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EXPORT- LED GROWTH HYPOTHESIS FOR GHANA: A TVAR & TVECM ANALYSIS

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ABSTRACT

This study employs threshold models to examine the export-led growth hypothesis (ELG) for Ghana from 1970-2018. The analysis commences as follows. Firstly, using real GDP as threshold variable, the study conducts a non-linearity test for the threshold vector autoregressive (TVAR) model as against the linear vector autoregressive (VAR) model. Secondly, the study evaluates whether the ELG hypothesis is best explained with linear co-integration models or threshold co-integration models. The empirical results indicate that, the ELG hypothesis is supported by the two-threshold vector autoregressive model (threshold values of 2.35 and 2.46) and a two-threshold vector error correction model (threshold values -0.50 and -0.20). The error correction term of the TVECM is negative and statistically different from zero, signifying speed of long run convergence. In terms of threshold co-integration, real GDP versus real exports and real GDP vs real imports are threshold co-integrated. In contrast, the null hypothesis of linear co-integration is not rejected for real export versus real import.

Contribution/Originality: This study uses new estimation methodology to evaluate the export – output growth nexus for Ghana for the period spanning from 1970-2018.

1. INTRODUCTION

According to Ulrich (2014); Krueger (1978); Ram (1985); Salvatore and Hatcher (1991) export-output hypothesis (ELG) is described as the positive effects of export growth on output through its multiplier effect. The unanimous argument gravitates towards the believe that exports stimulates output growth (see for instance Rivera-Batiz and Romer (1991)). Alternatively, Arnade and Vasavada (1995); Ghartey (1993); Lancaster (1980); Stavrinos (1987) argued in favour of the growth-led exports (GLE) hypothesis, that is output growth causes export growth.

Hitherto, the literature on ELG has documented some findings and they are categorised as follows. The earlier studies such as Balassa (1978); Michaely (1977); Heller and Porter (1978); Tyler (1981); Feder (1983) focused on cross-country analysis. They found that exports positively affect output growth in developing countries. However, their study precluded the plausibility of causality running from exports to imports or vice versa. Another group of studies evaluated the export-output nexus for individual countries using (Granger, 1969) or Sims (1972) causality test. Findings showed exports growth has no causal impact on output growth (see for instance (Dodaro, 1993; Love, 1994; Riezman, Summers, & Whiteman, 1996; Sharma & Dhakal, 1994)). Another strand of studies that employed co-integration and error correction found long run convergence between output and export. Generally, their findings revealed causality running from exports to output or in both ways (see for instance (Asafo, 2017; Asafo &

Matuka, 2019; Bahmani-Oskooee, 1993; Bahmani-Oskooee & Economidou, 2009; Bahmani-Oskooee & Oyolola, 2007; Fosu, 1990; Love & Chandra, 2004). Another strand of studies employed panel co-integration methods to examine the ELG hypothesis. Findings presented by Abu-Qarn and Abu-Bader (2004); Bahmani-Oskooee, Economidou, and Goswami (2005); Reppas and Christopoulos (2005); Jun (2007); Richards (2001) found causality running from output to exports. Also, Parida and Sahoo (2007) showed that higher exports stimulate higher output growth. In addition, more recent works such as Yamada (1998); Awokuse and Christopoulos (2009); Liu and Zhang (2015) explained the ELG hypothesis via neo-classical production function or augmented production functions. Given that studies on the ELG hypothesis has been dominated by linear VAR models, findings from such models might be susceptible to different periods of the business cycle (recessions, recoveries and growth) leading to misleading policy conjecture. That is, in the presence of structural break, linear VAR models might not capture the true dynamics in the time series (see for instance (Haddad, 2010; Lee & Huang, 2002)).

Motivated by the above argument, this paper contributes to the existing literature by examining the dynamics between exports, imports and output in Ghana using threshold regression models as developed by Hansen (2000). The paper follows (Arisara, Liu, & Sriboonchitta, 2019) to evaluate the ELG hypothesis for Ghana via a two-threshold vector autoregressive (TVAR) model and two-threshold vector error correction (TVECM) model. At the time of writing this paper, there is no known study employing TVAR and TVECM to examine the ELG for Ghana. The contribution of the study depends on providing answers to the following research questions.

(a) Is the relationship between exports, import and output growth non-linear in Ghana? if yes,

(b) Is the relationship threshold co-integrated?

The empirical analysis to the above research questions is presented as follows. Firstly, the paper conducts a non-linearity test for the two-TVAR model as against the linear VAR model by employing the logarithm of real GDP (lGDP)[1] as threshold variable. Following the multivariate extension of the linearity test of Hansen (1999); Lo and Zivot (2001), the likelihood ratio (LR) test suggests a rejection of the null hypothesis of linearity in favour of non-linearity. The implication is that, the export-output nexus in Ghana is non-linear and it is validated by the two-TVAR model. The generated threshold values of 2.35 and 2.46 represents the turning points at which real output growth passes-through above the threshold signifies the expansive stage of the business cycle. In the lower regime ($\pi \leq$ 2.35) and upper regime ($\pi \geq$ 2.46), none of the lagged values of real output is positive and statistically significant. However, in the middle regime (2.35$<\pi\leq$2.46), real output values at the first lag pass through are positive and statistically significant. This implies that real GDP, real export and real import pass-through at varied stages of the business cycle. Secondly, results of the two-TVECM model for IEX versus IGDP showed threshold values of (-0.52 and -0.20). The error correction term (ECT) is negative and statistically significant in regime 1 and 2, implying speed of adjustment to the long term. In terms of threshold co-integration, a residual bootstrap approach with 100 simulation replications is used to ascertain whether the relevant variables converge to long run equilibrium. Findings indicate that real GDP vs real exports and real GDP vs imports are threshold co-integrated. On the other hand, the null hypothesis of linear co-integration is not rejected for real exports versus real imports.

A further justification for the usage of threshold models for the study is provided in Figure 1. That is, albeit the endogenous variables (lGDP, lEX, lIM) are subjected to first differencing, they still remained non-stationary due to structural breaks and regime changes.

[1] Henceforth output and real GDP will be used unchangeably to mean the same thing.

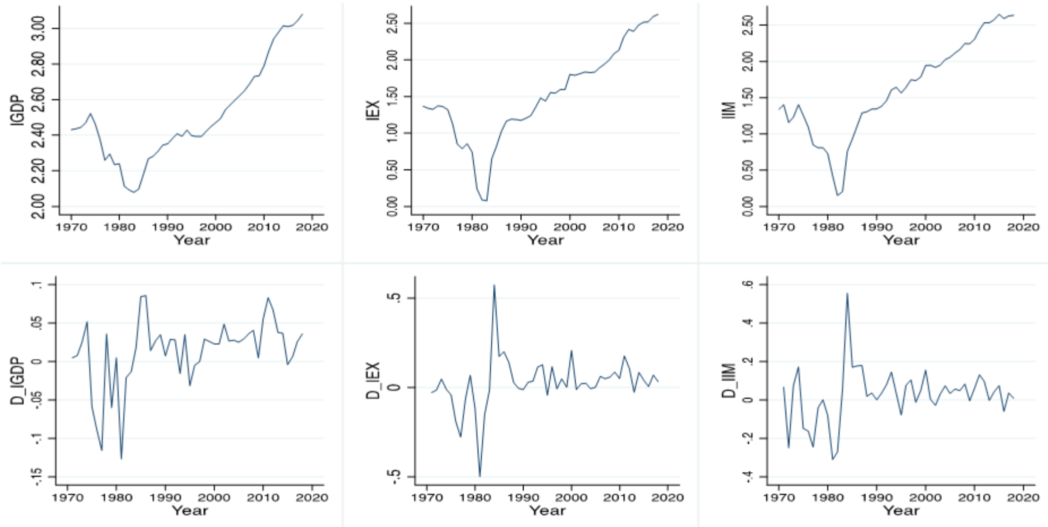

Figure-1. Levels and first differences of endogenous variables. Note: The upper panel are variables in log-levels whilst the lower panel are first differenced series. The D_ = the first difference of the relevant series and l= logarithm of the relevant series.

The rest of the paper is structured as follows. Section 2 describes the methodology. Section 3 presents the data description. Section 4 shows the empirical results. Section 5 provides the concluding remarks.

2. METHODOLOGY

2.1. Threshold Vector Autoregressive Model (TVAR)

The paper estimates a two-threshold model in Equation 1 as follows.

$$y_t = \begin{cases} a_1 + \Psi_1(L)y_t + \varepsilon_{1t} & \text{if } q_t \leq \gamma_1 \\ a_2 + \Psi_2(L)y_t + \varepsilon_{2t} & \text{if } \gamma_1 < q_t \leq \gamma_2 \\ a_3 + \Psi_3(L)y_t + \varepsilon_{3t} & \text{if } q_t > \gamma_2 \end{cases} \tag{1}$$

Where, y_t refers to vector of endogenous variables, q_t is the threshold variable(s), γ_1 and γ_2 are threshold values, a_i is a 3x1 vectors of intercepts, whilst the lag polynomial $\Psi_i(L)$ = $\Psi_{i1}(L)+\Psi_{i2}(L^2)+\ldots+\Psi_{iP}(L^P)$ with 4x4p matrix, where Ψ_{ij}, J=1,2…p and L refers to the lag operator. The compact form of the TVAR model is expressed in Equation 2 as follows:

$$y_t = \begin{cases} a_1 + \Psi_{11}(L)y_{t-1} + \cdots + \Psi_{1p}(L)y_{t-p} + \varepsilon_{1t})I(q_t \leq \gamma_1) \\ a_2 + \Psi_{21}(L)y_{t-1} + \cdots + \Psi_{2p}(L)y_{t-p} + \varepsilon_{2t})I(\gamma_1 < q_t \leq \gamma_2) \\ a_3 + \Psi_{31}(L)y_{t-1} + \cdots + \Psi_{3p}(L)y_{t-p} + \varepsilon_{3t})I(q_t > \gamma_2) \end{cases} \tag{2}$$

Where I(.) is a binary indicator which takes the value of 1 if the argument is satisfied and zero otherwise. Given that $\lambda = (a_1, a_2, a_3, \Psi_1, \Psi_2, \Psi_3, \gamma_1, \gamma_2)$ is the vector of coefficients, the study uses ordinary least squares (OLS) to minimize the following function in Equation 3 as follows:

$$\hat{\lambda} = \operatorname{argmin}_{\lambda}\left(\sum_{t=1}^{T}\left(\begin{array}{c} y-(a_1+\Psi_{11}(L)y_{t-1}+\cdots+\Psi_{1p}(L)y_{t-p}+\varepsilon_{1t})I(q_t \le \gamma_1) \\ -(a_2+\Psi_{21}(L)y_{t-1}+\cdots+\Psi_{2p}(L)y_{t-p}+\varepsilon_{2t})I(\gamma_1 < q_t \le \gamma_2) \\ -(a_3+\Psi_{31}(L)y_{t-1}+\cdots+\Psi_{3p}(L)y_{t-p}+\varepsilon_{3t})I(q_t > \gamma_2) \end{array}\right)\right) \qquad (3)$$

2.2. Threshold Vector Error Correction Model (VECM)

Balke and Fomby (1997) proposed the TVECM to examine the adjustment of variables to long run equilibrium. In a bivariate case such as (IGDP, lEX), the two variables behave differently across regimes as stated in Equation 4 as follows:

$$\Delta y_t = u_t + F(e_{t-1})I + \sum_{i=1}^{k}\chi_k \Delta y_{t-k} + u_t \text{ ; } t=1,..,n. \qquad (4)$$

Where, $F(e_{t-1}) = \delta a_1 e_{t-1} + (1-\delta) a_2 e_{t-1}$ and $\delta = \left\{\begin{array}{l} 1 \text{ if } e_{t-1} \le \lambda_1 \\ 0 \text{ if } e_{t-1} > \lambda_2 \end{array}\right\}$, F(…) = is an indicator function of the error correction term (e_{t-1}) with mean zero and constant variance , $a_i{'} = (a_{1,i}, a_{2,i})$ and $\chi_i{'} = (\chi_{1,i}, \chi_{2,i})$ refers to the adjustment and short term equilibrium coefficients, the TVECM error term (u_t) is Gaussian, that is E(u_t, u_t) = Σ.. Following (Hansen & Seo, 2002) the threshold effects is explored via a quasi-maximum likelihood estimator on a grid search[2], as shown in Equation 4 above with $\lambda_1 = \lambda_2 = \lambda$ and $\beta_0 = \beta_2 = 0$. The likelihood function of Hansen and Seo (2002) is specified as follows in Equation 5:

$$L(a_i{'}, \chi_i{'}, \beta_1, \Sigma, \lambda) = -\frac{n}{2}\log|\Sigma| - \frac{1}{2}\sum_{t=1}^{n} u_t(a_i{'}, \chi_i{'}, \beta_1, \Sigma, \lambda)' \sum_{t=1}^{n-1} u_t(a_i{'}, \chi_i{'}, \beta_1, \Sigma, \lambda) \qquad (5)$$

The parameters ($a_i{'}, \chi_i{'}, \Sigma$) are maximized by the likelihood function by assuming that (β_1, λ) are fixed which leads to a constrained maximum-likelihood estimator (MLE) of Δy_t on the error correction (e_{t-1}) and $\Delta y_{t-1}, .., \Delta y_{t-k}$ for each of the fixed coefficients (β_1, λ). The function is presented in Equation 6 as follows:

$$L(\beta_1, \lambda) = L(\beta_1, \lambda, \hat{a}_i{'}(\beta_1, \lambda), \hat{\chi}_i{'}(\beta_1, \lambda), \hat{\Sigma}(\beta_1, \lambda)) = -\frac{n}{2}\log|\hat{\Sigma}(\beta_1, \lambda)| - n. \qquad (6)$$

In Equation 7, the MLEs ($\widetilde{\beta_1}$, $\hat{\lambda}$) minimizes $\log|\hat{\Sigma}(\beta_1, \lambda)$ with the probability, *P* that observations are outside the following threshold:

[2] The grid search is conducted through a co-integrating vector and the threshold coefficients together with fixed regressors and residual bootstrap method.

$$\pi_0 \leq P(e_{t-1} \leq \lambda) \leq 1-\pi_0 \qquad (7)$$

Where π_0 = trimming parameter (15% trimming value is assigned in this study). By employing the Supremum Lagrange Multiplier test (sup-LM) of Andrews and Ploberger (1994) the study examined the null hypothesis of linear co-integration against the alternative of threshold co-integration. The test is shown below in Equation 8:

$$\text{SupLM}=sup_{\lambda_1 \leq \lambda \leq \lambda_2} \text{LM} (\beta_1, \lambda) \qquad (8)$$

3. DATA

3.1. Datasets

The datasets used in this study is taken from the International Finance Statistics of the International Monetary Fund for the period 1970-2018. All datasets are taken as millions of domestic currencies and later transformed into logarithm to remove the trend components. The vector of endogenous variables is stated as: Y = (lGDP, lEX, lIM)[3]. The Table 1 shows the descriptive statistics of the endogenous variables. On average, output, export and import at current prices is about 35241.57 million (Ghc), 10427.37 million (Ghc) and 12831.05 million (Ghc) respectively. In terms of variability, the variables are respectively 70918.72, 23647.34 and 26922.16.

Table-1. Descriptive statistics.

Variable	Mean	Std.Dev	Min	Max
GDP	35241.57	70918.72	0.5535181	300596.1
EX	10427.37	23647.34	0.0478192	105111.2
IM	12831.05	26922.16	0.0353296	108378.7

Note: Descriptive statistics in millions of domestic currencies, Std.Dev=standard deviation, Min=minimum, Max=maximum.

4. EMPIRICAL RESULTS

4.1. Unit Root and Co-integration Analysis

Given that macroeconomic time series often are non-stationary, the underlying series is specified in a linear VAR model to check the presence or otherwise of unit root (see for instance (Dickey & Fuller, 1979; Dickey & Fuller, 1981)). Results presented in Table 2 suggest that the null hypothesis of unit root is not rejected when variables are at levels[4]. However, at first differences the null hypothesis is rejected, implying that the series is first difference stationary.

Table-2. Unit root test.

Variables	Levels ADF p-value	First Difference ADF p-value	Levels PP p-value	First Difference PP p-value
lGDP	0.5202	0.0318**	0.9901	0.0002***
lEX	0.3399	0.0102***	0.9391	0.0003***
lIM	0.3497	0.0091***	0.9338	0.0003***

Note: ***, ** and * reveals 1%,5% and 10% level of significance. ADF=Augmented Dicker Fuller Test, PP = Phillips Perron Test.

Subsequently, the Akaike information Criterion (AIC) and the Hanna-Quinn Information Criterion (HQIC) are used to select the optimal lag order for the linear VAR model. Both the AIC and HQIC indicated 4 lags see Table 3. Following the approach of Johansen (1988); Johansen and Juselius (1990) the co-integrating rank of the time series is examined by employing Johansen trace statistics and maximum eigenvalue statistics. Reports in Table 4 suggests a rejection of the null hypothesis of no co-integration at the 5% level. At maximum ranks 1 and 2, both the trace and

[3] lGDP=logarithm of gross domestic product, lEX=logarithm of export, lIM=logarithm of import.

[4] This is true for both Augmented Dickey Fuller test and Phillips Perron test.

maximum eigenvalue statistics are lower than the 5% critical value. The implication therefore is that, there is the presence of at least 1 or 2 co-integrating equations in the model.

Table-3. Lag selection criteria.

Lag	FPE	AIC	HQIC	SBIC
0	.000016	-2.50088	-2.45538	-2.37676
1	5.7e-08	-8.17301	-7.99103	-7.67653*
2	4.9e-08	-8.32958	-8.01112	-7.46074
3	3.8e-08	-8.61129	-8.15634	-7.3701
4	2.8e-08*	-8.93866*	-8.34723*	-7.32511
5	3.0e-08	-8.91326	-8.18535	-6.92736
6	4.5e-08	-8.6062	-7.74181	-6.24794
7	5.0e-08	-8.6348	-7.63392	-5.90418

Note: Akaike information Criterion (AIC) and the Hanna-Quinn Information Criterion (HQIC), Final Prediction Error (FPE), Schwarz-Bayesian Information Criterion (SBIC).

Table-4. Johansen cointegration test.

Hypothesis	Trace Statistic	5% Critical Value	Eigen Statistic	5% Critical Value
0	42.47**	29.68	29.51**	20.97
1	12.95	15.41	10.58	14.07
2	2.36	3.76	2.36	3.76

Note: ***, **, * refers to 1%, 5% and 10% significance levels.

4.2. The Non-Linearity Test

The paper conducts a non-linearity test for the two-TVAR model as against the linear VAR model by using IGDP as threshold variable. The threshold values are the turning points at which real output passes through beyond the threshold represents the expansive regime. To test the null hypothesis of linearity as against the alternative hypothesis of non-linearity (t=1,2), where t=threshold value, the study relies on the multivariate extension of linearity test by Hansen (1999); Lo and Zivot (2001). In Equation 9 the likelihood ratio (LR) test is stated as follows.

$$LR_{01} = T\left(\ln(\det \widehat{\Sigma}_0) - \ln(\det \widehat{\Sigma}_1)\right) \qquad (9)$$

Where, $\widehat{\Sigma}_0$ represents the estimated covariance matrix for the model under the null hypothesis and $\widehat{\Sigma}_1$ represents the estimated covariance matrix for the alternative hypothesis. Findings from the LR test leads to the rejection of the null hypothesis of linearity in favour of non-linearity. These empirical results show that, the ELG hypothesis for Ghana is supported by the two-threshold VAR model see Table 5.

Table-5. Likelihood ratio test.

LR test for linearity vs. 1 threshold	
LR statistic.	163.38
p-value	0.00
Estimated threshold	2.35
LR test for linearity vs. 2 thresholds	
LR statistic.	403.39
p-value	0.00
Estimated threshold	2.35; 2.46

4.3. Threshold VAR Results[5]

The Table 6 below reports findings of the ELG hypothesis by way of the two-TVAR model. In the lower regime ($\pi \leq 2.35$) and upper regime ($\pi \geq 2.46$), none of the lag values of real output is positive and statistically

[5] The generalized impulse response functions (GIRFs) for each regime can be provided on request.

significant. However, in the middle regime (2.35< π ≤2.46), real output values at the first lag pass through are positive and statistically significant. The implication is that, real GDP, real export and real import pass-through at varied phases of the business cycle. In effect, structural breaks in the series has the tendency to influence the regimes. The model's threshold values of 2.35 and 2.46 see Figure 2 appendix are generated from a grid search over a range of probable values of the threshold variable (IGDP) that guarantee a switch between regimes.

Table-6. Results of the two-threshold VAR model.

Variables	Regime 1 π(-1) ≤ 2.35 Percentage of observations = 31.1%	Regime 2 2..35< π (−1) ≤ 2.46 Percentage of observations = 31.1%	Regime 3 π(-1) ≥ 2.46 Percentage of observations = 37.8%
lGDP			
Intercept	3.6292 (1.7559)	1.7223 (1.7990)	0.0022 (0.5774)
lGDP-1	-0.1049 (1.0178)	1.0406 (0.3761)*	1.9230 (0.9290)
lEX-1	0.0224 (0.8967)	0.5623 (0.2758)	-0.1287 (0.2926)
lIM-1	0.0244 (0.8951)	-0.3544 (0.3429)	-0.3715 (0.3589)
lGDP-2	-0.5658 (1.2461)	0.6429 (0.5300)	-0.9302 (0.8784)
lEx-2	-0.2032 (0.5217)	0.2919 (0.2442)	0.1529 (0.3044)
lIM-2	0.4888 (0.5547)	-0.1068 (0.2274)	0.3990 (0.3743)
lGDP-3	-0.2098 (1.1473)	-0.7047 (0.5695)	-0.4086 (0.8498)
lEX-3	-0.3337 (0.5518)	-0.1871 (0.2007)	-0.2325 (0.3566)
lIM-3	0.3116 (0.6156)	0.1173 (0.1586)	-0.0587 (0.2866)
lGDP-4	0.0614 (0.7093)	0.4073 (0.9870)	0.3713 (0.5840)
lEx-4	-0.4568 (0.7884)	0.0666 (0.1560)	-0.0891 (0.3348)
lIM-4	0.5561 (0.8010)	-0.0574 (0.2679)	0.3837 (0.2264)
lEX			
Intercept	9.5282 (2.5842)*	1.3438 (2.6477)	-0.4072 (0.8498)
lGDP-1	2.2157 (1.4980)	0.4180 (0.5535)	1.4125 (1.3673)
lEx-1	0.1763 (1.3198)	-0.7643 (0.4058)	0.2397 (0.4306)
lIM-1	0.0437 (1.3173)	1.1671 (0.5046)	0.0924 (0.5283)
lGDP-2	-1.9458 (1.8339)	0.6279 (0.7801)	-2.0394 (1.2928)
lEx-2	0.0725 (0.7678)	0.5747 (0.3594)	0.0820 (0.4480)
lIM-2	0.7013 (0.8163)	-0.8314 (0.3347)*	0.3062 (0.5508)
lGDP-3	0.2522 (1.6885)	-0.4927(0.8381)	0.2676 (1.2507)
lEx-3	-3.9604 (0.8121)**	-0.0821 (0.2953)	0.1794 (0.5248)
lIM-3	4.2810 (0.9060)**	0.9124 (0.2334)**	0.2529 (0.4218)
lGDP-4	-0.7793 (1.0439)	-1.0778 (1.4526)	0.3678 (0.8595)
lEX-4	-2.7731 (1.1602)	0.1332 (0.2296)	-0.6198 (0.4927)
lIM-4	2.8703 (1.1788)	-0.2026 (0.3942)	0.5967 (0.3332)
lIM			
Intercept	7.9265 (2.2520)*	5.9470 (2.3073)*	-0.0821 (0.7406)
lGDP-1	-0.1139 (1.3054)	-0.4206 (0.4823)	3.0357 (1.1915)*
lEx-1	0.5974 (1.1501)	-0.4201 (0.3537)	0.1301 (0.3752)
lIM-1	0.5265 (1.1479)	1.3981 (0.4398)*	-0.1621 (0.4604)
lGDP-2	-3.5463 (1.5981)	-0.3157 (0.6798)	-2.9090 (1.1266)*
lEx-2	0.5647 (0.6691)	0.7723 (0.3132)*	-0.6058 (0.3904)
lIM-2	0.1624 (0.7114)	-1.1361 (0.2917)**	1.1344 (0.4800)
lGDP-3	1.2464 (1.4714)	-0.2283(0.7304)	0.7619 (1.0899)
lEx-3	-3.8609 (0.7078)**	0.2595 (0.2574)	-0.1678 (0.4573)
lIM-3	4.1736 (0.7896)**	1.0413 (0.2034)**	0.0772 (0.3676)
lGDP-4	-1.4320 (0.9097)	-1.6522 (1.2659)	-0.9897 (0.7491)
lEX-4	-3.3393 (1.0111)*	-0.0085 (0.2001)	0.1689 (0.4294)
lIM-4	3.5393 (1.0273)*	-0.6093 (0.3436)	0.8143 (0.2904)*

Note: ***, ** and* represents 1%, 5% and 10% critical values.

4.4. Threshold VECM Results

The Table 7 below shows the results of the two-TVECM model for IEX versus IGDP[6]. The threshold values of (-0.52 and -0.20) are generated via a grid search with percentage of observations of 25%, 25%, 50% for the lower,

[6] Results for the other variables can be provided on request.

middle and upper regimes respectively. The error correction term (ECT) is negative and statistically significant in regime 1 and 2. The implication is that, the model undergoes adjustment to the long term

Table-7. Results of Two-Threshold VECM Model

Variables	Regime 1 $\pi(-1) \leq -0.52$ Percentage of observations = 25%	Regime 2 $-0.52 < \pi(-1) \leq -0.20$ Percentage of observations = 25%	Regime 3 $\pi(-1) \geq -0.20$ Percentage of observations = 50%
lGDP			
ECT	-0.2609 (1.6e-05)***	-3.1536 (0.0002)***	0.0010(0.9766)
Intercept	-0.2666 (1.3e-05)***	-0.9134 (0.0002)***	0.0184(0.1462)
lGDP-1	-1.5691 (0.0001)***	-2.2860 (0.0030)**	0.5388(0.0848)
lEX-1	0.5513 (1.6e-06)***	1.8803 (0.0002)***	0.0254(0.7873)
lGDP-2	-1.3606 (0.0001)***	-8.3109 (0.0002)***	-0.2408(0.3949)
lEx-2	0.4655 (6.4e-05)***	1.3930 (0.0042)**	0.1427(0.1266)
lGDP-3	-1.4416 (1.8e-05)***	-6.1288 (0.0002)***	-0.0823(0.7382)
lEX-3	0.3737 (4.8e-05)***	3.3352 (0.0006)***	-0.0404(0.6710)
lGDP-4	0.4748 (0.1093)	-6.4178 (0.0006)***	0.0961(0.7124)
lEx-4	0.3800 (0.0048)**	-0.2738 (0.0814)	-0.0526(0.4822)
lEX			
ECT	-0.3562 (0.0151)*	-7.5890 (0.0017)**	-0.0255(0.8214)
Intercept	-0.1808 (0.1832)	-2.2395 (0.0016)**	0.0332(0.3947)
lGDP-1	1.8489 (0.0662)	-5.6918 (0.0137)*	1.5441(0.1150)
lEX-1	0.8261 (0.0022)**	4.6901 (0.0013)**	-0.2470(0.4116)
lGDP-2	0.2392 (0.7743)	-17.2635 (0.0047)**	-0.7778(0.3852)
lEx-2	-0.1968 (0.4653)	4.5358 (0.0034)**	0.0119(0.9666)
lGDP-3	-1.2594 (0.1020)	-16.0986 (0.0011)**	-0.1367(0.8606)
lEX-3	-0.1940 (0.3590)	6.7633 (0.0133)*	-0.1122(0.7086)
lGDP-4	4.0248 (0.0004)***	-13.3990 (0.0111)*	0.5255(0.5259)
lEx-4	-0.0179(0.9610)	-0.9917 (0.0495)*	0.0348(0.8822)

Note: ***, ** and* represents 1%, 5% and 10% levels.

4.5. Linear Co-Integration vs Threshold Co-Integration

This section of the paper follows (Krolzig, 1997) to evaluate whether the ELG hypothesis is best described using linear co-integration models or threshold co-integration models. Using the residual bootstrap approach with 100 simulation replications, the null hypothesis of linear co-integration is examined against the alterative of threshold co-integration. Results of the Supremum Lagrange Multiplier (Sup-LM) is shown in Table 8 below. The study rejects the null hypothesis of linear co-integration in favour of threshold cointegration for IGDP versus IEX and IGDP versus IIM. However, the study refuses to reject the null hypothesis of linear co-integration for IEX versus IIM. The economic intuition is that, whereas IGDP versus IEX and IGDP versus IIM converges to long run equilibrium, there is no evidence of long run adjustment for IEX versus IIM. The density of bootstrap distribution confirms normality in the endogenous variables (see Figure 3, Figure 4 and Figure 5 in appendix).

Table-8. Linear co-integration vs threshold co-integration.

Variables	Sup-LM p-value	Critical Values	Maximized threshold value	Co-integrating value
IGDP versus IEX	26.87* [0.07]	25.89 (90%) 27.04 (95%) 28.06 (99%)	-2.30	-1.51
IGDP versus IIM	29.69* [0.01]	26.25 (90%) 27.73 (95%) 29.55 (99%)	-0.63	-0.80
IEX versus IIM	26.599 [0.19]	27.91 (90%) 29.52 (95%) 31.06 (99%)	-0.053	-1.07

Note: p-values in squared brackets. The co-integrating value is estimated under restricted linear model.

5. CONCLUDING REMARKS

The study employs annual data from 1970-2018 to examine the ELG hypothesis for the Ghanaian economy using threshold models. Findings indicate that the ELG hypothesis is characterised by two-threshold VAR model (threshold values of 2.35 and 2.46) and two-threshold TVECM (threshold values of -0.50 and -0.20). Further empirical reports show that real output, real exports and real imports pass through at various times in the business cycle. In addition, the error correction term is negative and statistically significant in regime 1 & 2, implying long run adjustment. The Supremum Lagrange Multiplier test indicates that exports versus output and output versus imports are threshold co-integrated. In contrast, exports versus imports are not threshold co-integrated.

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APPENDIX

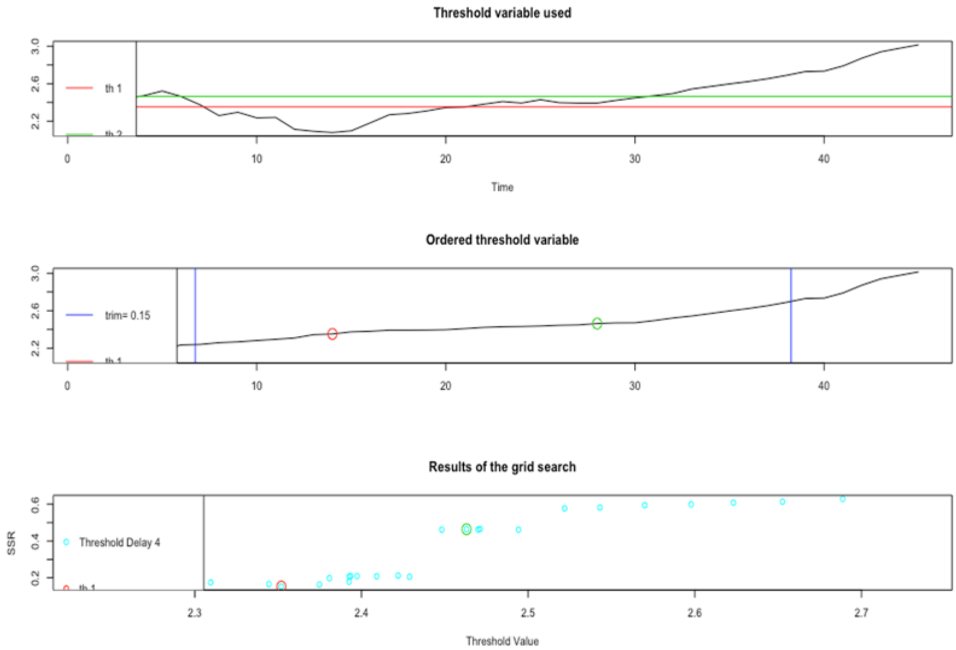

Figure-2. Grid search for the two-threshold VAR model.

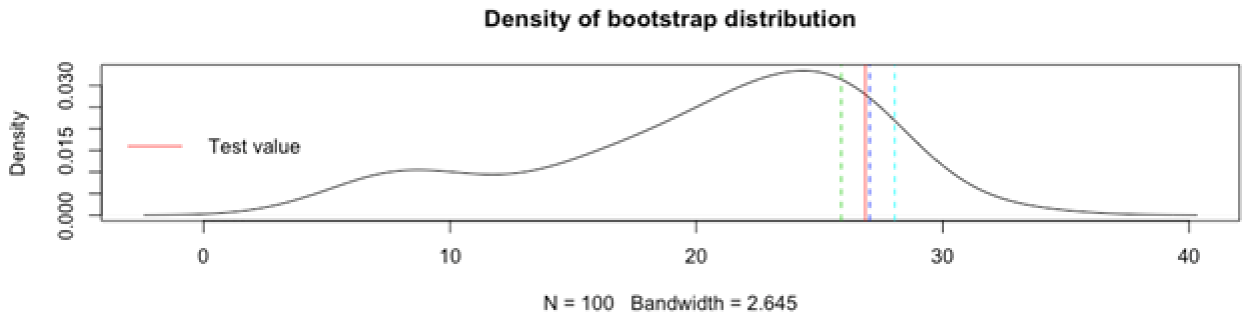

Figure-3. Density of Bootstrap Distribution for IGDP versus IEX.

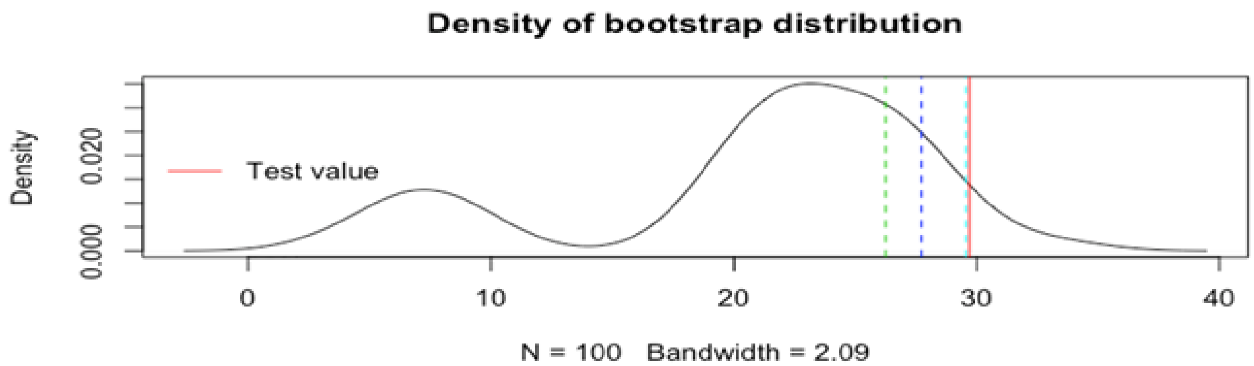

Figure-4. Density of bootstrap Distribution for IGDP versus IIM.

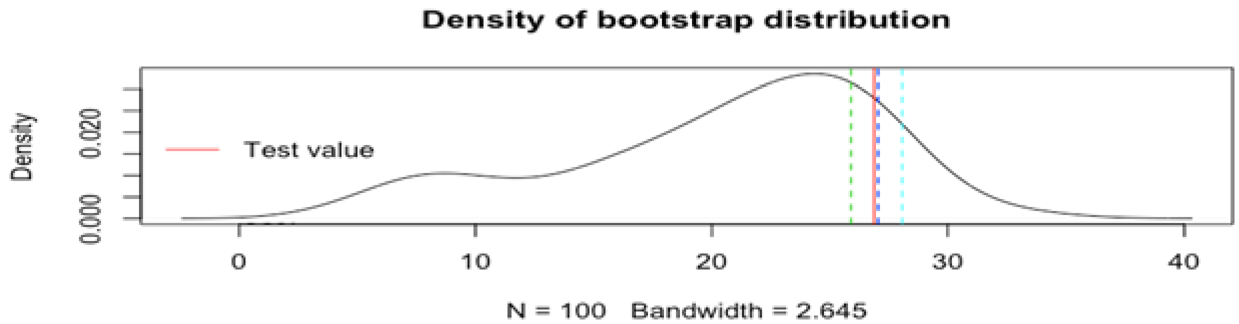

Figure-5. Density of Bootstrap Distribution IEX versus IIM.