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THE ASYMMETRIC EFFECT OF TRADE OPENNESS ON OUTPUT VOLATILITY: EMPIRICAL EVIDENCE FROM ETHIOPIA

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ABSTRACT

A better understanding of the effect openness on volatility can lead to more effective government policy that addresses the adverse outcomes of volatility. By using NARDL model, Hodrick-Prescott (HP) filter, and annual time-series data from the period 1981 to 2020, this study examined the effect of openness on output volatility in Ethiopia. From the NARDL bound test, the research find a long-run cointegration between output volatility, agricultural output, trade openness, lending rate, and money supply. We also found a long-run negative asymmetric effect, and short-run negative symmetric effect of openness on volatility—suggesting this open trading activity has a relationship that can reduce output volatility in Ethiopia. This possibility shows Ethiopia would benefit from international trade and openness reduces the adverse effects of volatility. Besides, we confirmed the positive asymmetric effect of agricultural output both in the long run and short run. The lending rate, that represents the cost of borrowing, has a positive effect on output volatility. The long-run and short-run coefficients of money supply have a negative and significant effect on output volatility.

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Introduction

In the mid-1980s, the developed world especially the United States, experienced a significant decline in output volatility, commonly known as the "Great Moderation." (Andraz and Norte, 2017). Meanwhile, the issue of volatility has been a major concern of policymakers and researchers, since it has effects on growth, poverty, and welfare, particularly in poor economies (Hegerty, 2014). Despite the output volatility effects on economic growth and the stock market largely believed, there is no consensus among scholars on the effect of output volatility on growth (Abubaker, 2015). One block of argument is that output volatility, which was firstly mentioned by Keynes (1936), increase economic uncertainty, hinder investment due to its irreversibility, and in turn worsen economic growth (Antonakakis & Badinger, 2012)—establishing a negative influence between volatility and growth (Ramey & Ramey, 1995). Particularly, Ramey & Ramey (1995) empirically argued that the unpredictability of economic policy harms economic growth. On the contrary others (see, Aghion & Banerjee, 2005) argued that the interaction between volatility and growth is positive. The argument follows that fluctuations in economic activity improve the efficiency of the economic system and, it could increase precautionary saving and thus improve the long-term growth. Empirically Grier et al. (2004), Fountas & Karanasos (2006), and Lee (2010) discovered that nations with higher production volatility tend to have higher economic growth rates. Finally, there is also another view backing insignificant connection between growth and volatility (Friedman, 1968). The argument of Friedman (1968) follows that output growth is largely affected by the real factors of production like labor skills and technological changes, not by its volatility.

In literature fiscal policy and government size (See, Iseringhausen & Vierke, 2018), institutional factors (See, Acemoglu et al. 2003), financial factors (See, Aigheyisi & Isikhuemen, 2018), demographic factors (See, Iseringhausen & Vierke, 2018) and trade openness (See, Hegerty, 2014; Aigheyisi & Isikhuemen, 2018; Abubaker, 2015; Eduardo, 2007; Huchet, et al., 2018; Bejan, 2006; Giovanni & Levchenko, 2009; Cavallo, 2008; Mireku, et al. 2017), are some factors mentioned as possible source volatility. Trade openness, despite its numerous advantages to economic growth (See, Briguglio & Vella, 2016), this volatility is created and can be considered a dangerous state of affairs for the economy (Karim & Stoyanov, 2019), especially for low-income countries (Güreşçi, 2018). This idea is backed by the compensation hypothesis. In the theory volatility of growth is considered as the subsequent impact on international markets (Ehrlich & Hearn, 2014). Trade openness is also considered one major source of volatility (Giovanni & Levchenko, 2009) and propensity to crises in developing countries. Trade openness affects economic volatility through deeper specialization and utilization of a large global market. Increased vulnerability to global trade shocks is also **a** channel (Karim & Stoyanov, 2019). Asnake & Liu (2019) argue that new technological transfer could be the channel of how trade openness affects the economic volatility. As globalization deepens trade integration, economies are inherently more vulnerable to external shocks (Antonakakis & Badinger, 2012). Several crises and instabilities in developing nations, such as in Ethiopia, have been connected to international trade shocks (Mireku, et al. 2017). As a result, emerging economies are facing the challenge of balancing the benefits and drawbacks of trade openness.

The influence of openness on output volatility is largely studied in literatures, albeit, it is controversial, regarding the direction of the effect (Čede et al., 2016). The intuition underlying the controversy is that an open economy is more likely to be exposure to external shocks. Many scholars believe that trade openness improves capital mobility and, as a result, is important to boost economic growth and wellbeing (Mireku, et al. 2017). Others believe that more openness may aggravate the economy's responsiveness to external shocks (See, Haddad et al., 2013). Empirically there are several studies documented a positive influence of trade openness on volatility (See, Aigheyisi & Isikhuemen, 2018; Čede et al., 2016; Abubaker, 2015; Danilo & Lorenzo, 2018; Eduardo, 2007; Mujahid & Alam 2014; Mireku, et al. 2017). The major driver behind the positive interaction among openness and volatility, according to Čede et al. (2016), is specialization accompanied by openness. On the contrary other studies (See, Huchet et al., 2018; Giovanni & Levchenko, 2009) established that trade open leads to negative output volatility. Despite the influence of trade open on volatility is largely studied, the extent to which openness impacts volatility could also relied on other features (Caldero, & Schmidt-Hebbel, 2008) such as; developmental stage (Abubaker, 2015), the level of volatility of tourism (Jackman, 2014), export concentration, the degree of specialization (Giovanni & Levchenko, 2009), the wealth of a country (Čede et al., 2016; Hegerty, 2014) and it could be country-specific. More dominant knowledge among economists and policymakers, however, is that global trade leads to bigger output volatility (Giovanni & Levchenko, 2009), which is frequently mentioned as a detrimental effect of openness to international trade (Karim & Stoyanov, 2019).

One of the most noticeable features of emerging nations is their macroeconomic instability—which is manifested by output volatility. (See, Caldero, & Schmidt-Hebbel, 2008) and these countries are more volatile than developed ones (Güreşçi, 2018). A country such as Ethiopia, whose foreign trade largely depends on primary product export and import of manufactured goods (Mamo, 2019), in addition to its poor economic growth, is often vulnerable to persistent trade deficit as documented by the Prebisch-Singer hypothesis. Most developing countries have been experiencing fluctuation in the price of their primary exports due to foreign inelastic demand and unstable domestic supply and its concentration on few agricultural commodities and geographical markets (Mamo, 2019). The export sector of these nations is manifested by fluctuation in both value and volume of trade that ultimately generates instability in the future economic prospects. In this case trade openness, not only unstable country's foreign income but also creates growth volatility.

In spite of a substantial amount of research on the issue, there is no clear consensus on whether openness influences growth volatility. This needs empirical investigation. A better understanding of whether the openness has promoted volatility can lead to more effective government policy that directly addresses the underlying causes of volatility. Accordingly, the aim of this research is to study the effect of trade openness on output volatility in Ethiopia. Particularly, the study focuses on the asymmetrical long-run effect of openness on volatility by using the latest NADRL model. There are previous studies focused on the impact of trade openness on volatility (see, Čede et al., 2016; Abubaker, 2015; Danilo & Lorenzo, 2018; Mireku et al., 2017; Giovanni & Levchenko, 2009; Eduardo, 2007; Mujahid & Alam, 2014; Huchet et al., 2018; Aigheyisi & Isikhuemen, 2018; Bejan, 2006; Hegerty, 2014). However, most of the empirical studies concentrated on the links between trade openness and economic growth and/or, between volatility and growth. In addition, none of them addressed this issue in developing countries, for instance in Ethiopia. Thus, this study, to the best of my knowledge, is the first empirical study that has examined the asymmetrical effect of trade openness on output volatility in Ethiopia. In contrast to autoregressive distributed lag (ARDL), which assumes that potential impact of explanatory variables would remain the same, the NARDL model recognizes the possible asymmetric impact of positive and negative changes in the explanatory variables.

This study added value to the existing literature by using improved econometric methods such as NARDL and, by incorporating other possible factors such as; agricultural output, lending rate, and money supply, as an additional explanatory variable of output volatility. The NADRL model, the extension of ARDL model, captures the possible asymmetry effect of openness on output volatility in context of Ethiopia by taking annual data from the period 1981 to 2020. The previous studies considered trade openness to have symmetric (linear) effect on economic growth, and hence output volatility. The major advantage of the NARDL model is it enables us understand whether the negative or the positive elements of openness dominates output volatility in the case of Ethiopia. Finally, the rest of the paper is organized as follows: Section 2 presents a summary of the relevant empirical literature concerning; the effects of openness on volatility and economic growth. Section three explains the source of data and variable definition, and the methodological aspects of the study such as; the HP filtering method, model specification, and the NARDL models. Section four provides the findings and analysis of the empirical model results and the final section addresses the conclusions of study.

Literature Review

Theoretically, trade openness is seen as a major source of volatility in developing countries (Giovanni & Levchenko, 2009). It affects output volatility through deeper specialization, exposure to terms-of-trades shocks (Karim & Stoyanov, 2019), exploitation of a large global market, and technological dissemination (Asnake & Liu, 2019). As trade integration through globalization expands, economies are naturally more vulnerable to external crisis

(Antonakakis & Badinger, 2012)—which ultimately creates instability in the economy. Many crises and instabilities in emerging nations, such as in Ethiopia, have been connected to shocks from foreign trade.

There are several empirical studies on the effect of trade openness and output volatility on growth at the global level and in the Ethiopian case. Qamruzzaman & Karim (2020) explored as to if regional economic instability and openness impacted the pattern of FDI inflows into four South Asian countries from 1975 to 2019. Mainly, using NARDL model, their study confirmed a long-term asymmetrical relationship and, long-term and short-term asymmetry between trade openness, and inflows of FDI. Moreover, directional causality among economic volatility, openness, and FDI was established.

By using time series data from the period 1970-2010, Bhoola & Kollamparambil (2011) studied the pattern and causes of output growth volatility in South Africa. According to the result, South Africa witnessed a severe structural interruption in production growth. Besides, monetary policy is recognized as the possible cause of the falling growth volatility. Iseringhausen & Vierke (2018) studied the causes of output volatility in 22 OECD countries. Their study shows that demographic variables and the size of a government are the main factors of macroeconomic volatility in the study countries. Mujahid & Alam (2013) explored the link between trade and financial openness, and macroeconomic volatility in Pakistan. Using annual data from the period 1970 up to 2010 and, employing the ARDL cointegration method, their study found that in the long run, trade openness produces volatility in investment and output, while financial openness affects investment volatilities. Mireku et al. (2017) studied the effect of openness on volatility of Ghanaian economy. Using yearly data from 1970 to 2013 and the cointegration method, their study revealed that openness positively affects economic growth volatility—both in the long and short run. Aigheyisi & Isikhuemen (2018) examined the effect of financial and trade openness on growth volatility in Nigeria. Using annual time-series data from the period 1970 to 2015, EGARCH process, and the ARDL cointegration approach, the study indicated that financial and trade openness intensified output growth volatility in Nigeria.

Abubaker (2015) examined the effect of openness to trade on output volatility of 33 countries. Using quarterly panel data from the period 1980-2009, his study showed that openness increases the output volatility, where countries with a better development is less affected by openness. Eduardo (2007) examined the effect of openness on output volatility of 77 panel countries. The study showed that openness to trade increases volatility through the terms of the trade channel. Karim & Stoyanov (2019) examined the effect of demand and supply shocks in one country on output volatility in other countries. Using panel data of 173 countries ranging from 1976 up to 2000, their study found that supply shock in one country causes output volatility in other countries. Giovanni & Levchenko (2009) investigated how volatility is related to openness using a panel of 61 countries from the period 1970 to 1999. The result revealed that trade openness and volatility had a positive and significant relationship. Besides, sectors more exposed to global trade were more volatile. Danilo & Lorenzo (2018) examined the dynamics and drivers of macroeconomic volatility in the world. Using a panel of 42 countries in the world, the study found that the global volatility component has been systematically declining over time and, trade openness seems to be the most robust explanatory reason for changes in international output volatility. Using GMM estimator and a panel of 169 countries from the period 1988 to 2014, Huchet et al. (2018) examined the influence between openness and economic growth. Their research confirms that openness has a negative impact on the growth of countries specifically with low quality products. Alouini & Hubert (2019) studied the link between country size, economic performance, and growth Volatility in 163 Countries. Using panel data from the period 1960 up to 2007, their study indicated that country size had a significant and negative correlation with growth. Besides, the study verified that openness was conducive to long-term growth, however, failed to get evidence that it increases volatility. Besides, Asnake & Liu (2019) assessed the impact of openness on the economic growth of Ethiopia. Use two-stage least squares estimation technique and time series data from 1981-2017, their study revealed that openness impacted growth negatively and significantly.

In most previous studies, the link between openness and volatility has been studied with the use of the linear methods; such as the Johanson cointegration test, Engle-Granger methodology and ARDL cointegration approaches. Estimating the long-run relationship by applying the aforementioned techniques is based on the underlying symmetric assumption that the explanatory variables linearly affect the explained variable. However, practically, the motion in a variable can change in either direction, positive or negative (Qamruzzaman & Jianguo, 2018). For that reason, we used the NARDL Model for this study.

Data and Research Methods

Data type and source

This research article uses secondary data for time series taken from the National Bank of Ethiopia (NBE) and the World Bank dataset, which ranged from 1981 to 2020. The variables we used in this study are Output volatility, agriculture GDP, lending rate, money supply, trade openness, and a dummy for regime change. Variables such as agricultural output and trade openness are drawn from the World Bank database, while, money supply and lending rate data are taken from the NBE dataset. Output volatility was extracted from GDP by using Hodrick-Prescott (HP) filter technique. The symbol, definition, and the sources of variables are briefly presented in Table 1 below.

Table 1: Definition and Source of data

Variable	Definition	Source
Output volatility	It was extracted from the GDP using HP technique. GDP was measured in constant 2010 US$	WB
Agriculture GDP	Including added value from fishing activities, cultivating crops and livestock, forestry, and hunting. Data are in constant 2010 US$	WB
Lending rate	The rate at which banks charge borrowers for their loan	NBE
Broad money supply	The broad money includes Currency outside banks, Demand Deposits and Quasi-Money, and the value is given in millions of Birr	NBE
Trade openness	Total export and import value divided by GDP	Computed based on WB data
Policy change	‘0’ is assigned for the years prior to 1991 (The Dergue regime) and ‘1’ afterward (The EPDRF era)	

As output volatility is an unobservable quantity, it must be inferred from a given data set. Measuring volatility requires evaluating the deviance of an economic variable from its equilibrium value (Cariolle, 2012). In literature, output volatility is measured as; the standard deviation of the residual of an estimate (using ARCH, GARCH, and EGARCH) (See for example, Kehinde & Agnes, 2017; Laurenceson & Rodgers, 2020; Safdar et al., 2012), the standard deviation of the growth rate of a value (See, Abubaker, 2015), and the standard deviation of the cycle separated by using statistical filter (See, Duran, 2019; Emmanuel et al., 2019; Mireku et al.,2017) . In this study, we use statistical filter methods to extract output volatility. Among the several filtering ways such as Kalman filter, Christiano and Fitzgerald filter and Hodrick Prescott filter, we employed Hodrick-Prescott (hereafter HP) filter, originated by Hodrick & Prescott (1997) to extract the trend from the output series, though there is no consensus on which filter to use. The HP filter, in contrast to the other techniques, is relatively appropriate for yearly data with a lower frequency, which is the situation for the majority of emerging economies like Ethiopia. However, according to Duran (2019), the fundamental downside of these methods is that their execution necessitates the loss of at least a few observations from the periods' beginning and ending points. The HP filter is a basic smoothing method that has gained popularity because to its adaptability in revealing the features of irregularities in trend output. The major benefit of the HP filter is that it is suitable for research in underdeveloped nations due to its significantly lower data requirements (Emmanuel et al., 2019). The HP filter primarily reduces the gap between actual and potential output as shown below.

$$\min\left[\sum_{t=1}^{T}(y_{t+1}-\tau_t)^2+\lambda\sum_{t=2}^{T-1}\{(\tau_{t+1}-\tau_t)-(\tau_{t+1}-\tau_{t-1})\}^2\right] \tag{1}$$

From the above specification, T, yt, τt and λ respectively represents the number of observations, the actual output, the trend value, and the determining factor of the smoothing parameter and penalizing shocks. In HP Filter λ is proposed to be 100 for annual time series data. The initial component in the form of this equation can reduce the difference that has between the actual value and the potential value, while the next component is able to reduce the changing trend value. The HP filter is used to refine series, obtain long-term trends, and account for fluctuations by calculating the deviation of the actual series from the long-term trend. HP filtering has become one of the most extensively used filters due to its well-known benefits (Buch & Scholetter, 2013). Filters also make it possible to catch nonlinearities in long-term trends and have been described more accurately than other approaches. (Duran, 2019). Following (Mireku et al., 2017) we used the cyclical component of the filtered, as a proxy of output volatility.

Model specification

The major goal of this empirical investigation is to explore the asymmetry effect of trade openness on output volatility in Ethiopia use the NARDL technique. The literature identified different factors as a cause of output volatility; including; trade openness variables (Čede et al., 2016; Abubaker, 2015; Danilo & Lorenzo, 2018; Mireku et al., 2017; Giovanni & Levchenko, 2009; Eduardo, 2007; Mujahid & Alam, 2014; Huchet et al., 2018; Aigheyisi & Isikhuemen, 2018; Bejan, 2006), financial variables, fiscal policy and government size indicators, institutional variables and demographics variables. In this study, we include trade openness and other four control variables namely; agricultural output, lending rate, and money supply (monetary policy indicator) as explanatory variables. We also include the Dummy variable for regime change[1] to capture the possible effect of policy change on volatility. Accordingly, '0' is assigned for the year before 1991, and '1' is assigned afterward. We also included agricultural output in the regression to capture the effect of the structure of the Economy. Because, the Ethiopian economy is largely dependent on the agricultural sector (Adisu, 2020), any shocks in the sector affect output volatility. The lending rate plays an essential role in macroeconomic policy. Change in the lending rate (the closest proxy for interest rate) directly affects domestic private investment, which in turn affects economic growth, and hence, volatility. We also used Money supply to reflect monetary-related policy effect on output volatility. The increase of the money supply has a direct effect on the general price level (as documented in the quantity theory of money). This shows the fundamental view of monetarists that the general price level mainly arises due to a money supply increase (Bane, 2018). Therefore, money supply causes price instability, which in turn affects output and hence will be linked with output volatility. Following Giovanni & Levchenko (2009), Bhoola & Kollamparambil (2011), and, Mireku et al. (2017), the explained and explanatory variables are expressed by the following econometric equation.

$$Y_t=\alpha_0+\beta_t+\prod D_t+\sum_{t=1}^{T}\gamma i X_{t-1}+e_t \tag{2}$$

Where: Yt captures the volatility of output over the study periods, β denotes a time trend, Dt is a Dummy variable to reflect the possible effect of policy change, Xt comprises a set of explanatory variables such as; agricultural output, lending rate, money supply, and trade openness, and finally et is the error. The above equation (2) is to be estimated through the newly developed NARDL (Pesaran et al., 2001) model.

Nonlinear Autoregressive Distributed Lag Model

Traditional estimate approaches are unsuitable when the variables are integrated with different orders (for instance a combination of I(0) and I(1)). In this scenario, the long-run interaction between variables must be investigated using theARDL model techniques raised by Pesaran Shin and Smith in 2001. The advantage of this approach is its applicability irrespective of variables are of different order provided none of these variables is I(2). The ARDL model is further split into long run and short run equations. The ARDL cointegration test, on the other hand based on that assumption is the dependent variable affects the dependent variable linearly (Ahmad et al., 2018). However, the motion in a variable can change in either direction, positive or negative (Qamruzzaman & Jianguo, 2018). For instance, studies identified an asymmetric relationship between; inflation and economic growth (Karahan & Çolak, 2020); food price, real income, oil price (Ibrahim, 2015), and, oil price shocks and investor sentiment (He & Zhou, 2018). To address these problems, we use an alternative technique, the NARDL model.

In view of the presence of negative and positive changes in independent variables, we attempted to study the asymmetry relationship between variables by using the recently established NARDL technique suggested by Shin et al (2014). In this situation, even if the ARDL model allows for the analysis of short and long-run ties between variables, according to He and Zhou (2018), it becomes irrelevant and will be misspecified when these interactions are nonlinear. The link between output volatility and explanatory variables is shown by the following specification.

$$\begin{aligned} OV_t = ao + a_1 \ln AG_t^+ + a_2 \ln AG_t^- + a_3 \ln TO_t^+ + a_4 \ln TO_t^- + a_5 LR_t + \\ a_6 \ln MS_t + a_7 PO_t + e_t \end{aligned} \tag{3}$$

Where OV_t is output volatility, $\ln AG_t^+, \ln AG_t^-, \ln TO_t^+, \ln TO_t^-, LR_t, \ln MS_t$ natural log of agricultural output (Pos), natural log of agricultural output (Neg), natural log of trade openness (Pos), natural log of trade openness(Neg), lending rate and natural log of money supply, respectively. While PO_t represents regime change and, ε_t is the error term. α (α_o to α_7) is long-run parameters to be estimated. The long run coefficients of trade openness ($\alpha 3$ and $\alpha 4$) and agricultural output ($\alpha 1$ and $\alpha 2$) are assumed to be unequal to reflect the asymmetric effect on output volatility. This indicates that an increase and decrease in openness will have different magnitude effects. Since our area of interest is trade openness, we can represent the partial sums of positive (TO_t^+) and negative (TO_t^-) changes in TO_t (trade openness) in equation (3) as follows.

$$To_t^+ = \sum_{i=1}^{t} \Delta To_t^+ = \sum_{l=1}^{t} \max(\Delta To_i, 0), \quad \text{and;} \quad To_t^- = \sum_{i=1}^{t} \Delta To_t^- = \sum_{l=1}^{t} \min(\Delta To_i, 0) \tag{4}$$

Likewise, we can write the asymmetric effect of agricultural output on output volatility as;

$$AG_t^+ = \sum_{i=1}^{t} \Delta AG_t^+ = \sum_{l=1}^{t} \max(\Delta AG_i, 0), \quad \text{and;} \quad AG_t^- = \sum_{i=1}^{t} \Delta AG_t^- = \sum_{l=1}^{t} \min(\Delta AG_i, 0) \tag{5}$$

The superscripts (+) and (-) in the above equation (4 and 5) represents the positive and negative partial sums decomposition, respectively. By incorporating both the negative and positive changes in trade openness and agricultural output the usual ARDL model can be rearranged to give the following general NARDL equation (6).

$$\Delta(OV)_t = \alpha_0 + \beta_1 OV_{t-1} + \beta_2 \ln AG^+_{t-1} + \beta_3 \ln AG^-_{t-1} + \beta_4 \ln TO^+_{t-1} + \beta_5 \ln TO^-_{t-1} + \beta_6 LR_{t-1} + \beta_7 \ln MS_{t-1} + \beta_8 PO_{t-1} + \sum_{i=1}^{q} \theta_i \Delta OV_t + \sum_{i=1}^{p} (\Omega^+_i \Delta AG^+_{t-1} + \Omega^-_i AG^-_{t-1}) + \sum_{i=1}^{p} (\Phi^+_i \Delta TO^+_{t-1} + \Phi^-_i TO^-_{t-1}) + \sum_{i=1}^{p} \chi_i \Delta LR_t + \sum_{i=1}^{p} \lambda_i \Delta \ln MS_t + \sum_{i=1}^{p} \delta_i \Delta PO + e_t \quad (6)$$

In the above equation (6), *ln* denotes the logarithmic operator, 'Δ' is the first difference operator, '*l*' is the maximum lag number β_i s captures the long-run relation coefficients, while $\theta, \chi, \delta, \Omega^+, \Omega^-, \Phi^+$ and Φ^- capture the short-run estimates, and e_t is the error term. The presence of a long-run link is investigated by setting the coefficients of lagged level variables to zero ($\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=\beta_6=\beta_7$), and this hypothesis is tested by an F-test. Testing of the hypothesis is based on a assessment between the f-statistic and critical values.

Test for asymmetry

Furthermore is testing for the long run and the short run asymmetric influence of openness and agricultural output on volatility using *Wald test*. Following Qamruzzaman & Karim (2020) the null hypothesis of long-run symmetry (H_0) and the alternative hypothesis of asymmetry (H_1) effects of openness and agricultural output are given as;

$$H_0{:}\beta_4 = \beta_5; H_1{:}\beta_4 \neq \beta_5 \text{ and } H_0{:}\beta_2 = \beta_3; H_1{:}\beta_2 \neq \beta_3 \text{ respectively}$$

The rejection of the null hypothesis (the symmetry effect) confirms the existence of the asymmetrical effects of openness and agricultural output on volatility. The long-run elasticity of trade openness (α3 and α4) and agricultural output (α1 and α2) expressed in equation (3) can also be computed as follows:

$$\alpha_1 = \frac{-\beta_2}{\beta_1}; \alpha_2 = \frac{-\beta_3}{\beta_1}; \alpha_3 = \frac{-\beta_4}{\beta_1}; \alpha_4 = \frac{-\beta_5}{\beta_1}$$

Similarly, the short run symmetry (H_0) and the alternative hypothesis of asymmetry (H_1) effects of openness and agricultural output are given as;

$$\sum_{i=1}^{n} \Omega^+_i = \sum_{i=1}^{n} \Omega^-_i \text{ and } \sum_{i=1}^{n} \Phi^+_i = \sum_{i=1}^{n} \Phi^-_i \text{ respectively.}$$

A typical Wald test is also used to examine the null hypothesis. If the positive and negative partials of openness and agricultural production are equal, it indicates the nonlinearity relationship between openness, and agricultural output and output volatility. The NARDL model may also be used to generate a dynamic error correction (ECT) model as follows.

$$\Delta(OV)_t = \alpha_0 + \sum_{i=1}^{q} \theta_i \Delta OV_{t-1} + \sum_{i=1}^{p} \chi_i \Delta LR_{t-1} + \sum_{i=1}^{p} \lambda_i \Delta \ln MS_{t-1} + \sum_{i=1}^{p} \delta_i \Delta PO + \sum_{i=1}^{p} (\Omega^+_i \Delta AG^+_{t-1} + \Omega^-_i AG^-_{t-1}) + \sum_{i=1}^{p} (\Phi^+_i \Delta TO^+_{t-1} + \Phi^-_i TO^-_{t-1}) + \gamma ECT_{t-1} + e_t \quad (7)$$

$\theta, \chi, \delta, \Omega^+, \Omega^-, \Phi^+$ and Φ^- are the short-run adjustment coefficients of the explanatory variable, while γ is, the coefficient of ECT. A negative and significant ECT signifies the long run relationship between variables (Adisu, 2020). The NARDL method has a similar procedure to the traditional ARDL technique. First, the ARDL framework requires the variables to be integrated of order one, zero, or a mixed result. Hence, it is important to check the order of variables using unit root tests. In our case the test was achieved using the breakpoint unit root test, to tackle the possible structural break as suggested by Perron (1989). Second, the optimal lag length will also be decided using Akaike Information Criterion (AIC). Next, Equation (6) is estimated to give the NARDL model which is used to check for the presence of cointegration among variables using a bounds test (this involves the Wald F test of the null hypothesis, β*i* 's = 0). Lastly an analysis of long run and short run asymmetries between output volatility and explanatory factors will be performed.

Finding and Discussion

Breakpoint Unit Root Tests

There are several unit-root tests such as, PP test, ADF and the KPSS test proposed by Kwiatkowski et al. (1992), they are not suitable for data with structural break. This is because traditional unit root tests are incapable of incorporating structural changes. In this study we applied breakpoint unit root test, it is used to calculate the structural breaks present in the time series data (Furuoka, 2018). The form of the test results is depicted in the table below (Table 2).

Table 2: Breakpoint unit root test results

Variables	With intercept			With trend and intercept		
	ADF test stat.	Prob.	Breakpoint	ADF test stat.	Prob.	Breakpoint
OV	-5.266653	< 0.01*	1994	-5.332412	0.0329**	2002
*ln*AG	-2.824189	0.7759	2005	-5.871866	< 0.01*	2006
*ln*TO	-4.507625	0.0424**	2002	-2.945033	0.9687	2006
LR	-7.849180	< 0.01*	1992	-5.264640	0.0396**	1992
*ln*MS	0.240108	> 0.99	2007	-3.548360	0.7920	2005
Δ(OV)	-7.501913	< 0.01	1995	-6.984996	< 0.01	1996
*Δ(ln*AG)	-8.119732	< 0.01*	2003	-8.645914	< 0.01*	2003
*Δ(ln*TO)	-10.00830	< 0.01	1991	-10.59187	< 0.01	1991
Δ(LR)	-7.057456	< 0.01	1998	-11.31477	< 0.01*	1993
*Δ(ln*MS)	-4.948309	0.0100*	2006	-5.534773	0.0186**	1995

*and ** represents 1 and 5% significance level, respectively.

The test statistics showed that three variables namely output volatility, trade openness, and lending rate are stationary at level, I(0), while agricultural output and money supply are stationary after the first difference, I(0). Thus, based on the results, we can conclude that the variables under consideration are a mixture of I(0) and I(1), which is suitable for the ARDL cointegration application.

Cointegration

There are several cointegration testing techniques—including Engle-Granger two-step, Johansen & Juselius tests, and, ARDL bound tests. However, ARDL bound test has been extensively applicable in time series analysis for its numerous advantages over the other techniques. First, ARDL enables irrespective the variables are purely I(0), purely I(1), or both I(0) and I(1), which is impossible in the Johanson cointegration test approach. Second, the ARDL technique, based on the ordinary least square (OLS) gives unbiased and efficient estimates of coefficients and valid t-statistics even if all the variables are endogenous. Lastly, the technique is suitable for small sample sizes and, it gives highly consistent short-run and long-run parameters (Bane, 2018). However, all the aforementioned techniques are based on the underlying symmetric assumption that the dependent variable linearly affects the explanatory variable (based on a symmetric relationship). However, in reality, the explanatory variables can affect the dependent variable asymmetrically. For that reason, we used the NARDL Model. The only major difference between ARDL and NARDL models is that the latter includes both the positive and negative change effect of explanatory variables—to indicate an asymmetric relationship.

In the NARDL framework, the bound test can be confirmed based on F-test. The Null hypothesis of no cointegration is tested, based on the three decisions making critical values. If the critical values are less than lower bound, it confirms variables are not cointegrated. Conversely, if the critical values are above the lower bound, it confirms variables are cointegrated. However, if the critical values are within two limits, then it is impossible to suggest a decision about cointegration.

Table 3: Bounds test for nonlinear cointegration

Selected Model		ARDL(2, 2, 1, 0, 0, 2, 0)	
F-statistic		5.993134	
		Critical Values	
		I(0) Bound	I(1) Bound
Significance level	10%	1.99	2.94
	5%	2.27	3.28
	1%	2.88	3.99
H_0: No long-run relationships exist			

The appropriate lag length of variables are selected by AIC as; 2, 2, 1, 0, 0, 2, and 0 lag for the output volatility, agricultural output (Pos), agricultural output (Neg), trade openness (Pos), trade openness (Neg), lending rate and money supply, respectively. Accordingly, the F-statistics 5.99 far exceed any of the upper bound critical values of 1%, 5%, and 10%, indicating the research existence of a long-run cointegration among output volatility, agricultural output, openness, lending rate, and money supply, when output volatility is modeled as an dependent variable.

Table 4: Long Run and short run model Estimation Results

Panel A				
Long-run Model: VO is dependent variable				
Explanatory Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.179030	0.171284	6.883470	0.0000
$lnAG^{+}$	0.473723	0.078106	6.065160	0.0000
$lnAG^{-}$	0.345700	0.088598	3.901900	0.0008
$lnTO^{+}$	-0.056406	0.029025	-1.943342	0.0655
$lnTO^{-}$	-0.121642	0.044382	-2.740780	0.0122
$lnLR$	0.012968	0.003123	4.152120	0.0005
$lnMS$	-0.149154	0.021534	-6.926526	0.0000
Po	-0.128888	0.034569	-3.728397	0.0012
Panel B				
Short-run Model: D(VO) is dependent variable				
Explanatory Variables	Coefficient	Std. Error	t-Statistic	Prob.
$D(VO(-1))$	0.370596	0.110572	3.351630	0.0030
$D(lnAG+)$	0.506362	0.076093	6.654557	0.0000

Explanatory Variables	Coefficient	Std. Error	t-Statistic	Prob.
$D(lnAG+(-1))$	-0.295617	0.101896	-2.901156	0.0085
$D(lnAG-)$	0.607759	0.099305	6.120133	0.0000
$D()$	-0.046112	0.027646	-1.667921	0.1102
$D()$	-0.099442	0.033722	-2.948904	0.0077
$D(LR)$	0.004566	0.002462	1.854164	0.0778
$D(LR(-1))$	-0.006939	0.002149	-3.229291	0.0040
$D(lnMS)$	-0.121933	0.027101	-4.499286	0.0002
$D(Po)$	-0.105365	0.019420	-5.425466	0.0000
$ECT(-1)$	-0.817495	0.148892	-5.490509	0.0000

Cointegration equation = OV - (0.4737*lnAG_POS + 0.3457*lnAG_NEG -0.0564 *lnTO_POS -0.1216*lnTO_NEG + 0.0130*LR -0.1492 *lnMS -0.1289*PO + 1.1790)

Long run and Short run Results

The result of the long-run and the short-run equations test result are presented in table 4. To begin with our main target variable, trade openness, we note the asymmetric long-run relation between openness and volatility, with both the positive and negative changes in openness, significantly affecting volatility. Specifically, the estimates show that a 1% increase in openness leads to a 0.05% decrease in output volatility. Similarly, a 1% decrease in openness results in about a 0.12% increase in volatility. Thus, in the long-run trade openness, in either direction has a significant effect on output volatility. From this, we can conclude that trade openness reduces volatility. This outcome in parallel with the study of Huchet et al. (2018), Bejan (2006), Hegerty (2014); Giovanni & Levchenko (2009); Cavallo (2008) and contradictory with Aigheyisi & Isikhuemen (2018), Čede et al. (2016), Abubaker (2015), Danilo & Lorenzo (2018), Eduardo (2007), Mujahid & Alam (2014), and Mireku et al. (2017). According to Hegerty (2014), trade openness seems to be correlated with lower volatility in emerging nations. If export trade is diversified, trade openness may bring stability to output growth (Ali, 2016). It is argued that openness can lessen volatility by moving demand and production towards items with relatively stable trading conditions. This suggests that foreign trade allows a country to better integrate into the world economy (Briguglio & Vella, 2016), thereby reducing the inflationary and deflationary effects of output volatility. Ethiopia, whose foreign trade is mainly dependent on primary agricultural export (such as coffee and oilseeds) (Yetsedaw, 2014), would benefit from international trade via trade openness. Such benefits could sustainable growth, FDI inflow, expansion of markets for domestically produced goods, technological transfer (diffusion), and employment opportunities (Meidayati, 2017; Rizaldi & Jayadi, 2022). Hence, openness reduces the adverse effects of volatility such as; uncertainty (for instance more investment risk), risk about future demand that impedes investment, a risk of policy failure, and poor economic leadership, which further intensifies rather than calms the trade cycle. However, since Ethiopia has been chronically run a negative trade balance (Asnake & Liu, 2019) this form of advantage should not come at the cost of the trade balance. Foreign trade in developing countries, especially in countries with low income categories, can be disrupted because the distribution of income in these countries tends to deteriorate.

The coefficients of all other control variables significantly affect output volatility. In particular, a 1% increase in the agricultural output (positive change in agriculture output) leads 0.47% increase in the output volatility. Likewise, a 1% decrease in the agricultural output (negative change in agriculture output) leads 0.34% decrease in the output volatility. The possible explanation for this significant effect is that the sector is considered the backbone of the Ethiopian economy; it provides food & raw material, it is a source of foreign currency and, it is used as a market destination for non-agricultural products. The lending rate on the other hand has a positive and statistically significant effect on output volatility. A 1% increase in the lending rate leads to about a 0.013% increase in output volatility. A higher lending rate, hence a high interest rate for borrowers, could prohibit firms, not to borrowing and expanding their business. At a higher lending rate firms tend to be refraining from borrowing and investing in the economy. Thus, the lending rate has the potential exacerbating effect on output volatility in Ethiopia. Money supply, contrarily from other control variables, has a negative and, significant effect on output volatility. The long-run money supply coefficient suggests that a 1% increase in money supply is related to a decrease in the output volatility by about 0.15%. Money supply, the major monetary policy instrument, is used to stabilize the economy. At the time of deflationary pressure, the central bank releases money so that demand for goods increases, and thereby price starts to rise to their initial equilibrium. In this case, any cyclical deviation of output from its trend (long run) can be tackled through a monetary policy instrument. This view is backed by the so-called 'Supply-leading hypothesis. The theory advocated that financial intermediaries operations cause the real economy to expand its productive potential consequently enlarging the economy. The coefficient of the dummy for regime change has a negative statistically significant effect on volatility—both in the long run and short run. This indicates that the EPDRF regime (after 1991) reduces output volatility. This could be since the EPRDF regime follows a free-market economy than the Dergue regime, which possibly stabilizes the economy.

Most of the results (Table 4 panel B) of the short run coefficients of the control variables are in parallel with their long-run counterparts in terms of sign and statistical significance, particularly; agriculture output, lending rate, and money supply. The lagged value output volatility has a positive and statistically significant effect on its current value. Particularly a one percent increase in the lagged value volatility leads to a 0.37 percent increase in the current value of output volatility. The short-run coefficients of trade openness have a similar sign to their long-run counterparts. However, the positive dimension ($\Delta(ln\text{TO}+(-1))$) is not statistically significant. Besides, the coefficient of ECT(-1) is observed negative (-0.81) and significant at a 1% level. This further confirms our finding of a long-term cointegration between explained and explanatory variables.

Long-Run And Short-Run Asymmetry Test Results

Table 5: asymmetry test results

Null hypothesis	Variables	Statistics	Decision
Long-run symmetrical relationship	Trade openness	4.592596 (0.0321)**	Reject
	Agriculture output	3.912600(0.0479)**	Reject
Short-run symmetrical relationship	Trade openness	-	-
	Agricultural output	6.441282(0.0111)**	Reject

** is 5% significance level and P-Values are in parenthesis

We performed a standard Wald test to explore the asymmetrical link between openness and volatility and, agricultural output and volatility. Based on the standard Wald test, shown in Table 5 below, the long-term null hypothesis of the symmetrical relationship was rejected at a 1% significance level both for trade openness and agricultural output. This indicates that the positive and negative components of the long-run coefficients of trade openness and agricultural output are significantly different from each other (see Panel A in Table 5). Therefore, it can be concluded that there is a prevailing asymmetrical link between trade openness and output volatility and, agricultural output and output volatility in the long run. Moreover, we found short-run asymmetry between agricultural output and output volatility. However, we failed to get short-run asymmetry among trade openness and output volatility.

To draw inferences about the model results, it is worthwhile to check various diagnostic statistics. These diagnostic statistics include normality test, serial correlation test, heteroskedasticity test, and specification test. Table 6 shows the results of tests regarding diagnostic tests. Accordingly, the model residuals are normally distributed with constant variance, free from serial correlation and the model has no specification problem—as confirmed by the Ramsay RESET test. Consequently, we can conclude that the model estimates are efficient and, policy implications are reliable.

Table 6: Diagnostic tests

Tests	F- Statistics	P-value
Jarque-Bera Normality test	2.492757	0.287544
Breusch-Pagan-Godfrey Heteroskedasticity test	7.845884	0.8972
Breusch-Godfrey LM serial correlation test	0.568517	0.7526
Ramsey RESET test	1.791202 (1, 20)	0.1958

Conclusion

The issue of volatility and its effect has been a concern of policymakers. A better understanding of whether the openness has promoted volatility can lead to more effective government policy that directly addresses the underlying causes of volatility. However, the previous study considered openness to has a symmetric (linear) effect on growth, and hence output volatility. By incorporating other possible factors such as; agricultural output, lending rate, and money supply, as additional explanatory variables and using NARDL Model, the study examined the possible asymmetry effect of openness on output volatility in the context of Ethiopia by taking annual data from the period 1981–2020. In addition, the study employed an HP filter to extract output volatility.

Accordingly, the NARDL framework of the bound test confirmed the existence of a long-run cointegration between output volatility, agricultural output, openness, money supply, and lending rate, while output volatility is modeled as a dependent variable. Besides, the coefficient of the ECT(-1) has a negative sign with a 1% level of significance. This further confirms cointegration between variables. From the long-run model, a significant negative asymmetric effect of openness on volatility was found. The short-run coefficients of positive and negative dimensions of trade openness have a similar sign to their long-run counterparts; however, we did not find a short-run asymmetric effect. This leads to the conclusion that openness appears to be linked to lower output volatility in Ethiopia. Trade openness can lessen volatility by restricting recourse and directing demand and production to items with generally stable trading conditions. This illustrates how international trade may help a forming and unifying the nation into the global economy, thereby reducing the inflationary and deflationary effects of output volatility. Ethiopia, whose foreign trade is mainly dependent on primary agricultural export (such as coffee and oilseeds), would benefit from international trade via trade openness and, openness reduces the adverse effects of volatility. However, since Ethiopia has been chronically run a negative trade balance, this form of advantage should not come at the expense of the trade balance. Both the positive and negative dimensions coefficients of agricultural output show that agricultural output has a direct impact on output volatility. In agrarian economies like Ethiopia, agriculture is considered the backbone of the economy. The sector has been a source of livelihood, employment, raw material, market for other sector, capital and currency. Any increase in the sector could cause the economy to deviate from its trend. Hence, the sector needs to be accompanied by other complementary sectors such as the industrial and service sectors. Besides, we confirmed the asymmetric effect of agricultural output both in the long run and short run.

In contrast, the lending rate has a positive and statistically significant influence on output volatility in both time dimensions. Thus, the lending rate has the potential to exacerbate the effect of output volatility in Ethiopia, and, maintaining of lending rate to an affordable level could help to reduce volatility. The coefficients of money supply, contrarily from other control variables, have a negative and, significant effect on volatility. It possibly indicates any cyclical deviation of output from its trend can be tackled through monetary policy instruments. Therefore, money supply, as advocated by the Supply-leading hypothesis, could help the country to reduce its output volatility. However, at the same time, the adverse effect of money supply such as higher inflation rate (quantity theory of money), need also be considered.

Declarations

Conflict of Interest

No any competing interest.

Availability of data and materials

The data of this research are obtained from NBE and the World Bank.

Authors' contributions

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