What moves commodity terms-of-trade? Evidence from 178 countries

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ABSTRACT

Despite the important impact of commodity terms-of-trade (CTOT) on GDP growth, child mortality rates and public debt, little is known about its determinants. Using data from 178 countries (grouped according to their commodity export-import structure) over the period 1962 to 2020, we examine the short and long-run effects of global economic activity, OECD and emerging markets growth, the exchange rate of U.S. dollar, stock price volatility and real interest rates on CTOT growth. We demonstrate their typical asymmetric effect on exporters and importers, and show, for example, that the exchange rate of the U.S. dollar also exhibits opposite effects over the short and long-run due to inelastic commodity demand. We find that the growth of emerging market economies provides the most general and consistent effect across all of our subsamples (i.e., energy and non-energy exporters and importers) - this latter point underscores the contemporary global importance of developing countries growth.

Keywords: commodity terms-of-trade, macro-determinants, developing countries

JEL classification: O13, Q02, F62

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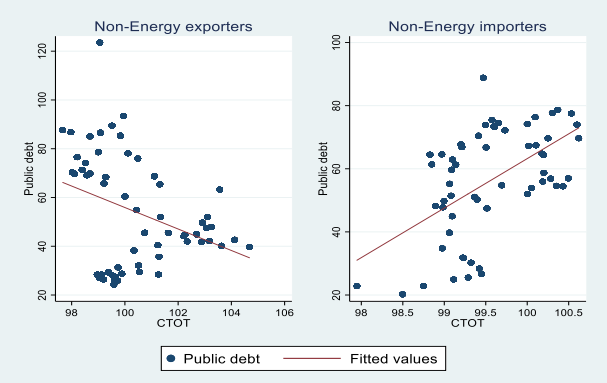
1 Introduction

Fluctuations in commodity prices lead to serious economic challenges for countries including developing nations, many of which are commodity dependent. A measure of countries' exposure to these fluctuations, commodity terms-of-trade (CTOT), has recently been shown to affect economic growth (Spatafora and Tytell, 2009 Cavalcanti *et al*., 2015 and Vinogradov and Makhlouf, 2021), child mortality (Makhlouf *et al.*, 2017) and real exchange rates (Ricci *et al.*, 2013; Aizenman *et al.*, 2012). As a proxy for national commodity revenue, CTOT is also closely related to the government budgetary positions, as shown in Figure 1. In this paper, for the first time, we investigate the macro-factors that underlie CTOT.

Figure 1: The association between CTOT and public debt



Notes: Each dot represents the average value of public debt as percentage to GDP(*y-axis*) and CTOT level (*x-axis*) for non-energy exporters and non-energy importers in each particular year from 1962 to 2020. Public debt data is from the International Monetary Fund. The source of other data is listed in Section 3.

There is an extensive literature on determinants of individual commodity prices. The most popular, as we discuss below, include real interest rates, global economic activity, the exchange rate of the U.S. dollar and stock price volatility. Some authors also highlight the effect of emerging

market economies, such as China and India, on commodity price movements.[1] From these studies one can conclude that effects of the above determinants differ across commodities. For example, real interest rates may be expected to negatively affect commodity prices because an interest rate increase would either diminish commodity demand (via increasing the cost of holding inventories, suppressing economic activity and/or shifting commodity investors to the bond market) or raise commodity supply, especially for exhaustible commodities such as oil and minerals, by creating incentives to extract them and invest the proceeds at a higher rate of return (see, *e.g.*, Williams and Wright, 1991; Deaton and Laroque, 1992; Frankel and Rose, 2010). However, Frankel (2006) finds that the effect of the real interest rate is negative and statistically significant in only 11 out of 23 commodities considered over the period 1970-2005; moreover, the effect is positive and statistically significant for most commodities after 1980. Lombardi *et al.* (2012) find an asymmetric impact of interest rates shocks on prices of non-oil commodities, whilst Roache (2012) shows that the interest rate has a small, negative, and short-lived effect only for crude oil and, to a lesser extent for aluminum. More evidence on the mixed effect of interest rates across commodities can be found in Akram (2009) and Karali and Power (2013).

Similarly, although economic activity is expected to positively affect commodity prices by raising demand (Frankel and Rose, 2010),[2] the empirical evidence is mixed. Whilst some authors use developed countries' growth as a proxy of global demand (e.g., Frankel and Rose, 2010 and Byrne *et al.*, 2013), other studies employ the growth of emerging market economies such as China and India, as they have become more prominent in the world trade of commodities (see, e.g., Roache, 2012 and Lombardi *et al.*, 2012).[3] With regards to the latter, Pain *et al.* (2006) show that emerging economies recently exhibited significant and permanent effects on real oil prices, temporary effects on real metals prices and no effect on agricultural prices. Roache (2012) demonstrates that a Chinese demand shock increases both copper and oil prices whilst the response

[1] Of course, there are many non-macroeconomic/idiosyncratic determinants e.g., speculation and inventories. The focus of the current study is on macro-determinants.

[2] Whilst the growth of output of developed countries increased the demand for, and hence the price of, commodities in 1970s, the weak industrial production in these countries during the early 1980s, reduced commodity prices (Borensztein and Reinhart, 1994).

[3] Cheung and Morin (2007) find evidence of a positive historical relation between oil and metals prices and developed countries' business cycles, but this relationship has broken down since mid-1997. After that, emerging Asia becomes the driver of oil price fluctuations. Consistent with this view, Frankel and Rose (2010) suggest that the growth in economic activity of China, India and other entrants to the list of important economies contributed to the recent commodity price boom. Other literature that relates to commodity super-cycles include Heap (2005), Cuddington and Jerrett (2010) and Gilbert (2023).

of other base metals is, in general, smaller and statistically insignificant. Besides, Lombardi *et al.* (2012) find that 4 out of 15 non-energy commodity prices do not respond to a rise in global industrial production. These mixed results can be potentially explained with reference to short and long run impact of a shock to economic growth. Clearly, the response of commodity supply in short run is commonly restricted (e.g., in agriculture, where harvested crop quantity is a function of planting earlier in the season); however, in the long run, planning decisions around quantity can be adjusted with prices reverting to the cost of production.

The exchange rate of the U.S. dollar is typically expected to negatively affect commodity prices. The initial theory was outlined by Ridler and Yandle (1972) and extended by Gilbert (1989) who noted that the response of dollar-denominated commodity prices to a change in U.S. dollar value should be between zero and minus one. Given that commodities are priced in dollars, dollar depreciation increases the demand for, and hence the price of, commodities by enhancing the purchasing power of foreign importers and vice versa for dollar appreciation (see Akram, 2009 and Vansteenkiste, 2009). During the early 1980s, the dollar appreciated by nearly 50 percent in real terms leading to significant fall in commodity prices (Borensztein and Reinhart, 1994). Most commodities indeed show a significant negative price response to U.S. exchange rate appreciation (see Akram, 2009; Roache, 2012; Lombardi *et al.*, 2012 and Karali and Power, 2013), whilst some respond insignificantly (among them, coffee and cocoa exhibit an insignificant positive response, see Lombardi *et al.*, 2012).

Last but not the least, we turn to uncertainty. On the one hand, high uncertainty makes commodities less desirable for risk-averse investors, reducing commodity inventories and therefore their prices (see Beck, 1993, 2001). In support of this, Byrne *et al.* (2013) document a negative association between stock market uncertainty and the principal component of 24 non-oil prices on annual data over 1900-2008. On the other hand, Dixit and Pindyck (1994) suggest that uncertainty raises the opportunity costs of investing in the irreversible production of primary commodities, leading to a reduction in supply and a rise in commodity prices. From a portfolio diversification perspective, stock market volatility triggers portfolio re-allocation leading to a change in commodities demand and, consequently, prices. Chan *et al.* (2011) find that periods of low stock volatility are associated with "flights from quality" from commodities (specifically gold) to stocks, whilst high stock volatility is associated with flights to quality (from oil to bonds).

In sum, although there exists a set of commonly used macro-determinants of commodity prices, there are heterogeneity of responses across different commodities. This creates further ambiguity about the country-level CTOT effects of these determinants as each country may trade a basket of diverse commodities, and these baskets vary among countries.[4] In particular, one would expect differences between net importers and exporters, as well as between the groups of countries with diversified and non-diversified trade baskets.

To address the above issues, we examine within a panel Autoregressive Distributed Lag (ARDL) framework, the impact of the most commonly used global determinants of commodity prices on CTOT growth. We split our sample initially into two groups - all net exporters (100 countries) and all net importers (78 countries) - and subsequently, four groups of countries based on their commodity trade composition – net energy[5] exporters (30 countries), net energy importers (50), net non-energy commodity exporters (70) and net non-energy commodity importers (28)[6] (see Section 3 for more details and Appendix for the list of countries); the sample period covers 1962 to 2020. The determinants under consideration are those discussed above: global commodity demand (proxied by the world GDP growth), the real interest rate, stock price volatility and the real effective exchange rate of the U.S. dollar. Furthermore, we explore the role of GDP growth of both OECD and major emerging economies (i.e., China, India, and Brazil) as alternative proxies of global demand. Finally, as the persistence of any effect on CTOT probably differs among determinants, we assess both short and long run impacts by estimating panel ARDL models.

The results reveal asymmetric effects for most macro-determinants across net importers and exporters: for example, typically world GDP growth increases the CTOT growth of exporters and reduces that of importers. Additionally, the real exchange rate of the U.S. dollar exhibits opposing effects over the long and short run. Interestingly, the real interest rate provides consistent results over the long run, with the more mixed results of the extant literature found in the short run or over shorter sample periods. Stock price volatility is commonly negative (positive) for exporters (importers), aside for the response for non-energy groupings which is often weaker and more

[4] Some studies explore the effect of macro-determinants on commodity price indices such as Dow Jones, Commodity Resources Board (CRB) and Moody's (Frankel, 2006), and aggregate non-fuel primary commodity price index (Swaray, 2011). This might be useful in circumventing the above inconsistency effects mentioned above but does not assess the national effect of these determinants since these indexes are global rather than national.

[5] Our energy commodities are crude petroleum, natural gas, and coal.

[6] The non-energy category could be split into more specific categories such as food and metals. However, this would lead to small groups and hence, low degrees of freedom.

mixed. Finally, the growth of emerging economies provides a more general effect than OECD growth across all four country groups, over both the short and long run. Given that CTOT is closely related to economic growth, child mortality, public finances and development, our results shed new light on the linkages between the above macro-factors and economic performance. In particular, the growth of three countries (i.e., China, Brazil, and India), appears important for the successful development of other countries in our sample.

The rest of the paper is set out as follows: Section 2 defines CTOT and reviews some relevant literature. Section 3 describes the data. Section 4 outlines the methodology employed to estimate the effects of CTOT determinants. The empirical results are presented and interpreted in section 5. Finally, section 6 concludes.

2 Commodity terms-of-trade (CTOT)

As Cuddington and Urzùa (1989) note, the Prebisch-Singer hypothesis (Prebisch, 1951, 1962; Singer, 1950) that there has been a secular decline in the net barter terms-of-trade between primary commodities and manufactures, has underpinned much empirical work in the extant literature (see e.g., Harvey *et al.*, 2010). The CTOT index differs from the traditional notion of terms of trade in that it focuses solely on commodities in the trade structure of a country. The first versions of the index, to the best of our knowledge, were suggested by Ricci *et al.* (2013) and Spatafora and Tytell (2009). Ricci *et al.* (2013) construct their CTOT based on the prices of six commodity categories (food, fuels, agricultural raw materials, metals, gold and beverages) whilst Spatafora and Tytell (2009) use prices of 32 primary commodities. The latter approach is more specific about the county's trade structure; therefore, we extend Spatafora and Tytell (2009) and construct CTOT index using prices of 36 primary commodities as follows:

$$CTOT_{it} = \prod_j \left(\frac{P_{jt}}{MUV_t}\right)^{X_{ij}} / \prod_j \left(\frac{P_{jt}}{MUV_t}\right)^{M_{ij}} \quad (1)$$

where P_{jt} is the price of commodity *j* at year *t*, MUV_t is a manufacturing unit value index of year *t* used as a deflator, X_{ij} (M_{ij}) is the share of exports (imports) of commodity *j* in country *i*'s GDP, time-averaged over the whole period of study. Taking the logarithm of (1) is instructive to highlight

that it is the country-specific net export $(X_{ij} - M_{ij})$ that determines how the country's CTOT responds to the movements of global relative commodity prices (P_{jt}/MUV_t):

$$lnCTOT_{it} = \sum_j (X_{ij} - M_{ij}) \ln (P_{jt}/MUV_t) \quad (2)$$

Consequently, countries with similar net export structures do not differ much in their CTOT. This property of CTOT is used later to group countries according to their net export position (positive or negative, *i.e.*, net exporter or net importer) as well as according to the composition of their commodity trade (diversified versus non-diversified). The resulting groups of countries are discussed in the next section. Given that weights are time-averaged, any fluctuations in the CTOT are only due to the changes in global commodity prices. This is a convenient property as it implies that changes in CTOT are explained by the drivers of global commodity prices, which themselves are global rather than country specific. This underlies the very idea of the current study to investigate the impact of global commodity determinants on country specific CTOT.

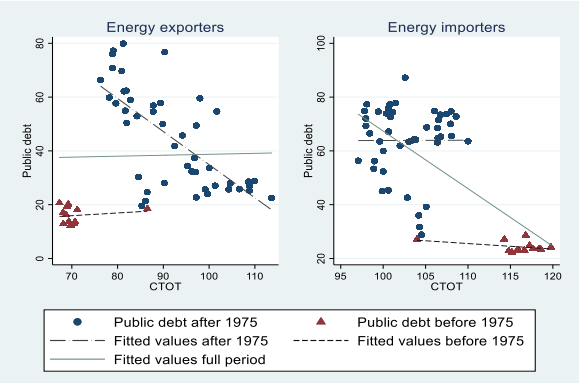
CTOT can be seen as a proxy for the countries' resource revenue, i.e., quantities of traded commodities multiplied by their prices. The changes in this revenue in the short-run are mainly induced by fluctuations of prices rather than quantities traded,[7] therefore should be driven by the same factors as changes in CTOT. This resource revenue is an important source of public finance, explaining the association between the CTOT levels and the public debt in non-energy countries depicted in Figure 1 earlier. Figure 2 presents the same association for energy exporters and importers. For energy exporters, the oil price shock in the early 1970s leads to two clusters, before and after 1975: the post-1975 period showing a negative association between CTOT and public debt. For energy importers, we also have two clusters before and after 1975: however, in this instance, the post-1975 period presents a weaker association.

The critical role of commodity trade composition is elucidated in several papers studying the influence of commodity prices on economic performance and demonstrating that this influence depends on a commodity's weight in the country's trade structure. For example, Robinson *et al.* (2000) show that the expected impact of a 5 dollar per barrel oil price hike on the net trade balance to GDP differs not only between oil exporters and importers but also across oil exporters

[7] The quantities of traded commodities do not change much in the short run (see Cavalcanti *et al.*, 2015).

(importers) reflecting the relative weight of oil in the economy.[8] Blattman *et al.* (2007) demonstrate the impact of commodities' behaviour on economic growth, where, the exporters of commodities with high price volatility have grown much more slowly relative to the industrial leaders and to other primary product exporters. Cashin *et al*. (2004) contend that the real exchange rates of commodity-dependent countries (e.g., Australia), are driven by their principal export prices with Bodart *et al.* (2012) reporting a strong long-run relationship between the price of commodity which has a large share (greater than 20%) of a country's export and the real exchange rate.

Figure 2: The association between CTOT and public debt for Energy exporters and importers



Notes: Each dot represents the average value of public debt in percent of GDP(y-axis) and CTOT level(x-axis) for energy exporters or importers in each particular year from 1962 to 2020. Public debt data is from International Monetary Fund.

[8] They report that most of the Heavily Indebted Poor Countries (HIPC) and the Commonwealth of Independent States (CIS) countries are net oil importers and have high level of oil imports relative to GDP. Thus, these countries are seriously affected by higher oil prices, the expected deterioration of net trade balance to GDP for HIPC and CIS economies in response of a 5 dollar per barrel oil price hike is 0.8 and 1.7 percent respectively. On the other hand, the expected improvement of the OPEC group is approximately 7 percent, and this improvement differs across OPEC *e.g.*, the largest beneficiary is Iraq, 13 percent, and the lowest beneficiary is Venezuela, 4 percent.

Of course, significant movements in CTOT imply challenges for economies as they signify a change in national commodity revenue in response to global commodity price fluctuations. Spatafora and Tytell (2009), for instance, show that median GDP growth is approximately 2 percentage points higher during CTOT booms than busts for both fuel and non-fuel commodity exporters over the period 1970–2007. Additionally, Cavalcanti *et al.* (2015) demonstrate that CTOT growth (volatility) boosts (mitigates) economic growth of 62 commodity exporting countries over the period 1970-2005. Ricci *et al.* (2013) show that a 10 percent increase in CTOT is associated with a long-run real exchange rate appreciation of 5.5 percent for a set of 48 industrial countries and emerging markets in 1980-2004. Finally, Aizenman *et al.* (2012) highlight the effect of CTOT shocks on the volatility of real exchange rates. These studies demonstrate the macroeconomic consequences of movements in CTOT. By estimating the effect of global commodity price drivers *on* CTOT we therefore indirectly estimate their impact on public finance and the overall economic performance of commodity dependent countries.

3 Data

We use a sample of 178 countries (see Appendix, Table A.1) over a newly extended period of 1962-2020 to assess the country-level effect of commodity price determinants. The commodities we consider are the 32 commodities used in Spatafora and Tytell (2009), as well as Coal, Phosphate Rock, Potash, and Natural Gas.[9] Above we have conjectured that the impact of commodity price drivers should differ between net exporters and importers, as well as between groups of countries with diversified or non-diversified commodity exports/imports. To address this, we split the sample into sub-samples according to the structure of the countries' commodity baskets, simultaneously ensuring that the number of countries and hence observations in each sub-sample is large enough. We define exporters (importers) as countries with positive (negative) net export of the above commodity basket.

To identify countries with a non-diversified commodity trade structure, we condition on commodities that have the largest share *both* in exports and imports in the largest number of countries in our sample. Unsurprisingly, taken together, energy commodities (i.e., crude

[9] We thank an anonymous referee for the suggestion of adding these four important commodities. See Adams (2019) and Tilton and Guzmán (2016) for further information on the additional mineral commodities.

petroleum, natural gas,[10] and coal) are the dominant commodities in about half of the countries in our study (see online Appendix). An energy exporter is defined as a country, for which these three commodities constitute over 50 percent of the net commodity basket export (similarly for energy importers); otherwise, the country is classified as non-energy exporter or importer. We end up with four sub-samples: energy exporters (30 countries), energy importers (50 countries), non-energy exporters (70 countries) and non-energy importers (28 countries) (see Appendix for the full list). We also aggregate these sub-samples into two groups – 'all exporters' (100 countries) and 'all importers' (78 countries) for some later analysis.

Non-energy exporters and importers have a more diversified trade structure then the exporters and importers of energy commodities. More specifically, non-energy exporters (see online Appendix, Figure A.1) depend on gold, coffee, copper, cocoa beans, iron ore and sugar, among other leading commodities. Rice and wheat are the key commodities for non-energy importers in our sample; their imports are three to four times higher than the import of other prominent commodities such as sugar, natural gas, soybean oil and so on. This still provides a higher diversification of the commodity basket than the one achieved by energy exporters and importers (see online Appendix, Figure A.2), for which the volume of crude petroleum trade is at least twenty times higher than that of other commodities.

The prices of the 36 commodities are taken from the IMF *Commodity Price System* database and *World Bank Commodity Price Data*. The MUV deflator is the historical price index of manufactures, also from the World Bank. The exports and imports of 36 commodities are obtained from the United Nations' *COMTRADE* database and are available from 1962; the weights are averaged and CTOT in (1) is constructed for 1962-2020. The sources of our explanatory variables are as follows: (i) real GDP of the World, OECD, and emerging economies (China, India, and Brazil), as well as the U.S. real interest rate, are from the *World Development Indicators* (WDI) dataset, and (ii) the U.S. dollar real effective exchange rate and global stock price volatility are from *Bank of International Settlements* and *World Data Bank – Global Financial Development* datasets, respectively.

Table 1 provides some summary statistics for CTOT growth across the four most disaggregated sub-samples. On average, energy exporters display higher CTOT growth than any

[10] For natural gas we employ the Amsterdam TTF price. However, results are available in the online Appendix for the NYMEX "Henry Hub" price. Again, we thank an anonymous referee for this suggestion.

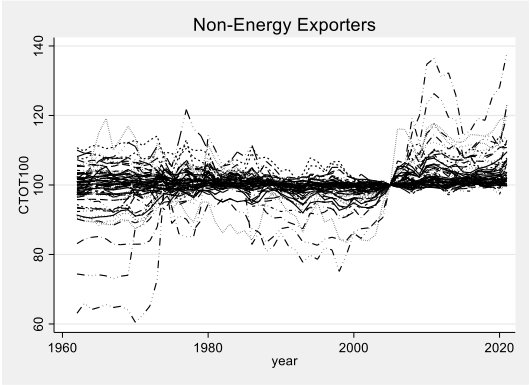
other sub-groups, 0.6 percent. Additionally, energy exporters and importers show opposite growth signs; exporters (importers) have positive (negative) growth. Moving to the second moment, energy exporters exhibit the highest volatility of CTOT growth across all sub-groups, 7.1 percent. Energy subsamples are characterized by higher volatility compared with non-energy groups, reflecting the high volatility of crude petroleum and natural gas (see online Appendix, Table B.1). Lastly, note the volatility of non-energy exporters is high comparing with non-energy importers. A potential explanation is the high volatility (see online Appendix, Table B.1) of main commodities in the trade structure of non-energy exporters (i.e., gold, coffee, copper, and iron ore), relative to the leading commodities of non-energy importers (i.e., rice and wheat).

Table 1: CTOT growth statistics

	Obs.	Mean	S.D.	Min	Max
Non-Energy Exporters	4,060	0.086	1.7592	-18.082	33.126
Non-Energy Importers	1,624	0.002	0.472	-3.301	3.026
Energy Exporters	1,740	0.568	7.137	-43.851	55.922
Energy Importers	2,900	-0.148	3.844	-99.481	79.004
Full sample	10,324	0.088	3.747	-99.481	79.004

Figures 3 and 4 present the CTOT for all countries in each sub-group. CTOTs of non-energy sub-groups exhibit relatively lower correlation, since the sample selection focused on countries with a variety of significant commodities in their basket. In contrast, energy sub-groups demonstrate a relatively high co-movement of CTOT, not least because the prices of energy (i.e., petroleum, natural gas, and coal) are reasonably correlated as shown in Figure 5.

Figure 3: CTOT for non-energy sub-groups



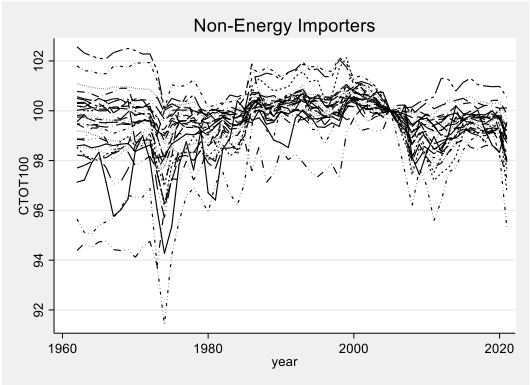
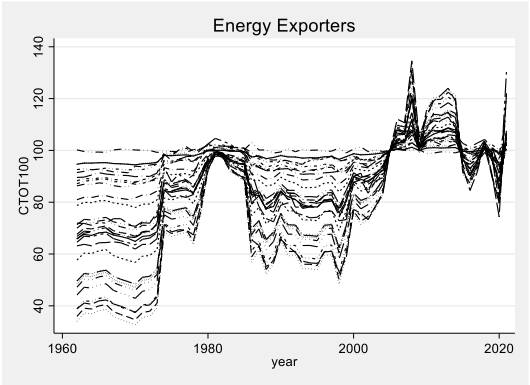


Figure 4: CTOT for energy sub-groups



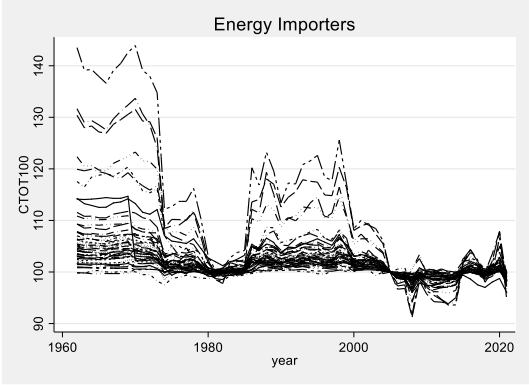
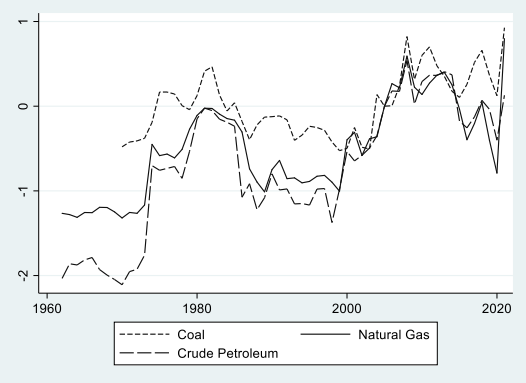


Figure 5: Energy commodity prices relative to MUV



4 Methodology

At the preliminary stage, and over the over the period 1962-2020, we test for a unit root (see Table 2a) in the logarithm of both CTOT and possible determinants;[11] whilst the Levin-Lin-Chu panel test is employed for sub-groups' CTOT (see Table 2b), both the Augmented Dickey-Fuller and Philips-Perron univariate tests are used for determinants. The results illustrate that all sub-group CTOTs and determinants typically exhibit unit root behavior, except stock price volatility.

[11] Except for volatility where we do not take logarithms as this would smooth spikes.

Table 2a: ADF and PP tests

	Augmented Dickey- Fuller		Philips-Perron	
	Level	*1st Diff*	*Level*	*1st Diff*
World GDP	-3.245*	-4.277***	-3.183	-4.166***
OECD GDP	-2.124	-3.878***	-1.856	-3.904***
Emerging GDP	-0.936	-3.996***	-0.620	-4.030***
Real interest rate	-1.769	-6.060***	-2.008	-6.036***
U.S. Exchange rate	-3.170	-4.906***	-2.375	-4.831***
Stock price volatility	-4.702***	--	-4.203**	--

Notes: * p<0.10, ** p<0.05, *** p<0.01. All variables are logarithms except stock price volatility. All tests include an intercept and trend.

Table 2b: Panel-data unit-root test (Levin-Lin-Chu test)

	Level	*1st Diff*
Non-Energy Exporters	-1.125	-35.201***
Non-Energy Importers	-1.238	-25.457***
Energy Exporters	2.621	-26.242***
Energy Importers	1.910	-41.287***
Full sample	1.791	-68.918***

Notes: * p<0.10, ** p<0.05, *** p<0.01.

To distinguish clearly between short and long run effects, we use a panel autoregressive distributed lag (ARDL) model.[12] Specifically, Pesaran and Smith (1995), Pesaran (1997) and Pesaran *et al*. (1999) employ an ARDL (*p*, *q*) approach, establishing dynamic heterogeneous panel regressions in an error-correction form, which in our context can be expressed:

$$\Delta CTOT_{i,t} = \lambda_i\left[CTOT_{i,t-1} - \left\{\beta_{i,0} + \beta_1 X_{t-1}\right\}\right] + \sum_{j=1}^{p-1} \theta_{i,j}\, \Delta CTOT_{i,t-j} + \sum_{j=0}^{q-1} \eta_j\, \Delta X_{t-j} + \varepsilon_{i,t} \quad (3)$$

where θ and η are the short-run coefficients of the lagged dependent variable and other regressors respectively, whilst β represents the long-run coefficients. λ is the speed of adjustment (on the error correction term) to the long-run equilibrium and return to that equilibrium would imply $\lambda < 0$. The literature provides three alternative methods (e.g., Pesaran *et al.*, 1999; Makhlouf et al., 2020) to estimate the coefficients of (3) - dynamic fixed effects (DFE), the mean group (MG) and pooled mean group (PMG).

[12] Makhlouf *et al*. (2020) employed an analogous panel ARDL model to assess the relationship between financial development and inequality over the period 1870 to 2011.

The different estimation methods have different assumptions about the homogeneity of short-run dynamic terms and long-run parameters. On one hand, DFE assumes all of the coefficients (although not intercepts) to be the homogenous across cross-sectional units and therefore in our case, countries – an assumption that might be overly restrictive. On the other hand, the MG estimator (see Pesaran and Smith, 1995) imposes no homogeneity restrictions on coefficients; as a first step, the approach estimates separate regressions for each cross-sectional unit (i.e., country) and, in a second step, calculates group coefficients by averaging those from the first step. Between the two approaches is the PMG estimator (see Pesaran et al., 1999), which allows the short run coefficients to vary across cross-sectional units but assumes long-run coefficients are homogenous.

Given the mixed empirical evidence regarding the effect of commodity price determinants, and that non-energy and energy exporters and importers present differing levels of trade structure diversification, the restrictions of the DFE approach seem unlikely to be met. Consequently, we focus on the MG and PMG estimators. Pesaran and Smith (1995) show that the former approach generates consistent estimates when N and T are reasonably large. Also worth noting is that the PMG estimator is only more efficient than the MG alternative if long run homogeneity holds (Pesaran, et al., 1999). To test this assumption, we employ an appropriate likelihood ratio (LR) test.[13] Analogously to Samargandi et al. (2015) and Makhlouf et al. (2020), we use the Schwartz Bayesian Criterion (SBC) to find an ARDL lag structure of $p = 1$ and $q = 1$ for all our panel regressions of (3). In fact, this specification, $p = q = 1$, is very common in literature that uses ARDL models to test a variety of economic issues (e.g., Samargandi et al., 2015 and Li et al., 2016) and appears reasonable for our 60-year time horizon (see Ojede and Yamarik, 2012).

Although, as already discussed, the literature shows some mixed evidence for the impact of our determinants, we generally expect a positive effect of global demand on commodity prices and a negative effect for both the real effective exchange rate of U.S. dollar and the real interest rate of U.S. Conditioning on this, we therefore expect that exporters (i.e., the net sellers of commodities) CTOT will respond to determinants in an analogous manner to commodity prices themselves. Importers (i.e., the net buyers of commodities) CTOT, on the other hand, should

[13] The well-known Hausman test could be used also to test this assumption. However, we prefer LR test as Hausman test has poorer power with a smaller N, which may be considered the case for some of our four groups of non-energy and energy exporters and importers (Pesaran et al., 1996 and Byrne and Davis, 2005).

respond in an inverse manner. Given the mixed views explored earlier about the commodity prices/uncertainty relationship, it is difficult to anticipate the effects of stock market volatility on CTOT. Finally, we conjecture that the macro-determinants considered may exhibit the same effect in the short and long run, except for the exchange rate of dollar, where we expect a positive pricing effect in the short run and negative effect in long run. As commodities are priced in dollars, prices are typically positively associated with the dollar value over the short run. However, commodity demand adversely responds in the long run, leading to a negative association between commodity prices and exchange rate movements.

5 Empirical results

5.1 Panel ARDL model

Table 3 contains the results of estimating (3) for whole sample and two sub-groups: all exporters and all importers, over the period 1962-2020 and using the MG estimator. The top section of Table 3 presents the long run coefficients whilst the bottom section provides the short run coefficients.[14] For all regressions, the error-correction coefficients, λ, are negative and significant, and therefore the null hypothesis of no long-run relation is rejected. Both MG and PMG estimators give similar results; however, we focus on the MG estimator given the LR test (in all cases) shows that the assumption of homogeneity of short-run dynamics is not valid, illustrating the heterogeneous impact of the determinants across commodity prices.

[14] Given the stationarity of stock market volatility (see Table 2a), we confine it to the short-run component of the Panel ARDL for all regressions.

Table 3: CTOT growth determinants – All exporters and importers (1962-2020)

	(1) All	(2) All exporters	(3) All importers
World GDP	0.018***	0.047***	-0.021***
	(2.87)	(5.92)	(-2.78)
Real interest rate	-0.334***	-0.731***	0.175***
	(-5.24)	(-7.90)	(5.07)
Exchange rate U.S.	-0.113***	-0.310***	0.140***
	(-2.74)	(-5.66)	(2.79)
EC term	-0.209***	-0.233***	-0.180***
	(-21.12)	(-14.60)	(-20.53)
Δ World GDP	0.083***	0.223***	-0.097***
	(3.10)	(6.18)	(-3.34)
Δ Real interest rate	0.018	-0.001	0.043*
	(0.75)	(-0.02)	(1.67)
Δ Exchange rate U.S.	0.024**	0.074***	-0.040***
	(1.98)	(4.52)	(-2.73)
Stock price volatility	-0.107	-0.342***	0.193**
	(-1.55)	(-3.41)	(2.41)
Country/Obs.	178/9968	100/5600	78/4368
Adjusted R^2	0.759	0.757	0.763
F	1.559	1.571	1.532

Notes: t statistics in parentheses. all variables in first lag. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

Examining the long-run effects first (i.e., the top section of Table 3), column (1) shows a positive effect of world GDP, and a negative effect of the real interest rate and real effective exchange rate of the U.S. dollar. Interpreting these results is problematic since the whole sample includes both commodity exporters and importers and our determinants are expected to have opposite effects on these categories. Therefore, we re-estimate (3) for all exporters and importers (columns 2 and 3). The results for the world GDP variable are consistent with theories suggesting its positive effect on commodity prices, thus, it improves (deteriorates) CTOT growth for commodity exporters (importers). On the other hand, the coefficients for both the real interest rate and real effective exchange rate of U.S. dollar support the hypothesized negative effect (see Frankel, 2006) of these variables on commodity prices via decreasing (increasing) CTOT growth for commodity exporters (importers).

Moving to the short-run effects (i.e., the bottom section of Table 3), and as might be anticipated, world growth has the same sign as its long run counterpart across all categories. As discussed earlier, this doesn't occur for the U.S. dollar real exchange rate where the signs are

reversed e.g., the variable in the short run now presents a positive (negative) effect on CTOT growth for exporters (importers).[15] As commodities are priced in dollars, dollar appreciation (depreciation) raises (reduces) the price of commodities, therefore a positive association between dollar value and commodity prices in the short term. In the longer term though, the resultant lower commodity demand leads to negative effects commodity prices. This supports work such as Cashin *et al.* (2004) who found it takes at least 10 months for such adjustment to take place. It is also worth noting that compared to their long-run counterparts, the short-run coefficients for the real interest rate show less significance. Finally, and in line with work that posits a negative association between uncertainty and commodity prices (see Byrne *et al.*, 2013), stock price volatility has negative (positive) effect on the CTOT growth for exporters (importers)

Next, we assess the effect of these determinants on the exporters and importers of our two commodity categories (i.e., non-energy and energy) in Table 4, and by re-estimating (3), see whether this further disaggregation provides any further insights. Comparing with our previous Table 3, we can see that in Table 4 the long run typically provide similar results for exporters and importers and in line with the theory previously outlined – with one exception, the real effective exchange rate is insignificant for non-energy importers. By contrast, some differences emerge between Table 4 and Table 3 when considering short-run effects. Examining the real interest rate first, one can observe in Table 4 that all the coefficients are now significant, with energy exporters and importers presenting signed coefficients similar to the long run, while the short-run coefficients for the non-energy groups are reversed. Moreover, for the real effective exchange rate, the short-run coefficients for the non-energy groups are now insignificant. Finally, with stock price volatility, while energy exporters and importers have signed coefficients similar to Table 3, analogously to the real interest rate, these signs are reversed for the non-energy groups.

[15] This reversal of signs between the long and short-run effects is indicative of a type of J-curve phenomenon.

Table 4: CTOT growth determinants – 4 subsamples (1962-2020)

	(1) Non-Energy Exporters	(2) Non-Energy Importers	(3) Energy Exporters	(4) Energy Importers
World GDP	0.010***	-0.000	0.134***	-0.032***
	(3.23)	(-0.22)	(7.64)	(-2.84)
Real interest rate	-0.818***	0.211***	-0.529***	0.155***
	(-6.40)	(7.89)	(-7.65)	(3.00)
Exchange rate U.S.	-0.059**	0.002	-0.895***	0.216***
	(-2.36)	(0.36)	(-7.65)	(2.84)
EC term	-0.253***	-0.206***	-0.185***	-0.165***
	(-12.21)	(-9.53)	(-9.37)	(-29.26)
Δ World GDP	0.074***	-0.029***	0.573***	-0.135***
	(2.68)	(-2.85)	(8.40)	(-3.06)
Δ Real interest rate	0.177***	-0.052***	-0.416***	0.097**
	(6.27)	(-4.69)	(-6.57)	(2.54)
Δ Exchange rate U.S.	-0.006	-0.000	0.259***	-0.063***
	(-1.23)	(-0.12)	(7.47)	(-2.79)
Stock price volatility	0.129***	-0.074***	-1.440***	0.343***
	(2.59)	(-5.26)	(-7.11)	(2.86)
Country/Obs.	70/3920	28/1568	30/1680	50/2800
Adjusted R^2	0.733	0.779	0.760	0.762
F	1.773	1.399	1.544	1.533

Notes: *t* statistics in parentheses. all variables in first lag. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

To examine the role of both emerging economies and industrial countries as a driving force of the global commodity demand, we re-estimate Table 4 using two global demand proxies. Specifically, Tables 5 and 6 show the results of MG estimation of (3) using emerging market and OECD GDP, respectively. Focusing on GDP, Table 5 reports that the impact of emerging market GDP is typically statistically significant for the sub-groups, and as expected, is positive for exporters and negative for importers (except for non-energy importers in the long run, where the coefficient is insignificant).

Table 5: CTOT growth determinants - Emerging market growth (1962-2020)

	(1) Non-Energy Exporters	(2) Non-Energy Importers	(3) Energy Exporters	(4) Energy Importers
Emerging GDP	0.008***	0.001	0.081***	-0.019***
	(2.88)	(1.63)	(7.30)	(-2.66)
Real interest rate	-0.655***	0.190***	-0.083*	0.037
	(-6.22)	(8.32)	(-1.70)	(1.62)
Exchange rate U.S.	-0.065**	-0.006*	-0.479***	0.115***
	(-2.08)	(-1.72)	(-7.30)	(2.69)
EC term	-0.266***	-0.240***	-0.223***	-0.196***
	(-13.19)	(-12.12)	(-9.47)	(-29.13)
Δ Emerging GDP	0.049***	-0.011*	0.142***	-0.047***
	(4.58)	(-1.89)	(8.79)	(-4.84)
Δ Real interest rate	0.193***	-0.066***	-0.079***	0.018
	(5.57)	(-6.40)	(-2.81)	(1.12)
Δ Exchange rate U.S.	-0.005	-0.001	0.219***	-0.054***
	(-1.15)	(-0.42)	(7.50)	(-2.83)
Stock price volatility	0.011	-0.059***	-1.570***	0.370***
	(0.32)	(-3.12)	(-7.33)	(2.81)
Country/Obs.	70/3920	28/1568	30/1680	50/2800
Adjusted R^2	0.750	0.777	0.798	0.796
F	1.635	1.419	1.245	1.272

Notes: *t* statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

Turning to OECD GDP in Table 6, interestingly, this variable exhibits much less significance than previous GDP variables. In particular, OECD is not significant in the long run for non-energy exporters or importers. Moreover, for the short-run coefficients, OECD growth is insignificant for non-energy exporters. Taken as a whole, the results from Tables 5 and 6 suggest that the demand derived from emerging economies for commodities is more general and consistent than that from the OECD.

Table 6: CTOT growth determinants - OECD growth (1962-2020)

	(1) Non-Energy Exporters	(2) Non-Energy Importers	(3) Energy Exporters	(4) Energy Importers
OECD GDP	0.004	0.000	0.135***	-0.032***
	(0.67)	(0.03)	(7.66)	(-2.85)
Real interest rate	-1.017***	0.219***	-0.853***	0.224***
	(-4.17)	(7.87)	(-9.07)	(3.02)
Exchange rate U.S.	-0.056**	-0.001	-0.870***	0.209***
	(-2.43)	(-0.16)	(-7.64)	(2.84)
EC term	-0.258***	-0.214***	-0.193***	-0.175***
	(-12.77)	(-10.65)	(-10.21)	(-33.87)
Δ OECD GDP	0.012	-0.013*	0.130***	-0.020*
	(0.51)	(-1.73)	(7.41)	(-1.77)
Δ Real interest rate	0.208***	-0.060***	-0.219***	0.046**
	(6.51)	(-5.75)	(-5.50)	(2.03)
Δ Exchange rate U.S.	-0.008*	0.000	0.250***	-0.061***
	(-1.76)	(0.21)	(7.45)	(-2.77)
Stock price volatility	0.089*	-0.062***	-1.820***	0.446***
	(1.69)	(-4.44)	(-7.25)	(2.93)
Country/Obs.	70/3920	28/1568	30/1680	50/2800
Adjusted R^2	0.744	0.794	0.774	0.775
F	1.679	1.287	1.431	1.431

Notes: *t* statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

5.2 Robustness checks

Given Figure 2 earlier, it is possible that the early to mid-1970s are a breakpoint for some commodity prices. Moreover, some government and industry, rather than market forces, influenced prices in this earlier period: for example, the US Treasury and the Texas Railroad Commission steered gold and global petroleum prices prior the middle of 1970s (see Jacks, 2019). Thus, we re-estimate Table 4, 5 and 6 for the 1975-2020 period and show the results below in Tables 7, 8 and 9 respectively.

Table 7: CTOT growth determinants – 4 subsamples (1975-2020)

	(1) Non-Energy Exporters	(2) Non-Energy Importers	(3) Energy Exporters	(4) Energy Importers
World GDP	-0.014	-0.007***	0.146***	-0.037***
	(-0.43)	(-4.06)	(7.45)	(-3.18)
Real interest rate	-1.389*	0.050**	-0.063	-0.002
	(-1.96)	(2.51)	(-0.44)	(-0.05)
Exchange rate U.S.	0.113	0.048***	-1.036***	0.264***
	(0.47)	(3.90)	(-7.49)	(3.17)
EC term	-0.271***	-0.232***	-0.136***	-0.121***
	(-12.28)	(-7.27)	(-5.82)	(-15.98)
Δ World GDP	0.094***	-0.012	1.214***	-0.290***
	(3.70)	(-0.89)	(7.97)	(-2.89)
Δ Real interest rate	0.156***	-0.020**	-0.434***	0.109***
	(5.97)	(-2.53)	(-6.71)	(2.76)
Δ Exchange rate U.S.	-0.003	-0.008***	0.291***	-0.073***
	(-0.61)	(-3.50)	(7.51)	(-2.87)
Stock price volatility	0.149***	0.012	-0.789***	0.217***
	(4.42)	(1.19)	(-6.32)	(3.56)
Country/Obs.	70/3220	28/1288	30/1380	50/2300
Adjusted R^2	0.687	0.565	0.673	0.680
F	1.656	2.641	1.757	1.703

Notes: *t* statistics in parentheses. all variables in first lag. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

Table 8: CTOT growth determinants - Emerging market growth (1975-2020)

	(1) Non-Energy Exporters	(2) Non-Energy Importers	(3) Energy Exporters	(4) Energy Importers
Emerging GDP	0.016**	-0.003***	0.066***	-0.017***
	(2.39)	(-4.20)	(7.22)	(-2.83)
Real interest rate	-0.523***	0.036***	0.141*	-0.043***
	(-2.77)	(3.35)	(1.69)	(-2.71)
Exchange rate U.S.	-0.093**	0.018***	-0.405***	0.102***
	(-2.30)	(4.09)	(-7.25)	(2.84)
EC term	-0.294***	-0.259***	-0.205***	-0.186***
	(-14.35)	(-9.58)	(-7.43)	(-23.39)
Δ Emerging GDP	0.054***	-0.010*	0.364***	-0.089***
	(5.28)	(-1.94)	(8.37)	(-3.32)
Δ Real interest rate	0.166***	-0.030***	0.074***	-0.013
	(5.86)	(-4.91)	(5.25)	(-1.31)
Δ Exchange rate U.S.	0.000	-0.007***	0.261***	-0.065***
	(0.00)	(-3.30)	(7.51)	(-2.87)
Stock price volatility	-0.036	0.012	-1.610***	0.417***
	(-1.03)	(0.89)	(-7.34)	(3.09)
Country/Obs.	70/3220	28/1288	30/1380	50/2300
Adjusted R^2	0.673	0.594	0.762	0.762
F	1.754	2.378	1.163	1.163

Notes: *t* statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

Table 9: CTOT growth determinants - OECD growth (1975-2020)

	(1) Non-Energy Exporters	(2) Non-Energy Importers	(3) Energy Exporters	(4) Energy Importers
OECD GDP	0.048	-0.008***	0.228***	-0.056***
	(1.50)	(-3.61)	(7.55)	(-3.27)
Real interest rate	-0.012	0.071***	-0.695***	0.156*
	(-0.02)	(3.26)	(-3.92)	(1.91)
Exchange rate U.S.	-0.322	0.054***	-1.527***	0.378***
	(-1.45)	(3.48)	(-7.56)	(3.26)
EC term	-0.276***	-0.237***	-0.120***	-0.106***
	(-12.66)	(-7.43)	(-5.10)	(-13.64)
Δ OECD GDP	0.027	0.002	0.813***	-0.187***
	(1.32)	(0.20)	(7.98)	(-2.81)
Δ Real interest rate	0.184***	-0.026***	-0.278***	0.069***
	(6.49)	(-3.73)	(-6.13)	(2.59)
Δ Exchange rate U.S.	-0.005	-0.008***	0.284***	-0.071***
	(-1.02)	(-3.50)	(7.52)	(-2.88)
Stock price volatility	0.104***	0.026**	-0.990***	0.270***
	(2.94)	(2.22)	(-6.59)	(3.53)
Country/Obs.	70/3220	28/1288	30/1380	50/2300
Adjusted R^2	0.708	0.581	0.722	0.728
F	1.508	2.489	1.418	1.377

Notes: *t* statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

In many respects, the estimations over the 1975-2020 period are similar to those of the full sample. For example, in terms of the GDP/economic growth proxies, these typically impact on CTOT growth with the expected signs in the long-run and short-run for our four disaggregated categories, although there are again a few exceptions (e.g., see the insignificant long-run coefficient for non-energy exporters in Table 7). As previously, emerging market growth (see Table 8) provides the most general and consistent effects of all the GDP/economic growth proxies. Exchange rates effects are also typically as expected (although there is some insignificance in the non-energy exporter categories, particularly in Tables 7 and 9). Notably, results for stock market volatility post-1975 are also similar to full sample results, particularly for the energy groupings. This speaks to the growing association between energy and equity markets since the early 1970s. Turning to the real interest rate, there is a little less consistency than for the full sample – see the insignificant coefficients for energy groups in the long run shown in Table 7 or the negatively signed long run coefficient for energy importers in Table 8.

Moving on, the results above show the important role of emerging market growth (i.e., China, India, and Brazil) for determining commodity prices and CTOT. Much literature (e.g., Roache, 2012 and Lombardi *et al.*, 2012) emphasises China as a main driver of global commodity demand over the last few decades. Thus, we re-estimate the panel ARDL model to assess the impact of China's GDP/growth across the four subsamples.[16] Table 10 reports the results of MG estimator 1975-2020 and the results illustrate the key role of China in driving CTOT with the impacts of GDP/growth typically significant and with signs as expected. However, comparing these findings with the results in Table 8, it could be argued that emerging market index outperforms the influence on China at the margin, given the impact of the latter is not significant for non-energy exporters in the short run. However, this is only a marginal gain and it should be noted that the adjusted R^2s given in both tables are very similar.

[16] We thank an anonymous referee for this suggestion.

Table 10: CTOT growth determinants – China growth (1975-2020)

	(1) Non-Energy Exporters	(2) Non-Energy Importers	(3) Energy Exporters	(4) Energy Importers
China GDP	0.012***	-0.002***	0.051***	-0.013***
	(2.74)	(-3.75)	(7.33)	(-2.84)
Real interest rate	-0.655***	0.088***	-0.530***	0.125***
	(-3.03)	(6.66)	(-8.85)	(2.77)
Exchange rate U.S.	-0.068**	0.013***	-0.301***	0.075***
	(-2.54)	(3.68)	(-7.28)	(2.83)
EC term	-0.306***	-0.257***	-0.205***	-0.188***
	(-14.92)	(-9.58)	(-8.09)	(-23.63)
Δ China GDP	0.008	-0.012***	0.088***	-0.022***
	(1.12)	(-3.18)	(6.82)	(-3.54)
Δ Real interest rate	0.179***	-0.043***	0.242***	-0.056***
	(5.60)	(-6.19)	(8.94)	(-2.94)
Δ Exchange rate U.S.	-0.003	-0.007***	0.236***	-0.059***
	(-0.74)	(-3.36)	(7.46)	(-2.85)
Stock price volatility	-0.061*	-0.007	-1.440***	0.372***
	(-1.91)	(-0.49)	(-7.38)	(3.08)
Country/Obs.	70/3220	28/1288	30/1380	50/2300
Adjusted R^2	0.682	0.596	0.791	0.788
F	1.688	2.359	0.990	1.011

Notes: *t* statistics in parentheses. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

Finally, we note that the employment of lagged dependent variables potentially incurs the "Nickell bias" issue, whereby these coefficients are biased towards zero (Nickell, 1981). Our dataset's time dimension *T* is potentially sufficiently long to make this bias small, however the Dhaene and Jochmans (2015) split-panel jackknife bias correction procedure can check.[17] This method is more effective to deal with small sample bias than recursive mean adjustment (see Chudik and Pesaran, 2015). The MG estimate of the "half-panel" jackknife bias-corrected estimator is:

$$\tilde{\pi}_{MG} = 2\widehat{\pi_{MG}} - \frac{1}{2}\left(\widehat{\pi_{MG}^{a}} + \widehat{\pi_{MG}^{b}}\right) \quad (4)$$

[17] We thank an anonymous referee for this suggestion.

where $\widehat{\pi_{MG}^{a}}$ and $\widehat{\pi_{MG}^{b}}$ are the MG estimate of the first half, i.e. ($t = 1, \ldots, {T_i}/{2}$), and the second half, i.e. ($t = {T_i}/{2}, \ldots, T_i$), of the panel, respectively. As an example, Table 11 re-estimates benchmark Table 3 but with a jackknife approach over the full sample.[18]

Table 11: CTOT growth determinants – Jackknife (1962-2020)

	(1) All	(2) All exporters	(3) All importers
World GDP	0.036***	0.091***	-0.033**
	(2.81)	(4.92)	(-2.35)
Real interest rate	-0.275	-0.670*	0.232***
	(-1.18)	(-1.65)	(3.01)
Exchange rate U.S.	-0.258***	-0.637***	0.228**
	(-2.88)	(-4.96)	(2.36)
EC term	-0.121***	-0.134***	-0.103***
	(-11.29)	(-7.56)	(-12.22)
Δ World GDP	0.180***	0.527***	-0.265***
	(2.73)	(6.07)	(-3.48)
Δ Real interest rate	-0.027	-0.121**	0.093**
	(-0.70)	(-2.07)	(2.14)
Δ Exchange rate U.S.	0.044**	0.137***	-0.075***
	(2.11)	(4.85)	(-2.87)
Stock price volatility	-0.025	-0.175**	0.168***
	(-0.45)	(-2.06)	(3.05)
Country/Obs.	178/9968	100/5600	78/4368
Adjusted R^2	0.516	0.508	0.531
F	2.707	2.729	2.652

Notes*: t* statistics in parentheses. all variables in first lag. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

As in previous tables, a qualitatively similar result emerges. In particular, again GDP/economic growth has a positive (negative) impact for exporters (importers) for both long and short-run coefficients. The interest rate has a negative (positive) impact for exporters (importers) for both the long-run and the short-run. The exchange rate has a negative (positive) impact for exporters

[18] Note the Nickell bias can be particularly problematic when *N* is relatively large, and *T* is relatively small. Of course, in our most disaggregated groups, *N* is smaller.

(importers) for the long-run coefficients and vice-versa for the short-run. Lastly, stock price volatility is negative (positive) for exporters (importers).[19]

6 Conclusion

Whilst previous studies suggest several macro-determinants of commodity prices and extensively estimates their effects across individual commodity prices, the country-level effects have been overlooked. Moreover, the ambiguous effects of commodity determinants across individual commodity prices reported by the extant literature, together with the fact that nations export and import a basket of diverse commodities, causes uncertainty about any country-level effects.

Specifically, we evaluate the impact of macro-determinants on a commodity terms-of-trade index (CTOT) for set of 178 countries (and over different levels of country disaggregation, according to their commodity trade structure) for the period 1962-2020. The CTOT index depicts a country's position in the commodity market and has a strong association with macroeconomic performance and public finance for many countries; including developing countries, given many can be classified as commodity dependent. We estimate, using panel ARDL framework, the effect of commonly used macro-determinants of commodity prices – commodity demand (proxied by global GDP growth), the exchange rate of the U.S. dollar, stock price volatility and real interest rates – on CTOT growth. Furthermore, this paper highlights the role of emerging economies (i.e., China, India and Brazil) growth as drivers of global demand and also provides a number of robustness checks including examining the 1975-2020 sample period and a jackknife estimation approach.

The results show that the determinants typically have an opposing effect on exporters and importers (even when countries are split into non-energy and energy exporters and importers). For example, GDP/economic growth has a positive (negative) impact for exporters (importers) over both the long and short run as would be expected theoretically. Additionally, the exchange rate commonly has a negative (positive) impact for exporters (importers) over the long-run and vice-versa for the short-run, again as might be expected. The real interest rate provides consistent results over the long run with the more mixed results of the extant literature found in the short run or over

[19] In further robustness tests, we also estimate the regression in Table 3 for the 1990-2020 period (see Table B.3. in the online Appendix). In this table, we also employ VIX data for volatility (see columns (4)-(6)) as a comparator for stock price volatility ((see columns (1)-(3)).

shorter sample periods. Stock price volatility is often negative (positive) for energy exporters (importers). Finally, it is worth noting that the demand derived from emerging economies for commodities appears more general and consistent than that from the OECD.

Our findings have clear policy implications. Firstly, it is important for countries (and in particular, commodity dependent countries) to be aware of their current, and forecast their likely future, trading position in the global commodity market. For example, whilst future exporters will benefit from rising global economic growth and the consequent improvement in their CTOT, importers will suffer a counter-cyclical CTOT deterioration. In other words, whilst global growth is usually thought of as a good, the subsequent rising food, energy and metals prices requires careful management at a country level. Secondly, it is important to forecast not just the sign but the magnitude of any net positions. Large net positions suggest a vulnerability to the negative effects of volatile commodity prices including declining investment, lower country economic growth and higher infant mortality. Besides attempting to obtain a more balanced trading position, countries with short-term large, forecasted imbalances may require hedging in financial markets, whilst those with more permanent imbalances may well need to consider heightened social safety nets.

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Appendix

Table A.1. Country list

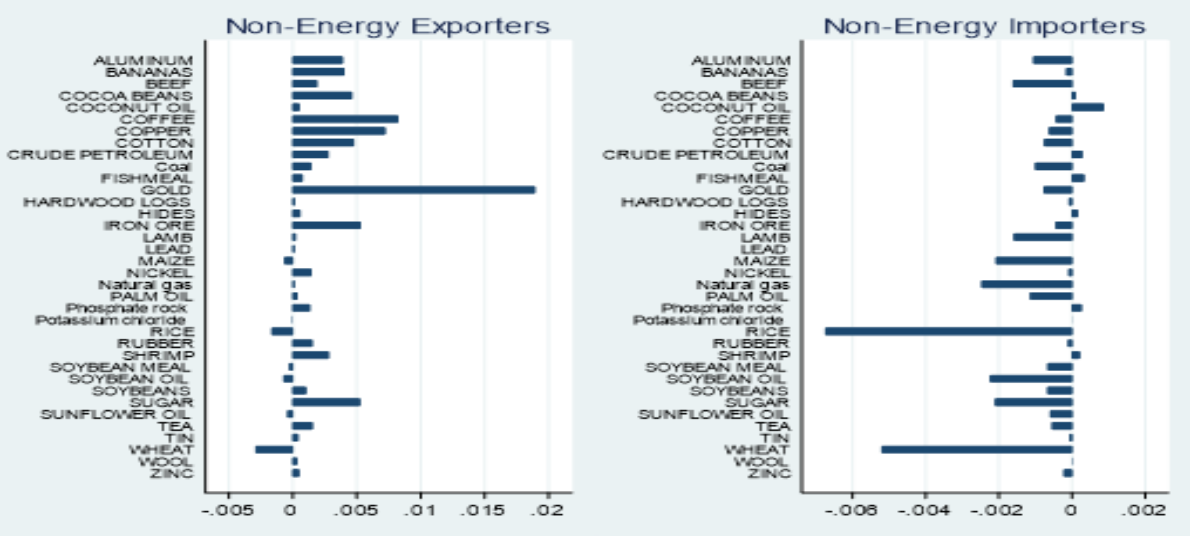
Non-Energy exporters	Non-Energy importers	Energy exporters	Energy importers
70	28	30	50
Argentina	Albania	Algeria	Afghanistan
Australia	Antigua and Barbuda	Angola	Austria
Belize	Bangladesh	Azerbaijan	Bahamas
Benin	Barbados	Bolivia	Bahrain
Brazil	Bhutan	Brunei Darussalam	Armenia
Burkina Faso	Botswana	Colombia	Belgium
Burundi	Cabo Verde	Congo	Bosnia Herzegovina
Cote D'Ivoire	China	Ecuador	Bulgaria
Cambodia	Comoros	Gabon	Belarus
Cameroon	Cyprus	Indonesia	Croatia
Canada	Eritrea	Iran	Czechia
Central African Rep.	Djibouti	Iraq	Denmark
Chad	Gambia	Kazakhstan	Dominican Rep.
Chile	Kiribati	Kuwait	Estonia
Costa Rica	China, Hong Kong SAR	Libya	Finland
Dem. Rep. of the Congo	Lebanon	Mexico	France
Dominica	Lesotho	Oman	Georgia
El Salvador	Maldives	Nigeria	Germany
Eswatini	Malta	Norway	Greece
Ethiopia	Nepal	Qatar	Hungary
Fiji	Timor-Leste	Russia	Israel
Ghana	Seychelles	Saudi Arabia	Italy
Grenada	Switzerland	Viet Nam	Jamaica
Guatemala	Tonga	Sudan	Japan
Guinea	Tunisia	Syria	Jordan
Guinea-Bissau	Egypt	Trinidad and Tobago	Korea
Guyana	United Kingdom	United Arab Emirates	Latvia
Haiti	Samoa	Turkmenistan	Lithuania
Honduras		Venezuela	Rep. of Moldova
Iceland		Yemen	Morocco
Ireland			Netherlands
Kenya			Pakistan
Kyrgyzstan			Philippines
Lao People's Dem. Rep.			Poland

Luxembourg	Portugal
Madagascar	Romania
Malawi	Saint Vincent and the Grenadines
Malaysia	Senegal
Mali	Serbia
Mauritania	India
Mauritius	Singapore
Mongolia	Slovakia
Montenegro	Slovenia
Mozambique	Spain
Myanmar	Sweden
Namibia	Thailand
New Zealand	Turkey
Nicaragua	Ukraine
Niger	North Macedonia
Panama	USA
Papua New Guinea	
Paraguay	
Peru	
Rwanda	
Saint Lucia	
Sao Tome and Principe	
Sierra Leone	
Solomon Isds	
South Africa	
Sri Lanka	
Suriname	
Tajikistan	
Togo	
Uganda	
United Rep. of Tanzania	
Uruguay	
Uzbekistan	
Vanuatu	
Zambia	
Zimbabwe	

Online Appendix A: Data description.

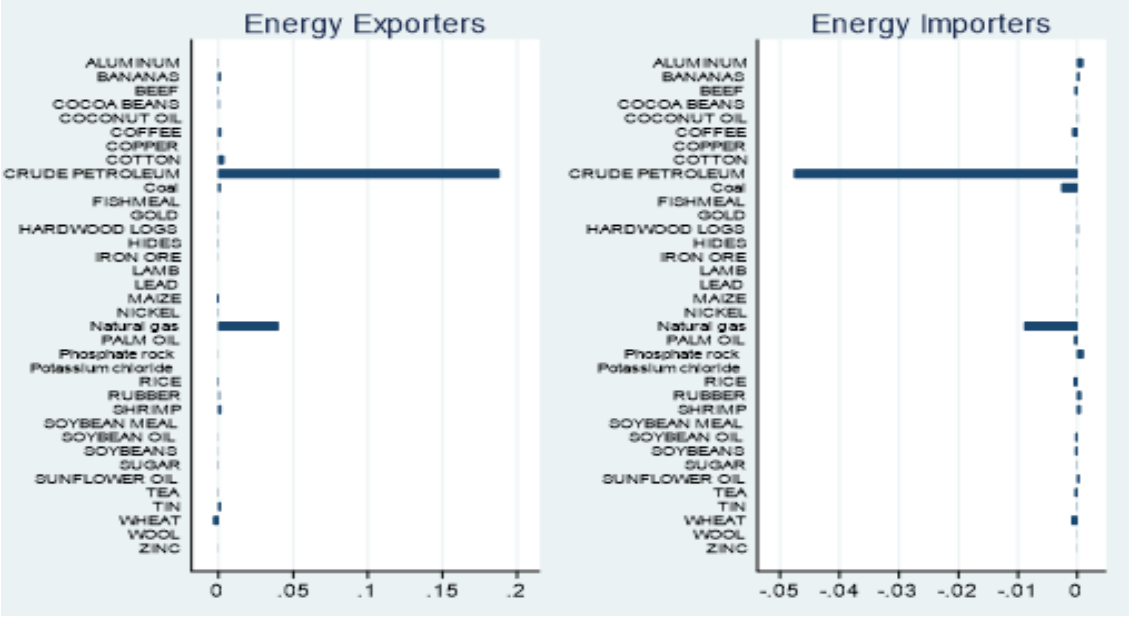
This appendix contains additional details on the sample used in the paper. The figures below show, for each of the four sub-groups, the net export structure of 36 commodity basket which used to construct CTOT index.

Figure A.1. Net export composition of non-energy exporters and importers.



Notes: Each bar represents the average (across subsample and years) of each commodity net export as a percentage to GDP, hence positive (negative) values indicate net imports (net exports).

Figure A.2.Net export composition of energy exporters and importers.



Notes: Each bar represents the average (across subsample and years) of each commodity net export as a percentage to GDP, hence positive (negative) values indicate net imports (net exports).

Online Appendix B. Auxiliary results.

Table B.1: Stock price volatility correlation with commodities' relative prices - Positively correlated commodities in bold

Commodity	Correlation	Mean	Std. Dev.
Aluminium	-0.327	-0.038	0.197
Bananas	-0.019	0.051	0.251
Beef	-0.567	0.176	0.280
Coal	-0.038	0.018	0.375
Coca Beans	-0.283	0.309	0.432
Coconut Oil	-0.413	0.274	0.393
Coffee	-0.541	0.274	0.444
Copper	-0.145	-0.066	0.460
Cotton	-0.601	0.468	0.324
Crude Petroleum	**0.337**	-0.728	0.767
Fishmeal	-0.449	0.314	0.416
Gold	**0.354**	-0.021	0.683
Hardwood	**0.374**	-0.031	0.250
Hides	**0.033**	0.046	0.275
Iron Ore	-0.066	0.045	0.753
Lamb	-0.089	-0.208	0.186
Lead	-0.151	0.016	0.461
Maize	-0.468	0.480	0.318
Natural Gas	**0.285**	-0.504	0.557
Nickel	**0.232**	-0.425	0.377
Palm Oil	-0.366	0.430	0.374
Phosphate rock	**0.139**	0.274	0.481
Potassium chloride	**0.369**	-0.072	0.400
Rice	-0.388	0.318	0.381
Rubber	-0.316	0.025	0.355
Shrimp	-0.114	0.218	0.212
Soybeans	-0.472	0.384	0.301
Soybeans Meal	-0.399	0.331	0.269
Soybeans Oil	-0.336	0.316	0.294
Sugar	-0.181	0.184	0.220
Sunflower Oil	-0.222	-0.316	0.307
Tea	-0.193	0.171	0.318

Tin	-0.310	0.197	0.448
Wheat	-0.419	0.286	0.279
Wool	-0.277	0.172	0.296
Zinc	**0.067**	-0.005	0.338

Notes: Commodity prices are relative to MUV. The last two columns show some summary statistics, mean and standard deviation, for each commodity price.

Table B.2: CTOT growth determinants - All exporters and importers (1962-2020), using NYMEX 'Henry Hub' prices.

	(1) All	(2) All exporters	(3) All importers
World GDP	0.018***	0.048***	-0.021***
	(2.88)	(5.92)	(-2.82)
Real interest rate	-0.285***	-0.579***	0.091**
	(-4.03)	(-5.08)	(2.25)
Exchange rate U.S.	-0.116***	-0.318***	0.144***
	(-2.75)	(-5.67)	(2.86)
EC term	-0.208***	-0.224***	-0.187***
	(-22.32)	(-15.20)	(-20.05)
Δ World GDP	0.087***	0.239***	-0.107***
	(3.03)	(5.98)	(-3.64)
Δ Real interest rate	0.002	-0.050	0.070**
	(0.08)	(-1.03)	(2.58)
Δ Exchange rate U.S.	0.027**	0.084***	-0.046***
	(2.10)	(4.67)	(-3.06)
Stock price volatility	-0.110	-0.346***	0.193**
	(-1.60)	(-3.47)	(2.41)
Country/Obs.	178/9968	100/5600	78/4368
Adjusted R^2	0.750	0.744	0.760
F	1.639	1.678	1.549

Notes: t statistics in parentheses. all variables in first lag. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.

Table B.3: CTOT growth determinants - All exporters and importers (1990-2020)

	(1) All	(2) All exporters	(3) All importers	(4) All	(5) All exporters	(6) All importers
World GDP	0.003	0.027*	-0.027***	0.009**	0.029***	-0.016***
	(0.35)	(1.65)	(-4.12)	(2.40)	(5.31)	(-3.94)
Real interest rate	-1.744***	-3.279***	0.225**	-1.170***	-2.677***	0.761***
	(-2.82)	(-3.05)	(2.07)	(-4.51)	(-7.59)	(3.05)
Exchange rate U.S.	-0.051	-0.248**	0.202***	-0.083**	-0.249***	0.129***
	(-0.69)	(-2.05)	(3.92)	(-2.54)	(-5.46)	(3.73)
EC term	-0.214***	-0.237***	-0.185***	-0.267***	-0.284***	-0.247***
	(-15.30)	(-11.83)	(-9.93)	(-19.48)	(-14.87)	(-12.67)
Δ World GDP	0.268**	0.758***	-0.360***	0.296***	0.840***	-0.401***
	(2.58)	(5.53)	(-2.80)	(2.63)	(5.67)	(-2.89)
Δ Real interest rate	-0.068	-0.366***	0.314***	0.082	0.045	0.131**
	(-0.79)	(-2.99)	(3.06)	(1.62)	(0.56)	(2.38)
Δ Exchange rate U.S.	0.003	0.012**	-0.007***	0.002	0.014**	-0.012***
	(1.07)	(2.27)	(-3.89)	(0.61)	(2.28)	(-4.56)
Stock price volatility	0.151***	0.165***	0.132***			
	(4.16)	(2.67)	(5.39)			
VIXCLS				0.458***	1.110***	-0.379***
				(4.53)	(8.89)	(-3.48)
Observations	178/5518	100/3100	78/2418	178/5518	100/3100	78/2418
Adjusted R^2	0.351	0.355	0.336	0.326	0.328	0.317
F	2.670	2.624	2.783	2.868	2.836	2.949

Notes: t statistics in parentheses. all variables in first lag. * p<0.10, ** p<0.05, *** p<0.01. Estimated volatility coefficients are multiplied by 1000.