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The long run effects of commodity price volatility on growth and inflation: A cross-country panel estimation

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Abstract

We study the impact of commodity terms of trade (CToT) volatility on long-term economic growth and its drivers as well as on inflation, in a sample of 118 countries over 1970-2019, including 69 commodity exporters. Our econometric approaches account for bi-directional feedback effects, cross-country heterogeneity, and cross-sectional dependences. We find that CToT volatility exerts a negative impact on long-term economic growth, mainly through lower capital accumulation. This offsets the positive impact on growth from commodity price booms (especially in resource-rich economies). Furthermore, we observe that higher CToT volatility leads to greater volatility in inflation rather than structurally higher inflation.

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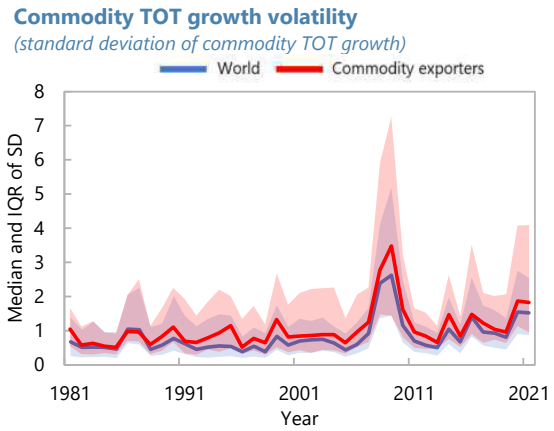
1. Introduction

Even as the sharp rise in commodity prices following the Covid-19 pandemic and after Russia's invasion of Ukraine faded out, the macroeconomic policy challenges proved more persistent, due to the marked increase in CToT volatility (Figure 1). Using data over the period 1970–2007, Cavalcanti *et al.* (2015) show that CToT volatility exerts a negative impact on long-term economic growth. However, the post-2007 era has witnessed significant global shifts, including the aftermath of the global financial crisis, evolving commodity market dynamics (e.g., driven by new shale-oil supply, geopolitics, energy transition), and changes in broader macroeconomic fundamentals like monetary and exchange rate regimes. These transformations suggest that the relationships observed in the pre-2007 era may have evolved, highlighting the need for updated research to understand the contemporary interplay between CToT volatility and growth. Moreover, what is less well understood is whether CToT volatility also impacts inflation—in terms of structurally higher inflation, or increased inflation volatility.

Figure 1. Terms of Trade Growth Volatility



Sources: Gruss and Kebhaj (2019), and authors calculations.
Note: Median and interquartile range of standard deviation of year-on-year growth rates of the commodity TOT, which has increased since 2019, and more so for commodity exporters. Sample: 182 countries (62 commodity exporters, defined as in Cavalcanti *et al.* 2015). TOT: terms of trade.

In this paper we revisit the evidence on the effects of CToT volatility on long-term economic growth found in Cavalcanti *et al.* (2015) with much more recent data. We also study the relative importance of the key channels of the impact on growth (total factor productivity, physical capital accumulation, and human capital acquisition). Further, we explore whether there is a link between CToT volatility and inflation or inflation volatility. Our hypothesis is that higher CToT volatility could lead to higher headline inflation volatility but not necessarily structurally higher inflation, the latter thanks to the evolution of policy institutions to manage inflation and anchor inflation expectations worldwide (Jahan 2012). Studying the impact of CToT volatility on inflation volatility is important as evidence suggests that supply shocks can have more persistent effects on inflation during periods of high inflation volatility (Arndt and Enders, 2023), which could pose challenges for policy makers.

Our estimates show that CToT volatility exerts a negative impact on long-term economic growth (operating through lower accumulation of capital), reinforcing the previous findings in the literature. We also show that higher CToT volatility leads to more volatile inflation, although it does not necessarily lead to structurally higher inflation per se.

Our estimation methodology uses annual observations (1981-2019), and data over non-overlapping 5-year intervals (1970-2019) for 118 countries, employing Cross-Sectionally Augmented Autoregressive Distributive Lag (CS-ARDL) methodology and the system Generalized Method of Moments (GMM) approach. Econometrically, the CS-ARDL and GMM

approaches account for cross-sectional heterogeneity, joint endogeneity of explanatory variables, and cross-sectional dependences.

Accounting for these factors is particularly important in our panel data analysis for three reasons. (i) *Country specific features:* the impact of CToT volatility on growth and inflation could vary across countries depending on country-specific features and channels (such as monetary policy regimes/effectiveness, quality of institutions, level of economic and financial development, strength of public financial management, capital costs, and type of stabilization buffers)— Aghion *et al.* (2009); Aizenman and Pinto (2005); Blattman *et al.* (2007); van der Ploeg and Poelhekke (2010); Lee (2023); Houndoga and Picone (2024). (ii) *Simultaneity:* In addition, GDP growth and its drivers could be simultaneously determined, including by other factors (i.e., omitted variables)— Aghion *et al.* (2009); Beck *et al.* (2000). (iii) *Unobserved common factors:* moreover, controlling for observed characteristics specific to countries and fixed effects alone need not ensure error cross-section independence. Cross-section dependence could be caused by unobserved common factors (e.g., the stance of the global financial cycle, oil price shocks, trade and/or financial integration)— Pesaran (2006). The CS-ARDL regression additionally addresses such dependences, as neglecting them can lead to biased estimates and spurious inference, particularly given the rapid increase in globalization in our sample period and more correlated shocks across countries— Chudik and Pesaran (2015).

To investigate whether CToT volatility has a differential impact on growth in primary-commodity exporters, we split our GMM sample into groups A with 62 primary commodity exporters, and group B with 56 other countries with a more diversified export basket. Our findings indicate that the experience of countries in group A facing CToT volatility is indeed different— i.e., higher CToT volatility harms GDP per capita growth through lower accumulation of human and physical capital. For this reason, we focus on group A in the CS-ARDL growth regressions, which confirm the GMM results. Notably, we do not find a statistically significant negative association between CToT volatility and TFP growth in group A countries, in both the GMM and the CS-ARDL regressions.

Regarding inflation, we find that countries facing higher CToT volatility experience more inflation volatility, but there is no impact on the long-term level of inflation. This can occur, for example, as greater volatility in the cost of imported goods passes through to domestic prices and thereby result in more volatile consumer price inflation. CToT volatility may also amplify swings in core inflation. For example, increased uncertainty and higher input costs for firms could lead to price adjustments in other economic sectors.

The remainder of this paper is organized as follows. Sections 2 and 3 report the empirical results for growth and headline inflation, respectively. Section 4 concludes. The Data Appendix discusses the data sources and their compilation.

2. CToT Volatility and Per Capita GDP Growth

We examine the impact of CToT growth and volatility on per-capita GDP growth as well as on changes in Total Factor Productivity (TFP), physical capital accumulation, and human capital acquisition. We estimate the following dynamic panel data model:

$$\Delta y_{\boldsymbol{it}} = (\varphi - 1) y_{it-1} + \boldsymbol{\beta}' \boldsymbol{x_{it}} + \boldsymbol{\gamma}' \boldsymbol{z}_{it} + c_i + \eta_t + \varepsilon_{it} \qquad (1)$$

where, $i = 1 \ldots N$ and $t = 1 \ldots T/5$ (with T being the interval between 1970 and 2019); Δy_{it} is the geometric average growth rate of Y={real GDP per capita, or TFP, or physical capital, or human capital} between t and $t-1$; y_{it-1} is the log of Y in the first year of each 5-year interval; $\boldsymbol{x_{it}} = [g_{CToT}, \sigma_{CToT}]'$, in which $gCToT$ is the growth rate of the CToT index and $\sigma CToT$ is the standard deviation of $gCToT$ in each 5-year interval; and $\boldsymbol{z}_{it}$ is a set of standard additional control variables from the growth literature including export sophistication, education levels, trade openness, government consumption expenditure, and lack of price stability. c_i is a country-specific fixed effect, η_t is a period-specific time effect, and ε_{it} is an idiosyncratic error term.

Table I. Effects of CToT growth and volatility on GDP per capita growth and its drivers: System GMM regressions and non-overlapping 5-year averages (1970-2019)

Sample:	All	Commodity exporters				Others
The dependent variable is the growth rate of:	GDP per capita	GDP per capita	TFP	Physical capital	Human capital	GDP per capita
CToT growth	0.247*	0.0931	-0.108	0.315***	0.0662	0.382
	(0.135)	(0.163)	(0.250)	(0.111)	(0.0417)	(0.277)
CToT volatility	-0.290***	-0.358***	-0.0546	-0.0284	-0.0532***	0.0983
	(0.0940)	(0.0850)	(0.202)	(0.0963)	(0.0188)	(0.216)
Initial value	-0.830*	-0.542	-3.727**	-1.595**	-0.605	-3.444***
	(0.481)	(0.501)	(1.664)	(0.711)	(0.667)	(0.975)
Control variables						
Export sophistication	0.934	0.341	1.849	4.965*	-1.591**	8.939**
	(1.630)	(2.127)	(2.990)	(2.793)	(0.628)	(4.344)
Education:	1.483***	0.936	1.201	0.304	1.098***	2.067
	(0.499)	(0.664)	(1.275)	(0.779)	(0.277)	(1.712)
Trade openness	3.924***	4.496***	3.461**	2.743**	0.541**	2.751*
	(0.836)	(1.559)	(1.424)	(1.185)	(0.262)	(1.411)
Government burden	-3.591***	-2.952***	-5.183**	-1.488	0.00755	-2.761
	(0.900)	(1.033)	(2.106)	(1.385)	(0.400)	(1.747)
Price instability	-5.948***	-5.243*	-4.250	-7.028*	1.060*	-17.24***
	(2.136)	(2.762)	(4.605)	(3.698)	(0.625)	(3.495)
Constant	19.71	17.65	34.32	0.741	3.743	23.96
	(14.99)	(16.77)	(33.03)	(23.55)	(7.047)	(39.28)
Observations	873	460	448	464	465	413
No. of Countries	118	62	62	62	62	56

Note: System GMM estimates are from equation (1). Standard errors are in parentheses. Asterisks indicate statistical significance at 1% (***), 5% (**), and 10% (*).

We employ the system GMM approach for estimation and correct for the small sample bias using the Windermeijer (2005) approach. The system GMM approach accounts for the joint endogeneity of explanatory variables and the problems induced by unobserved country-specific effects. Results in Table I indicate that in the full sample of 118 countries, CToT volatility is negatively associated with growth in per capita GDP. Looking at commodity exporters and other countries separately, this effect is only observed among the former, operating through reduced human capital acquisition.

We then estimate the following CS-ARDL model, using the Pooled Mean Group (PMG) estimator on annual observations over 1981–2019 for robustness:

$$\Delta y_{it} = c_i^* + \varphi_i \Delta y_{it-1} + \boldsymbol{\beta'}_{\mathbf{0}i} \Delta \boldsymbol{x}_{it} + \boldsymbol{\beta'}_{\mathbf{1}i} \Delta \boldsymbol{x}_{it-1} + \boldsymbol{\vartheta'}_{\mathbf{0}i} \Delta \bar{\boldsymbol{z}}_t + \boldsymbol{\vartheta'}_{\mathbf{1}i} \Delta \bar{\boldsymbol{z}}_{t-l} + \varepsilon_{it}, \qquad (2)$$

where, y_{it} is the log of Y=\{real GDP per capita, or TFP, or physical capital, or human capital\} of country i in year t; $\boldsymbol{x_{it}} = [g_{CToT}, \sigma_{CToT}]'$, in which $g_{CToT_{it}}$ is the growth rate of the CToT index, and $\sigma_{CToT_{it}}$ is the volatility of CToT growth in year t for country i; and $\bar{\boldsymbol{z}}_{\boldsymbol{t}} = [\overline{\Delta y}, \bar{\boldsymbol{x}}']'$ is a vector of cross-sectional averages of the variables (i.e., proxies for unobserved common factors, such as global commodity price volatility movements in this instance). c_i^* is a country-specific fixed effect. We calculate the long-run effects, $\boldsymbol{\theta_i}$, from OLS estimates of the short-run coefficients in equation (2):

$$\boldsymbol{\theta_i} = \frac{\boldsymbol{\beta_{0i}} + \boldsymbol{\beta_{1i}}}{1 - \varphi_i}.$$

The CS-ARDL method allows for heterogeneous error variances, short-term slope coefficients, and intercepts, while restricting the long-run coefficients to be the same across countries (namely, $\boldsymbol{\theta}_i = \boldsymbol{\theta}$ for $i = 1, 2, \ldots, N$). Other considerations behind the use of panel ARDL are set out in Pesaran and Smith (1995), Pesaran (1997), and Pesaran and Shin (1999). They show that the traditional panel ARDL approach (i) can be used for long-run analysis; (ii) is valid regardless of whether the underlying variables are I (0) or I (1); and (iii) is robust to bi-directional feedback effects between economic growth and its determinants. The PMG estimator and the inclusion of $\bar{\boldsymbol{z}}_{\boldsymbol{t}}$ also account for dynamic cross-country heterogeneities and cross-sectional dependences.[1]

We estimate the CS-ARDL regressions in the sample of 62 commodity exporters, for which CToT volatility is expected to impact per-capita GDP growth and its determinants. The CS-ARDL results confirm the GMM results and indicate that the main channel of the association between CToT volatility and economic growth is through both human and physical capital accumulation (Table II). In line with the findings of Cavalcanti *et al.* (2015), we show that an improvement in CToT raises growth but the negative impact of CToT volatility can offset the positive impact of commodity booms on real GDP per capita growth. Therefore, if a country can successfully manage its rents from commodity export windfalls by investing in human and physical capital, and insulating against external shocks by conducting structural reforms, it can greatly benefit from its natural resources in the long run (Mohaddes and Raissi 2017).

[1] See Chudik and Pesaran (2015), Chudik *et al.* (2013), Chudik *et al.* (2016), and Chudik *et al.* (2017) for details.

Table II. Long-term effects of CToT growth and volatility on GDP per capita growth and its drivers in primary commodity exporters: CS-ARDL regressions and annual date (1981-2019)

The dependent variable is the growth rate of:	GDP per capita	TFP	Physical Capital	Human Capital
Long-run coefficients				
CToT growth	0.0028***	0.0014*	0.0020***	0.0005***
	(0.0006)	(0.0008)	(0.0006)	(0.0002)
Volatility of CToT growth	-0.0015*	-0.0014	-0.0029***	-0.0042***
	(0.0009)	(0.0013)	(0.0008)	(0.0005)
Short-run coefficients				
Error-correction term	-0.6199***	-0.7863***	-0.2595***	-0.3320***
	(0.0332)	(0.0339)	(0.0265)	(0.0370)
Δg_{CToT}	-0.0006	-0.0007	-0.0002	0.0001
	(0.0008)	(0.0012)	(0.0002)	(0.0003)
$\Delta \sigma_{CToT}$	-0.0018	-0.0026	0.0022*	0.0019**
	(0.0025)	(0.0041)	(0.0012)	(0.0008)
Constant	0.0067***	0.0001	0.0047***	0.0060***
	(0.0014)	(0.0020)	(0.0011)	(0.0008)
No. of Countries (*N*)	62	62	62	62
Average T	35.8	33.7	35.6	35.8
N x T	2219	2090	2207	2219

Note: The PMG estimates are from the CS-ARDL model as shown in equation (2). Standard errors are in parentheses. Asterisks indicate statistical significance at 1% (***), 5% (**), and 10% (*).

3. CToT Volatility, Inflation, and Headline Inflation Volatility

We now turn to the impact of CToT volatility on headline inflation and its volatility, using CS-ARDL regressions. We ask: (i) does persistent CToT volatility lead to structurally higher inflation *levels* in the long term? And (ii) does persistent CToT volatility lead to higher inflation *volatility* in the long term? To do so, we estimate the following CS-ARDL regression via the PMG estimator:

$$\Delta y_{it} = c_i^* + \varphi_i \Delta y_{it-l} + \beta_{0i} \Delta \sigma_{CToT_{it}} + \beta_{1i} \Delta \sigma_{CToT_{it-1}} + \boldsymbol{\vartheta}'_{\mathbf{0}i} \Delta \bar{\boldsymbol{z}}_t + \boldsymbol{\vartheta}'_{\mathbf{1}i} \Delta \bar{\boldsymbol{z}}_{t-l} + \varepsilon_{it} \qquad (3)$$

where, y_{it} represents either the standard deviation of monthly CPI inflation growth (yoy) in year t for country i, namely $\sigma_{\pi_{it}}$ or simply the headline inflation, namely π_{it}; $\sigma_{CToT_{it}}$ is the volatility of CToT growth in year t for country i; and $\bar{\boldsymbol{z}}_{\boldsymbol{t}} = [\overline{\Delta y}, \overline{\sigma_{CToT}}]'$ is a vector of cross-sectional averages of the variables. The long-run effects, θ_i, are calculated from the OLS estimates of the short-run coefficients in equation (3):

$\theta = \theta_i = \frac{\beta_{0i}+\beta_{1i}}{1-\varphi_i}$, for $i = 1, 2, \dots, N$.

The results in Table III show that CToT volatility has not led to a structurally higher inflation over the long term. This could potentially be a result of improved institutions and policy frameworks in many economies contributing to better anchoring of inflation expectations. However, CToT volatility is found to be associated with higher inflation *volatility* over the long

run across countries. Price swings in key commodities can directly affect the cost of imported goods, leading to changes in consumer prices. CToT volatility can intensify fluctuations in core inflation, as increased uncertainty and higher input costs for businesses may lead to price adjustments across various economic sectors. Andrews and Rees (2009) also find that terms of trade volatility has a statistically significant and positive impact on the volatility of output growth and inflation, although the magnitudes of these effects depend on the policy framework and the structure of markets.

Table III. Long-term effects of CToT volatility on headline inflation and its volatility: CS-ARDL regressions and annual date (1981-2019)[1]

Dependent variable:	Inflation	Inflation volatility
Long-run coefficients		
CToT growth volatility	-0.0001	0.1119***
	(0.0004)	(0.0216)
Short-run coefficients		
Error-correction term	-0.4324***	-0.5630***
	(0.0187)	(0.0259)
$\Delta\sigma_{CToT}$	-0.0032	-1.8898
	(0.0047)	(3.4305)
Constant	0.0305***	3.6338**
	(0.0024)	(1.7649)
No. of Countries (*N*)	180	81
Average T	35.5	31.2
N x T	6386	2529

Note: The PMG estimates are from equation (3). Standard errors are in parentheses. Asterisks indicate statistical significance at 1% (***), 5% (**), and 10% (*).
[1] The sample size for inflation volatility regressions is smaller than for inflation regressions. This reflects gaps in the availability of historical monthly inflation data that we use to calculate the within-year inflation volatility measure among a number of countries.

4. Concluding Remarks

We empirically examined the effects of CToT volatility on GDP per capita growth and its contributing factors as well as inflation and its volatility using the GMM and CS-ARDL approaches. Our findings reveal that CToT volatility has a detrimental effect on economic growth, primarily through its negative impact on capital accumulation. Additionally, we show that while increased CToT volatility does not necessarily result in higher overall inflation levels, it does lead to greater fluctuation in inflation rates. This result aligns with the findings of previous literature, such as those by Andrews and Rees (2009), which suggest that terms of trade volatility can induce significant volatility in inflation—an impact that is conditional on the strength of policy frameworks and institutions. Furthermore, the literature indicates that inflation volatility can amplify and perpetuate the downstream price impact of upstream supply shocks, posing challenges for policy makers. To further elucidate the mechanisms underlying the impacts on inflation volatility, additional research utilizing more granular data, such as core inflation metrics, is

warranted. Overall, we interpret our results as support for the establishment of robust institutions (e.g., Sovereign Wealth Funds or enhanced monetary/exchange rate regimes) as buffers against CToT volatility, thereby promoting stability in both economic growth and inflation.

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Data Appendix

Data on CToT are taken from Gruss and Kebhaj (2019), which provides GDP-weighted CToT indices for 182 countries at annual frequency (1962-onwards) and monthly frequency (1980 onwards). CToT volatility is calculated as the standard deviation of year-on-year growth rates of annual CToT over each 5-year interval in the GMM regressions, and as the yearly standard deviation of monthly year-on-year growth rates in the CS-ARDL regressions. Data on GDP per capita (2015 US dollars) were taken from the World Bank WDI database. IMF data on headline CPI, nominal exports, imports, and nominal GDP were used to calculate inflation, lack of price stability, and openness. Lack of price stability is calculated as log(100 + inflation). Openness is calculated as (exports + imports)/GDP. For the remaining variables, the principal data source for this exercise is Cavalcanti et al (2015) up to 2007. Data on per capita physical capital and human capital growth rates are extended to 2019 using Penn World Tables (version 10) data on real physical capital (national accounts), population, and human capital growth rates. Data on export sophistication, government consumption expenditure, and education (secondary enrolment rates) are extended to 2019 using World Bank data.