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Asymmetric Non-Commodity Output Responses to Commodity Price Shocks

by James Wilson, Amine Mati, and Monique Newiak

I N T E R N A T I O N A L   M O N E T A R Y   F U N D

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Asymmetric Output Responses to Commodity Price Shocks[1]

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Abstract

This paper focuses on identifying potential asymmetric responses of non-commodity output growth in times of positive and negative commodity terms-of-trade shocks. Using a sample of 27 oil-exporting countries and a panel VAR method, the study finds: 1) the short-and medium-run response of real non-commodity GDP growth is larger for negative shocks than positive shocks; 2) this asymmetry is more pronounced in countries with weak pre-existing fundamentals–high levels of public debt and low levels of international reserves–which also serve to amplify the volatility of the response; 3) the output response to positive shocks is stronger following a sustained period of CTOT increases, while the impact of negative shocks on output are more damaging when they occur after a period of CTOT decline.

JEL Classification Numbers: E6; Q30.

Keywords: Commodity price shocks, output, asymmetric responses.

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I. INTRODUCTION

A recovery in oil prices could undoubtedly be good news for oil exporters, but the pace at which it will boost growth in these countries is unclear. From a low of less than $30 per barrel in February 2016, the international price of oil[2] more than doubled by the end of October 2018, before sliding in 2019 and more recently on the back of the COVID-19 pandemic. While some countries started to see positive results of their reforms to diversify the economy and increase non-oil revenue, many commodity exporters were struggling to repair balance sheets and shore up their macroeconomic fundamentals, even when oil prices were high. With prices now expected to recover, one question mark is on how quickly this price recovery will translate into high economic growth, in particular in the non-commodity sectors of the economy.

This paper explores the asymmetric response of the non-commodity economy to changes in commodity prices. After looking at stylized facts, it conducts an empirical analysis with a sample of 56 developing commodity exporters (of which 27 are oil-exporting) from 1970-2016, using a novel approach by including a country-specific commodity terms-of-trade index to examine the dynamic impact of commodity prices on the non-commodity part of the economy. The main focus of the paper is on the oil-exporting countries in the sample given the extent of recent oil price moves and the considerable impact on these economies. At the heart of the analysis is testing for asymmetric responses, allowing for different output responses to positive and negative shocks. A panel VAR method allows for impulse response and variance decomposition analysis.

Our findings provide conclusive support in favor of asymmetric responses of non-commodity output to commodity price shocks. The findings for oil-exporting countries—supported by various robustness tests—are as follows:

- *Assuming symmetric responses,* positive (negative) commodity terms-of-trade shocks significantly increase (decrease) non-commodity real GDP growth in oil exporters, with a pronounced reaction up to three years after the shock. For a 1 percentage point rise in the commodity terms of trade index,[3] the non-commodity real GDP growth rises 0.3 percent in the first period, with the impact fading quickly after. The elasticity of this growth to *commodity price changes* will be this percentage multiplied by the net commodity exports share of GDP. For Gabon, where this share is 50 percent, the elasticity is 0.15, whereas for Nigeria it is 0.03 due to the smaller share.

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[2] WTI spot oil price.

[3] Gruss and Kebhaj (2019): "Variations in the commodity terms-of-trade index provide an estimate of the windfall gains and losses of income associated with changes in international prices. That is, a one percentage point change in the commodity terms-of-trade index can be interpreted as a change in aggregate disposable income equivalent to one percentage point of GDP."

- *The volatility of the response to commodity price shocks* is greater for countries with high public debt and low international reserves, highlighting that strong initial macroeconomic fundamentals can help smooth adverse output responses to shocks, as was the case in a number of commodity-exporting countries.

- *The short- and medium-run response of real non-commodity GDP growth* is larger for negative shocks than for positive shocks. The impact on growth is approximately twice as large for negative shocks, both in the first period and cumulatively over a longer horizon. High public debt exacerbates the extent of the asymmetry.

- *In addition, previous terms-of-trade developments matter for the size of the impact.* The response to positive shocks is strongest following a period of commodity terms-of-trade increases, rather than after a period of decline, while negative shocks are more impactful after a decline in commodity terms-of-trade.

- *Among oil exporters, commodity terms-of-trade shocks have historically explained up to 12 percent of non-commodity GDP variance,* for years after oil discoveries. The contribution of commodity terms-of-trade shocks appears to have been lowest in the 1980s, perhaps reflecting the reduced integration between different sectors of the economy. It is largest in Latin America and sub-Saharan Africa, and smallest in the Middle East and North Africa.

In the remainder of the paper, Section 2 discusses the literature on the link between the non-commodity and commodity sectors, and previous related empirical studies; Section 3 describes the data and presents stylized facts; Section 4 outlines the methodology; Section 5 presents the empirical findings; Section 6 provides robustness checks; Section 7 concludes.

II. Literature Survey

There is a sizeable literature on the macroeconomic effects of commodity terms-of-trade shocks. One line of approach looks at the initial conditions that may amplify or mitigate shocks. Much research has also been done on the way in which commodity price shocks transmit through to the real economy. More recently, some focus has shifted to the asymmetry of economic responses, which is developed in the empirical part of this study.

A. Macroeconomic Fundamentals

Research has considered the potential factors that could amplify or mitigate the response to commodity price shocks.

- *International reserve buffers.* A sufficient level of reserve assets can help smooth the external adjustment to a commodity terms-of-trade shock. Grigoli (2017) finds countries with more adequate reserve buffers experienced less severe consequences of the 2014-16 oil price declines.

- *Fiscal space.* Having the fiscal capacity (e.g. low levels of public debt-to-GDP) to accommodate terms-of-trade shocks should help adjust to the shock, as it allows for countercyclical policy in periods of commodity price decline. Roch (2017) finds that greater fiscal space had a significant impact in Chile and Peru in dampening the effects of shocks, and similar conclusions are found elsewhere in the literature (Kinda 2018, Grigoli 2017).

There is also evidence in the literature that other conditions may help to mitigate the volatility of shocks. While fixed exchange rate regimes continue to serve some commodity-exporting countries well, flexible exchange rate regimes may smooth shocks to the commodity terms of trade (Fornero et al. 2016; Cespedes and Velasco 2012), while institutional quality may also play a role (Cavallo and Cavallo 2010; Moshiri 2015). On the other hand, various factors may exacerbate the volatility, such as lower levels of financial development (IMF 2015) and procyclical investment (Aghion 2009 – notably when financial development is low).

B. Transmission Mechanism from the Commodity Sector to the Real Economy and Asymmetry

The literature also describes the ways in which commodity price shocks may transcend the natural resource sector and have meaningful consequences for the real economy.

- *Fiscal.* Commodity price shocks directly impact the fiscal position through their impact on government revenues, and the inherent price volatility can lead to uncertain government revenues and a destabilizing fiscal policy (Gelb et al. 1998; Van der Ploeg and Poelhekke 2008), as public expenditure programs that were launched during commodity booms may need to be reversed in commodity price downswings, which can be a painful process. Given many commodity exporters are active players in the global financial markets, there is a heightened scrutiny on fiscal balances and levels of public debt, ensuring a close link between public expenditures and commodity prices (Spatafora, 2012).

- *Financial sector.* Kinda (2010) finds that price booms lead to lower country risk premium and cheaper funding, but often also to excessive credit growth. In a subsequent commodity price decline, there can be an increase in non-performing loans, a deterioration of banking profitability and solvency ratios, and a drawdown in deposits. Moreover, exporting firms may struggle to service debt obligations to the banks, and this increases the probability of a banking crisis (Eberhardt and Presiberto, 2018). These risks are found to be more common in countries with poor governance, high public debt, and lower levels of financial development. In addition, commodity price impact the magnitude of FX inflows and banking sector liquidity, increasing credit and thus possibly enabling more private investment and consumption.

- *Demand effects.* Christensen (2016) describes how fluctuating commodity revenues hit households and the corporate sector through domestic demand, while Gruss (2014) notes the secondary demand from the oil sector for industries such as transportation and logistics. Christensen also finds that falling commodity prices can lead to a drop in foreign investor sentiment and a consequent increase in the risk premium for sovereign borrowing, putting further pressure on the fiscal balance through higher debt servicing costs. Fornero et al. (2016) observed that at first commodity terms-of-trade gains tend to be saved because they are seen as temporary, but if price increases become persistent then this can trigger an investment boom with spillover effects for investment in other sectors.

More recently, there has been greater focus on whether positive and negative commodity price shocks could have asymmetric impacts on macroeconomic outcomes for commodity exporters.

- *Growth*. When looking directly at output responses, the findings with respect to asymmetries have not been conclusive. Dehn (2000) finds highly asymmetric effects on growth, notably that large, negative commodity price shocks tend to have a larger and statistically significant impact on economic growth. Edwards and Levy-Yeyati (2004) support this conclusion, attributing it to the presence of asymmetries in domestic prices that require larger quantity adjustments in commodity price busts. Conversely, Camacho and Perez-Quiros (2013) estimate that output in Latin America reacts more strongly to large *positive* shocks, with this impact accentuated when they occur in recessions. Broda (2004) also picks up a bigger impact on GDP from positive shocks, though the asymmetry is exclusive to flexible exchange rate regimes. Among oil exporters (or importers) in a sample of 18 OECD countries, Herrera et al. (2015) find no evidence of asymmetric responses in economic activity to oil price changes, despite the theoretical underpinnings that imply that negative shocks would be more impactful. However, there are no OECD countries within the UN's classification of primary commodity exporters used in this study, and it is likely that responses are of a different nature given OECD economies are more developed, including with respect to institutions that influence policy responses to shocks, and thus able to better manage external shocks.

- *Fiscal.* Arezki (2010) finds that government's current expenditure is downwardly sticky if commodity prices fall but increases in commodity booms. Capital expenditure shows the opposite trend, whereby it is often cut in downswings and less responsive during upswings. He posits this is because current spending (e.g. salaries) has a higher domestic content than capital spending and is generally more politically sensitive than investment projects.

- *Financial sector.* Al-Khazali and Mirzaei (2017) calculate that negative oil price movements have a larger impact on non-performing loan ratios than positive changes. Eberhardt and Presiberto add that only falls in commodity prices matter for financial stability, and Agarwal et al. (2017) finds bank lending is much more sensitive to declines in commodity prices than increases.

- *Labor markets.* On the labor market, Benguria (2017) uses evidence from Brazil to show that the regional skill premium decreases during a commodity price boom but does not increase in a bust. Downward wage rigidities generate dynamic misallocation between sectors, triggering a persistent recession characterized by unemployment and a sluggish recovery of the tradables sector.

C. Contribution to the Literature

This paper contributes to the existing literature by focusing on:

- *Expanded Terms of Trade Measure:* By using the Net Commodity Price Index (NCPI) developed by Gruss (2014; 2019) to measure commodity terms-of-trade shocks, this paper captures the importance of commodity exports as a percentage of GDP, country-specific commodity characteristics, and changes in the price basket over time (for example, distinguishing between periods before and after large commodity discoveries). With a few exceptions (including Dehn 2000; Collier and Goderis 2012; Cespedes and Velasco 2012), most studies have simply used standard terms-of-trade measures or individual commodity prices, typically oil prices. The use of the NCPI permits a much more sophisticated cross-country panel analysis.

- *Non-Commodity Economy:* The focus of this study is on the non-commodity part of the economy, whereas past studies have almost exclusively focused on total GDP. This distinction is important as analyses that include commodity GDP often obscure what is happening in the non-commodity economy due to the commodity sector's dominance and volatility. The push to diversify in resource-rich economies is a key policy goal and crucial to the goal of long-term sustainable and stable economic growth. As a consequence, a better understanding of how the non-commodity part of the economy—which often depends on flows that may originate from the commodity sector—reacts and which macroeconomic conditions and policies help smooth this impact is important. The analysis also accounts for variation across time and regions.

- *Initial Conditions:* International reserve buffers and public debt provide indications of countries' policy space, and these initial conditions are used to proxy the country's capacity to respond to commodity price changes, in particular negative shocks. For example, it might be hypothesized that a country with high public debt levels is less able to react to a negative shock by implementing expansionary fiscal packages, thus exacerbating the impact of a negative shock; or alternatively is forced to pay down debt rather than increase spending when faced with a commodity revenue windfall. We prefer the stock of debt to the fiscal balance as a measure of fiscal space, as the fiscal balance can fluctuate substantially from year to year and so gives a less clear gauge of medium-term fundamentals. As well as debt levels, the degree of pre-existing oil subsidies would impact fiscal space. According to IEA data,[4] for countries where data are available, oil consumption subsidies as a share of GDP among oil exporters range from almost 0 percent in the UAE to 12 percent in Venezuela. Unfortunately, there is not adequate time series data to include oil subsidies in the empirical analysis.

- *Cyclical Variation:* The analysis also looks at whether the non-commodity economy responds to commodity terms-of-trade shocks differently depending on whether the prior period was a commodity price upswing or a downswing. It allows for the possibility that

[4] Taken from World Energy Outlook (https://www.iea.org/weo/energysubsidies/). Note this outlook only covers subsidies on consumption, not extraction.

a negative commodity price shock could have a very different impact after a favorable period of prolonged price increases than it would after a persistent decline in prices.

III. Data & Stylized Facts

This study uses annual data from 56 developing countries categorized as primary commodity exporters by the United Nations (UN). Within this group, 27 countries are classified as oil exporters, following the UN's Standard International Trade Classification (SITC 3) for countries whose fuel export earnings exceeded 50 percent of total export earnings for the period 2008-2012. The rest of countries in the sample are classified as non-oil commodity exporters and are typically more diversified.

To measure the impact of commodity price shocks on the non-commodity economy, this paper uses non-commodity, non-agriculture GDP as the dependent variable. This distinction is important since it helps separate real GDP movements in the commodity sector that follow terms-of-trade shocks from those in the remainder of the economy. The breakdown of GDP is taken from the United Nations Statistical Database, with further details in Appendix A. The non-commodity, non-agricultural economy made up an average of 58 percent of oil exporters' real GDP in 2010, and 68 percent for non-oil commodity exporters. These numbers have increased 7 and 2 percentage points respectively since 1990, showing that the non-commodity, non-agricultural sectors have grown at a faster rate, despite generally favorable terms-of-trade movements over the period (terms-of-trade increased 33 percent on average for oil exporters, but just 3 percent for non-oil commodity exporters).

The main indicator of terms-of-trade movements is the Commodity Terms of Trade index (CTOT), following the approach used in Gruss (2014) and IMF (2016). This index captures the country-specific impact of commodity price movements, by weighting the global prices of 41 individual commodities by country-specific net exports. This approach is more holistic than looking at a single commodity index, particularly for non-oil commodity exporters, as it takes into account both the variety of commodities that countries export and the importance of commodity exports relative to total GDP for each country. The annual change in country *i*'s commodity terms-of-trade in year *t* is given by:

$$\Delta logCTOT_{i,t} = \sum_{j=1}^{J} \Delta P_{j,t} \tau_{i,j,t}$$

$$\text{with } \tau_{i,j,t} = {}^{1}\!/_{3} * \sum_{s=1}^{3} \frac{x_{i,j,t-s} - m_{i,j,t-s}}{GDP_{i,t-s}}$$

Where $P_{j,t}$ is the natural logarithm of the price of commodity j at time *t*; Δ represents first differences; $GDP_{i,t-s}$ denotes nominal GDP in country *i* at time *t*. The weight $\tau_{i,j,t}$ varies according to the country and its net export share of each commodity, but is also allowed to vary over time, in order to capture changes in countries' resource wealth (for example, Equatorial Guinea's weighting changed dramatically after it started producing oil in the late

1990s). A full list of the commodities included in the index is found in Appendix A that also includes the complete list of controls used in this paper.

Stylized facts suggest that non-commodity,[5] non-agricultural sectors of oil-exporting economies have been more sensitive to negative commodity price shocks. For example, a 1 percent increase in the index appears to decrease non-commodity non-agricultural real GDP by 0.6 percent, three times more than for a positive shock (Figure 1). That appears to hold for longer periods and also when the definition of a shock is narrowed to movements of larger than 5 percent in a country's commodity terms-of-trade (Figure 2).

However, for non-oil commodity exporters, this asymmetry disappears and appears to slightly reverse (see Appendix B), a result explored in the robustness section of the paper. These event studies offer a look at the headline trends but crucially do not control for several factors, such as global economic conditions, the duration of the shock, and time-invariant country-specific factors. Moreover, large negative shocks are less frequent in the sample than positive shocks, so it is perhaps unsurprising that they produce a greater disturbance to the growth rate. This motivates a more rigorous econometric approach to control for these factors and to more precisely identify the impact of the commodity terms-of-trade shocks.

Figure 1. Oil Exporters: Cumulative Change in Annual Real Non-Commodity, Non-Agricultural GDP Growth, 1970-2016
(Compared to three-year period prior to normalized 1 percent shock)

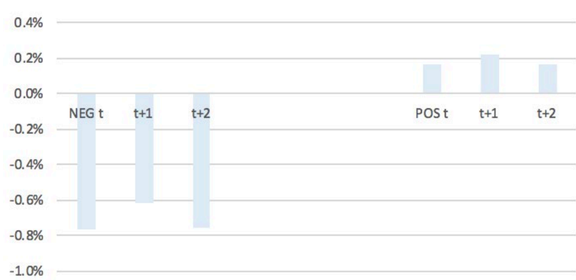
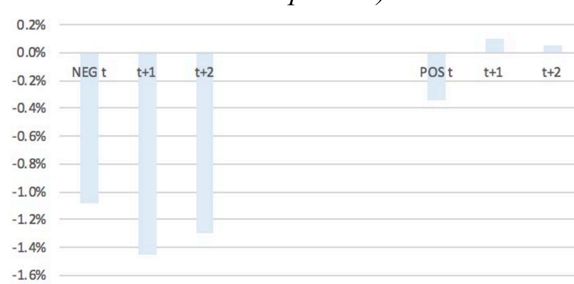


Figure 2. Oil Exporters: Cumulative Change in Annual Real Non-Commodity, Non-Agricultural GDP Growth, 1970-2016 – Large shocks
(Compared to three-year period prior to normalized 5 percent shock, only shocks larger than 5 percent)



Source: Authors' estimates.

[5] When only looking at the oil exporters we still focus on the non-commodity GDP, because time series data covering non-oil GDP are not widely available.

IV. METHODOLOGY

A panel VAR approach helps to show the dynamic response of output to commodity price shocks.[6] The methodological approach is similar to Broda (2004), and also follows further developments of the panel VAR procedure by Love and Zicchino (2006) and Shen et al. (2015).

The panel VAR is specified as follows:

$$\boldsymbol{A_0 Y_{it}} = \boldsymbol{A}(L)\boldsymbol{Y_{it}} + \boldsymbol{X_{it}} + \alpha_i + \gamma_t + \boldsymbol{u_{it}}$$

where $\boldsymbol{Y'_{it}}$ is a vector of stationary endogenous variables: $(\Delta lnCTOT_{it}, \Delta\ lny_{it})$ or $(\Delta^{+} lnCTOT_{it}, \Delta^{-} lnCTOT_{it}, \Delta\ lny_{it})$ where $\Delta^{+} lnCTOT_{it}$ = $\Delta lnCTOT_{it}$* D_{it}^{+} with D_{it}^{+} set equal to 1 if CTOT change is positive, 0 otherwise; and negative shocks are calculated in an analogous manner with $\Delta^{-} lnCTOT_{it}$ = $\Delta lnCTOT_{it}$* D_{it}^{-}. $A(L)$ and $B(L)$ are matrix polynomials in the lag operator order q. Specifically, the lag operator order q=1 is used as a result of Bayesian Information Criterion results (see Appendix C). $\boldsymbol{X_{it}}$ is a matrix of exogenous variables. α_i captures country-specific fixed effects, allowing for individual heterogeneity, while γ_t picks up components of the dependent variable that are common across countries at time *t*.

To account for the country-specific fixed effects, we use the Helmert procedure, introduced by Arellano and Bover (1995). This transforms the variables by subtracting the forward means,[7] a process which preserves orthogonality of the error terms, whereas the standard mean-differencing approach to removing fixed effects would bias coefficient errors due to the correlation between lagged dependent variables and the fixed effects. This method also means that lagged values remain valid instruments such that system GMM can be used, where lags of regressors are employed as instruments for the endogenous variables. In the baseline estimation, global real GDP growth is used to capture common macroeconomic shocks. This is preferred to time fixed effects because global oil prices are common to all oil exporters and so any variation resulting from oil price changes will be extracted from the CTOT variable.

The appropriateness of the above specification, in first differences, is supported by unit root and cointegration tests, displayed in Appendix D. Furthermore, consistent with other papers in the literature, the main identification strategy in this paper requires exogenous movements in terms-of-trade. This strategy is motivated by the idea that no single country is large enough to affect world relative prices, an assumption that is tested and widely accepted in the literature (Schmitt-Grohe and Uribe, 2015; Broda, 2004; Collier and Goderis, 2012). This assumption in the context of oil exporters is discussed in detail in Appendix D, including formal testing for Granger causality, which highlights that the results are robust to the exclusion of oil exporters with over 10 percent market share (see Appendix A for that list).

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[6] The estimation of the panel VAR uses the Stata programs developed by Love and Zicchino (2006).

[7] The mean of all future observations available for each country-year. As a consequence, the last year in the sample is excluded.

Impulse response analysis is used to describe the evolution of non-commodity output growth in the time horizon following a shock to the commodity terms of trade shock. In order to construct confidence intervals for the impulse response functions, Monte Carlo simulations are used, based on the estimated coefficients and standard errors. These confidence intervals are defined by the 5^{th} and 95^{th} percentiles of the distribution of coefficients generated by 500 bootstraps. While impulse response functions illustrate the future direction of variables following a shock, variance decompositions are also helpful by showing the percent of variation in one variable that can be explained by a shock to another. In this paper, the focus is on how much of non-commodity, non-agricultural output variation can be explained by commodity terms-of-trade shocks, both positive and negative.

The approach used follows the Sims (1980) proposal of a contemporaneous recursive causal ordering of variables in the panel VAR, from least endogenous to most endogenous. It is clear that, in this specification, the assumed exogeneity of terms of trade means that this variable enters the system first, followed by the growth measure (please see Appendix E for exogeneity tests).

In addition, this paper examines the impact of initial conditions on economic activity during positive and negative commodity price shocks. Dummy interactions allow testing for how public debt and international reserve levels affect the output response. The dummy variable for high public debt is equal to one if the public debt-to-GDP ratio exceeds 50 percent at the time of the shock, zero otherwise. This approach results in 27 percent of observations for oil exporters falling under 'high debt', and 39 percent for the broader group of commodity exporters. A 'low debt' dummy is interacted in the same way for countries with a public debt ratio below 50 percent.[8] For international reserves, the approach is identical, but the threshold is the historical median level.[9]

V. Empirical Findings

This section presents the impulse response function analysis, showing the non-commodity output response of a unit shock in commodity terms-of-trade growth. It first presents the shocks for an estimation that assumes the impact is symmetric, and then highlights the results for an estimation in which this assumption is relaxed. In addition, in each case, the section presents the impact of pre-existing macroeconomic fundamentals on the results.

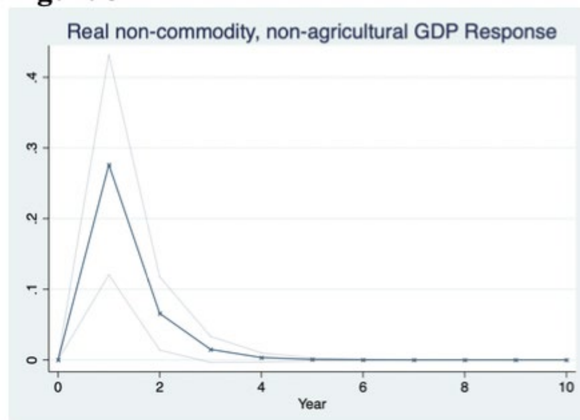
[8] This follows conclusions of Egert (2015), which uses econometric testing to find the negative debt-growth dynamic becomes visible if debt exceeds 45-50% of GDP. Results are robust to changes in the threshold.

[9] The same threshold as used in IMF Regional Economic Outlook: Sub-Saharan Africa (2015).

A. Symmetric Shocks

Figures 3-5 show the impulse responses generated by the panel VAR assuming a symmetric response to shocks, with the following main results:

Figure 3

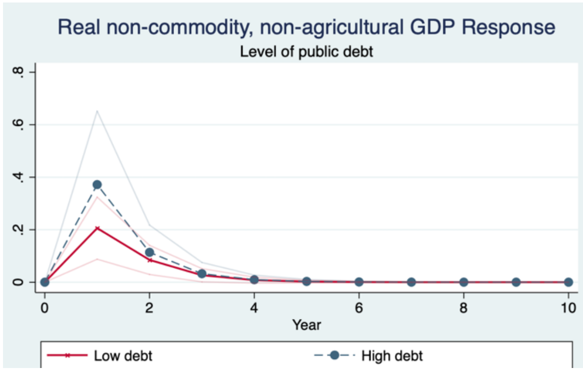
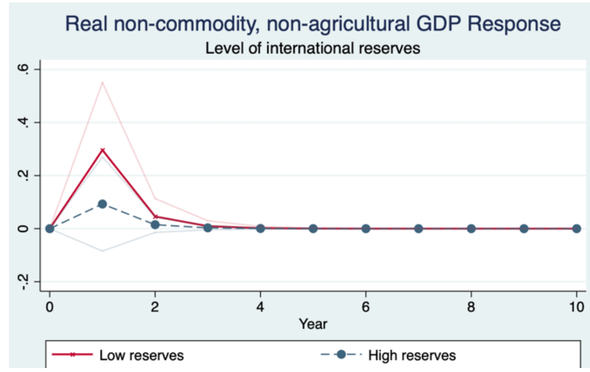


Note: light lines highlight 95 percent confidence interval.
Source: Authors' estimates.

- *A 1 percentage change in the commodity terms of trade index* would increase real non-commodity non-agricultural GDP by nearly 0.3 percent in the first period with the impact fading quickly afterwards (Figure 3). The country-specific elasticity of non-commodity real GDP to *commodity price changes* is this response multiplied by the country-specific net export weight $\tau_{i,j,t}$.[10] For a country such as Gabon, where net commodity exports are 50 percent of GDP, the elasticity to commodity price changes would be 0.15. However, for Nigeria, where this weight is just 10 percent of GDP, the elasticity would be five times smaller.

- *Weaker pre-existing economic fundamentals* appear to lessen the response of non-commodity output. These fundamentals are represented by either high levels of public debt (Figure 4), or low levels of international reserves (Figure 5 shows that response to the shock becomes insignificant). One rationale for this could be that when faced with negative shocks, countries with high debt stocks do not have the fiscal space to offset the adverse effects of the shock. Aizenman (2011) finds evidence that indicates active reserve accumulation is used as a policy to counter commodity terms-of-trade volatility, and the findings here support the logic behind this policy. The level of reserves could also proxy the quality of measures to dampen the effects of shocks, or even institute formal fiscal rules.

[10] See Appendix F for further detail.

Figure 4	**Figure 5**
	

Note: light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

The results indicate that commodity prices help explain output growth changes beyond the commodity sector captured in overall GDP in other studies, and Appendix G, which includes a forecast-error variance composition, provides an overview of the magnitudes.

B. Asymmetric Shocks

The main question of this paper is whether non-commodity sectors of oil-exporting countries respond in different ways to positive and negative commodity terms-of-trade shocks. Therefore, the restriction that positive and negative shocks lead to symmetric output responses is dropped, allowing the two types of shocks to have different coefficients.

The results suggest there is an asymmetry, with negative changes in commodity terms-of-trade being associated with larger movements in real non-commodity GDP. In Figure 6, and the following figures, the sign of the coefficients on negative shocks have been reversed, such that the graph represents a negative unit shock to commodity terms of trade. This figure suggests that the impact of a negative commodity terms-of-trade shock on non-commodity output after the first year is statistically and economically significant. It is nearly double the size of the impact of a positive shock which is statistically insignificant. This asymmetry continues into the medium term as the negative shock shows much more persistence. Figure 7 captures this persisting asymmetry through a cumulative impulse response function.

Figure 6

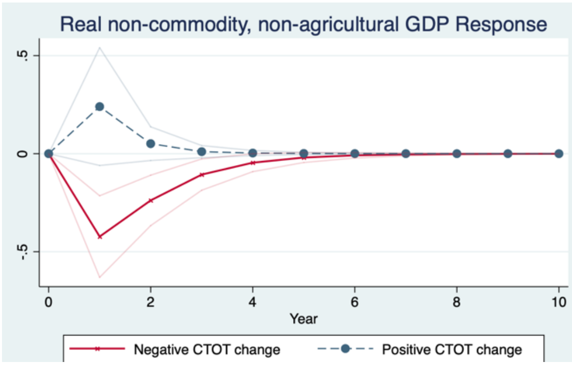
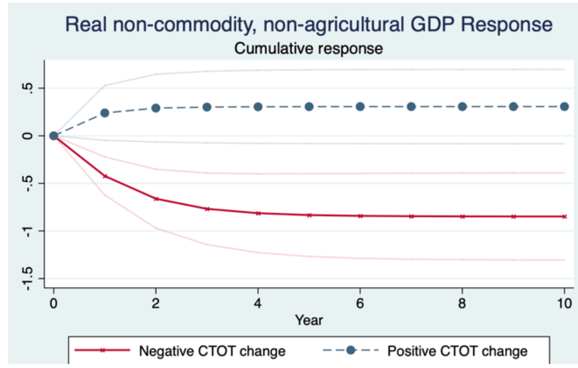


Figure 7



Note: Light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

Initial levels of public debt exacerbate the asymmetry, with negative shocks showing an even deeper impact. Figures 8 and 9 show the contrast between oil exporters with high and low public debt. While the asymmetry both in economic size and statistical significance persists for both scenarios, the scale of it is much more acute for high-debt economies: countries with pre-existing high levels of public debt are less well equipped to tackle the adverse impact of a negative shock, while positive shocks are not statistically significant. Additional borrowing may only be available at (prohibitively) high interest rates, while increasing the debt-to-GDP ratio may have implications for debt sustainability and could be viewed negatively by institutional investors. The resulting lack of fiscal space could mean that governments are left with little option to engage in counter-cyclical policies.[11] In a situation of low debt, the asymmetry remains, but is less pronounced and there is a more favorable response to positive shocks. This may be because high-debt countries are compelled to reduce the stock of debt, while low-debt countries have greater space to pursue growth-enhancing policies.

Figure 8

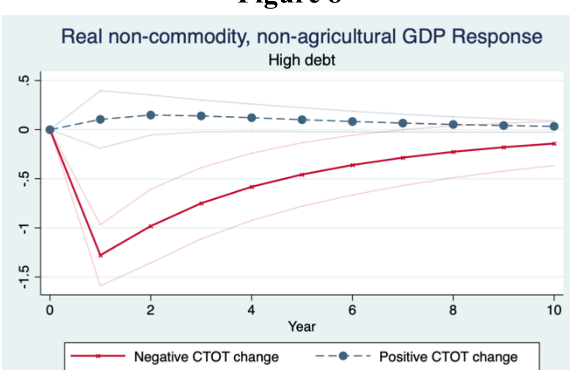
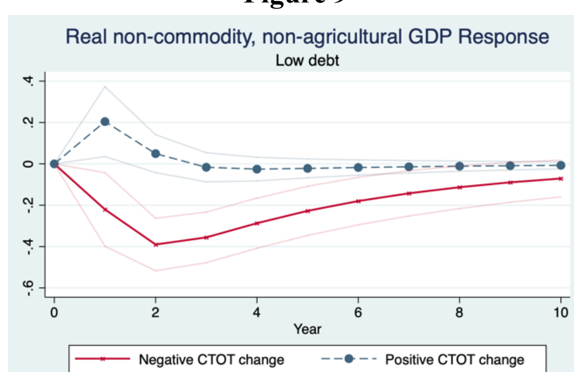


Figure 9



Note: Light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

[11] Appendix H tests for the significance of real government consumption directly but the approach reduced data availability and sample size, so that the paper proceeds without the statistically insignificant variable.

For those countries with relatively high levels of reserves there is a reversal in the asymmetry, with positive shocks provoking a more impactful response in non-commodity output growth (Figure 10). For low reserves however, the negative shocks are more than twice the size than for countries with high reserves, though the impact fades very quickly (Figure 11). International reserve buffers allow countries to respond to negative shocks, acting to dampen the direct transmission of the shock, in particular through smoothing the adjustment of external relative prices. In addition, the reserves dummy may capture a much broader sense of macroeconomic stability in a country. However, while higher external buffers may reduce risk premia, they may not always translate into fiscal prudence or a strong banking sector. Stronger fundamentals could also explain why positive shocks are more beneficial in this environment. This pre-existing macroeconomic stability could play an important role in how countries are able to absorb and respond to shocks.

A downswing in commodity terms-of-trade prior to the shock amplifies asymmetries.

Figure 10

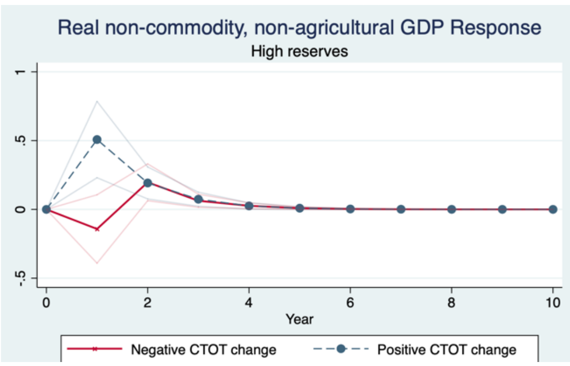
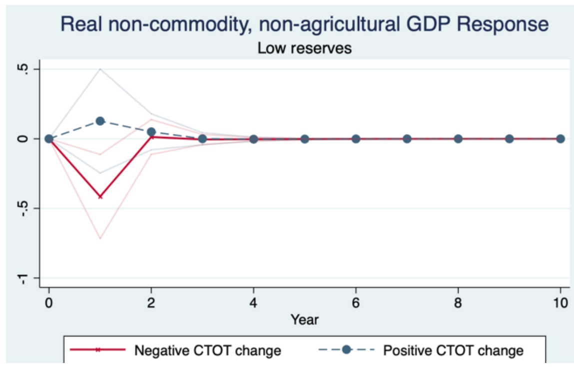


Figure 11



Note: light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

The impact on output growth could depend on the development of commodity terms-of-trade prior to the shock. For example, it might be that after a period of depressed commodity prices, the oil exporter is in a much weaker position to absorb price shocks than it would be after a period of booming prices, likely accompanied by strong economic activity. Figure 12 shows a relatively symmetric response function when shocks come after a period of increasing commodity terms of trade (defined as an aggregate increase in the CTOT index over the prior 5-year period). Figure 13 illustrates that the asymmetry prevails following a 5-year aggregate decrease in the commodity terms of trade. This result is intuitive as a long period of commodity price decline would be expected to weaken an oil-exporting economy, even beyond the direct impact on the commodity sector.

Figure 12

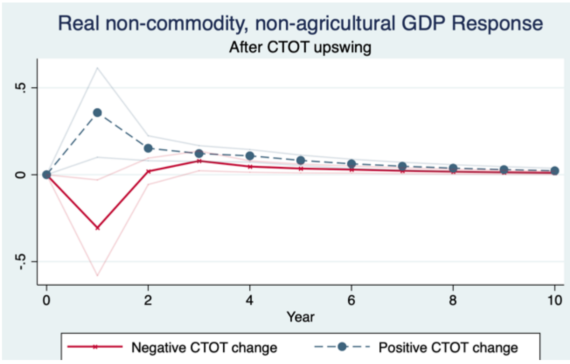
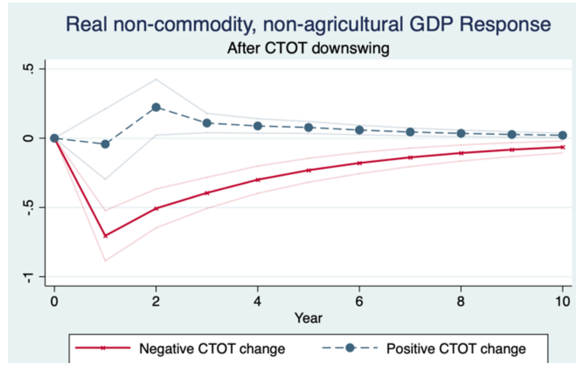


Figure 13



Note: Light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

VI. Robustness checks

This section finds the results are robust to changes in the specification, in particular that output responses to negative shocks are larger than the response to positive shocks. In particular, it provides some sensitivity analysis for the main results of the paper to different time periods, country samples and size of shocks.

A. Commodity Exporters

Figure 14 shows that when the sample is increased to all 56 commodity exporters, including the 29 non-oil commodity exporters, the asymmetry holds. However, the magnitude of the responses and the extent of the asymmetry is less than for oil exporters. Figure 15 shows that the asymmetry appears to reverse itself if only the non-oil commodity exporters are tested, suggesting that the result in Figure 15 is being driven by the oil exporters.

Figure 14

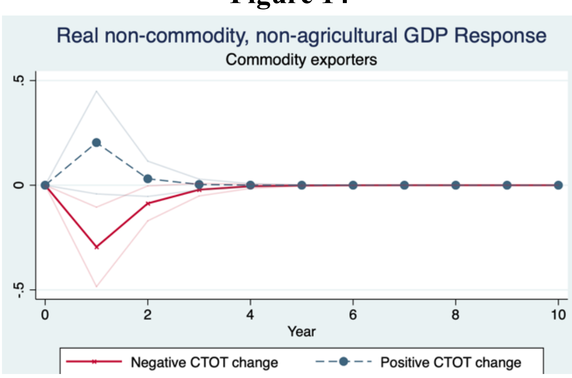
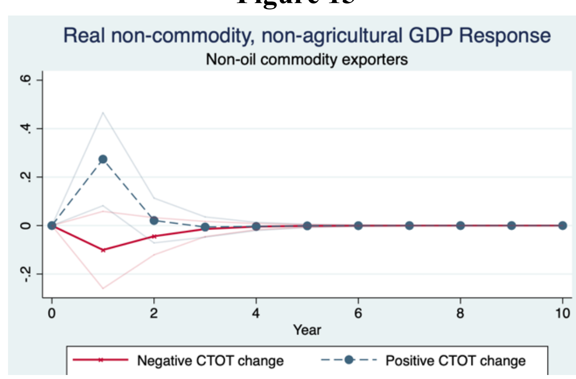


Figure 15



Note: Light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

A sample split between the commodity exporter sample into diversified and non-diversified suggests that diversification may also affect the results, as well as oil dependence. The split of the sample is based on the IMF Export Diversification Index (Appendix A). Interestingly, of the 27 non-diversified commodity exporters, only one third are not oil exporters (Burundi, Central African Republic, Guinea, Liberia, Malawi, Mali, Mauritania, Suriname, Zambia). While the main result holds for non-diversified commodity exporters, the smaller magnitude suggests that oil dependence is the driving force. Nonetheless, there is a suggestion that some of the adverse experience results from a lack of export diversification. The significant overlap between the two make it difficult to refine the result (Figures 16 and 17).

Figure 16

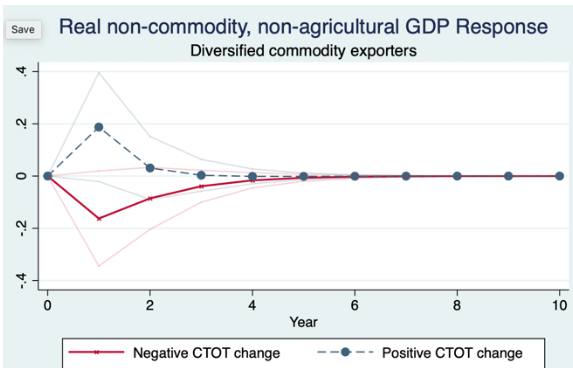
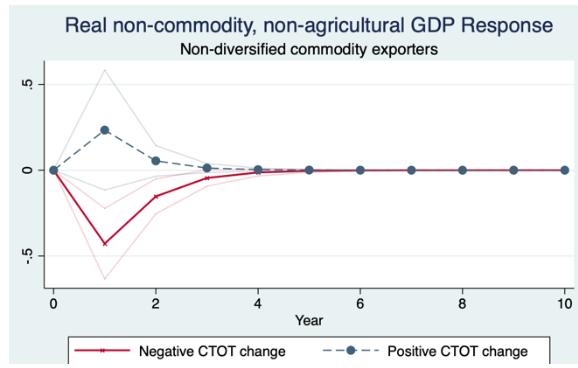


Figure 17



Note: Light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

B. Time Periods

The main results hold for a sample split between pre-2000 and post-2000s. The year 2000 marks the beginning of the 2000s commodity boom cycle, and so allows a comparison of the last two commodity cycles. The most marked difference between the two periods is that negative shocks in the latter period have same magnitude but have a much longer-lasting impact, possibly reflecting stronger stronger transmission channels, including through the financial sector.

Figure 18

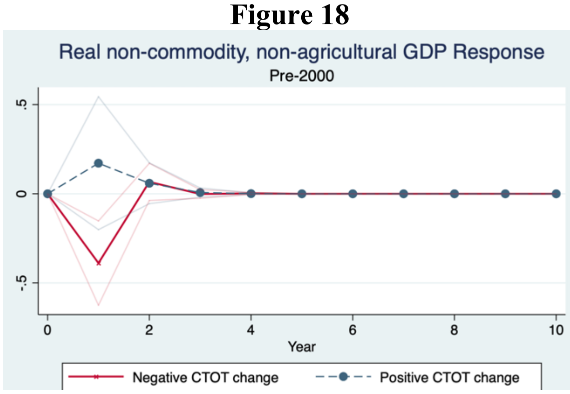
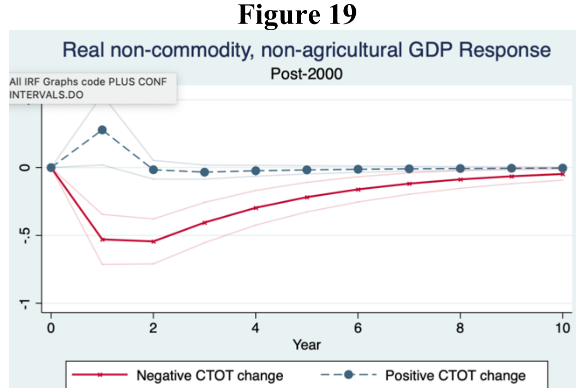


Figure 19



Note: Light lines highlight 95 percent confidence interval.
Source: Authors' estimates.

C. Size of Shocks

A re-definition of the shock to only include larger shocks does not alter the results significantly. As shocks are defined as any change in a country's commodity terms-of-trade index, this classifies even very small changes as shocks, when in reality they may just represent noise. To combat this, the definition of a shock is modified to be shown to be greater than 2 percent.[12] Figure 20 shows that this produces a very similar outcome to the baseline result in Figure 7, and with a slightly greater level of statistical significance. Figure 21 carries out the same analysis. Using 5 percent as the threshold[13] (Figure 21), the asymmetry persists but to a narrower extent.

Figure 20

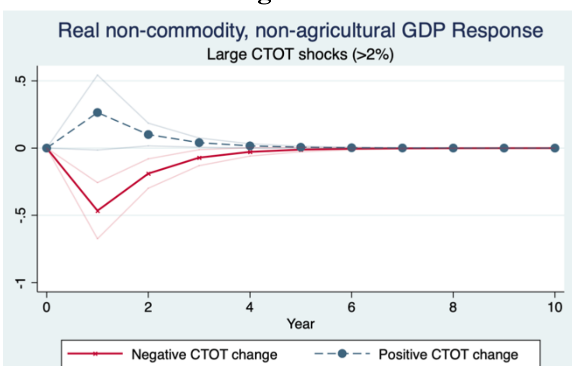
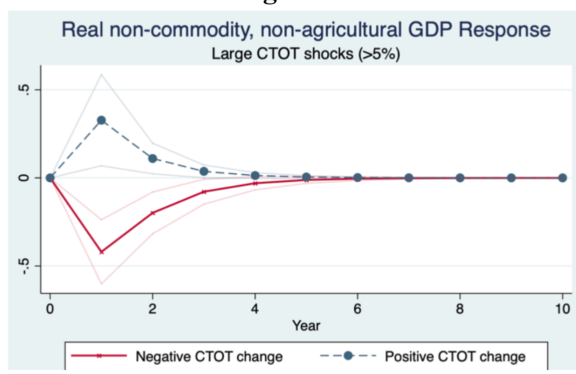


Figure 21



Note: Light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

D. Geographical Analysis

The asymmetric response is also found to be robust across most of the oil-exporting regions, in particular Middle East and North Africa and sub-Saharan Africa,[14] which together make up two-thirds of the oil exporters in the sample. This is also the case for Eastern Europe and Central Asia, though with large standard errors, while Latin America shows some indication of a slight asymmetry in the opposite direction, which is in line with the aforementioned findings of Camacho and Perez (2014).

[12] Together these shocks represent 51 percent of the CTOT changes. The median 'big' positive shock is 5.9% and median 'big' negative shock is -5.4 percent.

[13] The 'big' shocks represent 29 percent of all CTOT changes. The median 'big' positive shock is 8.7 percent and median 'big' negative shock is -10.6 percent.

[14] For Sub-Saharan Africa, the sample is taken from post-1990 as prior to this period oil production was very low in many of the component countries.

Figure 22

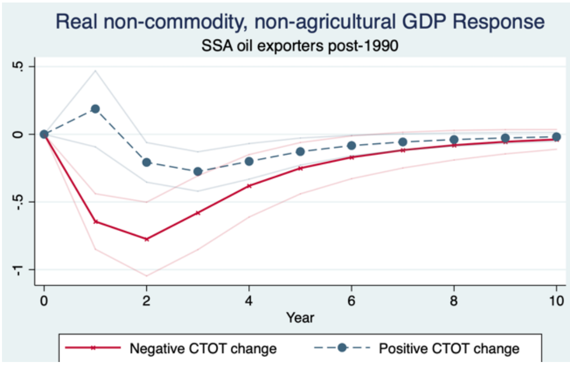


Figure 23

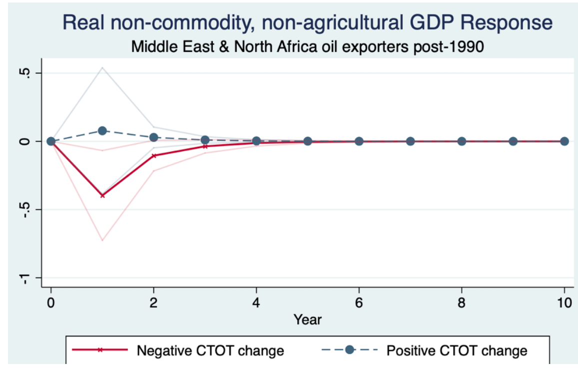


Figure 24

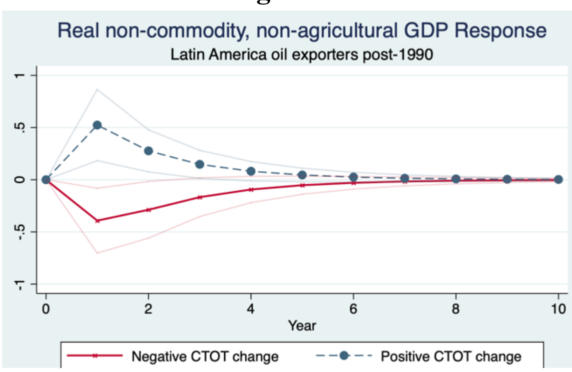
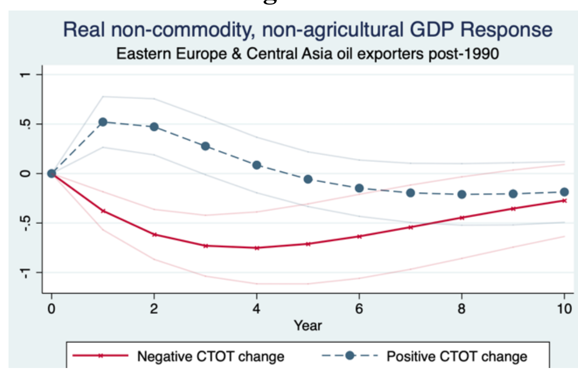


Figure 25



Note: light lines highlight 95 percent confidence interval.

Source: Authors' estimates.

E. Specification Change

The results are also robust to changes in the specification. As mentioned in Section 4, the baseline model uses global real GDP growth as an exogenous variable to capture common macroeconomic shocks. This was preferred to using time dummies because the global oil price is common to all oil-exporting countries and so removing these effects with time dummies risks removing a lot of the variation that the commodity terms-of-trade index is trying to capture. However, Figure 26 shows that the results seem to be relatively insensitive to this specification change. Figure 27 includes agriculture in the GDP measure, but does not meaningfully alter the results.

As the data on Libya are not seen as reliable, in particular since 2012, we ran the results without Libya. The results were very close to those in the full sample. Finally, we considered whether structural breaks in the weighted commodity index could be a problem, due to one-off changes in weights due to domestic policies such as subsidy reforms, which could lead to biased dynamic parameters.

Finally, if we use an index with fixed country commodity weights[15] over time (rather than time-varying weights), so that the index is invariant to changes in import and export volumes, the asymmetry is slightly less pronounced but the impact of negative price shocks remains larger. Nevertheless, we continue to believe the time-varying weights are the preferred approach, as fixed weights risk ascribing relevance to individual commodities in a misrepresentative way, given how the importance of commodities can significantly change over time.

Figure 26

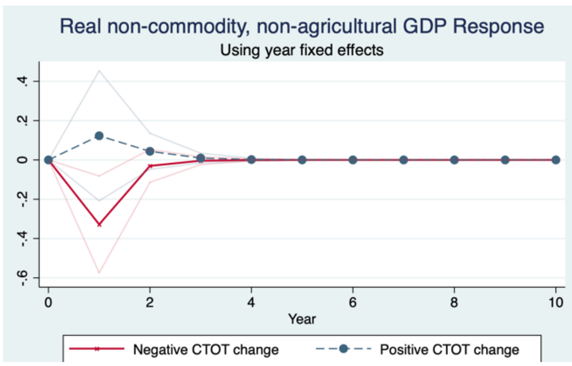
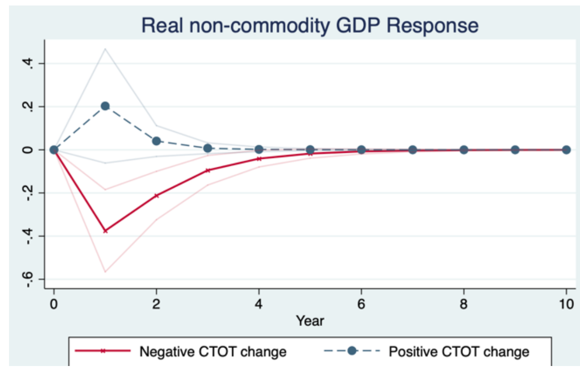


Figure 27



Note: Light lines highlight 95 percent confidence interval.
Source: Authors' estimates.

VII. Conclusion

The overall findings of this paper suggest that linkages between the commodity and non-commodity sectors are important and asymmetric. The results in this paper imply that negative commodity terms-of-trade shocks are more impactful on non-commodity output growth than positive developments, particularly in the presence of weak macroeconomic fundamentals or after a period of commodity price decline. They also imply that spillovers from the oil economy to the non-oil side must be carefully understood to assess appropriate policy responses.

These results have implications for forecasting the extent of anticipated recoveries or slumps following a shock to commodity prices and for adequate policy responses. Assuming a symmetric response to busts and booms may lead to inadequate or overzealous policy responses. Further, like much of the existing literature, it stresses the importance of strong pre-existing economic fundamentals.

The results also suggest the need for future work on the channels of asymmetric transmission between the commodity and the non-commodity sector. While the empirical findings capture the impact of commodity price shocks on the non-commodity economy, it does not explain the processes through which the price shocks are transmitted. To build on this paper, future work would explore the policy responses – both automatic and discretionary – for example,

[15] This index is also provided by Gruss and Kebhaj (2019).

how fiscal policy responds to price shocks. Finally, further research could examine more closely the impact of structural changes in oil- and commodity-exporting countries.

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APPENDICES

Appendix A. Data, Definitions, and Summary Statistics

Construction of non-commodity, non-agricultural GDP: the UN breakdown does not allow for a further decomposition of the group “Agriculture, hunting, forestry, fishing” nor “Mining and utilities”, where ‘Mining’ includes fuel and other primary products. As a result, these accompanying categories are also excluded from the GDP measure used in the study. One way to test robustness to this is the estimation of the main results of the paper using non-commodity GDP, thus including the agriculture sub-group. These robustness checks give qualitatively very similar results to the main specification. Removing utilities is not possible without also removing the natural resource sector, but looking at the size of this component for countries with a virtually non-existent primary sector can give an indicator as to the importance of utilities. Looking at a broad range of resource-poor countries (including Ireland, Switzerland, and Swaziland), ‘Mining and utilities’ has typically made up just 1.5-2.5 percent of GDP over time, and crucially has been very stable in its GDP share. As a result, it is unlikely that the exclusion of utilities from the output measure used in this research will have meaningful consequences for its conclusions.

Data definitions

Real non-commodity, non-agricultural GDP: Real GDP 2010 constant prices, local currency (IMF WEO database), with each year multiplied by share of non-commodity, non-agricultural GDP as described above.

Commodity terms-of-trade index: The weights used to calculate the terms-of-trade in Gruss and Kebhaj (2019) are based on trade patterns in the prior 3-year period using COMTRADE and IMF data.

Exchange rate classification: The Ilzetzki, Reinhart and Rogoff (2017) classification of *de facto* exchange rate regimes is used. A country is classed as following a fixed exchange rate regime if it scores 1 or 2 on the “coarse” *de facto* exchange rate classification.

Public debt-to-GDP ratio: General government gross debt, percent of fiscal year GDP. (WEO)

International reserves-to-GDP ratio: International reserves in US dollars (IMF IFS database) taken as a percent of nominal GDP in US dollars. (WEO)

Commodity revenue/GDP: General government commodity-related revenues. (IMF WEO)

Commodities included in CTOT index: Coal, crude oil, natural gas; aluminum, copper, iron ore, lead, nickel, tin, and zinc; bananas, barley, beef, cocoa, coconut oil, coffee, corn, fish, fish meal, groundnuts, lamb, oranges, palm oil, poultry, rice, shrimp, soybean meal, soybean oil, soybeans, sugar, sunflower oil, tea, wheat; cotton, hardwood logs and sawn wood, hides, rubber, softwood logs and sawn wood, soybean meal, wool.

Oil exporters: Algeria, Angola, Azerbaijan, Bahrain, Bolivia, Brunei, Chad, Republic of Congo, Ecuador, Equatorial Guinea, Gabon, Iran, Iraq, Kazakhstan, Kuwait, Libya, Nigeria, Oman, Qatar, Russia, Saudi Arabia, South Sudan, Trinidad and Tobago, Turkmenistan, United Arab Emirates, Venezuela, Yemen.

Non-oil commodity exporters: Afghanistan, Argentina, Burkina Faso, Burundi, Central African Republic, Chile, Côte d'Ivoire, Democratic Republic of Congo, Eritrea, Guinea-Bissau, Guinea, Guyana, Lao P. D. R, Liberia, Malawi, Mali, Mauritania, Mongolia, Morocco, Papua New Guinea, Paraguay, Sierra Leone, Solomon Islands, South Africa, Sudan, Suriname, Tuvalu, Uruguay, Zambia

Sub-Saharan African (SSA) oil exporters: Angola, Chad, Republic of Congo, Equatorial Guinea, Gabon, Nigeria, South Sudan (also tested including Cameroon).

Diversified commodity exporters are found using the IMF Export Diversification Database, which scores countries on export product diversification and ranges from 1 (most diversified) to 6.4 (least diversified), the oil exporters score an average 5.0 over the sample period whereas non-oil commodity exporters score 4.1.

Diversified commodity exporters: Afghanistan, Argentina, Bahrain, Bolivia, Burkina Faso, Chile, Côte d'Ivoire, Democratic Republic of Congo, Ecuador, Eritrea, Guinea-Bissau, Guyana, Lao P. D. R., Mongolia, Morocco, Papua New Guinea, Paraguay, Sierra Leone, Solomon Islands, South Africa, Sudan, Tuvalu, Uruguay

Table A1. Summary Statistics

Oil exporters	Observations	Mean	Standard deviation	Minimum	Maximum
Δ Non-commodity, non-agricultural GDP per capita (log)	1,021	0.05	0.14	-0.78	1.24
Δ Non-commodity GDP per capita (log)	1,021	0.05	0.13	-0.77	1.22
Δ Real GDP per capita (log)	1,050	0.04	0.11	-1.10	0.91
External debt as a % of GDP	577	0.39	0.43	0.00	3.43
International reserves as a % of GDP	913	0.17	0.22	0.00	3.03
Commodity and agricultural GDP share of total GDP (%)	913	0.48	0.20	0.11	0.99
Commodity terms of trade index (log)	1,228	4.27	0.31	3.15	5.29

Commodity exporters	Observations	Mean	Standard deviation	Minimum	Maximum
Δ Non-commodity, non-agricultural GDP per capita (log)	2,205	0.04	0.11	-0.78	1.24
Δ Non-commodity GDP per capita (log)	2,205	0.04	0.10	-0.77	1.22
Δ Real GDP per capita (log)	2,263	0.03	0.08	-1.10	0.91
External debt as a % of GDP	1,119	0.56	0.60	0.00	5.14
International reserves as a % of GDP	1,957	0.13	0.17	0.00	3.03
Commodity and agricultural GDP share of total GDP (%)	2,447	0.41	0.18	0.04	0.99
Commodity terms of trade index (log)	2,591	4.44	0.27	3.15	5.29

Source: Authors' estimates.

Table A2. 2017 Leading Oil Exporters

Oil exporter	2017 oil exports ($bn)	Global share
Saudi Arabia	133.6	15.9%
Russia	93.3	11.1%
Iraq	61.5	7.3%
Canada	54	6.4%
UAE	49.3	5.9%
Iran	40.1	4.8%
Kuwait	38.2	4.5%
Nigeria	33	3.9%
Angola	30.5	3.6%
Kazakhstan	26.6	3.2%
Norway	25.9	3.1%
Venezuela	23.1	2.7%
United States	21.8	2.6%
Mexico	19.9	2.4%
United Kingdom	19	2.3%
Other	170.5	20.3%
Total	840.3	

Source: The World Factbook, Central Intelligence Agency.

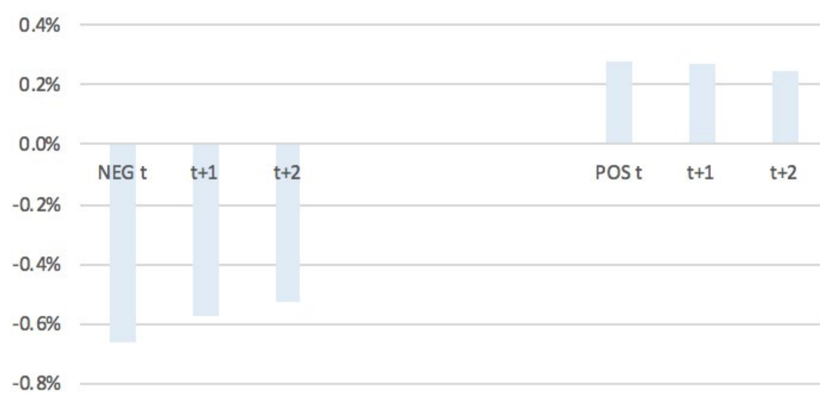
Appendix B. Asymmetric Response to Commodity Price Shocks by Commodity Exporters

This Appendix complements the main section that highlighted the impact for oil-exporters by presenting the estimates for the whole group of commodity exporters and non-oil commodity exporters, respectively.

Commodity exporters

Figure B1. Commodity Exporters: Cumulative Change in Annual Real Non-Commodity, Non-Agricultural GDP Growth

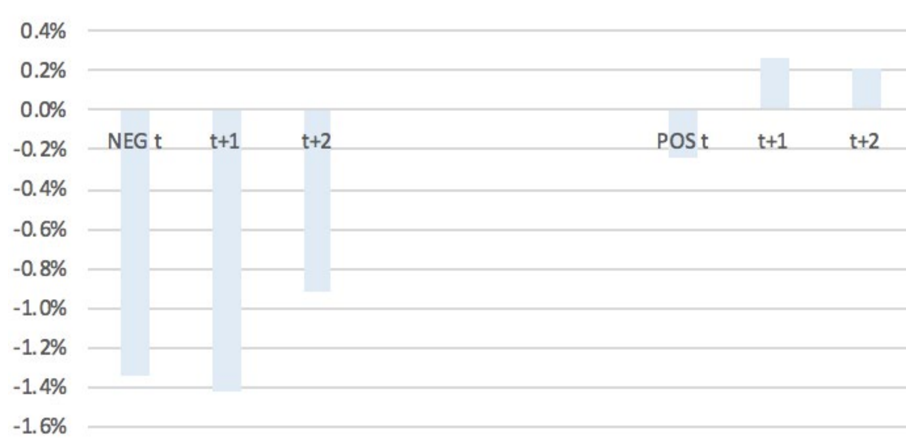
(Compared to three-year period prior to normalized 1 percent shock)



Source: Authors' estimates.

Figure B2. Commodity Exporters: Cumulative Change in Annual Real Non-Commodity, Non-Agricultural GDP Growth

(Compared to three-year period prior to normalized 5 percent shock, only shocks larger than 5 percent)

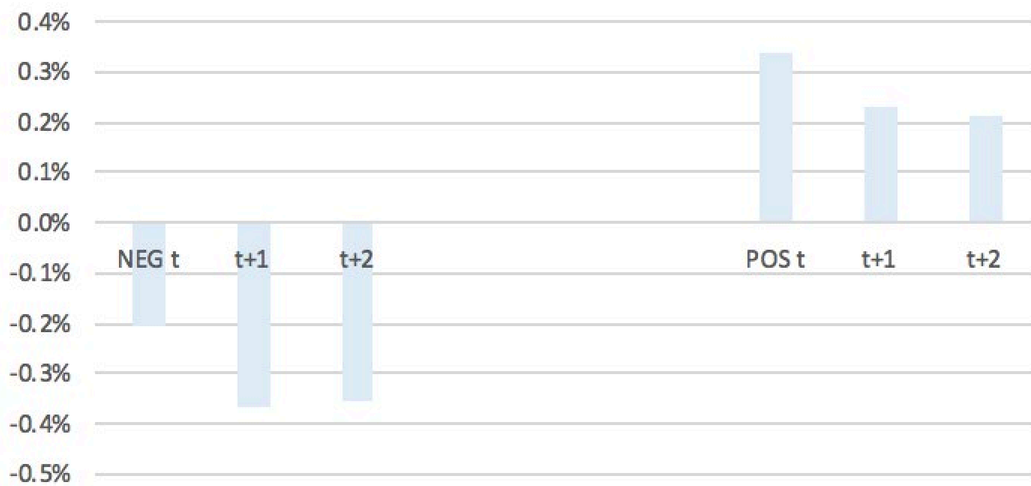


Source: Authors' estimates.

Non-oil commodity exporters

Figure B3. Non-oil Commodity Exporters: Cumulative Change in Annual Real Non-Commodity, Non-Agricultural GDP Growth

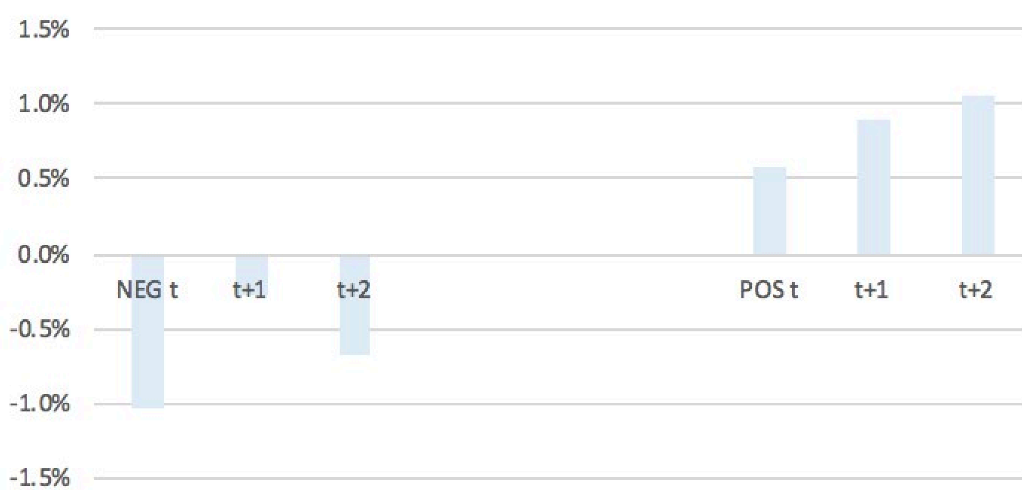
(Compared to three-year period prior to normalized 1 percent shock)



Source: Authors' estimates.

Figure B4. Non-oil Commodity Exporters: Cumulative Change in Annual Real Non-Commodity, Non-Agricultural GDP Growth

(Compared to three-year period prior to normalized 5 percent shock, only shocks larger than 5 percent)



Source: Authors' estimates.

Appendix C. Lag Order Test for Baseline Specification

Table C1

Selection order criteria
Sample: 1979 - 2015

No. of obs = 782
No. of panels = 26
Ave. no. of T = 30.077

lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	-13.6749	28.36605	.0048886	-51.57621	4.366048	-17.1475
2	-33.47858	36.02775	.0000174	-17.26709	20.02775	5.685379
3	-109.4669	8.878541	.0642081	-17.76888	.8785409	-6.292643
4	-2.460386	.	.	.	.	.

Source: Authors' estimates.

Appendix D. Stationarity Tests

To investigate the stationarity of the variables, the test proposed by Pesaran (2007) is used as it tests for unit roots in the presence of heterogeneous panels with cross-sectional dependence, a common feature in cross-country panel growth analyses, confirmed here by the Pesaran (2004) cross-sectional dependence test. This augments the standard Augmented Dickey-Fuller tests with the cross-sectional averages of lagged levels to deal with cross-dependence, as well as first differences to deal with residual serial correlation.

As the results of the tests are not fully conclusive for the null hypothesis of zero cointegration, this paper uses (stationary) first differences in its mains specifications. Table 1 displays the results of testing the variables in the VAR for all commodity exporters, including the sub-sample of oil exporters – the main focus of this paper. For the broader commodity sample, the panel test does not reject the null hypothesis of non-stationarity for the levels of real non-commodity, non-agricultural GDP, but does for commodity terms of trade. For oil exporters the reverse is true, as non-stationarity of the commodity terms-of-trade index cannot be rejected. As panel cointegration tests do not conclusively reject the null hypothesis for zero cointegration, I use first differences in the panel VAR. Table A4 indicates that the first differences of the endogenous variables are stationary, consistent with economic intuition.

Table D1: Pesaran (2007) Panel Unit Root Tests

	log real non-commodity GDP		logCTOT		Δlog real non-commodity GDP		ΔlogCTOT	
Sample	Z-stat	P-value	Z-stat	P-value	Z-stat	P-value	Z-stat	P-value
Commodity exporters	2.35	0.99	-4.58	0.00	-15.79	0.00	-25.87	0.00
Oil exporters	-4.09	0.00	-0.90	0.184	-4.53	0.00	-10.47	0.00

Source: Authors' estimates.

Appendix E. Exogeneity Tests

Exogeneity of Terms-of-Trade

The heuristic for whether a country is able to impact a commodity price through its own production decisions is that it must be greater than 15 percent of the global export share. Table 2 shows the leading 15 oil exporters in 2017 and their share of global oil exports. At 15.9 percent, Saudi Arabia is the only country that breaches the 15 percent threshold, and its inclusion in the sample is an additional concern given the influence it exerts over OPEC, responsible for 44 percent of global oil production in 2016 according to US Energy Information Administration. To alleviate these concerns, we find that the main results of the paper are robust to (i) the exclusion of Saudi Arabia from the sample; and (ii) lowering the production threshold to 10 percent, thus excluding Russia.

In addition, the endogeneity concerns are mitigated as changes in the commodity price index reflect contemporaneous variations in commodity prices, rather than changes in volumes. The identification question deserves extra focus due to the construction of the commodity terms-of-trade index. The calculation of the weights includes exports and imports of each commodity as a share of GDP, which could mean that changes in real non-commodity output could be expected to have a bearing on the commodity terms-of-trade. This concern is mitigated to some extent because the construction of the country-specific commodity terms-of-trade index is such that, when calculating the weights τ, three-year rolling averages of the trade values are used, and are lagged by one year (in contrast to potentially more endogenous contemporaneous movements in volumes).

Measuring the output response in terms of non-commodity GDP reduces the likelihood of endogeneity, an assumption that is supported by statistical tests. In oil exporters, the commodity sector constitutes a large share of exports, and is therefore excluded here. The Granger causality method supports the assumption of exogeneity, with Table A5 showing clearly that changes in real non-commodity output fail to Granger cause changes in the terms-of-trade, but that Granger causation runs in the other direction.

Exogeneity tests – Granger causality

Table E1

```
panel VAR-Granger causality Wald test
  Ho: Excluded variable does not Granger-cause Equation variable
  Ha: Excluded variable Granger-causes Equation variable
```

Equation \ Excluded	chi2	df	Prob > chi2
lnctot_chg			
growth	0.848	1	0.357
ALL	0.848	1	0.357
growth			
lnctot_chg	9.885	1	0.002
ALL	9.885	1	0.002

Source: Authors' estimates.

Appendix F. Deriving the Elasticity of Non-Commodity Real GDP to Commodity Price Changes

Let θ be the output of the impulse response function:

$$\theta = \frac{\partial y}{\partial CTOT}$$

Noting that all the variables are in log form and using the CTOT formula in section IIIA, I can calculate the elasticity of non-commodity real GDP to movements in commodity prices, defined as ε_i:

$$\varepsilon = \frac{\partial y}{\partial P} = \frac{\partial y}{\partial CTOT}\frac{\partial CTOT}{\partial P} = \theta\tau$$

which y is non-commodity real GDP. This gives the country-specific elasticity:

$$\varepsilon_i = \theta\,\tau_i$$

Therefore, if the impulse response shows a 0.3 response in year 1, then a 10 percent increase in commodity prices for a country with a net commodity export share of GDP of 0.2 would lead to a 10%*0.3*0.2 = 0.6 percent increase in non-commodity real GDP growth in year 1.

Appendix G. Variance decomposition

This Appendix, based on the results in Section V.A., provides a forecast-error variance decomposition analysis to gauge how important commodity terms-of-trade shocks are for the non-commodity economy of oil-exporting countries. Table A6 shows that in the initial estimates, among oil exporters, only 4.6 percent of non-commodity GDP variance has been explained by commodity terms-of-trade shocks. However, this number rises to 11.8 percent once an adjustment is made to try and remove years before oil discoveries. For instance, Equatorial Guinea was not classified as an oil exporter prior to its 1995 discovery of oil reserves.

These numbers cannot be directly compared to the literature, as previous papers have used real GDP, which includes the direct impact on the commodity sector. For reference, previous estimates using real GDP have ranged from 10 percent (Schmitt-Grohe, 2015) to 20-30 percent (Kose, 2002; Broda, 2004) and then as high as 40 percent (Drechsel and Tenreyro, 2017; Fernandez et al., 2015).

Table G1: Variance Decomposition

Variance decompositions (%)	Real non-commodity, non-agriculture GDP		
	All CTOT shocks		
Oil exporters	Short run	Long run	Countries in sample
Full sample	0.9%	4.6%	27
Adjusted full sample*	1.7%	11.8%	23
1980s	3.1%	5.0%	19
1990s	3.3%	16.2%	26
2000-2015	2.8%	7.5%	27
Sub-Saharan Africa	3.0%	14.4%	7
Middle East & North Africa	0.1%	1.8%	11
Latin America	5.8%	20.7%	4
Eastern Europe & Central Asia	5.6%	7.0%	4

Source: Authors' estimates.
Notes: Each figure represents the percentage of total short- or long-run variance of real non-commodity, non-agriculture GDP explained by commodity terms-of-trade shocks. The decompositions are based on Cholesky forecast-error variance decomposition using 100 Monte Carlo simulations. Short-run decompositions are based on a two-period-ahead forecast, long-run on a ten-period-ahead forecast.
*Adjusted full sample excludes country-years where commodity revenues-to-GDP is below 10 percent, or for which commodity revenue data is missing.

The share of non-commodity real GDP movements explained by commodity terms-of-trade shocks varies across time and regions.

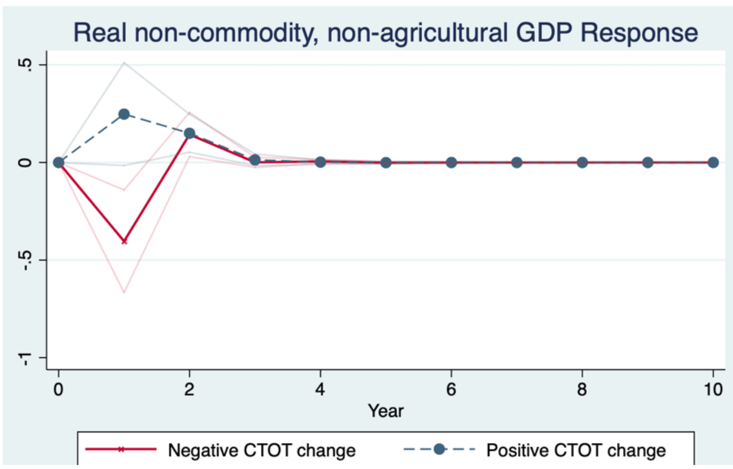
The contribution of commodity terms-of-trade shocks is lowest in the early years of the sample. An increase may be a function of increased global integration as well as more integrated domestic economies, particularly through the growth of the banking sector, one of the principal structures that ties the commodity and non-commodity sectors. This finding is also robust to the adjustment made for oil discoveries.

It is largest in Latin America, though this is a small sub-group, and sub-Saharan Africa. That the smallest contribution is in the Middle East and North Africa region is perhaps a surprising result given this is home to half of the top ten largest oil producers (Saudi Arabia, Iran, Iraq, UAE, and Kuwait, using 2016 U.S. Energy Information Administration data), but may be a function of the large sovereign wealth funds in the region acting as a stabilizing force.

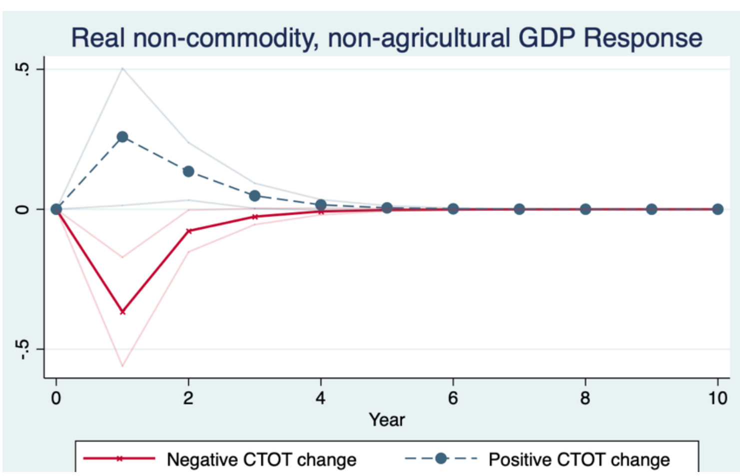
Appendix H. Robustness Check: Testing for Real Government Consumption

Following the specification in Section V.B., to have greater confidence in the identification strategy, this annex includes a fiscal variable in the panel VAR to test whether pure terms of trade shocks are not being confounded with fiscal shocks. We include the log of real government consumption in the specification, defining fiscal shocks as deviations from trend by using the Hodrick-Prescott filter. Due to data availability the sample size is reduced, but the asymmetry finding and magnitude of response is maintained, as shown in Appendix E. Given this invariance, and in order to preserve the full country set, we exclude the statistically insignificant fiscal variable.

Including shocks to real government consumption in panel VAR:



Using fixed-weight commodity terms of trade index:



Note: light lines highlight 95 percent confidence interval.