Effect of oil price volatility on the trade balance in sub-Saharan Africa

Priscilla Forson*, John Bosco Dramani*, Prince Boakye Frimpong*, Eric Arthur* and Sulemana Mahawiya**

*Department of Economics, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. Email: boscodramani@gmail.com
**Liberal Studies Department, Kumasi Technical University, Kumasi, Ghana.

Abstract

Crude oil price volatility as an important driver of the trade balance of economies has been widely documented in the literature. However, studies on the effect of oil price volatility on the trade balance in sub-Sahara Africa (SSA) are limited. In this paper, we explore the effect of crude oil price volatility on the trade balance across 34 SSA countries using Pooled Mean Group (PMG) and Common Correlated Effect Pooled Mean Group (CCEPMG) estimators for the period January 2004 to December 2017. We find that crude oil price volatility exerts a negative effect on the trade balance of SSA countries. We further demonstrate that inflation, interest rates and exchange rates are significant transmission channels for oil price volatility to impact trade balance. We suggest that policymakers hedge as well as adopt price-smoothing schemes to minimise the volatility of oil prices on trade balance. Again, countries should adopt an inflation-targeting regime to ensure the stability of the general price level. Finally, central banks of the respective countries should apply a combination of foreign exchange market interventions and interest rate changes to reduce the effect of oil price volatility on their trade balance when the exchange rate is taken into account.

1. Introduction

Crude oil is an essential part of every economy and it constitutes a significant percentage of energy for households, firms and government to perform functions such as heating, production and transportation. Since crude oil is important for these economic agents, the volatility of their prices has serious implications not just for the individuals, but also for various macroeconomic activities. For instance, volatility in crude oil prices can significantly affect the trade balance of most sub-Saharan African (SSA) countries because they rely profoundly on crude oil imports to meet their needs for petroleum products. The risk associated with high oil price volatility is that it causes uncertainty that can lead to a reduction in international trade flows for exporters and importers. The extent to which the trade balance of SSA countries is affected by oil price volatility can be attributed to their status as either importers or exporters of oil (Chen and Hsu, 2012). Oil exporting countries gain from oil revenue when oil prices increase, while oil-importing countries lose as they borrow to avoid shocks of unfavourable terms of trade (Jawad, 2013; Akinlo and Apanisile, 2014; Nusair, 2016). In addition, Oil price volatility's effect on trade flows can influence consumers to cut back their purchase and utilisation of durable goods, and firms to reduce productions and investments as transport cost increases (Chen and Hsu, 2012). This implies a fall in total demand and thus, a reduction in international trade flows.

The increased demand for crude oil in China, Latin America, Middle East and uncertainty of global oil supply also accounted for changes in oil price and resulted in high oil prices in the United States in 2008 (Liu *et al.*, 2016). In 2005, the price of oil was 54.57 dollars per barrel, it later rose to 72.44 bbl/d in 2007 and 96.94 bbl/d in 2008. As of 2018, the price of oil was 71.34 bbl/d. The high crude oil price, which averaged 111.26 bbl/d between 2010 and 2014 caused trade deficits for oil importers because of the inelastic nature of oil demand, while some oil exporters experienced trade surplus (Taghizadeh-Hesary *et al.*, 2019). These surges and downturns in oil prices over the years also affected transportation expenses and the volumes of goods and services traded across countries, thereby affecting the overall trade balance. For instance, between the period 1990 and 2000, global exports of crude oil rose from $344.5 billion to $579.4 billion and this rose again to $2,394.1 billion in 2008 (United States Energy Information Administration [USEIA], 2017). However, the Global Financial Crisis caused a fall in crude oil exports due to the decline in demand which triggered prices to fall. In addition, advances in technology led to discoveries and subsequent drilling caused oversupply leading to a fall in exports to $1,491.2 billion in 2009. Global imports rose again to $2,616.6 billion until the latter parts of 2011. Finally, global oil imports again decreased to $1,666 billion, attributed to hikes in oil prices in 2012 (USEIA, 2017). These changes in oil prices are likely to exert a significant effect on the macroeconomy especially the trade balance. [Correction added on 3 October 2022, after first online publication: A sentence in this paragraph and their corresponding cited references have been removed in this version.]

Most countries in SSA are exporters of unprocessed goods for a significant percentage of the American, European, and Asian markets but consumers for a weighty amount of finished goods from their trading partners. Some of the commodities exported by SSA are gold, timber, cocoa, copper, cotton, crude oil and coal (IMF, 2015). However, the volatility in crude oil price is considered the most important driver of a greater percentage of SSA of trade terms and balances (Jibril, 2016). Trade balance determines a country's trade performance, thus, an improved trade balance causes improvement in an economy and vice versa. Over the years, oil importers have experienced continuous trade deficits than oil exporters in the SSA. For instance, in 2015, Kenya's trade balance was −7.06 million US dollars, Zambia was −6.45 million US dollars and Cote d'Ivoire was −1.15 million US dollars. Even though the high cost of crude oil may not be the only cause of these staggering trade deficits in SSA, we cannot refute that it is not an important driver since crude oil imports constitute between 10 and 15 per cent of overall imports and consume about 30 per cent of export revenue of SSA economies (UNCTAD, 2006). Similarly, in 2016, deterioration in commodity prices such as crude oil caused a fall in the terms of trade of SSA countries by 16 per cent, with oil exporters experiencing the greatest losses in their terms of trade (Africa's, Pulse, 2016). The deterioration in the terms of trade caused the region as a whole to experience a decline in economic activity by 0.5 per cent and weakened the fiscal balance and current account by 2 and 4 per cent, respectively (Africa's Pulse, 2016).

Oil price volatility has drawn much attention from policymakers and academics across the globe because of its effects on macroeconomic outcomes. The conclusions from the empirical literature have also been varied. For instance, Le and Chang (2013) disclosed the presence of a one-way causality from oil price disturbances to non-related oil trade balances in Japan but found oil price variability to drive the total and non-related trade balances in Malaysia. Huynh (2016) established that oil price shocks improved the energy component of trade balance, deteriorated the non-oil trade balance but induced a diminutive effect on the total trade balance in Singapore. Gbatu *et al.* (2017) detected that the rising cost of oil ignited a redistribution of resources from oil-intensive production sectors leading to high labour intensity which brought weighty outcomes on economic growth in Liberia relative to crude oil. Other studies have suggested that oil price changes affect economic growth (Taghizadeh-Hesary *et al.*, 2019; Akinsola and Odhiambo, 2020; Dramani and Frimpong, 2020). However, prior literature have failed to exclusively examine the effect of crude oil unpredictability on the trade balance of SSA countries. Further, prior literature have omitted the sources of oil price volatility transmissions on the trade balance in a panel framework.

Our study attempts to contribute to the literature by providing empirical evidence on the influence of oil price unpredictability on trade balance across 34 sub-Saharan African economies. Our contribution to the literature is in two-fold. Firstly, we seek to estimate the effect of oil price volatility on the trade balance of SSA by dividing the countries into oil-exporting and importing countries in addition to the overall SSA perspective. Secondly, we attempt to explore the transmission channels of oil price volatility on the trade balance in SSA. There are a plethora of channels through which crude oil price volatility may affect economies, and the economic impacts are transmitted through demand and supply-side channels (Le and Chang, 2013). Such channels are consumption of durable goods, the recession channel, interest rate, exchange rate and inflation.

The remaining sections of the study are organised as follows; we present an empirical review of relevant prior studies on oil price volatility and trade balance in section 2. Following the literature review, we select the appropriate empirical estimation techniques, measurement and data frequency and discuss them in section 3. The estimated results and findings are discussed in section 4 while section 5 presents conclusion and policy suggestions.

2. Literature review

Backus and Crucini (2000) study predicted that the changes in relative relevance of oil can cause an economies to respond differently to shocks in oil supply. The author indicated that changes in the prices and volumes of oil traded can influence variations in the terms of trade over time which can lead to unstable correlation pattern between prices of goods and services and volumes traded. Again, the authors augmented a stochastic two-country growth equation using an oil producing economy and asserted that variations in the terms of trade are determined by fluctuations in oil prices for industrialised countries. Their empirical analysis revealed that the relationship between relative prices and volumes of goods and service traded are unstable when caused by oil price shocks.

Bodenstein *et al*. (2011) expanded the work of Backus and Crucini (2000) and inferred that variations in price of crude oil greatly influenced non-oil trade balance by the transmission channel of wealth transfer running from those importing to the exporting ones. Responses from oil and non-oil trade balances influence the changes of the total trade balance to factors such as multiple shocks occurring simultaneously, oil shocks affecting equilibrium non-oil balance and oil price movements from different sources and channels. Insignificant price response to demand expressed by importing countries deteriorates the oil component of the overall trade balance when oil price increases, but improves that of oil exporting countries driven by reallocation of financial resources from net consuming to net exporting economies. Financial resource reallocation causes a fall in purchasing power and a fall in value of the domestic currency for oil importing countries which improves the non-oil trade balance. However, there is oil trade balance surplus for oil exporting countries when oil price increases through more wealth accumulation, exchange rate appreciation and a deterioration in non-oil trade balance. This possesses the potential to enhance the total trade balance given that the oil trade balance outweighs its non-oil counterpart.

Empirically, Kilian *et al*. (2009) estimated the effects of oil price changes on external balances (trade balance, capital gains, net foreign assets and current account) of 14 oil importers and 27 oil exporters using structural vector autoregression model (SVAR). The authors disclosed that unexpected oil price movements depended on the extent of upsurges in oil price and growth in the external balances. Confirming the finding of Kilian *et al.* (2009), Bodenstein *et al.* (2011) revealed that the consequences of demand and supply sides unexpected oil price movements on balance of trade on consuming and producing economies hinge on the reaction of the non-oil balance of trade. Chen and Hsu (2012) provided significant empirical indication of the negative effect of unexpected oil price movements on the expansion in bilateral trade among a panel of 84 countries. The authors adopted Kilian (2009)'s method and revealed that oil price fluctuations caused an adverse influence on net oil-importing economies but insignificant for oil exporting countries. Similarly, Shiu-Sheng and Kai-Wei (2013) used a Gravity Model for 117 countries across the world and indicated that if trade volumes were reduced as a consequence of unexpected oil price movements, then the negative effect increases with the distance transported. In applying an autoregressive distributed lagged (ARDL) approach for Pakistan, Hassan and Zaman (2012) found both short- and long-term adverse association between balance of trade and oil price unpredictability. The authors confirmed the conclusions of Arouri *et al.* (2014), who indicated that oil price unpredictability negatively affected India's trade balance, using vector autoregressive (VAR) and monthly data from 1980 to 2011. On the contrary, Iwayemi and Fowowe (2011) established that the trade balance of Nigeria expanded in the presence of upward surges in crude oil prices.

Employing a vector autoregressive (VAR) and impulse response function (IRF) from January 1999 to November 2011, the findings of Le and Chang (2013) revealed that, the trade balance of oil exporters (Malaysia) improved with an increase in oil revenues, oil-importers (Japan) also experience trade deficits, while oil refinery economies like Singapore, experienced negligible long-run effects on trade balance when oil prices increased. Taghizadeh-Hesary *et al.* (2019), using a Simultaneous Equation model (SEM) via Weighted Two Stage Least Squares (W2SLS) for 21 countries from 2000 Q1 to 2015 Q4, also found evidence that oil producing economies reaped significant benefits due to oil price increases while countries importing turn to suffer greatly. Mohammed *et al.* (2014) revealed that oil prices exerted adverse consequences on the balance of trade of many economies. Similarly, applying a threshold Vector Autoregressive (TVAR) model for Nigeria over the period 1986Q1 to 2013Q4, Jibril (2016) disclosed that oil prices unpredictability exerted adverse consequences on the various parts of the trade balance when a certain threshold is exceeded.

Worthy of revealing from the reviewed literature is the strong nonexistence of a complete agreement on the consequences of oil price variability on trade flows of countries. In addition, prior studies have failed to explore the potential pathways for oil price volatility transmitting into trade balance, particularly in SSA. Thus, applying a panel of 34 countries in SSA together with generalized autoregressive conditional heteroscedasticity (GARCH) and Pooled Mean Group (PMG) we filled the acknowledged literature gaps by estimating the effect of oil price volatility and transmission channels on trade balances in SSA.

3. Methodology

3.1. Model specification

The International Monetary Fund (IMF), defines trade balance as earnings from exports minus expenditure on imports of goods and services over a specified period. Thus, following the IMF, the trade balance is calculated as the difference between exports and imports of goods and services as shown in equation (1). Equation (1) defines trade balance where X represents exports and M denotes imports. Theoretically, exports are driven by income and real exchange rate of foreign trade partners whiles imports are dependent on the income of a domestic economy and its real equation 1 can be rewritten to form equations 2 and 3 as follows.

$$TB = X - M \tag{1}$$

$$TB = X\left(r, Y^f\right) - M\left(r, Y^d\right) \tag{2}$$

$$TB = TB\left(r, Y^d, Y^f\right) \tag{3}$$

In equations (2) and (3), r denotes real exchange rate, Y^d represents domestic income, Y^f captures foreign income. We augment equation 3 with oil price volatility together with macro-aggregates such as foreign direct investment, exchange rate, inflation and interest rate, as shown in equation (4). Even though domestic and foreign incomes are important determinants of the trade balance, we dropped them due to lack of monthly data.

$$TB_{it} = \beta_0 + \beta_1 OPV_{it} + \beta_2 ER_{it} + \beta_3 INF_{it} + \beta_4 IR_{it} + \beta_5 FDI_{it} + \varphi_i + \delta_t + \epsilon_{it} \tag{4}$$

In equation (4), OPV captures oil price volatility, ER denotes exchange rate, IR represent interest rate, INF denotes inflation and FDI denotes foreign direct investment. The subscripts t and i are time and country, respectively, whereas φ_i and δ_i represent country and time-specific effect, respectively. The ϵ_{it} captures the error term. All other variables have been transformed using the natural logarithm, thus, the coefficients denote elasticities.

Having considered oil price volatility effect on trade balance, we now turn to examine the transmission mechanisms. We used an interaction term to determine the transmission mechanism of oil price volatility effect on trade balance. Thus, exchange rate, inflation and interest rate are explored as the pathways of transmission in this study. A statistically significant interaction coefficient indicates that the variables are transmission pathways of oil price volatility on trade balance in SSA. Based on this, equation 4 is modified into equation (5), where, α_i denotes interaction coefficient, W represents either ER, INF or IR and ($OPV*W$) denotes interactive term between oil price volatility and inflation, exchange rate or interest rate. The other variables are already explained.

$$\begin{aligned} TB_{it} = \beta_0 + \beta_1 OPV_t + \beta_2 ER_{it} + \beta_3 INF_{it} + \beta_4 IR_{it} \\ + \beta_5 FDI_{it} + \varphi_i + \delta_i + \alpha_i (OPV*W) + \epsilon_{it} \end{aligned} \quad (5)$$

3.2. Measuring volatility

Volatility indicates the level of risk associated with the price of an asset. It is a measure of variation in the price of an asset for a given period of time. The frequent change in the price of an asset in a relatively short time, indicates high volatility while a relatively stable price, indicates low volatility. According to Chen and Hsu (2012), volatility measures can be categorised into three, namely, realised volatility, standard deviation and GARCH (1,1) model. The standard deviation is less likely to be an appropriate measurement for risk because of the assumption of normal distribution, even though the risk many assets in reality are not normally distributed. Also, it may be highly sensitive to outliers in returns, leading to underestimation of risk. Realised Volatility measure on the other hand, does not take into consideration any major shock in the market and not forward-looking. The GARCH (1,1) model is effective in modelling asset returns because it allows for lagged conditional variances, hence, considered as a standard approach for volatility modelling. Following this, we employed GARCH (1,1) model as specified in equations (6) and (7) to compute the volatility of oil prices for estimating equation 5.

$$OPV = \beta 0 * \sqrt{H} + \beta 1 * OD + \beta 2 * OS \quad (6)$$

$$H_t = \beta 0 + \beta 1 * e_{t-1}^2 + \beta 2 * H_{t-1} \quad (7)$$

In equations (6) and (7), OPV represents oil price volatility, OS denotes oil supply (proxied by global oil production), OD captures oil demand (proxied by global oil consumption), β's represents coefficients, H_t denotes GARCH, $\sqrt{H}$ is the square root of GARCH, H_{t-1} is lag of the GARCH and e is the residual.

3.3. Pooled mean group (PMG) estimation technique

We adopt a variety of panel techniques to evaluate the influence of oil price volatility on the trade balance in SSA. Firstly, we adopt Pooled Mean Group (PMG) estimator suggested by Pesaran *et al.* (1999). This procedure is consistent, efficient, accounts for the assumption of long-run homogeneity among the regressors and appropriate for long time series with large frequency. The Mean Group (MG) estimator also offers reliable estimates of the average of the coefficients in the long run, but there is the likelihood of inefficiency if the assumption of slope homogeneity holds. In addition, PMG is insensitive towards outliers and permits variations in the short run to be based on the data from the various countries taking into account the span of the series being used (Pesaran *et al.*, 1999). Further, for a larger T, Pesaran *et al.* (1999) revealed that the traditional estimation methods such as fixed effect, random effect, instrumental variables and Generalized Methods of Moment (GMM) produce inconsistent results. This study adopt the PMG which comprises amalgamating and averaging of the sample, the constant terms, short-run coefficients and the error variances which are permitted to vary across countries (heterogeneous) while the long run coefficients are homogenous.

Following Pesaran *et al.* (1999), we begin with an autoregressive distributed lagged (ARDL) model $(p, q, q, \ldots, q)$ and specify an error correction model in equation (8). Equation (9) captures the transmission variables which influence the balance of trade.

$$\Delta TB_{it} = \theta_i\left[TB_{i,t-1} - \gamma_i' X_{i,t}\right] + \sum_{l=0}^{p-1} \sigma_{il} \Delta TB_{i,t-l} + \sum_{l=0}^{q-1} \beta_{il}' \Delta X_{i,t-1} + \varphi_i + \epsilon_{it} \quad (8)$$

$$\Delta TB_{it} = \theta_i\left[TB_{i,t-1} - \gamma_i' X_{i,t}\right] + \sum_{l=0}^{p-1} \sigma_{il} \Delta TB_{i,t-l} + \sum_{l=0}^{q-1} \beta_{il}' \Delta X_{i,t-1} + \varphi_i + \alpha_i(OPV * W) + \epsilon_{it} \quad (9)$$

In equations (8) and (9), TB_{it} represents trade balance, X denotes vector of explanatory variables, σ_{il} represents coefficient of the lagged dependent variable, β_{il}' represents coefficient of the explanatory variables, φ_i denotes country-specific fixed effect, ϵ_{it} captures the error term, p and q represent lags of the dependent and independent variable, θ_i represents the speed of adjustment for the group-specific. It is anticipated that $\theta_i < 0$, γ_i' also denotes vector of long-run relationship, $[TB_{i,t-1} - \gamma_i' X_{i,t}]$ denote an error correction term which gives the long-run information in the model, σ_{il} and β_{il}' denote short run coefficients, $p-1$ and $q-1$ captures the difference lag lengths. To determine the suitability of the estimation techniques, we adopt the Hausman test to choose among the PMG estimator, Mean group and Dynamic fixed effect estimators.

Secondly, the cross-sectional independence test using Pesaran's CD-test was conducted. This test helps to measure the degree of dependence based on some common economic indicators among the selected countries in SSA. The source of dependence among countries maybe as a consequence of international trade and exposure to some common shocks, such as oil price volatility. Ignoring such dependences may cause estimation results to be spurious.

Before applying the above estimation techniques, the study tested for the unit root characteristics of the data to reveal the degree of integration of the variables. PMG has the potential to provide estimates that are consistent as long as the number of integrations does not exceed unity. Kim *et al*. (2010) reiterated the efficiency of PMG estimator in the presence of a single vector capturing long-term connection among the series. Therefore, we test to see if the series meet this condition.

There exist a number of techniques for testing unit roots in a panel framework. These include Im *et al*. (2003) [IPS] and Levin *et al*. (2002) (LLC). However, the study uses Im *et al*. (2003) which is largely grounded on the AR (1) specifications as:

$$\Delta y_{it} = \delta_i + \lambda_i t + \rho_i y_{it-1} + \mu_{it} \tag{10}$$

where t denotes time trend, δ_i represents country-specific fixed effects, { denotes error term and ρ_i represents autoregressive coefficient. If $|\rho_i| = 1$ implies the presence of a unit root in y_{it} which is the variable of interest. LLC test is based on parameter similarity ($\rho_i = \rho$) thus, exposed to heterogeneity bias unlike the IPS which permits for separate unit root procedures. Based on this, the IPS is usually favoured in testing stationarity of the series.

3.4. Data description and source

A monthly panel data from January 2004 to December 2017 was employed across 34[1] SSA countries. Data on exports and imports of goods and services, exchange rate, inflation rate, foreign direct investment and interest rate were obtained from the International Financial Statistics (2019) of the International Monetary Fund. Inflation is measured using consumer price index, exchange rate is the nominal exchange rate, interest rate used is the lending rates and FDI is the net inflows of investment. Trade balance is calculated as exports minus imports of goods and services. In measuring oil price volatility, we used Brent crude oil price since it is the greatly favoured reference indicator on the crude oil market (Dowling *et al*., 2016), global oil consumption and production data were obtained from the U.S. Energy Information Administration. The choice of countries and span of the data were based on data availability on the relevant variables employed and because the countries were grouped into oil exporting and importing economies based on OPEC Annual Report, 2019. The division was made by virtue of the fact that SSA countries are made up of both oil exporting and importing countries. This will help make a comparison with regards to the effect of oil price volatility on each group. Table A1 (see Appendix) provides the list of countries employed in the paper, and Table A2 (see Appendix) also displays the summary statistics of variables for the sampled countries.

4. Results and discussion

4.1. Estimation of IGARCH (1,1) results

Table 1 shows the results of the IGARCH (1,1) equation applied to measure volatility in the oil prices. The coefficient of the ARCH and GARCH are statistically significant at 5 per cent and 1 per cent significance levels, respectively, and the predicted variance are shown in Fig. 1.

The volatility trajectory of crude oil is displayed in Fig. 1. The price movement of oil witnessed a stable growth, wondering between 100 and 80 dollars from January 2004 to December 2006. However, there was a significant spike in 2008, attributed to the extremely high demand for the commodity by investors for safe-haven purposes. The Figure again indicates a relatively low oil price in 2009 and this was due to a significant collapse in oil demand attributed to low demand by strong economies such as China and India. However, from 2010 to 2014, there were continuous series of high oil prices as a result of a resurgence of India and China economies whose rapid economic growth, coupled with population growth, increased their oil consumption. Figure 1 also demonstrates that there was a sudden fall in oil price after 2014, which seems to explain the actions of Saudi Arabia.

Table 1 Results of IGARCH (1,1) model

	Variables	Coefficients	Standard errors
OP	Global oil production (OS)	−1.1905***	−0.1255
	Global oil consumption (OD)	0.7861***	0.0663
	Constant	10.0653***	0.9085
ARCH	ARCH (L1)	0.5144**	0.1739
	GARCH (L1)	0.5229***	0.0864
	Constant	0.003	0.0028

Source of data: U.S. Energy Information Administration (2017).

***, ** denote statistical significance level at 1 per cent and 5 per cent, respectively.

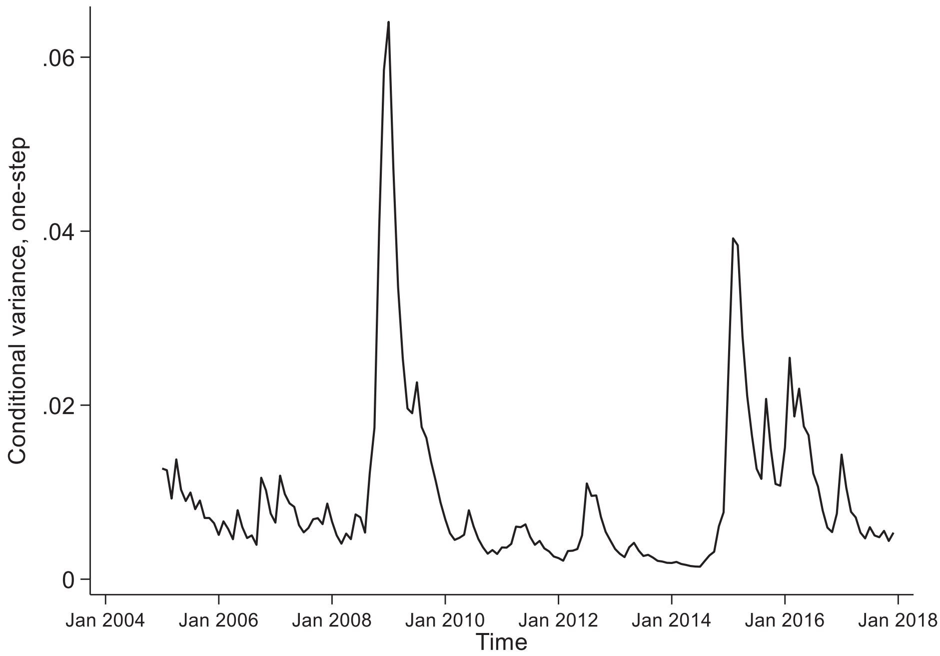

Figure 1 Oil price volatility estimated from IGARCH (1,1).
Data Source: International Financial Statistics (2019)

4.2. Unit root results

The outcome of the panel unit root test using IPS approach is presented in Table 2. It indicates non-stationarity for trade balance, inflation, interest rate, foreign direct investment and exchange rate variables at their levels. However, they were stationary after first difference. Therefore, they are integrated of order one, I (1). However, oil price volatility was stationary at its level, which implies that it is integrated at the level, I (0). The results indicate a mixture of different orders of integration for the variables under consideration.

4.3. Long-run results

We estimated both the PMG and MG and used the Hausman (1978) test to choose the most appropriate model. The results from the Hausman test suggests that the PMG is the most appropriate model. We also used the Pesaran (2004) test for cross-sectional dependence to assess the possibility of cross-sectional dependence in the estimates. The results suggest there is cross-sectional dependence among the selected countries. To correct for the cross-sectional dependence, the common correlated effect pooled mean

Table 2 Results of IPS unit root test

Variables	Level Statistics	First difference Statistics
Trade balance	−0.4585	−26.8425***
Oil price volatility	−21.0875***	−64.338***
Inflation	13.5244	−18.1789***
Foreign direct investment	0.0892	−19.9233***
Interest rate	−0.5037	−28.8814***
Exchange rate	12.7916	−21.1385***

The null hypothesis is that all panels contain unit roots. *** denotes rejection of the null hypothesis at the 1 per cent significance level.

group (CCEPMG) estimator was used. However, the PMG is also reported. The long-run results of both estimators are therefore presented in Table 3. Columns 1, 2 and 3 indicate the results of PMG while columns 4, 5 and 6 display CCEPMG results for SSA (entire sample), oil-exporting and oil-importing countries, respectively. The results in Table 3 seem to demonstrate similarities in sign and significance of coefficients of both estimators.

Table 3 Effect of oil price volatility on trade balance: the Long-run Results

	PMG			CCEPMG		
Variable	[1]	[2]	[3]	[4]	[5]	[6]
OPV	−0.0745***	−0.1410***	−0.0882***	−0.0001	−0.3075	−0.0329***
	(0.0113)	(0.0453)	(0.0314)	(0.0293)	(0.2154)	(0.0111)
ER	0.0018***	−0.0033	−0.0000	−0.0006*	0.0156	0.0010***
	(0.0002)	(0.0021)	(0.0000)	(0.0003)	(0.0134)	(0.0002)
IR	−0.0551***	−0.0575***	−0.0592***	−0.0497***	−0.0067	−0.0389***
	(0.0058)	(0.0159)	(0.0144)	(0.0095)	(0.0108)	(0.0040)
INF	−0.6474***	0.4496	−1.9175***	−0.4644*	−0.9372	−0.5282***
	(0.1000)	(0.2737)	(0.4738)	(0.2524)	(2.3129)	(0.1364)
FDI	−0.0011	−0.0087	−0.0000	−0.1786***	−0.1133	−0.0192***
	(0.0007)	(0.0059)	(0.0000)	(0.0349)	(0.0766)	(0.0020)

***, **, * denote statistical significance level at 1 per cent, 5 per cent and 10 per cent, respectively. Standard errors in brackets. For each estimator, the respective columns are estimations based on the full sample, oil-exporting and oil-importing countries.

The long-run results indicate that, overall trade balance consistently deteriorates on average as the oil price becomes more volatile (see columns 1 and 4). However, the coefficient is statistically imprecise when we consider the CCEPMG estimator. This is somewhat attributed to the huge importation of oil-related commodities in SSA. In 2006, crude oil imports of SSA countries ranged between 10 and 15 per cent of total import bill, representing about 30 per cent of export revenue (UNCTAD, 2006). Again, this may be due to limited substitutes for crude oil in performing services such as transportation. This caused a surge in the cost of oil imports resulting in trade balance deficit. Our finding is in line with that of Mohammed *et al*. (2014) and Chen and Hsu (2012) whose studies indicated a negative effect of oil price volatility on trade balance.

When we disaggregate the effect of oil price volatility by oil-exporting and oil-importing countries, the effect appears to concentrate on the former (see columns 3 and 6). This corroborates the earlier explanation that most SSA countries are oil dependents and as a consequence, import significant oil-related commodities. This exerts a high import bill during heightened periods of high oil prices leading to a higher deterioration of their balance of trade.

Exporting countries have low oil price elasticity due to a number of reasons. Firstly, inadequate refineries in most exporting countries in SSA causes them to export oil in its crude unrefined state, which does not generate higher exports revenue. Again, over supply of oil due to price-war can induce low demand for oil leading to a fall in the price. The fall in demand for oil due to the COVID-19 pandemic can affect the trade balance of exporting countries [Correction added on 3 October 2022, after first online publication: This sentence has been revised in this version]. The negative effect on trade balance for oil exporting countries is consistent with the findings of Jibril (2016) for Nigeria but inconsistent with Le and Chang (2013) for Malaysia.

The results further reveal a positive association between exchange rate and trade balance for SSA. However, the effects are not statistically significant when disaggregated into oil-exporting and oil-importing countries. Interest rate from the results exerts a significant negative effect on trade balance. This effect is also significant for both oil-exporting and oil-importing countries. With regards to inflation, the results suggest a significant negative effect on trade balance in SSA. This result means that high domestic prices of both oil exporting and importing economies does not only discourage local purchases of domestic products but also discourages importation which worsens the trade balance of those economies. Furthermore, FDI in general does not significantly affect the trade balance. It can be observed that the results of PMG almost validate those of CCEPMG.

4.4. Short-run results

Short-run outcomes as well as the error correction term (ECT) are displayed in Table 4. The ECT possesses its expected *a prior* negative sign and it is statistically significant for both PMG and CCEPMG, which confirms the long-run relationship among the series. The CCEPMG results seem to suggest that the rapidity of fine-tuning to long-run equilibrium due to any shocks in the oil market is faster for the entire sample followed by oil exporting economies with oil importing economies revealing the least of −0.0107.

The short-run results indicate a negative link between oil price volatility and trade balance for the full sample, oil-exporting and oil-importing countries. The effect is, however, not significant for the disaggregated samples. Inflation rate, exchange rate and interest rate are statistically insignificant except for oil-exporting economies where inflation exerts a positive and statistical significant at 1 per cent. The error correction term is consistently negative and significant confirming the existence of a stable long-run relationship between trade balance and its covariates.

4.5. Transmission channels

To evaluate the possible channels of transmission of oil price volatility on trade balance, equation (5) is estimated where exchange rate, inflation and interest rate channels are

Table 4 Short-run results and the error correction model

	PMG			CCEPMG		
Variable	[1]	[2]	[3]	[4]	[5]	[6]
ΔOPV	−0.0010**	−0.0247	−0.0011**	−0.0010**	0.0000	−0.0007
	(0.0004)	(0.0338)	(0.0005)	(0.0005)	(0.0013)	(0.0005)
ΔER	0.0018	0.3772	0.0003	0.0041	0.0148	0.0012
	(0.0033)	(0.2939)	(0.0040)	(0.0033)	(0.0110)	(0.0036)
ΔIR	0.0026	−0.0994	0.0035	0.0021	−0.0041	0.0040
	(0.0029)	(0.2155)	(0.0033)	(0.0029)	(0.0056)	(0.0033)
ΔINF	−0.2341	1.0063	−0.8024	0.1489	3.3969***	−0.5423
	(0.5220)	(4.0762)	(0.5150)	(0.5879)	(1.1223)	(0.5680)
ΔFDI	−0.0043	−1.3677*	0.0007	−0.0080	−0.0388	0.0005
	(0.0063)	(0.6985)	(0.0067)	(0.0083)	(0.0266)	(0.0071)
ECT	−0.0061**	−0.3740	−0.0112**	−0.0061**	−0.0078***	−0.0125**
	(0.0027)	(0.2435)	(0.0045)	(0.0028)	(0.0027)	(0.0056)
Cons	0.0084	0.0340	0.0180	0.0128	−0.6122	−0.0550
	(0.0066)	(0.0674)	(0.0132)	(0.0126)	(0.1452)	(0.0591)

***, **, * denote statistical significance level at 1 per cent, 5 per cent and 10 per cent, respectively. Standard errors in brackets.

explored independently as presented in Tables 5–7. The purpose of the interaction term shows that oil price volatility in the presence of exchange rate depreciation, worsening inflation and interest rate can speed the deterioration of the trade balance. We present only results of CCEPMG.

Table 5 shows the interaction between oil price volatility and exchange rate ($OPV*ER$) which indicates a positive effect on SSA's trade balance in the long run. Theoretically, this is possible because exchange rate depreciation causes the prices of domestic goods to fall relative to imports and this can stimulate an enhancement in the trade balance in the long term. However, it negatively affects trade balance of oil exporters and oil importers by about −0.01 per cent and −0.12 per cent, respectively. This means that, high oil price volatility in the presence of exchange rate depreciation harms the trade balance. Exchange rate does not serve as a channel of trade balance deterioration in the short run for oil exporting countries, but a channel for importing countries. The study attribute this to the introduction of standards and regulations by

Table 5 Oil price volatility and exchange rate channel

	Long run			Short run		
Variable	[1]	[2]	[3]	[1]	[2]	[3]
OPV	−0.1101**	−0.1008***	−0.1033	0.0437	0.3413	0.0442
	(0.0014)	(0.0013)	(0.0141)	(0.0304)	(0.3451)	(0.0220)
ER	0.1561	0.1210***	1.1235**	0.1012	−0.4315	−1.1103
	(0.1214)	(0.2313)	(0.2243)	(0.2012)	(0.4852)	(0.2230)
IR	−0.0051	−0.1433***	−0.1452***	−0.0534	0.0211*	−0.0395*
	(0.0211)	(0.0122)	(0.0142)	(0.0234)	(0.0122)	(0.0114)
INF	0.5342***	1.3312***	−1.0158***	0.2750	1.0053	−0.0776
	(0.1320)	(0.3403)	(0.2150)	(0.4150)	(2.0423)	(0.1443)
FDI	0.1322***	0.0221	−0.0014	−0.0292*	−0.0353	−0.1911
	(0.0340)	(0.0165)	(0.0622)	(0.0123)	(0.0321)	(0.1587)
*OPV*ER*	0.0305***	−0.0104***	−0.1243**	−0.0027	−0.4432	−0.0250**
	(0.0044)	(0.0102)	(0.0113)	(0.0016)	(0.3301)	(0.1341)
ECT				−0.0016**	−0.0102**	−0.0141**
				(0.0012)	(0.0111)	(0.1043)
Cons				−0.0053	0.0282	0.0447
				(0.0141)	(0.0493)	(0.0880)

***, **, * denote statistical significance level at 1 per cent, 5 per cent and 10 per cent, respectively. Standard errors in brackets. *OPV*ER* represents the interaction between oil price volatility and exchange rate.

Table 6 Oil price volatility and inflation channel

	Long run			Short run		
Variable	[1]	[2]	[3]	[1]	[2]	[3]
OPV	−0.1041	−0.1032***	0.2951	−0.0541	−2.2515	−0.2212
	(0.1043)	(0.0037)	(0.0441)	(0.0611)	(2.1104)	(0.3217)
ER	0.2568**	1.0989***	1.1633***	0.1005	−1.1623	0.8757
	(0.1184)	(0.2602)	(0.2611)	(0.3112)	(0.4210)	(0.0345)
IR	−0.0531	−0.1782***	0.3421***	−0.0554	−0.0211*	−0.0405
	(0.0154)	(0.0134)	(1.1013)	(0.0742)	(0.0124)	(0.0120)
INF	0.4212***	−1.1228***	−1.0124***	0.3871	−2.1242	0.2612
	(0.1661)	(0.2062)	(0.1505)	(0.5167)	(1.2540)	(0.2004)
FDI	0.2955***	0.0361	−1.1724***	−0.0342*	−0.0324	0.0245
	(0.0504)	(0.0291)	(0.3053)	(0.0150)	(0.0123)	(0.6514)
*OPV*INF*	0.0620***	−0.0278	0.1824**	−0.0005	1.1284	0.0122
	(0.0115)	(0.0513)	(0.0229)	(0.0003)	(0.1311)	(0.2350)
ECT				−0.0007*	−0.0142**	−0.0135**
				(0.0011)	(0.0121)	(0.0015)
Cons				−0.0057	0.0231	−0.0621
				(0.0152)	(0.0432)	(0.1121)

***, **, * denote statistical significance level at 1 per cent, 5 per cent and 10 per cent, respectively. Standard errors in brackets. OPV*INF represents the interaction between oil price volatility and inflation.

Europeans and other foreign countries which makes it difficult for SSA countries to penetrate their markets.

Table 6 shows the transmission channel between oil price volatility and inflation channel. The interaction between oil price volatility and inflation $(OPV*INF)$ shows a positive and statistically weighty outcome on trade balance for SSA countries and oil importers in the long run. A 1 per cent increase in the interaction term improves trade balance of SSA countries by 0.06 per cent, and 0.18 per cent increase for oil importers in the long run at 1 per cent significance level. The practice of inflation-targeting framework by SSA countries over the years has assisted in stabilising inflation and thus tend to reduce cost of domestic production and hence stabilised prices which induces significant domestic consumption while reducing importation of some goods in the long run.

The results of interest rate transmission channel for oil price volatility are displayed in Table 7. There is the presence of a statistically insignificant negative effects on SSA

Table 7 Oil price volatility and interest rate channel

	Long run			Short run		
Variable	[1]	[2]	[3]	[1]	[2]	[3]
OPV	−0.0422	0.0391	0.0223	−0.0335	0.0223**	0.0121
	(0.0113)	(0.0141)	(0.0202)	(0.0221)	(0.0211)	(0.0142)
ER	2.1601	1.1272***	0.0213	−0.0322	−1.1740	0.0221
	(1.1235)	(0.2914)	(0.0614)	(0.0411)	(0.5510)	(0.1403)
IR	1.1124	−0.0421**	0.0114*	0.0314	0.0020	−0.0127*
	(1.0423)	(0.0267)	(0.0150)	(0.0137)	(0.0013)	(0.0310)
INF	2.1587	−1.3801***	0.0428***	0.2341	1.0059	0.0210
	(3.0871)	(0.2243)	(0.0231)	(0.5510)	(2.0553)	(0.0277)
FDI	2.0635	0.0149	−0.5427***	−0.0293*	−0.0432	0.0443
	(1.3310)	(0.0291)	(0.1126)	(0.0142)	(0.0321)	(1.2216)
*OPV*IR*	−0.0133	−0.1780***	0.0291***	−0.0010	−0.0210**	0.0277
	(0.1201)	(0.0313)	(0.0113)	(0.0011)	(0.0094)	(0.0632)
ECT				−0.0021*	−0.0019**	−0.0133**
				(0.0011)	(0.0122)	(0.0024)
Cons				0.0120	0.0231	−0.0123
				(0.0651)	(0.0352)	(0.0322)

***, **, * denote statistical significance level at 1 per cent, 5 per cent and 10 per cent, respectively. Standard errors in brackets. OPV*IR represents the interaction between oil price volatility and interest rate.

and statistically significant negative and positive effects on oil exporting and importing economies, respectively in the long run. In the short run, interest rate is a channel through which oil price volatility affect trade balance of oil exporters. The interaction term negatively affects trade balance of oil exporters by 0.03 per cent in the short run. However, interest rate is not a channel for oil importers in the short run.

5. Conclusion and policy implications

The paper investigates the effect of oil price volatility on the trade balance of oil-exporting and oil-importing countries, as well as the transmission pathways for which oil price volatility affects trade balance. We apply IGARCH (1,1), Pooled Mean Group (PMG) and common correlated effect pooled mean group (CCEPMG) techniques to evaluate the effect of crude oil price volatility on the trade balance of SSA. The results reveal the presence of significant volatility in crude oil price. Further, we establish that oil price volatility negatively affect trade balance SSA countries. However, this effect appears to be greater and concentrated on oil-importing countries. Again, exchange rate, interest rate and inflation rate also serve as relevant transmission pathways oil price volatility to impact trade balance in SSA. We attribute these findings to the huge importation of costly refined oil and other oil-related products and goods relative to exports from SSA economies. We recommend that policymakers, especially those of importing countries, should hedge as well as adopt price-smoothing schemes to minimise oil price volatility while exporting countries hedge against future oil revenues. Again, countries that are currently not practising inflation-targeting should adopt it to ensure stability of their general price levels so as to reduce the effect of oil price volatility on trade balance in the presence of inflation and interest rate. Finally, central banks of the respective countries should apply a combination of foreign exchange market interventions and interest rate changes to reduce the effect of oil price volatility on their trade balance when exchange rate is taken into account.

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Note

1. Sub-Saharan Africa comprises 48 countries. We left out 14 countries due to lack of sufficient data on them.

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Appendix

Table A1 List of SSA countries sampled for the study

Angola	The Gambia	Mauritania	Sierra Leone
Benin	Ghana	Mauritius	South Africa
Botswana	Guinea-Bissau	Mozambique	Swaziland
Burkina Faso	Kenya	Namibia	Tanzania
Burundi	Lesotho	Niger	Togo
Cape Verde	Liberia	Nigeria	Uganda
Comoros	Madagascar	Rwanda	Zambia
Congo (Democratic Republic)	Malawi	Senegal	
Côte d'Ivoire	Mali	Seychelles	

Table A2 Descriptive Statistics for the full sample [1], oil exporting countries [2] and oil importing countries [3]

	[1]				[2]				[3]			
Variables	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Trade Balance	−0.403	0.423	−1.902	0.941	−0.026	0.366	−1.137	0.941	−4.832	0.388	−1.902	0.444
Oil Price Volatility	0.161	0.225	0.009	0.899	0.161	0.225	0.009	0.899	0.161	0.225	0.009	0.899
Exchange Rate	5.642	4.188	−2.168	20.778	4.39	2.166	−2.168	7.369	5.909	4.457	1.261	20.778
Interest Rate	2.051	1.067	−5.074	4.873	2.224	0.911	−2.514	3.753	2.016	1.093	−5.074	4.873
Foreign Direct Investment	−1.278	1.514	−5.702	16.694	1.204	1.002	−4.621	3.685	1.234	1.598	−5.702	16.694
Inflation	4.643	0.276	3.664	5.882	4.663	0.341	3.904	5.732	4.6639	0.259	3.664	5.882

Source of data: IMF's IFS and U.S EIA (2019)