the debt that the small open economy will owe to the external economies when it fails to transfer enough goods, services, physical and financial assets to the external economies. The residual δ or deficit is capital account transaction representing all the inflows and /or outflows to compensate or complement it.
If we now separate the net exports into the respective exports and imports (X – M) we have;
$\bar{S} - [X(\epsilon) - M(\epsilon)] = \delta$
Which can be re written;
$[\bar{S} + M(\epsilon) - X(\epsilon) = \delta$
Further separating the imports (M) into petroleum imports (M_{PET}) and non-petroleum imports (M_{OTH}) we have the relationship expanded to;
$[\bar{S} - X(\epsilon) + M_{PET}(\epsilon) + M_{OTH}(\epsilon) = \delta$
Putting back the macroeconomic variables for national savings;
$[\ \bar{Y} - _C(\bar{Y} - \bar{T}) - G\ ] - I(r^*)] - X(\epsilon) + M_{PET}(\epsilon) + M_{OTH}(\epsilon) = \delta$
Implying that;
$[\bar{Y} - _C\bar{Y} - \bar{C}\ \bar{T}) - G\ ] - I(r^*)] - X(\epsilon) + M_{PET}(\epsilon) + M_{OTH}(\epsilon) = \delta$
Factoring for GDP,
$[\bar{Y}(1 - _C) - \bar{C}\bar{T} - G] - I(r^*)] - X(\epsilon) + M_{PET}(\epsilon) + M_{OTH}(\epsilon) = \delta$
Due to the relative non-availability of data on taxation, we eliminated the disposable income notation and simply consider total consumption thus;
$[\ \bar{Y} - \bar{C} - G - I(r^*)] - X(\epsilon) + M_{PET}(\epsilon) + M_{OTH}(\epsilon) = \delta$
This identified the macroeconomic variables used in our time series petroleum imports to debt model where:
δ = National Debt; MPET = Petroleum Imports Expenditures; M_{OTH} = Non- Petroleum Imports Expenditures; $X(\epsilon)$ = Export Income; . $I(r^*)$ = Gross Capital formation at the world interest rate G = Government Expenditures; C = Final Private Consumption Expenditures and Y = GDP.
Source: Author

2.2 Empirical Framework

In their study "Econometric Model of Dependence between the Oil prices, and the Global National Debt Level and Oil Production", (Hasanli & Ismayilo, 2018) using Log linear data applied OLS, concluded that a rise in oil prices results into the growth of the world national debt, where they found that a 1% growth in oil prices increased the volume of foreign debt to World GDP by 3.17. But they fall short of isolating any particular country. Kretzmann and Nooruddin (2009) used a cross-national time-series analysis using a Generalized Method of Moments (GMM) and a comparative Least Squares Dummy Variable (LSDV) estimator model to examine the relationship between oil and debt where they found that increasing oil production led to increasing debt for 161 countries for the period 1991-2002, and collected further data on 88 developing countries for the period 1970-2000 to evaluate of debt burdens of both oil exporting and importing countries.. This study is not country specific and did not in any way apply the nonlinear approach Markov Switch approach. Nkomo (2006) using the Bacon & Mattar (2005) methodology established that SADC countries were heavily reliant on imported crude oil such that there could just be a relationship between the extreme dependence on crude oil imports and the debt burden that the SADC countries are currently carrying.

2.3 Markov Switch as a General Non-Linear Regression Model

The Markov Switching Model as introduced by (Quandt & Goldfeld, 1973) improved by (Engel & Hamilton, 1989.) equally termed as the regime switching model, is an outstanding nonlinear time series model in the literature applying multiple structures or equations that tends to characterize the nature of time series variable data in different regimes. By allowing for the switching between or among these structures, this model is affordably able to represent or capture more and relatively complex dynamic relations.

Lucas (1977), in discussing business cycles, emphasized on the co-movement of important macroeconomic variables with (Diebold & Rudebusch, 1996) further suggesting that a model for business cycles, features the co-movement of economic variables and persistence of economic states. As such a multivariate Markov switching model was suitable because it is able to characterize both of these features. Johansen (1990) investigated the vector autoregressive processes and discovered the underlying conditions for which the processes are 1(2) proving a representation theorem for such processes to point to the interpretation of the autoregressive (AR) model as an error correction model. Johansen (1995) further performed the statistical analysis of I(2) processes in the context of the vector autoregressive (VAR) model using modified likelihood methods, and was followed by papers by (Paruolo, 2000). Regression models of this configuration were utilized by (Stock & Watson, 2011) . Johansen (1995) theorized that the main idea was to regard I(2) models as non-linear regression models with integrated regressors. Connected to this study was an essential outcome about the consistency of the maximum likelihood estimator in a general non-linear regression model in an I(2) model with the maximum likelihood estimator existing with probability tending to an I(1) for any continuous restrictions on the parameters provided the process is I(2). The asymptotic distribution of the maximum likelihood estimator in I(2) model was further proven by Johansen including the result that the super consistent I(2) estimators are asymptotically mixed Gaussian and that the remaining ones are asymptotically Gaussian or, in some cases, even more complicated.

Markov switching regression models have been used with some examples of the applications of this model in economics having been done to investigate the time series asymmetrical behaviour over GDP expansions and recessions (Hamilton 1989) in investigating exchange rates (Engel & Hamilton, 1989.), interest rates (Garcia & Perron, 1996) and in investigating stock returns (Kim, Shephard, & Chib, 1998)). The time series in all those examples are characterized by data generating processes (DGP) with dynamics that are state dependent where the states may be recessive or expansionary, and/or of high volatility or low volatility. Smith et al (2005) further reinforced the usage of the Markov Switching Regression Models in that economic systems frequently undergo disturbance (shocks) that shift them to alternative states like nations plunging into recessions, government political regimes switching over different time frames and/or financial markets tending to go into bubbly booms and then crashes with these states tending to exhibit stochastic occurrence and relative dynamism whereby their original occurrence gives indications that they probably will recur.

The data in this study came out to integrated of the 2nd order or I(2) for which Johansen had theorized that the main idea was to regard the I(2) models as a non-linear regression models with integrated regressors. This was why the study chose to analyse the relative impact of petroleum imports to national debt in the Zambian case as a non-linear regression model. On the explicit case of debt and petroleum in Zambia there are relatively few studies that are that country specific, if not none, in as far as the author is concerned, that analyze the petroleum to national debt problem as a stationary nonlinear process.

3. Data Collection

The data principal sources were AFDB and COMSTAT (2020) data hubs and all data was in non- log format and at current values due to the lengthy data period. The data was analysed using Stata 15. Data statistics are shown in Table 1. Gross Domestic Product (GDP) ranged from US$1.8 Billion to US$28 Billion with a mean value of US$9.95 Billion and standard deviation of US$9.25 Billion showing that the maximum GDP for the period was about 3 standard deviations higher. Non-Petroleum Imports (IMPoth) ranged from US$518 Million to US$8.11 Billion with a mean value of US$2.51 Billion and standard deviation of US$2.43 Billion showing that the maximum Non-Petroleum Imports for the period was about 3 standard deviations higher (Table 1).

Table 1. Macroeconomic Variable Statistics

VARIABLE	MEAN.	STD.DEVIATION	MIN	MAX
DEBT	6.98e+09	4.12e+09	2.27e+09	1.97e+10
GDP	9.95e+09	9.25e+09	1.80e+09	2.80e+10
IMPOTH	2.51e+09	2.43e+09	5.18e+09	8.11e+09
IMPPET	4.68e+08	5.71e+08	4.19e+08	2.07e+09
XPT	3.64e+09	3.69e+09	7.67e+09	1.16e+10
INV	3.02e+09	3.69e+09	8.44e+09	1.12e+10
GOVT	6.71e+09	1.06e+09	3.09e+09	3.95e+10

CONS	6.71e+09	5.46e+09	1.30e+09	1.95e+10

Source: Stata 15 (2021)

Petroleum Oil imports (IMPPET) ranged from US$41.9 Million to US$2.07 Billion with a mean value of US$468 Million. The standard deviation for these was US$571 Million showing that the maximum Petroleum (Oil) imports for the period was almost 4 standard deviations higher. The Exports of goods and services (Xpt) ranged from US$767 Million to US$11.6 Billion with a mean value of US$3.64 Billion and standard deviation being US$3.69 Billion showing that the maximum Exports of goods and services for the period was almost 3 standard deviations higher. Gross Fixed Capital Formation (Inv) ranged from US$8.4 Million to US$11.2 Billion with a mean value of US$3.02 Billion and standard deviation being US$1.06 Billion showing that the maximum Gross Fixed Capital Formation for the period was almost 11 standard deviations higher. Government Final Consumption Expenditure (Govt). Government expenditure was ranged from US$309 Million to US$3.95 Billion with a mean value of US$1.3 Billion and standard deviation estimating at US$1.06 Billion showing that the maximum Government expenditure for the period was almost 4 standard deviations higher. Household Final Consumption Expenditure (Cons): ranged from US$1.3 Billion to US$19.5 Billion with a mean value of US$6.71 Billion. The standard deviation for these was US$5.46 Billion showing that the maximum Household final consumption expenditure for the period was almost 4 standard deviations higher than the mean.

4. Methods

4.1 Stationarity Tests: Augmented Dickey – Fuller (ADF) method

Data variables were tested for stationarity using the Augmented Dickey – Fuller (ADF) method and the null hypothesis could not be rejected for data in their levels and at first difference which made the model an I(2) process. Table 2 in section 5.1 shows the results. The stationarity results principally meant ruling out the traditional mainline times series models like Autoregressive Dynamic Lag (ARDL), Restricted or unrestricted Vector Auto Regression (VAR), Vector Auto Regression (VECM) or Structured Autoregressive Dynamic Lag (SVAR).

4.2 Multivariate Markov-Switching Model for the General Macroeconomic Variables.

For data analysis the study applied the Markov Switching Auto Regression model over the dynamic regression model due to the relative low frequency nature of the data (Annual). Borrowing from Sánchez (2016), the general dynamics that the Markov Switching Auto Regression specification followed for this study were represented as:

$y_t = \mu_{St} + x_t \alpha + z_t\beta_{St} + \sum_{i=1}^{p} \Phi i,_{St} (y_{t-i} - \mu_{St-i} - x_{t-i} \alpha + z_{t-1}\beta_{St-1}) + \varepsilon_{t,St}$

Where

y_t : is the Vector of the regressand variable (National Debt).

$\mu_{St:}$ is the State-dependent intercept.

x_t : is the Vector of exogenous variables with state invariant coefficients α.

z_t : is the Vector of exogenous with state-dependent coefficients $\beta_{St.}$

$\Phi i;_{St}$: is the *ith* Auto Regressive term in state St.

$\varepsilon_{t,St}$ ~iid $N(0; \sigma s^2)$ are the independent, identically and normally distributed error terms with mean 0 and variance σ^2 in state St.

With the established decomposed general macroeconomic theory variables, the Markov Switching Auto Regression model for the study was then specified as:

$DEBT_t = \mu_{St} + \alpha GDP_t + \beta_{St}GDP_t + \sum_{i=1}^{p} \Phi i,_{St} (DEBT_{t-i} - \mu_{St-i} - \alpha GDP_{t-i} + \beta_{St-1}GDP_{t-1}) + \varepsilon_{t,St}$

$DEBT_t = \mu_{St} + \alpha IMPOTH_t + \beta_{St}IMPOTH_t + \sum_{i=1}^{p} \Phi i,_{St} (DEBT_{t-i} - \mu_{St-i} - \alpha IMPOTH_{t-i} + \beta_{St-1}IMPOTH_{t-1}) + \varepsilon_{t,St}$

$DEBT_t = \mu_{St} + \alpha IMPPET_t + \beta_{St}IMPPET_t + \sum_{i=1}^{p} \Phi i,_{St} (DEBT_{t-i} - \mu_{St-i} - \alpha IMPPET_{t-i} + \beta_{St-1} IMPPET_{t-1}) + \varepsilon_{t,St}$

$DEBT_t = \mu_{St} + \alpha EXP_t + \beta_{St} EXP_t + \sum_{i=1}^{p} \Phi i,_{St} (DEBT_{t-i} - \mu_{St-i} - \alpha EXP_{t-i} + \beta_{St-1} EXP_{t-1}) + \varepsilon_{t,St}$

$DEBT_t = \mu_{St} + \alpha Inv_t + \beta_{St} Inv_t + \sum_{i=1}^{p} \Phi i,_{St} (DEBT_{t-i} - \mu_{St-i} - \alpha Inv_{t-i} + \beta_{St-1} Inv_{t-1}) + \varepsilon_{t,St}$

$DEBT_t = \mu_{St} + \alpha Govt_t + \beta_{St} Govt_t + \sum_{i=1}^{p} \Phi i,_{St} (DEBT_{t-i} - \mu_{St-i} - \alpha Govt_{t-i} + \beta_{St-1} Govt_{t-1}) + \varepsilon_{t,St}$

$DEBT_t = \mu_{St} + \alpha CONS_t + \beta_{St} CONS_t + \sum_{i=1}^{p} \Phi i,_{St} (DEBT_{t-i} - \mu_{St-i} - \alpha CONS_{t-i} + \beta_{St-1} CONS_{t-1}) + \varepsilon_{t,St}$

The model was run in the Markov Switching model module of Stata 15 with all the regressors integrated of the 2nd order I(2) where it converged with results as discussed and presented in sections 5 and 5.1 respectively.

5. Results and Discussion

The results revealed a significant negative impact of Petroleum imports on national debt for the period under study where on average a 1% increase in Petroleum imports significantly reduced national debt by an estimated 2.25% in state 1 the dormant state and an estimated 1.9% negative impact in state 2 the expansive state revealing that petroleum imports had debt reducing effects in the period under study in the Zambian case. It is conventional expectation from the many studies that increased petroleum imports could increase national debt but the model suggests some deep underlying economic multiplier factors that have been making the petroleum imports to be debt reducing in the Zambian case.

GDP was revealed to have had a consistent significant negative impact on national debt in both states with the negative impact where on average a 1% increase in GDP reduced national debt by an estimated at 0.77 % in state 1 and 0.33% in state 2 implying that GDP significantly had debt reducing impacts in both states of the model. This is quite in line with general macroeconomic theory expectations that it is valid to expect increased national output to impact national debt in reducing magnitudes.

The study additionally revealed an otherwise paradoxical result concerning the Zambian exports whereby the model reveals a significant positive impact of exports on national debt in both states where on average a 1% change in exports increased national debt by an estimated 1.6% in state 1 and 0.79% in state 2 – which is a matter of theoretical controversy! The economic reasoning though could border on the worldwide known issue of "Resource Curse" or "Dutch Disease" arising from the primary commodity exporting countries' export diversification inability which makes their terms of trade to be a shadow of the export commodity's world market price such that given high export prices, the high revenues tend to disguise the underlying structural problems with the primary commodity exporting nations' economies, such that when the export commodity's prices fall, there is inability for affected nations to effectively deal with the debt problems which arise thereafter.

Gross Capital Formation was brought out in the study as having had a significant negative impact on national debt with the model estimating a reduction in national debt by an estimated 0.85% in state 1 and 0.19% in the 2nd state from a 1% change in Gross Capital Formation showing the long run debt reducing impact coming from investment.
Government expenditures were revealed in the study as having had a significant national debt increasing impact for the period under study where on average a 1% increase in government expenditures increased national debt by an estimated 1.2% in state 1 and 0.075% in state 2.

Aggregate Private Final Consumption was brought out in the model as having a consistent negative impact on national debt where on average a 1% increase in private consumption expenditure reduced national debt by an estimated 0.45% in state 1 and 0.09% in state two. This should be through the Marginal Propensity to consume (MPC) multiplier effects on GDP (Vancouver Community College Learning, 2013). The multiplier effect is the magnified increase in equilibrium GDP that occurs when any component of aggregate expenditures changes. The greater the MPC (the smaller the MPS) and hence the greater the multiplier effect on GDP and consequently then the greater the decrease in national debt over the long run.

The study revealed other Non- Petroleum Imports as having insignificantly negatively impacted National debt at an estimate of 0.9% in state 1 and insignificantly positively impacted national debt in State 2 at an estimate of 0.1%. These results are inconclusive and can only be verified by further parallel studies

The autoregressive 1st lag of National debt on itself also significantly positively impacted national debt by 0.55% in state 1 but significantly negatively impacted national debt by 1.12% in state 2 which brings implies that in state 1 the lagged values of national debt had debt-increasing effects while in state 2 the lagged values had debt reducing effects.

The State1 intercept parameter was significantly negative suggesting a negative (contractionary) impact of unknown state variables holding all the known study variables constant. The State2 intercept parameter was on other hand significantly, positive suggesting an expansionary positive impact on National Debt from unknown state variables in state two. Sigma is the standard deviation of the dependent variable and it was around US$236 million with a standard error of US$20.7 million.

5.1 Numerical Results

Table 2 shows the results for stationarity of the model variables using the Augmented Dickey – Fuller (ADF) method where the null hypothesis could not be rejected for data in their levels and at first difference which made the model an I(2) process. The 1st column of the Table 2 shows the stationarity state of the variables in their levels at 1st difference and at 2nd difference. The 2nd column is showing the computed Test statistic which should be greater that the critical value at 95% level of significance (shown in the 3rd column) for the variable to be stationary. The 4th column shows the Mackinnon's P value showing the statistical significance of the variables. The 5th column shows the stationarity state of the variable if the Mackinnon's P value is significant (less than 5%).

The I(2) order of integration results principally meant ruling out the traditional mainline times series models like Autoregressive Dynamic Lag (ARDL), Restricted or unrestricted Vector Auto Regression (VAR), Vector Auto Regression (VECM) or Structured Autoregressive Dynamic Lag (SVAR). This was the reason why the study adopted the Markov Switch model for the analysis of the model variables as outlined in 2.2 above.

Table 3 outlines the results for the converged Multivariate two state Markov-Switching Model for the General Macroeconomic Variables showing the estimates of the macroeconomic variables coefficients at 2nd difference, the auto regressive lag coefficients and the intercept coefficients in both states in column 1. Equally shown in the 1st column are the Markov Switching Model Transition Probabilities. The explanations for column 1 are given in section 5 above. Column 2 shows the estimates of the macroeconomic variable coefficients. Column 3 gives the standard errors of the estimates while column 4 shows the empirical value of the Z statistic with the 5 column showing the statistical significance of the test statistic. The results in column 5 shows all the variables to be statistically significant except for the Non-Petroleum imports.

Table 2. The Augmented Dickey Fuller Test (ADF) Stationarity Results

Variable	*Test Statistic Z(t)*	*5% Critical Value Z(t)*	*MacKinnon P-value for Z(t)*	*Integration Order*
Debt	-0.658	-2.969	0.8574	I(0)
Debt1	-1.797	-2.972	0.3820	I(1)
Debt2	***-4.284***	***-2.975***	***0.0005***	***I(2)***
GDP	-0.326	-2.969	0.9785	I(0)
GDP1	-2.909	-2.972	0.0443	I(1)
GDP2	***-5.289***	***-2.975***	***0.0000***	***I(2)***
IMPoth	0.368	-2.969	0.9803	I(0)
IMPoth1	***-3.845***	***-2.972***	***0.0025***	***I(1)***
IMPPET	2.976	-2.969	1.0000	I(0)
IMPPET1	-2.285	-2.972	0.1769	I(1)
IMPPET2	***-6.309***	***-2.975***	***0.0000***	***I(2)***
Xpt	-0.131	-2.969	0.9463	I(0)
Xpt1	-2.885	-2.972	0.0472	I(1)
Xpt2	***-3.782***	***-2.975***	***0.0031***	***I(2)***
Inv	0.246	-2.969	0.9748	I(0)
Inv1	-1.766	-2.972	0.9463	I(1)
Inv2	***-5.037***	***-2.975***	***0.0000***	***I(2)***
Govt	-0.731	-2.969	0.8386	I(0)
Govt1	-2.238	-2.972	0.19260	I(1)
Govt2	***-4.082***	***-2.975***	***0.0010***	***I(2)***
CONS	-0.861	-2.969	0.8007	I(0)
CONS1	-2.542	-2.972	0.1055	I(1)
CONS2	***-4.185***	***-2.975***	***0.0007***	***I(2)***

Source: Stata 15 (2021)

Table 3. Markov Switch Auto Regression Model Results Source

D2.DEBT	**COEF.**	**STD.ERROR**	**Z**	**PROB(Z)**
STATE 1				
D2. GDP	-0.767097	0.0506504	-15.16	0.000
D2. IMPOTH	-0.3316939	0.1896253	-1.75	0.800

D2. IMPPET	-2.251835	0.5227109	-4.31	0.000
D2. XPT	1.599351	0.2267844	7.05	0.000
D2. GOVT	1.198707	0.2650045	4.52	0.000
D2. INV	-0.8515111	0.1163208	-7.28	0.000
D2. CONS	-0.4526043	0.057573	-7.86	0.000
AR LAG1.	1.122933	0.1807615	6.21	0.000
_CONS	-8.68e + 08	9.25e+07	-9.39	0.000
STATE 2				
D2. GDP	-0.3309875	0.0662946	-4.99	0.000
D2. IMPOTH	0.1032863	0.162098	0.64	0.524
D2. IMPPET	-1.8897	0.5142301	-3.67	0.000
D2. XPT.	0.7879281	0.1789507	4.40	0.000
D2. GOVT	0.7501462	0.1465783	5.12	0.000
D2. INV	-0.1894514	0.0373669	-5.07	0.000
D2. CONS	-0.087015	0.0425396	-2.02	0.044
AR LAG1.	-0.5493032	0.1394287	-3.94	0.000
_CONS	2.64e+08	8.81e+07	4.85	0.000
SIGMA	2.52e+08	2.20e+07		
P11	0.2136117	0.1097778		
P21	0.7025264	0.1221621		

Stata 15 (2021)

5.2 Graphical Results

5.2.1 Assessing Model Fit

The study further examined the model fit by comparing the fitted values of differenced Zambian National Debt and the residuals with the actual data. The fitted values were obtained using smoothed probabilities that consider all sample information and these were graphed as exhibited in Figure 1 which shows that our study did not have a good fit in state 1 as residuals accounted for much of the variation in the dependent variable. But the model had a good fit in state 2 as the residuals did not account for much of the variations in the dependent variable as shown by the fact that the residuals are lying a relatively far off distance from the predicted values.

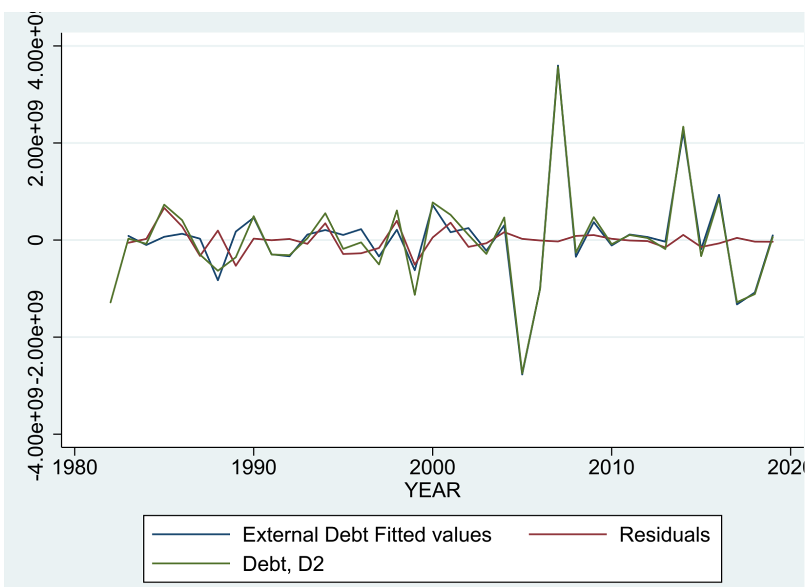

Figure 1. Post Estimation Tests – Differenced Model Fit and State Predictions

Source: Stata 15

As a control the study examined the model fit by comparing the fitted values of non - differenced Zambian National Debt and the residuals with the actual data. The fitted values were obtained using smoothed probabilities that consider all sample information and these were graphed as exhibited in Figure 2. The graph exhibited that study had an overall good fit as the residuals did not account for much of the variations in the dependent variable as shown by the fact that the residuals are lying a relatively far off distance from the predicted values.

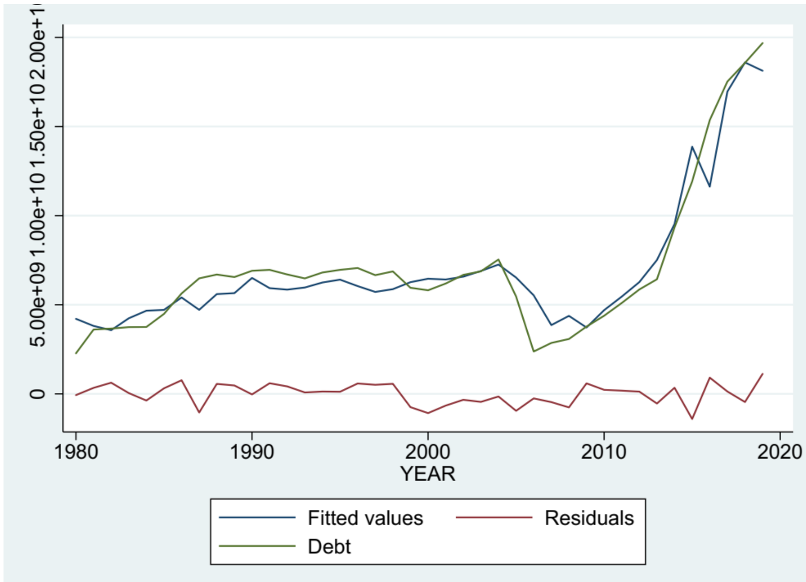

Figure 2. Non-Differenced Debt, Predicted Debt and Residuals State1 and State2

Source: Stata 15

5.2.2 Normality of the Model Residuals

The distribution of the model residuals was tested for normality by plotting the kernel density estimate as shown in Figure 3 which revealed a Gaussian kernel type distributed over the whole x-axis producing showing a fairly normally distributed kernel density estimate of the residuals (plot in Blue) when compared or contrasted to the normal density (plot in red) implying a well fitted model.

5.3 Proposed Improvements

Proposed improvements to the model would be an actual decomposition of the actual variables impact to the total effect on the dependent variable through either variable importance operationalized through variable dominance analysis or commonality analysis where the actual contribution of the macroeconomic variables to the national debt changes would be isolated. **(Nathans, Oswald, & Nimon, 2012)**.

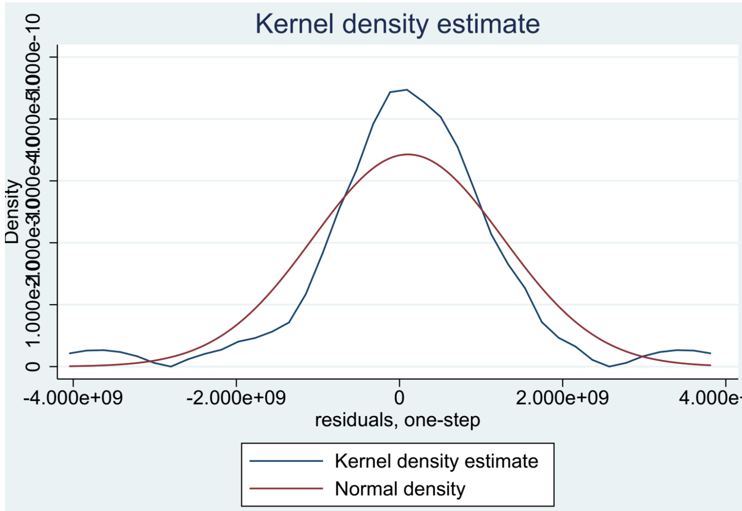

Figure 3. Kernel Density Estimate for Normality of the Model Residuals

Source: Stata 15

5.4 Validation

5.4.1 Shapiro-Wilk Test for Normal Data

The normality of the residuals was further tested using the Shapiro - Wilk log normalized test shown in Table 4 with the p-value of the Z- statistic for the test being larger than 5% resulting in the failure to reject the null that the residues were normally distributed.

Table 4. Shapiro-Wilk Test for Log-Normal Data

VARIABLE	OBS.	W	Z	PROB>Z
R	36	2.679	-1.788	0.96309

Source: Stata 15

5.4.2 Long Run Cointegration Relationship of the Model variables.

There was need for determining the lag order for the Johansen's tests for cointegration for the model variables at second difference. This was done using the VAR/VECM lag order selection criteria since the Markov Switching model is a reduced rank model of the underlying VAR/VECM model with regime changes (Jochmann & Koop, 2014) which is valid as long as the variables are integrated of the same order. This was evaluated as shown in Table 5 where the lag length for the cointegration test was 3 as unanimously chosen by the AIC, HQIC and SBIC lag information criteria.

Table 5. Lag Order selection for Johansen Test for Cointegration

Lag	*LL*	*LR*		*df*	*p*	*FPE*	*AIC*	*HQIC*	*SBIC*
0	-5910.85					2.e+141	348.167	348.29	348.527
1	-5755.26	311.17		64	0.000	1.e+139	342.78	343.882	342.012
2	-5625.41			64	0.000	5.e+137	338.906	340.989	345.012
3	-5376.79	497.24*		64	0.000	1.e+134	328.046*	331.108*	337.025*
4	.	.		64	.	-7.5e+25*	.		

Source: Stata 15 (2021)

Table 6. Johansen Test for Cointegration Results

Maximum Rank	*Parms*	*LL*	*Eigenvalue*	*Trace Statistic*	*5% Critical Value*
0	105	-5137.7041		348.5755	124.24
1	118	-5083.925	0.95372	241.0173	94.15
2	129	-5044.1365	0.89706	161.4402	68.52
3	138	-5018.3262	0.77119	109.8197	47.21
4	145	-4993.9851	0.75115	61.1375	29.68
5	150	-4970.8453	0.73347	14.8578*	15.41
6	153	-4965.0035	0.28381	3.1743	3.76
7	154	-4963.4164	0.08670		

Source: Stata 15 (2021)

Long run cointegration relationship results using Johansen's tests for cointegration of the variables at second difference are shown in Table 6 where the results revealed the Trace statistic being lower than the 5% critical value at maximum rank of 5 implying that the null hypothesis of five (5) cointegrating equations was accepted. This meant that there was long run relationship among the independent and dependent variables and corresponded to the maximum n -1 regressor/cointegrating equations requirement (With n being the number of regressors). As such the results from the study portrayed a valid long run cointegrated relationship among the variables.

6. Conclusion

The relationship between petroleum import expenditures and national is brought out by the study as running contrary to most of the reviewed studies and where the long run relationship is of an inverse nature where increased petroleum import expenditures had debt reducing effects. This meets the general objective and the specific objective of evaluating the extent to which crude petroleum imports impacted Zambian national debt as the study showed that petroleum imports did have an impact on the Zambian national debt and the impact was debt reducing.

The model brings out GDP increases to be an equally long run national debt reducing factor though with relatively lower magnitudes than the petroleum impact but consistent in both the dormant and expansive states of the model. This equally met the objective of evaluating the effect of gross domestic product on the Zambian national debt.
The objective of investigating the impact of private domestic consumption on the Zambian national debt was met by the study equally bringing out a debt reducing impact from the Final private consumption in both states of the model.

Gross capital formation was another general macroeconomic variable that had a long run national debt reducing impact on national debt. This met the specific objective of investigating the impact of gross capital formation on the Zambian national debt where the result was consistent debt reducing impact in both states of the model. Economically we may attribute this contribution to the reduction in national debt through the gross fixed capital formation positive boost to the economic growth channel.

The objective of evaluating the effect of government expenditure on the Zambian national debt was achieved by the study establishing that government consumption had consistent national debt increasing effects in the long run whose economic reason is largely that the government has been financing its expenditures through borrowed resources in the long run which has translated into this consistent and significant contribution of government expenditures to national debt.

Quite in contrast to the general macroeconomic theory expectation, the objective of determining the impact that exports had on the Zambian national debt was equally achieved by the study revealing that there had existed long run national debt increasing effects from national exports in the Zambian case. Ideally exports are supposed to be contributing to the current account surplus if not reducing the deficits. In the Zambian case this has not been the long run case. Finally the study brought out a non-consistent and as such inconclusive results on the effects of non-petroleum imports on the state of Zambian national debt which made the objective of evaluating the extent to which non - petroleum imports impacted the Zambian national debt in the period of the study a an inconclusive result open to further analysis.

References

COMESA/AFDB (COMSTAT) 2020 https://comesa.opendataforafrica.org/, 2020.

Diebold, F., & Rudebusch, G. D., Measuring Business Cycles: A Modern Perspective. *The Review of Economics and Statistics, 78*(1), 67-77, 1996.

Engel, C., & Hamilton, J. D., Long Swings in the Exchange Rate: Are they in the Data and Do Markets Know It? *National Bureau of Economic Research, Inc*, NBER Working Papers 3165, 1989.

Ferderer, J., Oil price volatility and the macroeconomy. *Journal of Macroeconomics, 18*(1), 1-26., 1996.

Garcia, R., & Perron, P., An Analysis of the Real Interest Rate under Regime Shifts. *The Review of Economics and Statistics*, 111-125, 1996.

Hasanli, Y., & Ismayilo, S., Econometric model of dependence between the oil prices, and the global external debt level and oil production . Baku: World Economy and International Economic Relations, 2018.

Johansen, S., & Juselius, K. (1990, Oxford Bulletin of Economics and Statistics, 52,2, 0305-9049 Maximum Likelihood Estimation And Inference on Cointegration – with Applications to the Demand for Money Søren Johansen, Katarina Juselius , 1990. https://onlinelibrary.wiley.com/doi/pdf/10.1111/).

Kim, S., Shephard, N., & Chib, S., Stochastic Volatility: Likelihood Inference and Comparison with ARCH Models. *The Review of Economic Studies*, 361–393, 1998.

Kretzmann, S., & Nooruddin, I., Drilling Into DEbt: An Investigation into the Relationship Between Debt and Oil . Oil Change International Oil Change International, 2009 .

Lucas, R. E., Methods and Problems in Business Cycle Theory. *Journal of Money, Credit and Banking,*, 696–715.

Mankiw, G. N., *Macroeconomics* (3rd ed.). New York: Worth Publishers, 1980.

Nathans, L. L., Oswald, F. L., & Nimon, K., Interpreting multiple linear regression: A guidebook of variable importance. *Interpreting multiple linear regression: A guidebook of variable importance Laura L. Nathans, Journal of Practical Assessment ,Research & Evaluation, 17*(9), 5-20, 2012.

Nkomo, J., The impact of higher oil prices on Southern African countries . *Journal of Energy in Southern Africa , 17*(1), 10-17, 2006.

Paruolo, P., Asymptotic efficiency of the 2 stage estimator in I(2) VAR systems. *Econometric Theory.*, 524-550, 2000.

Quandt, R., & Goldfeld, S., A Markov model for switching regressions. *Journal of Econometrics*, 3-15, 1973.

Smith, A., Naik, P. A., & Tsai, C.-L., *Markov-Switching Model Selection Using Kullback-Leibler Divergence.* Davis: University Of California, 2005.

Søren, J., The Statistical Analysis of Hypotheses on the Cointegrating Relations in the I(2) Model. *Journal of Econometrics*, 81-115, 2006.

Stock, J. H., & Watson, M., *Introduction to Econometrics.* (3rd ed.). Boston:: Pearson Education/Addison Wesley, 2011. .

Swaray, R., Primary Commodity Dependence And Debt Problem In Less Developed Countries. *Applied Econometrics and International Development., Vol. 5*(4), 131, 2005.

Vancouver Community College Learning, C, *Vancouver Community College* . Retrieved September 21, 2022, from Macroeconomics: MPC, MPS & Multiplier Effect Vancouver Community College © 2013 Vancouver Community College Learning Centre , 2013. https://www.leonschools.net/cms/lib/FL01903265/Centricity/Domain/2805/Multiplier%20Practice.pdf

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