Economics Bulletin

Volume 41, Issue 3

Does volatility hinder economic complexity?

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Abstract

This paper investigates the effect of the output and terms of trade volatility on economic complexity. To this end, we apply ordinanry least square, fixed effect and System GMM approach for a panel of 119 countries over the period 1998-2017. The findings reveal that the output and terms of trade volatility negatively affects economic complexity. Our empirical results also indicate that financial development, foreign direct investment, internet and income per capita have a positive effect on economic complexity while natural ressources have a negative effect.

Citation: Désiré Avom and Brice Kamguia and Joseph Pasky Ngameni, (2021) "Does volatility hinder economic complexity?", *Economics Bulletin*, Vol. 41 No.3 pp. 1187-1202.
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Submitted: November 19, 2020. **Published:** July 18, 2021.

1. Introduction

Does output and terms of trade stability affect country's specialization in more complex goods? With this paper we aim at answering this question. Literature defines complexity as technological diversification, i.e. the number of inputs used in production. The idea of economic complexity is based on two concepts: Diversity and ubiquity. Diversity indicates the number of products a country exports and ubiquity refers to the number of countries that export the same product (Hidalgo and Hausmann, 2009). Diversity could be one of the strongest words that could describe today's economic structure around the world. Hausmann et al. (2011) argue that producing a diverse set of goods implies that a country has many capabilities. The diversity of countries must be corrected with ubiquity of products and vice versa. In this perspective, ubiquity can be thought of an indicator for sophistication. Sophistication of economies can evolve by either increasing the quality of produced goods or switching to new, modern or more sophisticated products (Spatafora et al. 2012). Thus, through the concepts of diversity and ubiquity, economic complexity searches a way for countries to transform their productive structure.

Economic complexity incorporates not only the breadth of a country's exports, but also how knowledge-intensive they are. It infers the productive capabilities of countries by measuring whether the country merely exports standardized agricultural products or it is capable of producing and exporting a varied set of complex products such as machinery or chemical products (Saadi 2020). A country which is able to make many products (high diversity) that few countries on average are able to make (low ubiquity), is likely to have a broad range of productive capacities. A country which is able to make a few things (low diversity) that many countries are able to make (high ubiquity), is likely to have few productive capacities. When a country's production structure is more complex, the production capabilities are stronger. A country with greater capabilities will be able to participate in social production activities with higher productivity, and thus, the country will develop faster (Felipe et al. 2012). Differences in the ability of countries to improve their production and diversify into complex products seem to explain why they are taking off or remain poor (Saadi 2020).

In recent years, most specialists agree that economic sophistication accelerates economic growth (Hidalgo and Hausmann, 2009; Hausmann and Hidalgo, 2011) and reduces income inequality (Hartmann et al. 2017; Lee and Vu, 2019). Studies on economic complexity are limited because this topic is rather a new one. Indeed, the determinants of economic complexity still remain unexplored in the economic literature. Very few recent papers are available on this

topic, such as Hartmann et al. (2017), which shows that countries exporting complex products tend to be more inclusive and have lower levels of income inequality than countries exporting simpler products; Lapatinas (2019), which finds that the Internet has a positive effect on the sophistication of exported products.

In contrast, the influence of terms of trade and output volatility on many aspects of economic development is well known (Chauvet et al., 2018). A burgeoning literature that has documented a negative relationship between volatility and output, implies that volatility has first-order effects on welfare, even for developing economies where growth has traditionally been the major concern (Ramey and Ramey1995). Moreover, the welfare implications of volatility in developing economies have been highlighted by episodes of extreme volatility in a number of developing economies in the 1990s (Prasad et al. 2003). Output fluctuations are generally associated with uncertainty, with its unfavourable effects on both investment and consumption (Tang and Abosedra 2020). Developing countries have experienced large welfare losses arising from episodes of extreme volatility. Eicher et al., (2008) show that adverse shocks to a country's terms of trade not only may disrupt the economy's growth, but also may introduce considerable instability. Negative effects of output volatility in the forms of decreased economic growth (Martin and Rogers, 2000; Imbs, 2007), lower private investment in human capital (Aizenman and Marion, 1999; Hnatkovska and Loayza, 2005).

Terms of trade volatility has been shown to have significant negative impacts on the income level (Andrews and Rees 2009 ; Jawaid and Waheed 2011) and investment (bleaney and Greenaway 2001). Dibooğlu and Aleisa (2004) document recessions, uncertainty, and inflationary pressures associated with terms of trade shocks. Besides, some scholars have empirically studied the effect of economic complexity on economic growth. Hidalgo and Hausmann, (2009) in their empirical results show that economic complexity is highly correlated with income. Furthermore, their results also demonstrate that cross-country differences in income are the result of economic complexity differences. Fang et al. (2015) find that both foreign direct investment and public investment also play significant roles in promoting the upgrading of exports.

The two lines of research discussed above offer two different views about the determinants of comparative prosperity across countries. Hence, they have been generally examined separately as competing alternatives. This paper goes beyond the two different strands of the literature by bringing them together. In particular, this is the first study that empirically examines the effect of output and terms of trade volatility on export sophistication.

as output volatility and terms of trade volatility could result in lower trade openness (as the latter further exposes countries to external shocks), then one could expect that greater output volatility and terms of trade volatility would result in lower levels of economic complexity in countries that experience greater trade openness, in particular if trade openness resulted in greater economic complexity. The literature has shown that trade openness is more likely to be associated with higher complexity of export structure as countries that are more open may take advantage from technology diffusion (Keller, 2010; Saadi 2020). Trade openness has been important in developing economies. Studies show that greater openness of developing countries is beneficial for economic growth (Awokuse, 2007; Nannicini and Billmeier, 2011) and welfare (Jansen, 2004).

A number of cross-country empirical studies analyze the relationship between trade openness and volatility. Kose et al. (2003); Bejan (2006); Kpodar et al. (2019) find that trade openness generally increased output volatility[1]. Their argument is that openness leads to specialization and to more volatility if sector-specific shocks are prevalent (Bejan 2006). Bejan (2006) also point that, a part of the positive relation between openness and volatility may be explained by the positive relation between openness and government size. Giovanni and Levchenko (2009) show that trade openness affect volatility primarily by exposing industries to external shocks.

Another strand of literature also investigates the nexus between trade openness and terms of trade volatility. For example, Benarroch and Pandey (2008) find that trade openness increases terms of trade volatility particularly in developing countries. In both developing and emerging countries, volatility is mainly the consequence of external shocks (Reinhart and Rogoff, 2009, 2014). External shocks take the basic forms of trade shocks. Openness to trade is becoming an important transmission mechanism of external shocks throughout the world economy, especially in developing countries (Balavac and Pugh 2016). Thus, based on this we could derive the conclusion that if trade openness induces greater output volatility and terms of trade volatility, then countries with higher output volatility and terms of trade volatility would be willing to reduce their trade openness levels.

[1] However, other studies have shown that trade openness could have a volatility-reducing effect. For example, Giovanni and Levchenko (2009) argue that trade openness could have a volatility-reducing effect as it changes the co-movement between sectors within an economy and isolates open sectors from domestic fluctuations. Haddad et al., (2013) argue that the vulnerability of countries to idiosyncratic external shocks should be reduced when these countries are better diversified in their exports. The basic argument for a positive role of trade openness in reducing exposure to foreign shocks is that a high trade openness helps to adjust to a cut-off in international financing (Montalbano 2011). Cavallo and Frankel (2008) show that trade openness makes countries less vulnerable to both severe sudden stops and currency crashes.

Against this background, one could expect that if trade openness leads to economic complexity, and if at the same time, trade openness enhances output volatility and terms of trade volatility, then one could argue that countries that face greater output volatility and terms of trade volatility might adopt policies and measures to reduce their trade openness degree, which would in turn, result in a lower level of economic complexity.

Another channel through which output and terms-of-trade volatility is transmitted is through private investment[2]. Indeed, given that output and terms-of-trade volatility can have a negative effect on private investment and that an increase in private investment improves economic complexity, one would expect that greater volatility would lead to a deterioration in economic complexity through its negative effect on private investment.

Several studies have shown that investment has a positive effect on economic complexity (Fang et al. 2015; Saadi 2020; Lapatinas 2019; Javorcik et al. 2018). Another branch examines the effects of terms of trade and output volatility on investment (Bleaney and Greenaway 2001; Dabla-Norris and Srivisal 2013). The latter show that volatility has a negative effect on investment. Thus, volatility can be expected to have an effect on complexity through its negative impact on private investment.

The research question of this study is: what is the effect of the output and terms of trade volatility on economic sophistication? The current research focuses on economic complexity, which resolves several issues of the export sophistication index of Hausmann et al. (2007). Economic complexity provides better information than the measure of export sophistication when it comes to reflecting the level of sophistication of production (Felipe et al. 2012). Moreover, export sophistication is the subject of three major criticisms. The first criticism concerns the use of income information to calculate the level of sophistication of a product, which generates a circularity according to which "rich countries export products from rich countries" (Hidalgo and Hausmann, 2009; Jarreau and Poncet 2012). The second criticism concerns the consideration of quality differentiation within products. Schott (2004) distinguishes between inter-product sophistication and intra-product sophistication. The third criticism can be seen as an extension of the second. Participation in the global value chain (GVC) allows some developing countries to assemble technologically sophisticated intermediate inputs from developed countries and then export final products. The results show

[2] However, in the empirical part, we will not test this channel.

that an increase in the output and terms of trade volatility has a negative effect on the sophistication of production.

The rest of the paper proceeds as follows. Section 2 discusses the Model. Section 3 provides the main empirical findings, and the results of robustness. The paper concludes by summarizing the results and discussing some implications for policymakers.

2. Model

Based on earlier studies (Vu, 2021; Nguyen et al., 2020; Saadi, 2020; Lapatinas 2019; Gnangnon and Roberts 2017; Jouini et al. 2016), we perform empirical analysis using data from 119 developed and developing countries over the period of 1998–2017[3] to explore the influence of the output and terms of trade volatility on economic sophistication. In particular, we estimate the following regression:

$$ECI_{i,t} = \alpha ECI_{i,t-1} + \beta_1 Vgrowth_{i,t} + \beta_2 Vtot_{i,t} + \beta_k X_{i,t} + \gamma_i + \delta_t + u_{i,t} \quad (1)$$

where the subscripts i and t respectively denote country and time period, ECI the economic sophistication $Vgrowth$ represents real GDP growth volatility, $Vtot$ is the volatility of terms of trade, X is a set of control variables including inflation volatility, financial development measure by domestic credit to private sector, foreign direct investment (FDI), internet, trade openness, terms of trade, natural ressources rents and the real per capita GDP[4]. In order to account for country unobservable heterogeneity, we include country fxed efects, γ_i. We also include period fxed efects, δ_t, to account for global business cycles.

How is volatility measured?

The traditional approach in the literature has been to use the standard deviation of the growth rate of the given variable during a specific period. However, this approach relies on strong assumptions regarding the functional form of the long-term component. Following Chauvet et al. (2018), we use instead a more flexible approach, assuming that the long-term component follows an AR (1) process with a trend as follows:

[3] The choice of this period is dictated by the data availability.
[4] For the definition of the variables and their sources, see Table 2 in appendice

$$\ln(y_{i,t}) = \alpha_i + \beta_i \ln(y_{i,t-1}) + \gamma_i t + \varepsilon_{i,t} \quad (2)$$

$y_{i,t}$ is the real GDP for country *i* at time *t*, and $\varepsilon_{i,t}$ is the error term. Fitting this equation for each country individually with annual data over the period 1998-2017 allows estimating the error term $\varepsilon_{i,t}$, which captures the cyclical component of the logarithm of real GDP given the assumed functional form of the long-term component:

$$\widehat{\varepsilon_{i,t}} = \ln(y_{i,t}) - \widehat{\ln(y_{i,t})} \quad (3)$$

For each sub-period of 4 years, growth volatility *Vgrowth* is calculated as the standard error of the cyclical component $\varepsilon_{i,t}$, as shown below:

$$Vgrowth = \sqrt{\sum_{j-1}^{5} \frac{(\widehat{\varepsilon_{i,t}} - \overline{\widehat{\varepsilon_{i,t}}})}{4}} \quad (4)$$

To estimate the model, three econometric estimators are used: the ordinary least square estimator, the fixed effect estimator and the system GMM estimator. The fixed-effect estimator allows to control for time-invariant country-specific factors that may affect export sophistication, thereby reducing the risk of omitted variables. However, endogeneity issues may arise due to omitted variables (not addressed by the inclusion of country-specific effects), measurement errors and reverse causality. As an attempt to tackle potential endogeneity issues, we use the system GMM estimator developed by Blundell and Bond (1998) to instrument the right-hand side variables with the appropriate lags. Blundell and Bond (1998) find that the system GMM estimator, which uses both the difference panel data and the level specification, improves significantly the consistency and efficiency of the estimates compared to the first-differenced GMM[5] developed by Arellano and Bond (1991).

3. Results

[5] To test the validity of the lagged variables as instruments, we use the standard Hansen test of over-identifying restrictions, where the null hypothesis is that the instrumental variables are not correlated with the residual, and the serial correlation test, where the null hypothesis is that the errors exhibit no second-order serial correlation. The results from both tests support the validity of the instruments.

Table 1 presents the results of the effect of volatility on export sophistication. Column 1 gives the results when we control the volatility of GDP per capita and the volatility of the terms of trade. The coefficients associated with these variables are negative and statistically significant at 1%. This reflects the fact that an increase in the volatility of GDP and/or the terms of trade leads to a deterioration in export sophistication.

In the column 11, the coefficient associated with output volatility is -0.02, with a magnitude suggesting that an increase in output volatility of 10 units leads to a degradation of economic complexity of about 0.2 units. The coefficient associated with the volatility of the terms of trade is -0.01 with a magnitude suggesting that an increase in the volatility of the terms of trade of 10 units leads to a degradation of economic complexity of about 0.1 units. In column 14 where all control variables are entered, the coefficients associated with the variables output volatility and terms of trade volatility are -0.043 and -0.036, suggesting that a 10 unit increase in these variables leads to a decrease in economic complexity of 0.43 and 0.36 units respectively. Moreover, when comparing the coefficients of these variables across the different estimators, we find that the coefficients associated with OLS are higher than the coefficients of GMM and fixed effect. This result is not surprising because OLS estimators lead to upward bias while fixed-effect estimators introduce downward bias (Nickell 1981).

In column 3, we introduce financial development in addition to inflation volatility. We find that the coefficient associated with inflation volatility is negative and significant at 10%. An increase in inflation volatility reduces economic sophistication. On the other hand, financial development is positive and statistically significant at 10%. This suggests that an improvement in financial development increases the sophistication of exports. In column 4, we introduce in addition FDI. We find that the coefficients associated with the volatility of GDP and terms of trade remain negative and statistically significant at 1%. This confirms the negative effect of volatility on economic sophistication. The coefficient associated with FDI is positive and statistically significant at 1%. Thus, an improvement in FDI leads to an increase in the improvement of exports. This result is consistent with that of Saadi (2020) which shows that FDI has a positive effect on economic sophistication. We introduce in column 5 the internet variable. The coefficients associated with output and terms of trade volatility remain significant at 1%. This result shows that volatility is detrimental to the improvement of exports. As regards the internet variable, we note that this variable is positive and statistically significant at 1%. This indicates the importance of internet access in the process of export sophistication.

We also include as additional control variables income per capita, terms of trade and natural resources. We find that the coefficients of income per capita and the terms of trade are positive and statistically significant. This result reflects the fact that an increase in these variables leads to an improvement in economic complexity. These results are consistent with the literature that examines the determinants of economic complexity (Jouini et al. 2016; Saadi 2020; Gnangnon and Roberts 2017). In contrast, the coefficient associated with natural resources endowment is negative and statistically significant at 1%. This result reflects the fact that abundance of natural resources leads to a degradation of economic complexity, which confirms the resources curse hypothesis.

In order to test whether trade openness is the channel through which terms of trade volatility and output volatility negatively affect economic complexity, we also introduce in column 5 the interaction between these variables and trade openness. The coefficient associated with the interaction variable between trade openness and output volatility is negative and statistically significant at 1%. This result reflects the fact that trade openness exacerbates the negative effect of output volatility on economic complexity. This result is in line with those obtained by Giovanni and Levchenko, (2009) who show that countries open to international trade are more volatile. The coefficient associated with the interaction variable between trade openness and terms of trade volatility is negative and statistically significant at 10%. This result implies that an improvement in trade openness amplifies the negative effect of terms of trade volatility on economic complexity. This result is consistent with the work of Haddad et al, (2013) which shows that trade openness promotes volatility in low-diversification countries.

Table 1: The effect of the volatility on economic sophistication

	OLS					Fixed effect					System GMM			
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
L.ECI											1.11***	1.07***	1.227***	0.888***
											(0.003)	(0.009)	(0.0316)	(0.0474)
Vgrowth	-0.042***	-0.049***	-0.0461***	-0.0480***	-0.037***	-0.020***	-0.021***	-0.0217***	-0.021***	-0.017**	-0.02***	-0.02***	-0.017**	-0.0432***
	(0.0121)	(0.0142)	(0.0109)	(0.0114)	(0.007)	(0.00594)	(0.00598)	(0.00598)	(0.00591)	(0.006)	(0.001)	(0.001)	(0.0069)	(0.00864)
VTot	-0.082***	-0.091***	-0.070***	-0.0685***	-0.012*	-0.0035**	-0.0077**	-0.00913	-0.00957	-0.011*	-0.01***	-0.003***	0.00299	-0.0363***
	(0.00732)	(0.00811)	(0.00777)	(0.00781)	(0.007)	(0.00008)	(0.0002)	(0.00591)	(0.00584)	(0.006)	(0.0002)	(0.0006)	(0.0187)	(0.00427)
Vinflation		-0.0195	-0.0340*	-0.0365*	-0.045**		-0.053***	-0.0536***	-0.049***	-0.049***		-0.02***	-0.0556	-0.0283**
		(0.0214)	(0.0196)	(0.0190)	(0.02)		(0.0113)	(0.0116)	(0.0115)	(0.012)		(0.0004)	(0.0609)	(0.0117)
Financial depth			0.00610***	0.00587***	0.002***			0.00154***	0.00134**	0.0017***		0.0005***	-0.00061	0.00674
			(0.000493)	(0.000508)	(0.0004)			(0.000536)	(0.000530)	(0.0005)		(7.91e-05)	(0.0005)	(0.00160)
FDI				0.0145***	0.005*				0.0171***	0.016***			-0.0016	0.0306
				(0.00335)	(0.003)				(0.00266)	(0.002)			(0.002)	(0.00699)
Internet					0.017***					0.0021***			0.004***	0.00823***
					(0.0006)					(0.0007)			(0.0005)	(0.00116)
Gdp per capita					0.00838**					0.102**				1.181***
					(0.00061)					(0.002)				(0.198)
Terms of trade					0.002***					0.000535				0.00333
					(0.0004)					(0.000359)				(0.000961)
Natural Res.					-0.0219***					-0.0142***				-0.0107**
					(0.00154)					(0.002)				(0.00449)
Vgrowth X open					-0.0294***					-0.005				-0.0537***
					(0.00938)					(0.006)				(0.0110)
VTot X open					-2.739*					-1.650**				-15.48**
					(1.533)					(0.750)				(6.516)
Constant	-1.039***	-1.130***	-1.204***	-1.242***	-0.408***	-0.0435	-0.0529	-0.159*	-0.238***	-1.353*	-0.13***	-0288	0.242	-12.69***
	(0.0931)	(0.104)	(0.104)	(0.104)	(0.135)	(0.0688)	(0.0734)	(0.0827)	(0.0825)	(0.785)	(0.0090)	(0.652)	(0.246)	(2.288)
Observations	1,961	1,756	1,712	1,712	1,579	1,961	1,756	1,712	1,712	1,579	1,874	1,641	1,644	1,552
Number of id						118	114	114	114	114	118	114	114	114
AR(1)											0.0603	0.067	0.021	0.024
AR(2)											0.248	0.2843	0.242	0.208
Hansen											0.155	0.398	0.548	0.112

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

In columns 11-14 of the table, we focus on the dynamic setup and we report a two-step System GMM (SGMM) estimates. We consider that the only endogeneity present is that involving the lagged dependent variable. Again, the empirical results confirm our previous finding that output volatility and terms of trade volatility negatily affect export complexity of the developing and emerging countries. The results of the diagnostic tests suggest that all models are relatively well specified. The p-values of second-order serial correlation and Hansen's over-identification tests indicate that the model is adequately specified.

4. Conclusion

This paper has presented empirical evidence that output and terms of trade volatility is negatily associated with export complexity. The relationship is economically large and is robust to different model specifications and different econometric approaches. Volatility is relatively a more important issue in developing countries than developed ones. This study highlights the importance of understanding the factors driving volatility and its effect on economic complexity. This paper focuses on an important issue because macroeconomic stability is a prerequisite for sustainable and inclusive growth. Therefore, policy efforts must focus on reducing volatility.

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Appendix

Table 2. Variable Definitions and Sources

Variables	Definitions	Sources
ECI	measures the diversity and sophistication of a country's export structure, corrected for how difficult it is to export each product.	http://atlas.media.mit.edu
Gdp growth volatility	The standard deviation of the residual of the log of real GDP regressed on its lags value and a time trend (assuming an AR(1) process with a trend), calculated over a 5-year period	World Development Indicators and author's calculations
Terms of trade volatility	The standard deviation of the residual of the log of terms of trade index regressed on its lags value and a time trend, calculated over a 5-year period. The terms of trade	World Development Indicators and author's calculations
Inflation volatility	The standard deviation of the residual of the log of Consumer Price Index regressed on its lags value and a time trend, calculated over a 5-year period	World Development Indicators and author's calculations
Financial development (%GDP)	Domestic credit to private sector refers to financial resources provided to the private sector by financial corporations	WDI
Foreign direct Investment	FDI in stock measured as a share of GDP	WDI
Internet	Internet users ratio: the number of people with access to the world wide network divided by the total population	WDI
Terms of trade	Net barter terms of trade index is calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year 2000.	WDI
Trade openess	Trade is the sum of exports and imports of goods and services measured as a share of Gdp.	WDI
Natural ressources (%GDP)	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	WDI
Gdp per capita	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.	WDI