

# Sectoral output Volatility and Economic growth in Ethiopia

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Research

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# Sectoral output Volatility and Economic growth in Ethiopia

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## Abstract

In this study we examined the determinants of economic growth, and the effect of sectoral output volatility on economic growth of Ethiopia using national bank of Ethiopia (NBE) and the World Bank (WB) time series data ranging from 1981 to 2018. We included capital stock, working age population, trade balance and, sectoral output volatility as an explanatory variable. The sectoral output volatility was computed using Exponential General Autoregressive Conditional Heteroscedasticity (EGARCH) technique. Estimating three different ARDL models, we found long run relationship between economic growth and explanatory variables. From the long run ARDL model economic growth was positively and statistically significantly affected by capital stock—both in the long run and in the short run. In the long run trade balance (which has been negative throughout the study period) was found to have negative and statistically significant effect on economic growth. In the long-run volatility of industrial and service sector output growth was found to have negative and statistically significant effect on economic growth of Ethiopia. However, the study proved that the working age of population had no statistically significant effect on economic growth of Ethiopia. As the economy exhibits structural transformation from the agricultural to modern sectors the relative significance of sectors also change. In recent years the role of agriculture to Ethiopian economy, particularly in terms contribution to the national GDP has been declining—indicating the growing importance of service and industrial sectors. Therefore, smoothening and maintaining the positive sectoral output growth is advisable for the betterment of the economy. In addition, balancing the foreign trade, specially augmenting and diversifying of the export structure, and curbing of unrestricted importation of goods, is recommended as long as economic growth is concerned.

**Keywords:** Volatility, EGARCH, ARDL, Sectors, Growth

**JEL Classification:** E32, O40

## Introduction

Much research has been conducted on the matter of economic growth. However, as important as economic growth is its volatility (Meller, 2013), particularly much attention has been directed to the issue of the relationship between volatility and economic growth (Lin & Kim, 2013). Output volatility affects the aggregate economic growth, the stock market, and economic forecasting (Abubaker, 2015). In the realm of mainstream economics, the question of how volatility affects economic growth is relatively new (Dabušinskas, Kulikov, & Randveer, 2012). The output volatility gained center stage among economists and policy-makers (Lamaa, Jhab, Paula, & Gurunga, 2015).

According to Wen-Shwo Fang (2008) different models show a negative, positive, or independent relationship between the output growth rate and its volatility. Nevertheless, it is well known that volatility of output affects economic growth through two known channels. In one hand, high volatility indicates more income risk, which ultimately raises precautionary savings; this in turn boosts investment and hence economic growth (Kehinde & Agnes, 2017). On the other hand, high volatility causes investment risk, which tends to discourage investment in economy and consequently slow down economic growth. For output volatility generates risk about future investment, leading to a negative connection between output volatility and economic growth (Wen-Shwo Fang, 2008). Some studies based on endogenous growth theories framework, have also postulated different form of empirical relationships between volatility and long run economic growth (Onyimadu, 2016).

The economic discourse on the consequences of output volatility for an economy is multifaceted and, so far, it has rendered diverse results (Jungeilges & Ryazanova, 2018). Many researchers are concerned about high output volatility for it is closely associated with other negative aspects of economic problem (Center for Global Development). For instance, the output volatility can adversely affect economic growth, poverty and welfare among others (Bugamelli & Paternò, 2011). Ramey and Ramey (1995) concluded that there is a negative correlation between macroeconomic volatility and long run economic growth. Conventionally, business cycle and economic growth models have been treated as separate policies, in the sense that economic fluctuations are short-run and economic growths are a long-run phenomenon, and are determined independently in different time horizons (Lin & Kim, 2013). For example, in the Solow growth model and the IS-LM framework, it was believed that the two phenomena had different causes and that; consequently, long-term economic growth was independent of cyclical

factors (Dabušinskas, Kulikov, & Randveer, 2012). In the AK framework, however, the effect of volatility on economic growth is ambiguous as it depends on two offsetting effects. In the one way, higher volatility leads to higher precautionary saving, resulting in higher investment and thereby faster economic growth. On the other way, higher volatility reduces risk-adjusted incomes, which tends to lower investment and growth. The net effect depends on the elasticity of inter-temporal substitution, which is usually also equal to the coefficient of relative risk aversion, and particularly on whether it is bigger or smaller than unity (Dabušinskas, Kulikov, & Randveer, 2012).

Macroeconomic volatility varies significantly across nations (Tang & Leung, 2016), and much effort has been devoted to study the reasons behind and its subsequent effect on long term economic growth, and whether there are possibilities for policies to improve the situation. Sectoral volatility on the other hand is the primary source of aggregate GDP fluctuations for most economies and, understanding why some sectors have higher output volatility is therefore important (Olabisi, 2019). Therefore studying of how sectoral volatility affects economic growth is crucial for designing macroeconomic policies.

The Ethiopian economy, disaggregated in to the agricultural, industrial and service sectors, has been growing annually at the rate 10 in past two decades. The Agricultural sector, which is the backbone of the majority of Ethiopians, with an estimated more than 70 percent of the labor force engaged in this sector (Dechassa & Tolosa, 2015) is vulnerable for frequent drought and output shortfall. The service sector is becoming the main figure of the Ethiopian economy, particularly in its contribution to the national output. The industrial sector on the other hand, fueled by policy ineffectiveness (Adisu, 2019) has been experienced negligible contribution to the economy. This shift of sectoral contribution from agricultural to non-agricultural sectors to economic growth is due the underlying of structural transformation in the economy. Due to its volatility in growth rate, however, the Ethiopian economy is being considered as one of its stylized facts. However, whether this volatility would have negative, positive or neutral effect on GDP is doubtful. To the extent that most of the recent volatility in growth rate of GDP can attributed to the increasing share of the some volatility of the some prominent sectors (such as service sector), analysis of sectoral output volatility effect on can be useful in providing some enlightenment on the factors behind this phenomenon and its implications for policy formulation. Hence, the objectives of the study are; to assess the sectoral output volatility in Ethiopia over the study period, and to examine the effects of sectoral output volatility on economic growth. The rest of this paper is organized as follows; chapter two literature review, chapter three methodologies of the study, chapter four results and discussion, and chapter five concluding remarks.

## **Literature Review**

The causes of high volatility and economic crises in developing countries can be largely associated with higher exposure to exogenous shocks and augmenting factors, faulty policies and structural problems. The exposure to exogenous shocks includes both exposure to real external shocks (such as terms of trade) and financial external shocks (Center for Global Development). Output volatility in turn affects economic growth through two major networks. Firstly, high volatility implies more risk in income, which tends to raise savings and encourages investment and economic growth (Kehinde & Agnes, 2017). Secondly, high volatility means more investment risk, which depresses investment in economy and thereby slow downing of the economic growth. This ultimately establishes a negative relationship between output growth and its volatility (Wen-Shwo Fang, 2008).

There are numerous empirical studies conducted on the link between output volatility and economic growth. Abubaker (2015) investigated the impact of trade openness on output volatility. By using a panel dataset for 33 countries from the period of 1980 to 2009 and standard deviation of quarterly real GDP over a 5-year span as the dependent variable, the study revealed that trade openness increases the output volatility. Moreover, the study revealed that trade openness has less effect on output volatility of more developed countries. Dabušinskas, Kulikov and Randveer (2012) investigated the impact of macroeconomic volatility on growth in a panel of 121 countries over the period 1980 to 2010. Their study showed that macroeconomic volatility is negatively related to economic growth using a different empirical methodology. Meller (2013) studied the relationship between international financial markets integration and output volatility. In the framework of a threshold model, it is empirically shown that in countries with low financial risk, financial openness decreases output volatility while financial openness increases output volatility in countries with high financial risk. Onyimadu (2016) investigated the relationship between macroeconomic volatility and long run economic growth in a panel of 40 African countries over the period 1980 – 2014. Their findings concluded that there exist a significant and positive correlation between volatility and economic growth with reference to the sample data set used, which is against the negative relationship between volatility and economic growth postulated by Ramey and Ramey (1995) and Aghion *et. al.* (2005). Laurenceson and

Rodgers (2010) studied whether the growth volatility has an impact on the trend rate of growth of china. Using a GARCH-M model, the analysis results confirm that volatility had either positive or insignificant impact, but not negative. Kehinde and Agnes (2017) investigated the impact of agriculture output volatility on economic growth in Nigeria. By using time series data ranging from 1970–2013, employed Generalized Autoregressive conditional Heteroscedasticity (GARCH) model to calculate volatility of agriculture output and Eigen value test to capture the long term effects, the result revealed that agriculture output volatility have a negative and statistically insignificant impact on economic growth though. Iseringhausen and Vierke (2018) also studied the determinants of output volatility in a panel of 22 OECD countries. Using a Bayesian model selection to test for the presence of the non-stationary component, the results identified demographics and government size as important determinants of macroeconomic volatility. Specifically, a larger share of prime-age workers is linked with lower output volatility, while higher public expenditure intensifies output volatility. Safdar, Maqsood, and Ullah (2012) studied the agriculture sector volatility and its link with the economic growth in Pakistan. Using Auto Regressive Conditional Heteroscedasticity (ARCH) models to detect volatility of agriculture sector and cointegration test, their study showed that agricultural productivity and employment are positively and significantly associated with economic growth. The study also suggested agricultural volatility is negatively contributing for economic growth of Pakistan. Ćorić (2019) investigated variations in output volatility in 38 OECD and non OECD countries over the last two centuries. The study confirms significant structural changes in output volatility in all countries. A more than 70% of detected structural changes indicate a reduction in output volatility suggesting that output volatility has been declining over the last two centuries. The results also show that the patterns of output volatility are different across countries. Mekonnen and Dogreul, (2017) empirically assessed the impact of openness on growth volatility in 29 Sub-Saharan African countries. Using data from 1981 to 2010 and system GMM method their results showed that both trade and financial openness significantly reduce growth volatility in Sub-Saharan Africa. Furthermore, Trade in ‘manufacturing goods’ significantly reduce volatility in comparison to trade in ‘non-manufacturing goods’. Notwithstanding its importance of studying output volatility there is lack of such studies in the Ethiopian context.

## **Data and Methodology**

### **Data type and Source**

This study relied on secondary time series data. The dataset is taken from the national bank of Ethiopia (NBE) and the World Development Indicators of World Bank. Particularly the study used six variables namely; economic growth, capital stock, working age population, trade balance and, agricultural, industrial and service sectors output volatility. Economic growth is measured as the natural logarithm of Gross Domestic Product ( $\ln$ GDP) in 2010 constant price. However, there is no readymade data for capital stock. For this case we generated capital stock data following Degu and Bekele (2019) using perpetual inventory<sup>†</sup> technique. The data for trade balance which has been negative throughout the study period is defined as the natural log of net trade in goods and services is derived by compensating imports of goods and services against exports of goods and services, and data are in current U.S. dollars. While the working age population is defined as total number of population between the ages 15 to 64 and the value is concerted in to the natural logarithm. Finally, the sectoral output volatility data are generated using Exponential General Autoregressive Conditional Heteroscedasticity technique.

### **Exponential General Autoregressive Conditional Heteroscedasticity (EGARCH)**

The standard measure of volatility, the standard deviation of output growth, for it captures high-frequency shocks, is not suitable for an economy whose growth is characterized by frequent incidents of accelerated growth and growth breaks (Tang & Leung, 2016), which is the characteristic feature for many developing countries like Ethiopia. Therefore, sectoral output volatilities for this study are to be generated from the Exponential Generalized

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<sup>†</sup> Perpetual inventory approach is useful to generate capital stock data whenever the true capital stock data is unavailable. The technique uses the following equation;

$$K_t = I_t + (1 - \delta) K_{t-1}$$

Where  $K_t$  and  $K_{t-1}$  is capital stock at time  $t$  and  $t-1$ , respectively,  $I_t$  is investment at time  $t$  and  $\delta$  is the depreciation rate which is assumed to be 5% per annum. However, once again the initial level of capital stock ( $K_0$ ) is mandatory so as to compute the subsequent ones. Therefore, the initial capital stock can be estimated from the Solow model steady state equilibrium. Consider the following equation;

$$K_0 = I_0 / (\delta + g)$$

Where  $K_0$  is the initial capita stock,  $I_0$  is the initial real investment,  $\delta$  is annual average depreciation rate and  $g$  the average geometric growth rate of real investment over the study period (1981- 2018). Once we determined the values of  $K_0$ ,  $I_0$ ,  $\delta$  and  $g$ , we can compute the level of capital stock at each period using the above equation.

Autoregressive Conditional Heteroskedastic (EGARCH) process which is the extension of General Autoregressive Conditional Heteroscedasticity model. GARCH (General Autoregressive Conditional Heteroscedasticity) model was first developed by Bollerslev (1986), does not capture the asymmetric nature or skewness caused by the inverse correlation between volatility and returns referred to as the leverage effect (Ezzat, 2012). The GARCH model also uses declining weights for the squared residuals that are estimated by the model. The conditional variance equation of the standard GARCH model has a form of:

$$(\delta_t)^2 = \theta + \sum_{j=1}^a \beta \delta_{t-1}^2 + \sum_{i=1}^p \alpha \varepsilon_{t-1}^2 \dots \dots \dots (1)$$

Where  $\theta$ ,  $\alpha$ ,  $\beta$  are non-negative parameters with  $\alpha + \beta < 1$  but should be close to unity for an accurate model specification. Extension of GARCH model is Exponential GARCH (EGARCH) to capture the “leverage effect”. This effect explain unexpected value drop increases volatility more than an analogous unexpected value increase. In this paper we consider simple Exponential GARCH (1, 1) (EGARCH) model, which is adequate for time series volatility modeling (Risteski, Sadoghi, & Davcev, 2013). The specification for the conditional variance in the EGARCH (1, 1) model is given by:

$$\ln(\delta_t)^2 = \theta + \beta \ln \delta_{t-1}^2 + \alpha \left| \frac{\varepsilon_{t-1}}{\delta_{t-1}} \right| + \gamma \left| \frac{\varepsilon_{t-1}}{\delta_{t-1}} \right| \dots \dots \dots (2)$$

One major advantage of the EGARCH process is that it captures the leverage effect of past shock on the conditional variance and also ensures positive values for the conditional variance without preconditions for the signs on the volatility parameters (Scott, 2018). Besides, there are no restrictions on the parameters  $\theta$ ,  $\alpha$ , and  $\gamma$ . However, in order to maintain stationarity,  $\beta$  need be positive but less than one. The leverage effect, indicated by the value of  $\gamma$ , must be negative and significant for the leverage effect to be present (Ezzat, 2012). Once the sectoral output volatility is extracted the next step is examining the possible empirical link between sectoral output volatility and economic growth Ethiopia using the following regression equation. In the regression we included physical capital (Capital Formation), demographic factor (working age population), trade activities (trade balance) and sectoral output volatility that determine Economic growth in Ethiopia.

$$GDP = f(\text{Capital Formation, working age population, trade balance, Sectoral Volatility} \dots \dots \dots (2)$$

**Autoregressive Distributed Lag (ARDL) approach to Co-integration**

Co-integration which defined as the long-term relationship between explained and an explanatory variable is to be examined based Bound test to Co-integration. Bound test approach to co-integration is found from the ARDL framework. The above equation (2) is to be estimated via ARDL technique of estimation. ARDL models are suitable for small sample sizes, compared to the Johansen co-integration technique. Another advantage of ARDL model is it generates consistent estimates of long- run coefficients that are asymptotically normal, regardless of whether the variables are purely stationary al level, at first difference or a combination of them (Pesaran et al., 2001). Besides, one well-known advantage of working with ARDL specification, where all right-hand side variables enter the equation with a lag, is that it mitigates any contemporaneous causation from the dependent to the independent variables which might bias the estimates (Bane, 2018). The ARDL model can be separated further as Long run and short run equation. Consider the following equations for which the ARDL model constructed for economic growth as dependent variable.

$$\Delta(\ln GDP)_t = \beta_0 + \sum_{j=1}^p \alpha_j \Delta(\ln GDP)_{t-j} + \sum_{l=1}^p \alpha_l \Delta(X_t - l) + \beta_1(\ln GDP)_{t-1} + \beta_2(\ln X_t - i) + \varepsilon_t \dots \dots (3)$$

Where ‘ $\Delta$ ’ is the first difference operator,  $\ln$  denotes logarithmic operator,  $i$  is the maximum lag number,  $\ln GDP_t$  is natural log Gross domestic product measured by 2010 constant price, of,  $X_t$  is a vector of independent variables,  $\varepsilon_t$  are error terms.  $\alpha_i$  and  $\beta_i$  are the short-run and long-run coefficients of independent variables, respectively.

Pesaran, et al. (2001) suggested, ARDL bounds test for co-integration with two sets of asymptotic critical values to test the null hypothesis of no co-integration. The first set of critical values assumes that all variables in a study are stationary at level, I(0)—produces lower bound, whereas the second set of critical values constructed based on the assumption of all variables are stationary after first difference, I(1)—produces upper bound. If the test statistics greater than the upper bounds of critical values, the null hypothesis of no co-integration is rejected. Similarly, if the test statistics is below the lower bounds of critical values, the null hypothesis of no co-integration is accepted. However, if the test statistics is laid in between, the co-integration test becomes inconclusive. Since the ARDL

procedure is sensitive for a given lag length, the number of appropriate lags to be selected by Akaike Information Criteria (AIC). It is also worthwhile to examining the level of integration of variables using Augmented Dickey-Fuller (ADF) unit root test before proceeding to cointegration testing. Once the existence of co-integration is confirmed, a dynamic error correction model can be extracted from ARDL model. If error correction term (ECT) is negative and significant it will confirm the long-run relationship between economic growth and explanatory variables in Ethiopia. The following equation (4) represents the short-run dynamics for *lnGDP* model.

$$\Delta(\ln(GDP))_t = \beta_0 + \sum_{j=1}^p \beta_j \Delta(\ln(GDP)_{t-j}) + \sum_{l=1}^p \beta_l \Delta(\ln(X)_{t-l}) + YECT_{t-1} + \mu_t \dots (4)$$

Where  $\beta$ 's are the coefficients associated with short-run dynamics of the model coverage to equilibrium,  $ECT_{t-1}$  is the error correction term and  $\mu_t$  is stochastic error term.

### Estimation Results and Discussion

The first step in the time series analysis is to identify the order of integration of variables under consideration. Thus we applied the augmented dickey fuller (ADF) unit root test to evaluate the order of integration of variables. Accordingly, the test result as indicated in **Table 1** below, revealed that some variables such as sectoral output volatilities are integrated of order zero I(0), and rest of them are integrated order of one I(0). Hence all variables under consideration are a mixture of I(0) and I(0)—making suitable for ARDL estimation technique.

**Table 1 Unit Root Tests**

Variables	Level		First difference		Integration
	ADF test stat.	Probability	ADF test stat.	Probability	
<i>lnGDP</i>	-0.895067	0.9459	-6.220483	0.0001	I(1)
<i>lnK</i>	-1.028399	0.9271	-5.244252	0.0007	I(1)
<i>lnWAP</i>	-1.813809	0.6736	-3.790085	0.0308	I(1)
<i>lnNE</i>	-1.566472	0.7864	-10.89692	0.0000	I(1)
VA	-3.804961	0.0275	-7.517253	0.0000	I(0)
VIN	-4.341938	0.0090	-3.441375	0.0642	I(0)
VSR	-3.996502	0.0175	-6.936990	0.0000	I(0)

### Cointegration Tests

Cointegration refers to a long run stable relationship between series under consideration. There are different methods of test for Cointegration among the variables such as the Johansen test approach and the two steps Engle and Granger cointegration test. However, these tests for their application require the targeted independent variables expected to be stationary at same level of integration. Particularly, estimation of variables with the presence of a combination of different level stationary under the Johansen procedure may lead to biased results. Another problem associated with these techniques is that they are not dependable for relatively small samples. In this study we used ARDL bound test approach to cointegration to examine the possible link between GDP, capital stock, working age population, trade balance and sectoral output volatility. For this purpose we constructed three different models (A, B and C) by including the same dependent variable (*lnGDP*) and independent variables, except sectoral output volatilities. Agricultural sector output volatility, industrial sector output volatility and service sector output volatility are separately included as an explanatory variable in the first, the second and the third models, respectively.

**Table 2 ARDL bound test**

Model		A		B		C	
F-statistic		9.11799		20.50453		13.38960	
Selected lag length		ARDL (3, 1, 0, 1, 2)		ARDL (3, 1, 1, 3, 2)		ARDL (3, 1, 3, 3, 3)	
Bounds		I(0) Bound	I(1) Bound	I(0) Bound	I(1) Bound	I(0) Bound	I(1) Bound
Significance level	10%	2.2	3.09	2.2	3.09	2.2	3.09
	5%	2.56	3.49	2.56	3.49	2.56	3.49
	2.5%	2.88	3.87	2.88	3.87	2.88	3.87
	1%	3.29	4.37	3.29	4.37	3.29	4.37
Null Hypothesis: No long-run relationships exist				Note: K is 4 for all three models			

As the ARDL models are lag sensitive the appropriate lag length is chosen based on the Akaike information criterion (AIC). Accordingly, the ARDL (3, 1, 0, 1, 2), ARDL (3, 1, 1, 3, 2) and ARDL (3, 1, 3, 3, 3) is selected for

respective three models. The results of the Bound test of the three models are reported in the **Table 2**. Accordingly, the F-statistics of the first, the second and the third models is, 9.11799, 20.50453 and 13.38960, respectively, which is much higher than the above bound limit value, even at 1 % percent significance level. Therefore, we can conclude that there exists a long-run relationship between variables when economic growth is treated as an explained variable.

### Long run and Short run Estimation results

The long-run estimation results for all the three models are reported in **Table 3** below. In the first model (column A) economic growth (GDP) regressed against capital stock, working age population, trade balance and agricultural output volatility. Accordingly economic growth in Ethiopian is affected by capital stock positively and significantly. Similarly, trade balance has a negative and statistically significant effect on economic growth of Ethiopia, in the long-run. Whereas, working age population has negative but insignificant effect. However, agricultural output volatility has insignificant effect on Economic growth of Ethiopia. In the second model (column B) economic growth regressed alongside capital stock, working age population, trade balance and industrial output volatility. Capital stock once again has positive and significant level on economic growth. Trade balance on the other hand has negative and statistically significant effect on economic growth. Industrial output volatility is found to be affecting economic growth negatively at one percent significance level. This implies that economic growth is affected by the fluctuation of industrial sector performance.

In the third model (C) economic growth regressed on capital stock, working age population, trade balance and service output volatility. Service sector output volatility is found to be having a negative and significant effect on economic growth of Ethiopia. In recent years the service sector has been expanding and dominating the economic activities. The sector encompasses of 40 percent of GDP and 20 percent of total employment as of 2019. Capital stock has positive and significant effect on economic growth of Ethiopian, as depicted in the three estimated long run models. Capital stock which is scarce for most developing countries is more productive and it backs much an economy. This shows how capital stock is contributing factor for long run and sustained economic growth of the country. When capital stock grows by one percent, economic growth increases by about 0.57, 0.31 and 0.37 percent, in the first, second and third models, respectively. Trade balance (export value less import value) which is negative throughout the study year on the other hand, has a negative and statistically significant effect on economic growth of Ethiopian in all three estimated models. A one percent increase in the trade balance leads the GDP to decrease by about 0.19, 0.23 and 0.26 percent in the first second and third models, respectively.

**Table 3 The long-run estimation results**

Explanatory Variables	Long-run Models ( <i>ln</i> GDP is dependent variable))					
	A		B		C	
	Coefficient	P- value	Coefficient	P- value	Coefficient	P- value
<i>ln</i> K	0.57	0.0001	0.31	0.0021	0.37	0.0121
<i>ln</i> WAP	-0.33	0.3202	0.18	0.4168	0.015	0.9602
<i>ln</i> TB	-0.19	0.0024	-0.23	0.0000	-0.26	0.0001
VA	2.80	0.6328	--	--	--	--
VIN	--	--	-22.9	0.0003	--	--
VSR	--	--	--	--	-18.36	0.0338
C	8.74	0.0039	6.478	0.0010	6.95	0.0061

The significant and negative impact of trade balance on the on economic growth can be liked with the nature of foreign trade. Almost all developing countries, including Ethiopia, have an unfavorable trade balance due to their structure of exports and imports. These countries export fewer commodities (usually unprocessed and raw materials, such as such as coffee, hides, skins, oilseeds, and pulses) and imports more substantial amount of manufactured and final products. The price of primary products, which is price and income inelastic, is determined by international market. This leads to unfavorable trade balance that ultimately consumes the countries scare foreign currency reserve.

**Table 4 Short Run estimation results**

Explanatory variables	Short-run Models ( $\Delta$ <i>ln</i> GDP is dependent variable)					
	A		B		C	
	Coefficient	P- value	Coefficient	P- value	Coefficient	P- value
$\Delta$ ( <i>ln</i> GDP(-1))	0.2258267	(0.294111)	0.089861	(0.3653)	-0.072799	(0.5707)
$\Delta$ ( <i>ln</i> GDP(-2))	0.33554346	(0.123776)	-0.360151	(0.0026)	-0.344689	(0.0140)

$\Delta(K)$	0.93747872	(0.003125)	0.753185	(0.0010)	0.863342	(0.0010)
$\Delta(\ln WAP)$	-0.16681371	(0.342126)	3.653739	(0.1992)	-0.128743	(0.9754)
$\Delta(\ln WAP(-1))$					-14.511161	(0.1294)
$\Delta(\ln WAP(-2))$					7.731625	(0.0883)
$\Delta(\ln TB)$	-0.02285180	(0.286055)	0.011451	(0.5324)	-0.024384	(0.2917)
$\Delta(\ln TB(-1))$			0.040586	(0.0705)	0.047498	(0.0861)
$\Delta(\ln TB(-2))$			0.079037	(0.0011)	0.040330	(0.1446)
$\Delta(VA)$	1.65742473	(0.553036)				
$\Delta(VA(-1))$	6.13840302	(0.016052)				
$\Delta(VIN)$			-4.694646	(0.0310)		
$\Delta(VIN(-1))$			7.008578	(0.0021)		
$\Delta(VSR)$					-7.729906	(0.0219)
$\Delta(VSR(-1))$					6.048293	(0.0292)
$\Delta(VSR(-2))$					-3.406614	(0.1474)
ECT(-1)	-0.50235087	(0.0000)	-0.638287	(0.0000)	-0.535833	(0.0000)

After a long run relationship between the explanatory variables being established, next step this is to test error correction model for all three models, and the results are reported under **Table 4**. In the short run the capital sock has positive and significant effect on economic growth of Ethiopia as it is portrayed in all three models. The results of the error correction terms (ECT) of the first, the second and the third models are -0.50, -0.64 and -0.53 respectively, with a one percent significance level and expected negative sign, which confirms the existence of long run relationship between the economic growth and explanatory variables. Technically speaking, the estimated coefficients ECT (-0.50, -0.64 and -0.53) indicated that approximately 50%, 64% and 53 % of the disequilibria from previous year shock converge back to the long run equilibrium each period, in the first, second and third models, respectively.

### Diagnostic tests

So as to scrutinize the reliability of the estimated ARDL long-run and short-run models, we performed different diagnostic tests such as; Jaque-Bera Normality test Breusch-Godfrey LM serial correlation test, Breusch-Pagan-Godfrey Heteroskedasticity test, and Ramsey RESET test. The tests and their respective statistics results are summarized in **Table 5** below. Accordingly, the residuals are normally distributed, there is no serial correlation and the models have no specification problem. Therefore, the estimated coefficients are consistent and efficient—implying the basic classical assumptions are satisfied, and policy implications of the model are reliable.

**Table 5 Diagnostic tests**

Tests	A		B		C	
	F- Statistics	P-value	F-Statistics	P-value	F-Statistics	P-value
Jarque-Bera Normality test	2.041760	360278	1.195017	0.5502	0.613349	0.7359
Breusch-Godfrey LM serial correlation test	1.119713 (3,20)	0.3647	0.270554 (3,17)	0.8457	0.225193 (3,14)	0.8773
Breusch-Pagan-Godfrey Heteroskedasticity test	1.909683 (11,23)	0.0921	1.566125 (14,20)	0.1751	1.200235 (17,17)	0.3555
Ramsey RESET test	0.353620 (1, 22)	0.5581	0.896488 (1,19)	0.3556	1.644074 (1, 16)	0.2180

Note: the degree of freedom (d.f) is in parenthesis

### Concluding Remarks and Policy Implications

In this study we established determinants of economic growth, and the effect of sectoral output volatility on economic growth of Ethiopia using national bank of Ethiopia (NBE) and the World Bank (WB) time series data ranging from 1981 to 2018. We included capital stock, working age population, trade balance and, sectoral output volatility as an explanatory variable. Sectoral output volatility was computed using Exponential General Autoregressive Conditional Heteroscedasticity (EGARCH) technique. We estimated three different ARDL models to determine the cointegration and, the long-run and short run dynamic between variables. All three estimated models revealed the presence of long run relationship between economic growth and explanatory variables. From the long run ARDL model, we found that capital stock, trade balance, industrial and service sector output volatility had significant effect on economic growth of Ethiopia. Particularly, economic growth was positively and statistically significantly affected by capital stock—both in the long run and in the short run. This particular finding is parallel with some other empirical findings (such as Biruk, 2017; Khalid and Kenji, 2016; Mohanty, 2017) who claimed that

physical capital had positive and statistically significant effect on economic growth of Ethiopia. In the long run trade balance (which has been negative throughout the study period) was found to have negative and statistically significant effect on economic growth. In the long-run volatility of industrial and service sector output growth was found to have negative and statistically significant effect on economic growth of Ethiopia. However, the study proved that the working age of population had no statistically significant effect on economic growth of Ethiopia. This is in consistence with the study of Mohanty (2017), who showed that population and economic growth had no significant relationship in the long run. Thus, economic growth in Ethiopia is highly determined by the availability capital investment, trade balance and sectoral output fluctuations. The results of the error correction terms (ECT) of the first, the second and the third models are -0.50, -0.64 and -0.53 respectively, with a one percent significance level and expected negative sign, which confirms the existence of long run relationship between the economic growth and explanatory variables. Technically speaking, the estimated coefficients ECT (-0.50, -0.64 and -0.53) indicated that approximately 50%, 64% and 53 % of the disequilibria from previous year shock converge back to the long run equilibrium each period, in the first, second and third models, respectively.

As the economy exhibits structural transformation from the agricultural to modern sectors the relative significance of sectors also change. In recent years the role of agriculture to Ethiopian economy, particularly in terms contribution to the national GDP has been declining—indicating the growing importance of service and industrial sectors. Therefore, smoothening and maintaining the positive sectoral output growth is advisable for the betterment of the economy. In addition, balancing the foreign trade, specially augmenting and diversifying of the export structure, and curbing of unrestricted importation of goods, is recommended as long as economic growth is concerned.

### Declarations

**List of Variables and Data Sources:-** The dataset is taken from the national bank of Ethiopia (NBE) and the World Development Indicators of World Bank.

Variables	Data Sources
Economic growth (GDP)	World Bank, World Development Indicators (2020)
Capital stock	Author's extraction using National Bank of Ethiopia data (2020) & Perpetual inventory technique
Working age population	World Bank, World Development Indicators (2020)
Trade balance	World Bank, World Development Indicators (2020)
Agricultural sector output volatility	Author's extraction using the World Bank data (2020) & EGARCH approach
Industrial sector output volatility	Author's extraction using the World Bank data (2020) & EGARCH approach
Service sector output volatility	Author's extraction using the World Bank data (2020) & EGARCH approach

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