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By *Yousef Makhlouf, Neil M. Kellard, and Dmitri Vinogradov*

Abstract: A growing literature demonstrates the impact of commodity terms-of-trade (CTOT) on GDP growth, child mortality rates, public debt and exchange rates in developing countries. Despite its importance, little is known about the determinants of CTOT. In this paper, using data from 72 countries (grouped according to their commodity export-import structure) and covering the period from 1962 to 2010, we examine the effect of global economic activity, OECD and emerging markets growth, the real exchange rate of the U.S. dollar, stock price volatility and real interest rates on CTOT growth. Amongst other findings, we demonstrate the asymmetric effect of macro-determinants on exporters and importers, suggest the existence of a flight-to-safety effect and show that economies dominated by petroleum are better modelled by our chosen explanatory variables than their non-petroleum counterparts. Moreover, whilst measures of global growth of have little effect on non-petroleum focused exporters, emerging markets growth is positively related. Indeed, emerging markets growth is the only variable to universally and consistently affect all our country subgroups, underscoring the contemporary importance of developing country economies.

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What moves commodity terms-of-trade? Evidence from 72 countries

Yousef Makhlouf [§], Neil M. Kellard[†*] and Dmitri Vinogradov[**]

[§]College of Business Law and Social Sciences, Nottingham Trent University, UK.

[*] Essex Business School and Essex Finance Centre, University of Essex, UK.

[**] Adam Smith Business School, University of Glasgow, UK.

ABSTRACT

A growing literature demonstrates the impact of commodity terms-of-trade (CTOT) on GDP growth, child mortality rates, public debt and exchange rates in developing countries. Despite its importance, little is known about the determinants of CTOT. In this paper, using data from 72 countries (grouped according to their commodity export-import structure) and covering the period from 1962 to 2010, we examine the effect of global economic activity, OECD and emerging markets growth, the real exchange rate of the U.S. dollar, stock price volatility and real interest rates on CTOT growth. Amongst other findings, we demonstrate the asymmetric effect of macro-determinants on exporters and importers, suggest the existence of a flight-to-safety effect and show that economies dominated by petroleum are better modelled by our chosen explanatory variables than their non-petroleum counterparts. Moreover, whilst measures of global growth of have little effect on non-petroleum focused exporters, emerging markets growth is positively related. Indeed, emerging markets growth is the only variable to universally and consistently affect all our country subgroups, underscoring the contemporary importance of developing country economies.

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

JEL classification: O13, Q02, F62.

[†] Corresponding author: Essex Business School, University of Essex, Colchester, Essex, CO4 3SQ, UK. Email: nkellard@essex.ac.uk

1 Introduction

Fluctuations in commodity prices lead to serious economic challenges for developing countries, 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 and Cavalcanti *et al*., 2015), child mortality (Makhlouf *et al*., 2017) and real exchange rates (Ricci *et al*., 2013; Aizenman *et al*., 2012 and Coudert *et al*., 2015). 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.

[Insert Figure 1 about here]

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 real 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.*, Frankel and Rose, 2010). However, Frankel (2006) finds that the effect of the real

[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.

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 exhibit 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 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.

[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 last commodity price boom.

The exchange rate of the U.S. dollar is typically expected to negatively affect commodity prices. 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). The majority of commodities indeed show a significant negative price response to the 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, *e.g*., coffee and cocoa exhibit an insignificant positive response, see Lombardi *et al.*, 2012).

Last but not 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 using 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 conversely, high stock volatility are associated with flights to quality (*e.g.*, from oil to bonds).

In sum, although there exists a set of commonly used macro-determinants of commodity prices, their effects may be rather inconsistent across 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 groups of countries with diversified and non-diversified trade baskets.

To address the above issues, we examine within a panel framework, the impact of the most commonly used determinants of commodity prices on CTOT growth. We split our sample into four groups of countries based on their commodity trade composition – net petroleum exporters (19 countries), net petroleum importers (17 countries), net non-petroleum commodity exporters (18 countries) and net non-petroleum commodity importers (18 countries).[5] The newly extended sample covers the period 1962 to 2010 and in later sections, we also address any endogeneity and multicollinearity issues. The determinants under consideration are those discussed above: global commodity demand (proxied by world GDP growth), the real interest rate, stock price volatility and the real effective exchange rate of the U.S. dollar. We also explore the role of GDP growth of both OECD and major emerging economies (*i.e.*, China, India and Brazil) as alternative proxies of demand.

The empirical results reveal opposing effects of determinants on net importers and exporters: for example, typically world GDP growth increases the CTOT growth of exporters and reduces that of importers, whilst a rise in the real interest rate lowers the CTOT growth of

[4] Some studies explore the effect of macro-determinants on commodity price indices such as the Dow Jones AIG Commodity (now the Bloomberg Commodity) Index, the Commodity Research Bureau (CRB) Index and Moody's Index (Frankel, 2006) and an aggregate non-fuel primary commodity price index (Swaray, 2008). Although this might be useful in circumventing the inconsistency effects mentioned above, it does not assess the national effect of these determinants since these indexes are global rather than national.

[5] The non-petroleum 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.

exporters and raises that of importers. Additionally, economies dominated by petroleum are better modelled by our explanatory variables than their non-petroleum counterparts. This can be explained by non-petroleum countries trading a more heterogeneous basket of commodities; commodities that the extant literature suggests have an inconsistent reaction to movements in any particular determinant. Both these findings suggest that developing countries will need to carefully monitor their *specific* current and likely future trading positions to appropriately model and forecast CTOT.

Our results also show that increasing stock market volatility, providing a proxy for rising uncertainty, increases CTOT growth for exporter countries whilst decreasing CTOT growth for importers. This reflects the positive association stock market volatility appears to have with some individual commodity prices (*i.e.*, gold and petroleum) and suggests that countries' terms-of-trade may be a recipient of a *flight-to-safety* effect that begins in financial markets. This effect only appears absent for non-petroleum exporters, a category in which World GDP growth is also insignificant. To explore further, we ran separate panel regressions using either OECD or emerging markets growth as a replacement for the World variable. Strikingly, for non-petroleum exporters, CTOT growth is improved by economic growth in emerging economies but impaired by analogous growth in industrialized nations.

Finally, the growth of emerging economies is the only determinant that has a universal effect in the sense that it significantly and consistently impacts all four country groups. Given that CTOT is closely related to economic growth, child mortality, public finances and development, our results shed new light on the linkages between macro-factors and developing country economic performance. In particular, the growth of three countries, China, Brazil and

India, would appear particularly 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 and section 4 outlines the methodology employed to estimate the effects of CTOT determinants. The empirical results and robustness tests are presented and interpreted in section 5 whilst section 6 concludes.

2 Commodity terms of trade

The commodity terms-of-trade (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.* (2008) (published as Ricci *et al.*, 2013) and Spatafora and Tytell (2009). Ricci *et al.* (2013) construct their CTOT index based on the prices of six commodity categories (*i.e.*, 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 a country's trade structure; therefore, we follow Spatafora and Tytell (2009) and construct a CTOT index using prices of 32 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 equation (1) highlights 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 CTOT are only due to changes in global commodity prices. This is a convenient property as it implies that changes in CTOT are explained by drivers of global commodity prices, which themselves are global rather than country-specific. This underlies the 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 countries' resource revenue (*i.e.*, the 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[6], therefore should be driven by the same factors as changes in CTOT. This resource revenue is an important source of public finance for commodity-dependent nations, which explains the association between the level of CTOT and public debt in non-petroleum dependent countries depicted in Figure 1. Figure 2 presents the same association for petroleum exporters and importers.

[Insert Figure 2 about here]

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

For petroleum exporters, the oil price shock in 1973 leads to two essential clusters, before and after 1973. Pre-1973 suggests a weakly positive association, whilst post-1973, reveals a strongly negative association between CTOT and public debt. For petroleum importers, the association is weakly positive; this is not surprising as the majority of petroleum importers are developed countries and could perhaps be categorized as reasonably 'commodity-independent' nations (see Appendix A for the list of countries).

The critical role of commodity trade composition is elucidated in several papers that examine the influence of commodity prices on economic performance, demonstrating that this impact 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 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 (importers), reflecting the relative weight of oil in the economy[7]. 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. Bodart *et al.* (2012) report a strong long-run relationship between the price of commodity which has a large share (greater than 20 percent) of a country's export and the real exchange rate. Our paper, which models a CTOT-type index, allows us to nest the explanatory variables considered in the above studies.

In this vein, significant movements in CTOT imply challenges for economies as they signify a change in national commodity revenue in response to global commodity price

[7] 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 a 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).

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) the economic growth of 62 commodity exporting countries over the period 1970-2005. Makhlouf *et al*. (2017) establish that CTOT volatility increases child mortality in highly commodity-dependent importers, whereas 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 the public finances and the overall economic performance of commodity dependent countries.

3 Data

We use a sample of 72 countries over a newly extended period[8] of 1962-2010 to assess the country-level effect of commodity price determinants. The commodities we consider are the same 32 commodities as used in Spatafora and Tytell (2009). 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 trade structures. 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

[8] Spatafora and Tytell (2009) employed a sample period of 1970 to 2007.

observations in each sub-sample is large enough. We define exporters (importers) as countries with positive (negative) net exports of our included commodities.

To identify countries with a non-diversified commodity trade structure, we first condition on a commodity that has the largest share both in exports and imports, in the largest number of countries in our sample. Unsurprisingly, petroleum is the dominant commodity in about half of the countries in our study, and the only one that prevails both in exports and imports (see Appendix A). A petroleum exporter is defined as a country for which petroleum constitutes over 50 percent of the net commodity basket export (similarly for petroleum importers); otherwise the country is classified as non-petroleum exporter or importer. We end up with four balanced sub-samples: petroleum exporters (19 countries), petroleum importers (17 countries), non-petroleum exporters (18 countries) and non-petroleum importers (18 countries) (see Appendix A for the full list). The number of net petroleum exporters and importers in the world is limited, therefore a further increase in the total sample size would rather increase the samples of non-petroleum exporters and importers, hence reduce the relative size of the petroleum sub-groups.

Non-petroleum exporters and importers have a more diversified trade structure then the exporters and importers of petroleum. More specifically, non-petroleum exporters (see Figure A.1 in Appendix A) depend mainly on coffee, gold, cocoa beans and cotton. Rice is the key commodity for non-petroleum importers in our sample; its import being three to four times higher than the import of other prominent commodities like sugar, wheat, petroleum and so on. This still provides a higher diversification of the commodity basket than the one achieved by petroleum exporters and importers (see Figure A.2 in Appendix A), for which the volume of petroleum trade is at least twenty times higher than that of other commodities.

The prices of the 32 commodities are taken from the IMF *Commodity Price System* database. The MUV deflator is the historical price index of manufactures from Harvey *et al.* (2010)[9]. The exports and imports of our 32 commodities are obtained from the United Nations' COMTRADE database and are available from 1962. Therefore, the weights are averaged and CTOT in (1) is constructed for 1962-2010. The sources of our explanatory variables are as follows: (i) real GDP of the World, OECD and emerging economies (*i.e.*, 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 the Bank of International Settlements and World Data Bank – Global Financial Development datasets respectively.

[Insert Table 1 about here]

Table 1 provides some summary statistics for CTOT growth across the sub-samples. On average, petroleum exporters display higher CTOT growth than any other sub-groups, 0.561 percent per annum. Additionally, exporters and importers of the same commodity category show opposite growth signs; whilst non-petroleum exporters (importers) have negative (positive) growth, petroleum exporters (importers) have positive (negative) growth. On the other hand, petroleum exporters exhibit the highest volatility of CTOT growth across all sub-groups, 6.56 percent. Although the group of non-petroleum exporters has a more diversified trade structure as compared to both non-petroleum and petroleum importers, their CTOT exhibits higher volatility. A potential explanation of this is the high price volatility of coffee, the main commodity in the

[9] This deflator is based on 22 industrialized countries whilst World Bank MUV is based only on 15 countries.

trade structure of non-petroleum exporters. Indeed, coffee presents one of the highest volatilities among the 32 commodities basket[10].

[Insert Figures 3 and 4 about here]

Figures 3 and 4 present the CTOT for all countries in each sub-group. CTOTs of non-petroleum sub-groups exhibit relatively little correlation, since the sample selection focused on countries with a variety of commodities in their trade basket. In contrast, petroleum sub-groups demonstrate a relatively high co-movement of CTOT because of the single dominating commodity. Clearly, the common factor of the changes in petroleum sub-group CTOT is the price of petroleum relative to MUV, shown in Figure 5.

[Insert Figure 5 about here]

This supports the finding of Backus and Crucini (2000) that the terms of trade fluctuations for advanced economies (*i.e.*, the petroleum importers in our sample) are predominantly driven by oil price shocks.

4 Methodology

Given that CTOT is constructed annually over the period 1962-2010, estimating the determinants of CTOT growth individually for each country would lead to imprecise results due to a limited number of observations. Therefore, we use panel techniques applied to sub-groups identified in the previous section to estimate the determinants of CTOT growth. At the preliminary stage, we test for a unit root in the logarithm of both CTOT and possible determinants[11]; whilst the Levin-

[10] Only iron and fishmeal are more volatile than coffee (see Table B.2 in Appendix B).

[11] Except for the interest rate and volatility where we do not take logarithms; small net interest rates are approximately equal to a logarithm of equivalent gross rates, whilst taking the logarithm of volatility would smooth the spikes.

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 (see Table 2a), the results illustrating that all sub-group CTOTs and determinants typically exhibit unit root behavior, except stock price volatility.

[Insert Tables 2a and 2b about here]

Given the non-stationarity of our variables, we investigate using the Westerlund (2007) test, panel cointegration between CTOT and suggested determinants. Table 3 presents the four relevant test statistics with a null of no cointegration.

[Insert Table 3 about here]

Whilst Gt and Ga statistics are group-means which test against the alternative hypothesis that for at least one cross-sectional unit there is evidence of cointegration, the second pair of statistics, Pt and Pa, are pooled tests with the alternative hypothesis that the whole panel is cointegrated. Clearly, we fail to reject the null of no cointegration between CTOT and the determinants for the whole sample, as well as the four sub-groups. This test allows for a constant and deterministic trend in the cointegration relationship; however, the results without trend (see Table B.1 in Appendix B) support these findings.

As we find no evidence of cointegration, we proceed without the inclusion of an error-correction term. Specifically, we first use the first differences of CTOT and determinants to estimate a *lagged* model, where we use the first lag of the regressors as follows:

$$\Delta CTOT_{i,t} = \Delta X_{t-1}\,\beta + \Delta\varepsilon_{i,t} \qquad (3)$$

where $\Delta CTOT_{i,t}$ is the first difference of (log) CTOT for country i in year t, X_t is a set of explanatory variables including global demand proxied either by World, OECD or emerging economies (*i.e.*, a combination of China, India and Brazil) GDP growth, the real effective

exchange rate of the U.S. dollar, the real interest rate of the U.S. and stock price volatility (all in log first differences except volatility and the real interest rate[12]). A few points need to be noted here. To begin, the first lag of the explanatory variables is used to assess any delayed effect, particularly as commodity prices have been viewed as sticky, taking some time to respond to changes in possible determinants (see Cashin *et al*., 2004). Secondly, the coefficients of (3) are estimated via a panel least-squares model with cluster-robust standard errors at the country level to control for any potential autocorrelation and/or heteroskedasticity. Thirdly, endogeneity issues are likely minor given the dependent variable can be viewed as a local measure of developing country commodity terms-of-trade, whilst our explanatory variables represent global macro-factors (see also Ricci *et al*., 2013); additionally, using lagged explanatory variables is also likely to mitigate any issues in this regard. Finally, during the later empirical analysis, multicollinearity is assessed using VIF type tests[13] and shown not to be problematic.

Although 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 respond in an inverse manner. Given the mixed views about the commodity prices/uncertainty relation, it is not trivial to anticipate the effects of stock market volatility on CTOT. However, Figure B.1 suggests

[12] Similarly to Pindyck and Rotemberg (1990), we use the level of interest rates rather than its first difference since the level of interest rates is a good predictor of future inflation. Although the earlier unit root test reports that the real interest rate is non-stationary, this could be due to structural breaks. Indeed, a unit root test with two structural breaks shows that the real interest rate is stationary where the coefficient of Clemente-Montañez-Reyes test is statistically significant at the 5 percent level.

[13] Results available on request from the authors.

a positive association between relative petroleum prices and stock price volatility index (see Appendix B). Therefore, one might expect a positive (negative) relationship between CTOT growth of petroleum exporters (importers) and global stock price volatility. With regards to non-petroleum countries, it is even more difficult to anticipate the effects of stock market volatility due to the reasonably well-diversified trading basket of this sub-group.

5 Empirical results

5.1 Panel model estimation

Table 4 contains the results of estimating (3), for the whole sample and two sub-groups, exporters and importers, over the period 1962-2010.

[Insert Table 4 about here]

Column 1 shows a positive effect for world GDP growth and stock price volatility, coupled with a negative effect for the real interest rate and real effective exchange rate of U.S. dollar, on CTOT growth for the whole sample. Given the whole sample amalgamates both commodity exporters and importers, and the determinants of CTOT growth are typically expected to have opposing effects on these two categories, we re-estimate the lagged model separately for the sub-groups (*i.e.*, see columns 2 and 3 of Table 4). The results for the world GDP growth variable are consistent with theories suggesting its positive effect on commodity prices, with the estimated coefficients indicating that global growth improves (deteriorates) CTOT growth for commodity exporters (importers). On the other hand, the coefficients for the real interest rate and real effective exchange rate of U.S. dollar support the hypothesized negative effect of these variables

on commodity prices, with increases in both variables decreasing (increasing) CTOT growth[14] for commodity exporters (importers). Finally, rising uncertainty proxied by stock market volatility, boosts (lessens) CTOT growth for exporters (importers), reflecting the positive impact of this variable on commodity global prices and suggesting countries' terms-of-trade may be a recipient of a *flight-to-safety* effect that begins in financial markets.

As noted in section 3, petroleum is the dominant commodity in our dataset and therefore we further divide the exporter and importer sub-samples into non-petroleum and petroleum categories. Table 5 shows the results for the estimation of the lagged model across the four new groupings.

[Insert Table 5 about here]

Importantly, Table 5 illustrates that whilst each macro-determinant exhibits an asymmetric and significant impact[15] across petroleum exporters and importers (see columns 3 and 4), their impact in the non-petroleum category is less consistent. For example, although World GDP growth presents a negative and significant coefficient for non-petroleum importers (column 2), the analogous coefficient for exporters (column 1) is insignificant. Of course, by design the non-petroleum category is more heterogeneous with respect to the mix of commodities across countries and therefore, it is likely the inconsistency arises from the differing effect of these determinants across individual commodity prices. Clearly, developing countries will need to be aware of their *specific* current and future trading positions to appropriately model and forecast commodity terms-of-trade.

[14] Although, unlike the other coefficients in Table 4, it should be noted that the positively-signed coefficient for the real interest rate in column 3, is not significant.

[15] The strong association of the real interest rate and CTOT growth in petroleum dominated countries provides a counterpoint to Frankel (2006), who suggests the effect of the real interest rate on the oil price is the weakest among 23 individual commodities.

In particular, non-petroleum exporters appear to be immune (see column 1 of Table 5) to the effect of movements in most of the chosen macro-determinants, with only the real interest rate providing a significant coefficient. As reported in section 3, the group of non-petroleum exporters has a more diversified trade structure than the other groupings, with individual country CTOTs exhibiting relatively little correlation. This relative lack of commonality at a country level suggests a partial explanation for the insignificance of macro-determinants at a group level. However, it may appear anomalous that economic growth has no or limited effect on the CTOT growth of non-petroleum exporters and *a priori* this may be because our measure of World growth conflates different sources of demand. To examine separately the role of emerging economies and industrial countries as a driving force of commodity demand, we again re-estimate model (3), replacing our measure of World GDP growth using two global demand proxies.

[Insert Table 6 about here]

Table 6 reports that the impact of OECD growth is statistically significant for all sub-groups and as expected, positive for exporters and negative for importers, except for non-petroleum exporters (see column 5) where the impact is negative and significant. Note that imports of petroleum have a prominent weight in trade structure of non-petroleum exporters (see Figure A.1 in Appendix A) and it is possible that these are partially driving the negative sign.

On the other hand, the emerging economies' growth, interestingly, exhibits a statistically significant effect on all sub-groups; positive on all exporters and negative on all importers. In particular, growth now presents a positive coefficient for non-petroleum exporters (see column 1 of Table 6) and this new asymmetry (*i.e.*, that for non-petroleum exporters emerging market growth produces a positive effect, whilst the effect of OECD growth is negatively signed)

explains why when World GDP Growth is employed in Table 5, this combined effect results in an insignificant coefficient. It also suggests for developing countries that primarily export commodities other than oil, their CTOT position (and its associated positive effect on individual country growth; see Spatafora and Tytell, 2009) is improved by economic growth in emerging economies but impaired by analogous growth in industrialized nations. The economic growth of industrialized countries disproportionately increasing the price of petroleum relative to other commodities, whilst emerging market growth has a far more even influence on the commodity sector.

5.2 Robustness

In the preceding analysis, we use cluster-robust standard errors to control for autocorrelation. An alternative approach is to include the first lag of the dependent variable, $\Delta CTOT_{i,t-1}$. However, the error term, $\Delta\varepsilon_{it}$, is correlated with $\Delta CTOT_{i,t-1}$, as both are associated with ε_{it-1}. To cope with this issue, we follow Anderson and Hsiao (1981) by instrumenting $\Delta CTOT_{i,t-1}$ with $\Delta CTOT_{i,t-2}$. $\Delta CTOT_{i,t-2}$ is a valid instrument because it is correlated with $\Delta CTOT_{i,t-1}$ (as both depend on $CTOT_{i,t-2}$) and uncorrelated with $\Delta\varepsilon_{i,t}$. Altering equation (3) in this manner, leads to (4) as follows:

$$\Delta CTOT_{i,t} = \Delta X_{t-1}\,\beta + \Delta CTOT_{i,t-2}\gamma + \Delta\varepsilon_{i,t} \qquad (4)$$

We estimate this model using a panel least-squares model with cluster-robust standard errors[16]. In particular, Tables 7, 8 and 9 are the instrumented analogs of Tables 4, 5 and 6 respectively.

[Insert Tables 7, 8 and 9 about here]

[16] We also estimated (4) using only robust rather than cluster-robust standard errors. Typically these findings support those found in Tables 4, 5 and 6, although the interest rate becomes insignificant for petroleum countries when world or emerging market growth is employed as a proxy of global demand. Moreover, stock market volatility becomes insignificant in the emerging market growth case. Results are available on request from the authors.

Overwhelmingly[17], the findings from Tables 7, 8 and 9 support those found in the previous section. In particular, the asymmetric effects of macro-determinants on exporter and importer CTOT, the positive association between stock market volatility and commodity prices, the stronger relationship between petroleum sub-groups and macro-determinants vis-á-vis the non-petroleum grouping and the negative effect of industrialized country growth on the CTOT of non-petroleum exporters (whilst emerging markets growth provides a positive effect), are all maintained.

6 Conclusion

Whilst previous studies suggest several determinants of commodity prices and extensively estimate their effect on individual prices, the country-level effect of these determinants has been overlooked. Indeed, the inconsistent effect of these determinants reported by some studies, together with the fact that nations export and import diverse baskets of commodities, *a priori* creates a clear lacuna at the country-level.

We evaluate the impact of several macro-determinants on a commodity terms-of-trade index (CTOT) for set of 72 countries (classified into four groups according to their commodity trade structure: *i.e.*, petroleum and non-petroleum exporters and importers) and over a newly extended sample period of 1962-2010. This index depicts a country's position in the commodity market and has a strong association with macroeconomic performance, public finance and health issues, given many developing countries are commodity-dependent. The effect on CTOT growth of the following determinants – commodity demand (proxied either by global GDP growth,

[17] Only minor differences are obtained. To be specific, in Table 7 (as compared with Table 4), the real interest rate is now significant for importers; in Table 8 (as compared with Table 5), world GDP growth is significant for non-petroleum exporters; and, in Table 9, stock market volatility becomes insignificant in the emerging market growth case for non-petroleum importers.

OECD growth or emerging market growth), the U.S. dollar real exchange rate, real interest rates and stock price volatility – is estimated using a panel framework with cluster-robust standard errors.

The empirical results provide several findings. Firstly, it is shown that macro-determinants typically have an opposing effect on exporters and importers. For example, rising real interest rates lower the CTOT growth of exporters whilst raising that of importers. Secondly, increasing uncertainty, as proxied by equity market volatility, is linked with increasing CTOT growth for exporters and therefore suggestive of a flight-to-safety phenomenon as investors move from stocks to commodities during volatile regimes.

Thirdly, it is shown that macro-determinants are better at explaining the movements in the CTOT of countries where the trade basket is dominated by petroleum as compared with those with a non-petroleum focus. This arises because non-petroleum orientated countries are shown to have more diverse trade baskets and therefore the inconsistent effects of determinants on several individual but important commodity prices provides more ambiguity about the overall country-level effect.

Fourthly, we found the initially puzzling result that global GDP growth presented an insignificant effect on the CTOT growth of non-petroleum exporters. To investigate further we employed different proxies for demand, revealing the striking result that whilst emerging markets growth had the expected positive effect, the economic growth of industrialized nations actually diminishes CTOT growth in this grouping. Fifthly, and as an extension of the last point, we note that the growth of emerging economies is the only universal determinant given it has significant, consistently signed effects on all sub-groups. This emphasizes the significant role of

emerging economies in supporting demand for, and hence increasing the prices of, a broad range of primary commodities.

Our findings have clear policy implications. For example, it is important for developing 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 typically benefit from rising economic growth and the consequent improvement in their CTOT, importers will suffer a counter-cyclical CTOT deterioration. In other words, whilst such growth is usually thought of as a good, the subsequent rising food, energy and metals prices needs to be managed at a country policy level.

In particular, 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 trying to achieve 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.

Finally, given the importance of China, Brazil and India shown in this paper, national and international coordination to maintain and enhance their growth clearly has global implications. Initiatives like the New Development Bank, designed to direct resources towards sustainable development and infrastructure projects in BRICS and other emerging economies are likely to become increasingly important.

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Tables

Table 1. CTOT growth statistics (1962-2010)

	Obs.	Mean	S.D.	Min	Max
Non-petroleum exporters	864	-0.080	1.696	-7.205	8.943
Non-petroleum importers	864	0.037	0.693	-4.558	3.149
Petroleum exporters	912	0.561	6.560	-30.155	40.478
Petroleum importers	816	-0.049	0.693	-4.091	3.758
Full sample	3456	0.126	3.517	-30.155	40.478

Table 2a. ADF and PP tests

	Augmented Dickey- Fuller		Philips-Perron	
	Level	1^{st} *Diff*	*Level*	1^{st} *Diff*
		Intercepts & trends		
World GDP	-3.400*	-3.625**	-3.079	-5.014***
OECD GDP	-2.124	-3.948***	-1.863	-5.111***
Emerging GDP	-1.245	-3.698***	-0.553	-4.297***
Real interest rate	-1.908	-4.552***	-1.976	-4.686***
Real exchange rate	-3.170	-3.388*	-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-petroleum exporters	-0.016	-8.494***
Non-petroleum importers	-2.323**	-12.991***
Petroleum exporters	0.832	-27.495***
Petroleum importers	1.098	-25.252***

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

Table 3. Westerlund panel cointegration test

Panel	Gt	Ga	Pt	Pa	p*
Whole sample	-1.664	-3.086	-16.738	-2.229	3.17
	(11.229)	(14.015)	(5.561)	(11.492)	
	1.000	*1.000*	*1.000*	*1.000*	
Non-petroleum exporters	-1.308	-0.734	-7.108	-1.289	4.72
	(7.279)	(8.162)	(4.043)	(6.209)	
	1.000	*1.000*	*1.000*	*1.000*	
Non-petroleum importers	-2.282	-6.062	-7.42	-5.318	2.61
	(2.722)	(5.547)	(3.73)	(4.223)	
	0.997	*1.000*	*1.000*	*1.000*	
Petroleum exporters	-1.088	-1.017	-9.565	-1.013	4.16
	(8.534)	(8.242)	(1.889)	(6.519)	
	1.000	*1.000*	*0.971*	*1.000*	
Petroleum importers	-2.029	-4.738	-7.972	-4.723	1
	(3.795)	(6.022)	(2.863)	(4.39)	
	1.000	*1.000*	*0.998*	*1.000*	

Notes: p* is the number of lags included in the error correction equations (determined by AIC) with a maximum lag length of 5. Z-value is (in parentheses) and the *p*-value is in italics. We allow for a constant and deterministic trend in the cointegration relationship.

Table 4. Estimation of (3) for the whole sample and exporter and importer sub-groups

	[1] All countries	[2] Exporters	[3] Importers
World GDP growth	24.27***	58.29***	-11.69***
	(2.82)	(3.95)	(-8.85)
Real interest rate	-9.316***	-18.71***	0.618
	(-5.88)	(-8.96)	(1.21)
Exchange rate of US dollar	-4.846***	-12.58***	3.335***
	(-2.76)	(-4.37)	(9.98)
Stock price volatility	0.066***	0.152***	-0.024***
	(3.11)	(4.19)	(-7.00)
Constant	-1.458**	-3.587***	0.794***
	(-2.50)	(-3.51)	(8.70)
Observations	3240	1665	1575
Adjusted R^2	0.021	0.065	0.136
F	11.61	26.17	26.22

Notes: *t* statistics in parentheses, all explanatory variables in first lag, * p<0.10, ** p<0.05, *** p<0.01.

Table 5. Estimation of (3) for non-petroleum and petroleum sub-groups

	[1] Non petroleum exporters	[2] Non petroleum importers	[3] Petroleum exporters	[4] Petroleum importers
World GDP growth	-7.787	-10.12***	120.9***	-13.34***
	(-1.71)	(-5.06)	(6.19)	(-7.95)
Real interest rate	-18.33***	-1.189	-19.08***	2.531***
	(-5.16)	(-1.60)	(-7.96)	(10.10)
Exchange rate of US dollar	0.405	3.436***	-24.89***	3.228***
	(0.40)	(6.44)	(-6.62)	(7.88)
Stock price volatility	-0.010	-0.015***	0.305***	-0.034***
	(-1.04)	(-3.39)	(6.29)	(-7.87)
Constant	1.091***	0.695***	-8.019***	0.898***
	(3.18)	(5.09)	(-6.12)	(7.53)
Observations	810	810	855	765
Adjusted R^2	0.052	0.116	0.125	0.165
F	9.862	15.28	27.80	28.52

Notes: *t* statistics in parentheses, all variables explanatory variables in first lag, * p<0.10, ** p<0.05, *** p<0.01.

Table 6. Estimation of (3) for sub-groups and employing differing economic growth measures

	[1] Non petroleum exporters	[2] Non petroleum importers	[3] Petroleum exporters	[4] Petroleum importers	[5] Non petroleum exporters	[6] Non Petroleum importers	[7] Petroleum exporters	[8] Petroleum importers
Emerging market growth	4.656*** (4.94)	-4.599*** (-6.48)	28.26*** (6.46)	-3.754*** (-7.50)				
OECD growth					-7.743** (-2.14)	-7.287*** (-4.71)	100.1*** (6.19)	-10.93*** (-8.00)
Real interest rate	-17.79*** (-5.04)	-2.372*** (-3.27)	-9.649*** (-9.49)	1.378*** (9.71)	-17.59*** (-5.03)	-0.604 (-0.76)	-27.80*** (-7.37)	3.477*** (9.71)
Exchange rate of US dollar	1.122 (1.04)	3.597*** (6.29)	-28.74*** (-6.54)	3.606*** (7.96)	0.339 (0.33)	3.511*** (6.48)	-25.02*** (-6.62)	3.249*** (7.88)
Stock price volatility	0.004 (0.60)	0.005*** (3.96)	0.073*** (6.53)	-0.008*** (-7.17)	-0.012 (-1.36)	-0.012*** (-2.91)	0.302*** (6.29)	-0.034*** (-7.92)
Constant	0.306 (1.44)	0.359*** (5.07)	-2.300*** (-6.15)	0.307*** (6.39)	1.079*** (3.58)	0.510*** (4.68)	-6.609*** (-6.11)	0.735*** (7.49)
Observations	810	810	855	765	810	810	855	765
Adjusted R^2	0.053	0.105	0.086	0.126	0.053	0.105	0.117	0.156
F	10.01	19.30	26.40	28.23	10.04	15.10	28.29	28.40

Notes: *t* statistics in parentheses, all explanatory variables in first lag, * p<0.10, ** p<0.05, *** p<0.01.

Table 7. Estimation of (4) for whole sample, exporters and importers

	[1] All countries	[2] Exporters	[3] Importers
CTOT growth (second lag)	-0.00938	0.00981	-0.0572**
	(-0.85)	(0.60)	(-2.05)
World GDP growth	24.11***	58.69***	-11.28***
	(2.76)	(3.80)	(-8.45)
Real interest rate	-9.482***	-18.32***	0.954*
	(-5.94)	(-8.32)	(2.00)
Exchange rate of US dollar	-4.795***	-12.71***	3.176***
	(-2.68)	(-4.08)	(9.59)
Stock price volatility	0.066***	0.152***	-0.025***
	(3.12)	(4.26)	(-7.46)
Constant	-1.446**	-3.614***	0.777***
	(-2.44)	(-3.38)	(8.49)
Observations	3240	1665	1575
Adjusted R^2	0.021	0.064	0.138
F	14.93	22.51	24.69

Notes: *t* statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01.

Table 8. Estimation of (4) for non- petroleum and petroleum sub-groups

	[1] Non petroleum exporters	[2] Non petroleum importers	[3] Petroleum exporters	[4] Petroleum importers
CTOT growth (second lag)	-0.234***	-0.172***	0.0801***	0.0769***
	(-10.60)	(-7.91)	(8.99)	(5.62)
World GDP growth	-8.027*	-9.127***	127.2***	-13.99***
	(-1.83)	(-4.92)	(6.02)	(-7.93)
Real interest rate	-18.23***	-0.586	-12.81***	1.886***
	(-4.95)	(-0.70)	(-12.41)	(8.96)
Exchange rate of US dollar	-0.707	3.033***	-27.29***	3.479***
	(-0.93)	(6.18)	(-6.27)	(8.03)
Stock price volatility	-0.016	-0.017***	0.297***	-0.033***
	(-1.37)	(-3.84)	(6.38)	(-7.91)
Constant	1.164***	0.680***	-8.425***	0.938***
	(3.15)	(5.24)	(-5.97)	(7.61)
Observations	810	810	855	765
Adjusted R^2	0.103	0.140	0.128	0.168
F	75.06	59.93	182.5	44.88

Notes: *t* statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01.

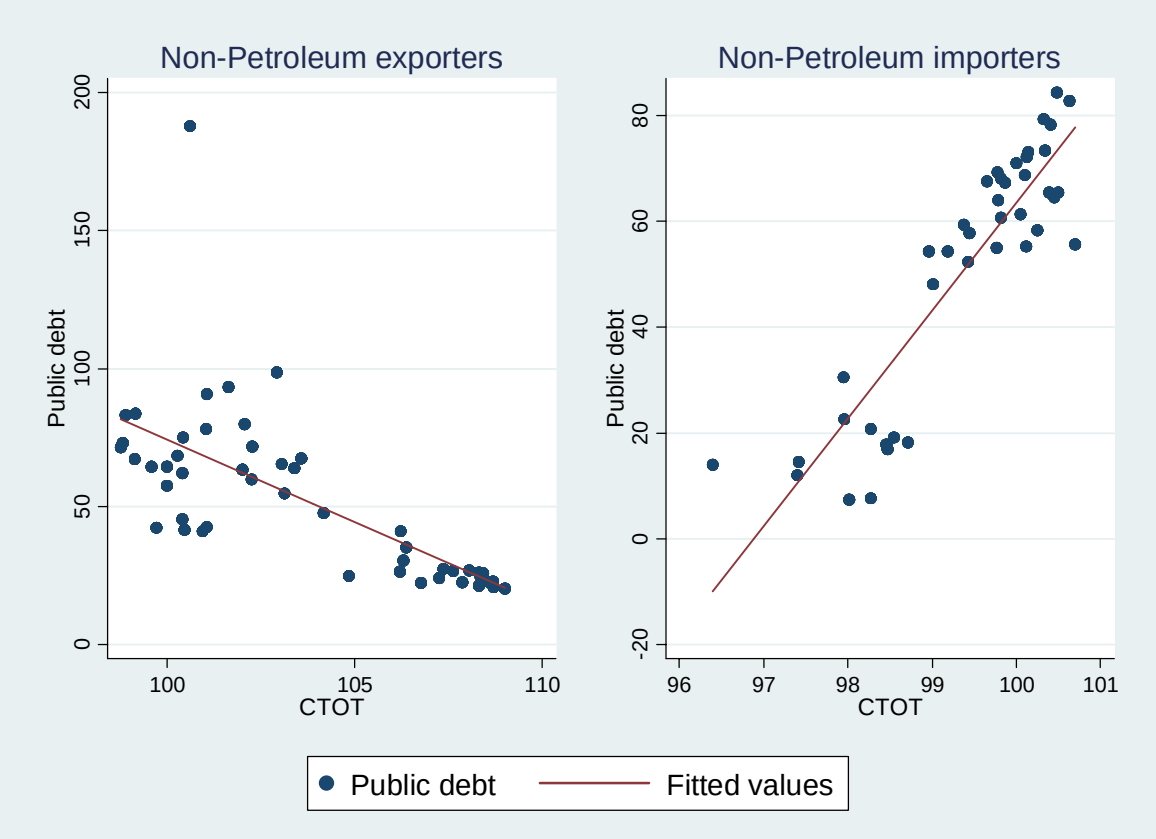
Table 9. Estimation of (4) for sub-groups and employing differing economic growth measures

	[1] Non petroleum exporters	[2] Non petroleum importers	[3] Petroleum exporters	[4] Petroleum importers	[5] Non petroleum exporters	[6] Non petroleum importers	[7] Petroleum exporters	[8] Petroleum importers
CTOT growth (second lag)	-0.249***	-0.187***	0.0374***	0.0247**	-0.238***	-0.173***	0.0887***	0.0911***
	(-11.22)	(-9.10)	(9.53)	(2.70)	(-11.01)	(-7.75)	(8.91)	(6.16)
Emerging market growth	7.664***	-4.495***	28.37***	-3.737***				
	(5.75)	(-6.21)	(6.43)	(-7.46)				
OECD growth					-9.381**	-6.076***	108.1***	-11.88***
					(-2.77)	(-4.42)	(5.95)	(-7.93)
Real interest rate	-17.18***	-1.658*	-6.597***	1.166***	-17.30***	-0.122	-21.65***	2.811***
	(-4.88)	(-2.05)	(-11.21)	(8.43)	(-4.79)	(-0.14)	(-9.37)	(9.48)
Exchange rate of US dollar	0.170	3.112***	-29.99***	3.698***	-0.873	3.128***	-27.56***	3.529***
	(0.21)	(6.11)	(-6.40)	(8.17)	(-1.15)	(6.24)	(-6.24)	(8.00)
Stock price volatility	-0.003	0.006	0.063***	-0.008***	-0.022*	-0.014***	0.298***	-0.033***
	(-0.45)	(0.34)	(7.00)	(-6.56)	(-1.90)	(-3.31)	(6.34)	(-7.99)
Constant	0.175	0.404***	-2.313***	0.306***	1.238***	0.483***	-7.114***	0.792***
	(0.92)	(5.55)	(-6.12)	(6.40)	(3.66)	(4.75)	(-5.89)	(7.59)
Observations	810	810	855	765	810	810	855	765
Adjusted R^2	0.109	0.135	0.085	0.125	0.105	0.129	0.122	0.160
F	50.36	78.10	75.87	28.33	76.80	59.82	210.6	49.72

Notes: *t* statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01.

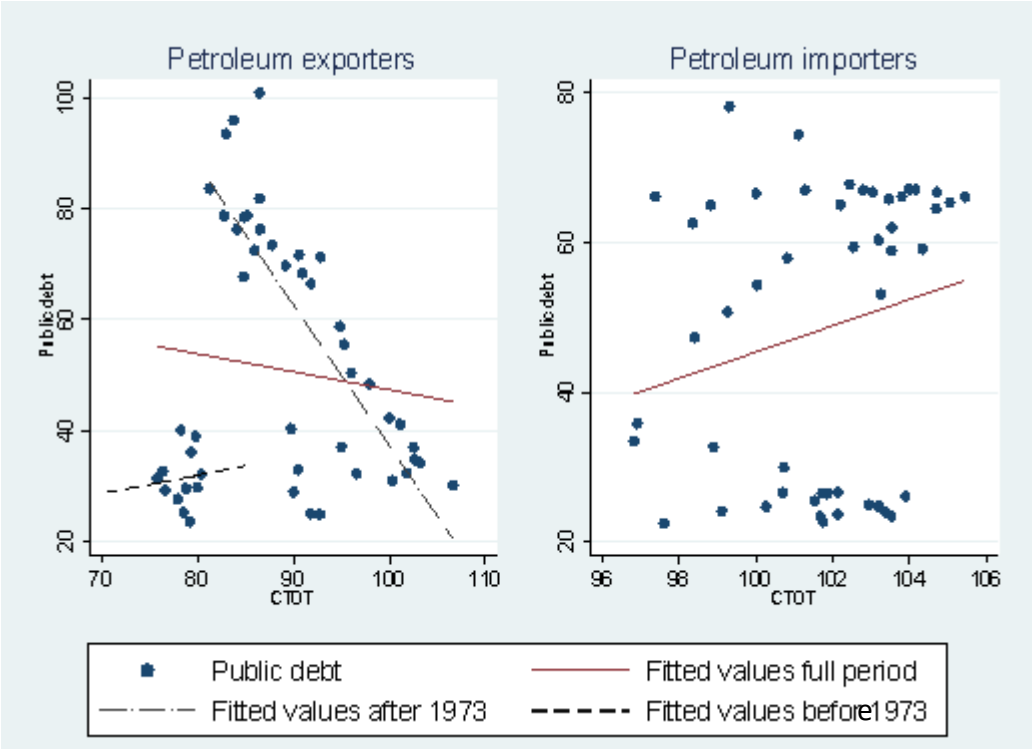
Figures

Figure 1. The association between CTOT and public debt in non-petroleum exporters and importers



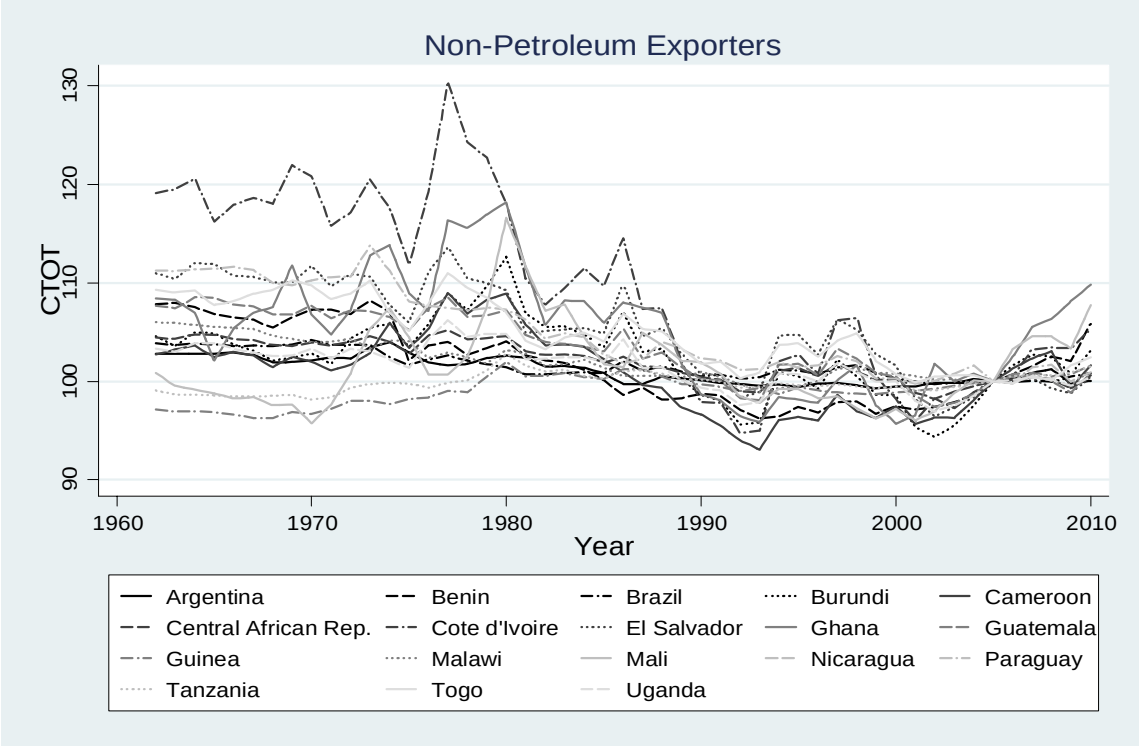
Notes: Each dot represents the average value of public debt as percentage to GDP (*y-axis*) and CTOT level (*x-axis*) for a sample of 18 countries (see Appendix A) in each year from 1962 to 2010. Public debt data is from the International Monetary Fund. The source of other data is recorded in Section 3.

Figure 2. The association between CTOT and public debt in petroleum 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 a sample of 19 petroleum exporters and 17 petroleum importers (see Appendix A), in each year from 1962 to 2010. Public debt data is from the International Monetary Fund. The source of other data is recorded in Section 3.

Figure 3. CTOT for non-petroleum sub-groups



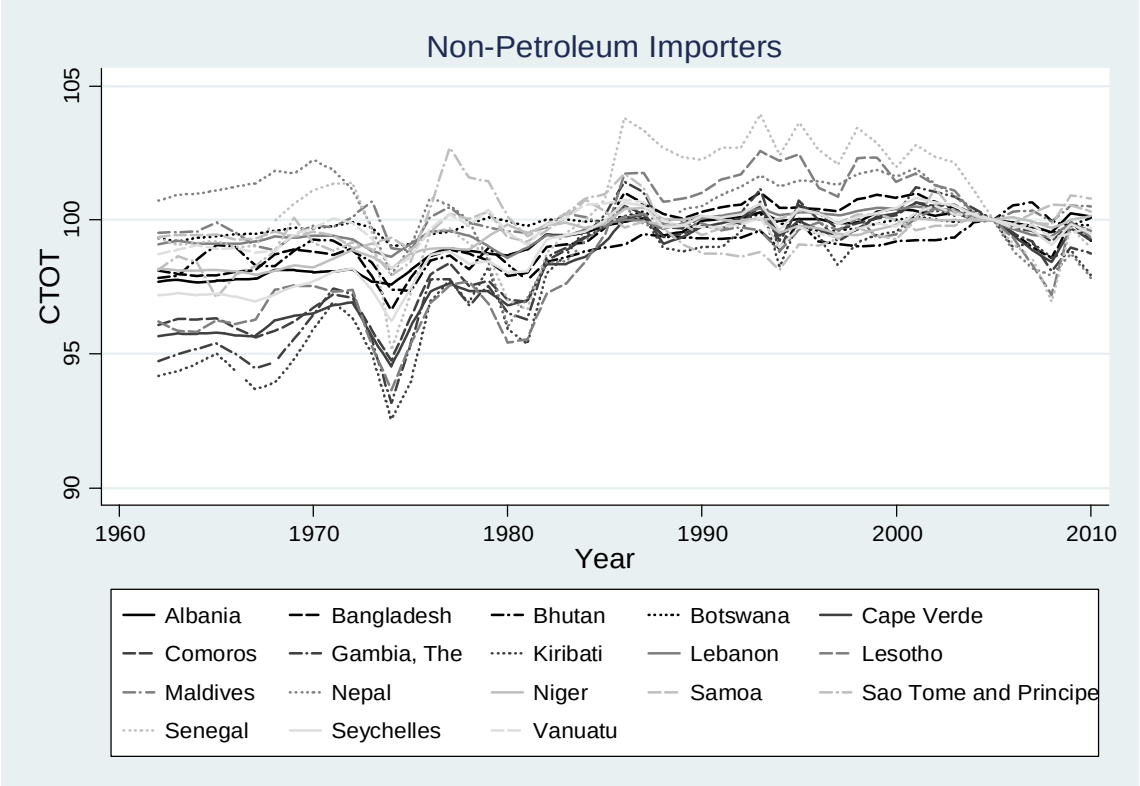
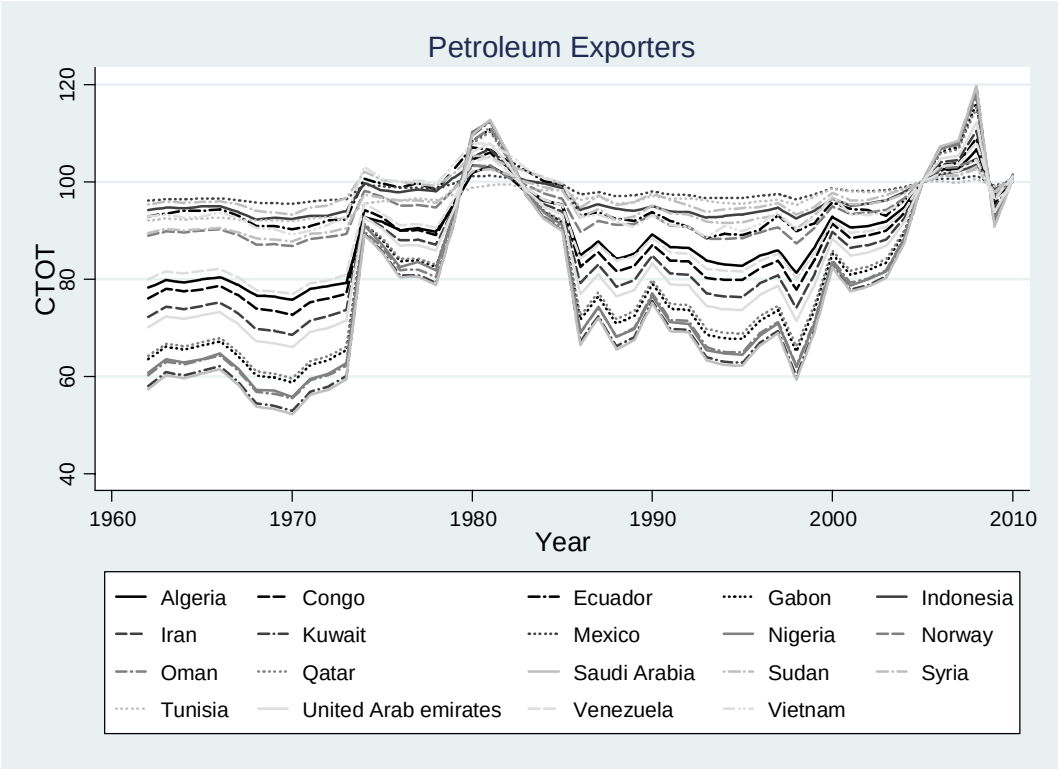


Figure 4. CTOT for petroleum sub-groups



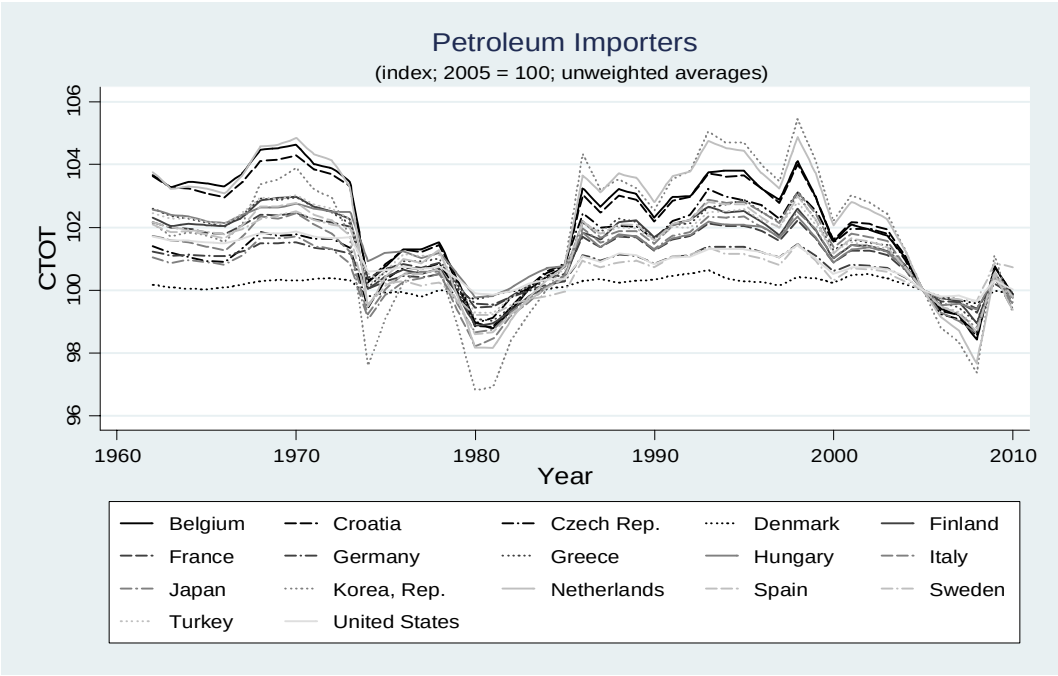
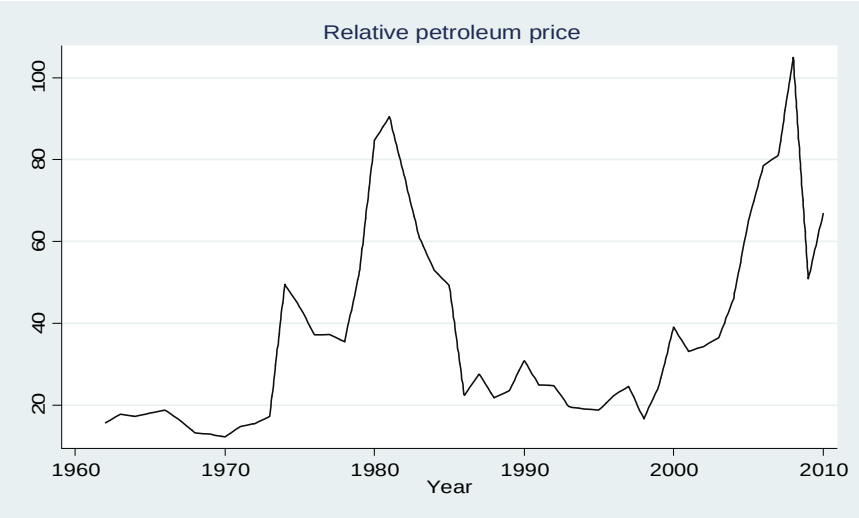


Figure 5. Petroleum price relative to MUV

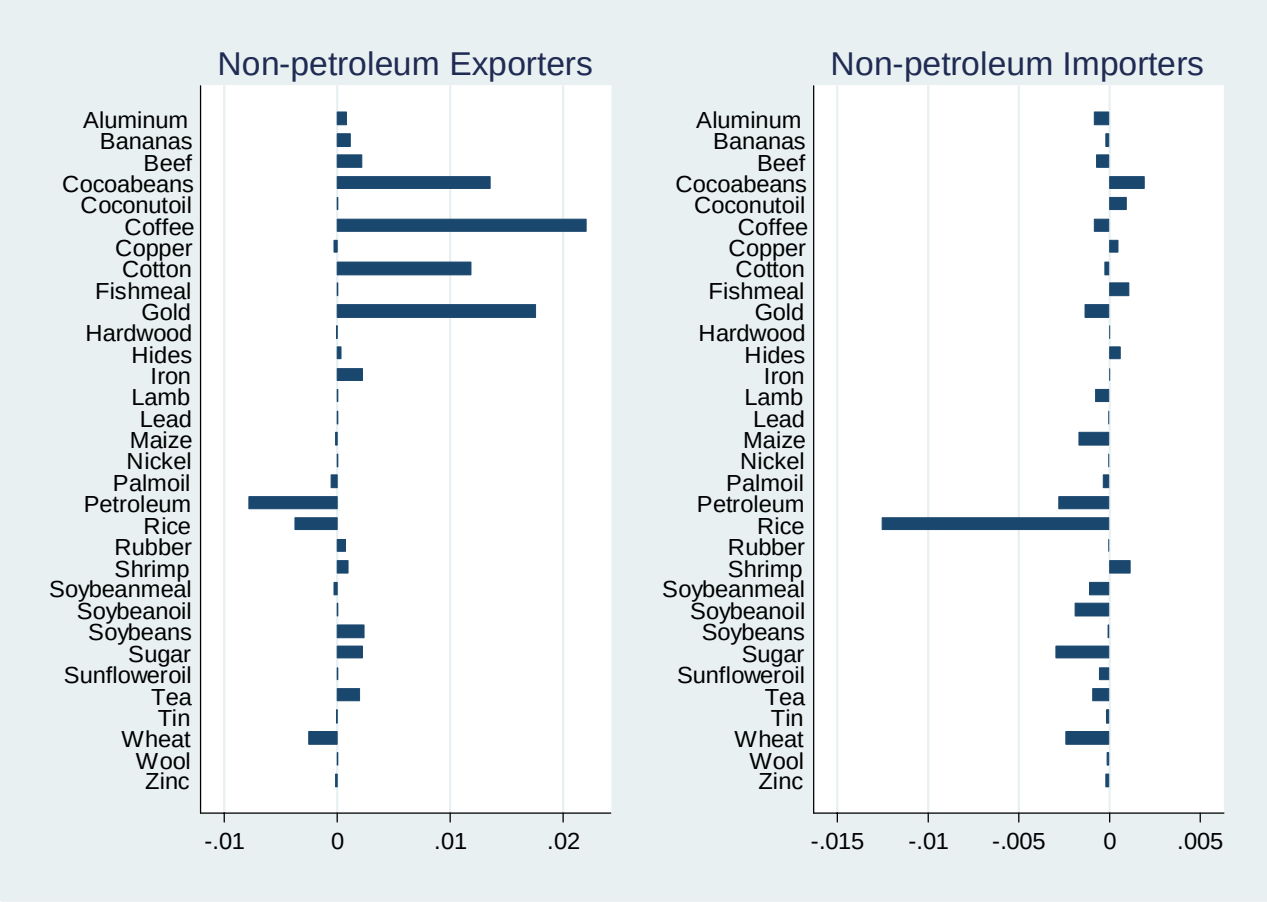


Appendix A. Data description

Table A.1. Country list

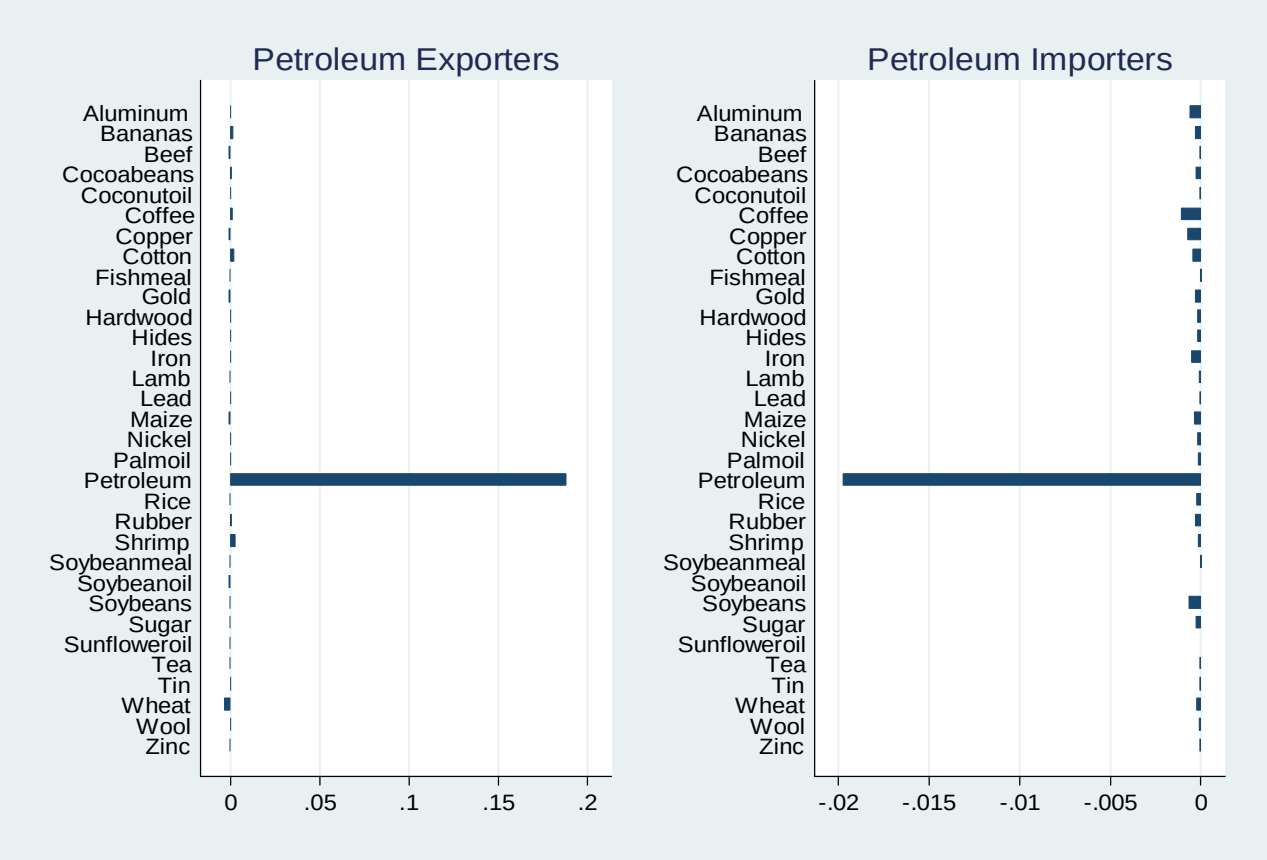
Non-Petroleum Exporters (18)	Non-petroleum Importers (18)	Petroleum Exporters (19)	Petroleum Importers (17)
Argentina	Albania	Algeria	Belgium
Benin	Bangladesh	Congo	Croatia
Brazil	Bhutan	Ecuador	Czech Republic
Burundi	Botswana	Gabon	Denmark
Cameroon	Cape Verde	Indonesia	Finland
Central African Republic	Comoros	Iran	France
Cote d'Ivoire	Gambia, The	Kuwait	Germany
El Salvador	Kiribati	Mexico	Greece
Ghana	Lebanon	Nigeria	Hungary
Guatemala	Lesotho	Norway	Italy
Guinea	Maldives	Oman	Japan
Malawi	Nepal	Qatar	Korea
Mali	Niger	Saudi Arabia	Netherlands
Nicaragua	Samoa	Sudan	Spain
Paraguay	Sao Tome and Principe	Syria	Sweden
Tanzania	Senegal	Tunisia	Turkey
Togo	Seychelles	United Arab Emirates	United States
Uganda	Vanuatu	Venezuela	
		Vietnam	

Figure A.1. Net export composition of non-petroleum 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 exports (net imports).

Figure A.2. Net export composition of petroleum 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 exports (net imports).

Appendix B. Auxiliary results.

Figure B.1. Relative petroleum and non-petroleum prices and stock price volatility

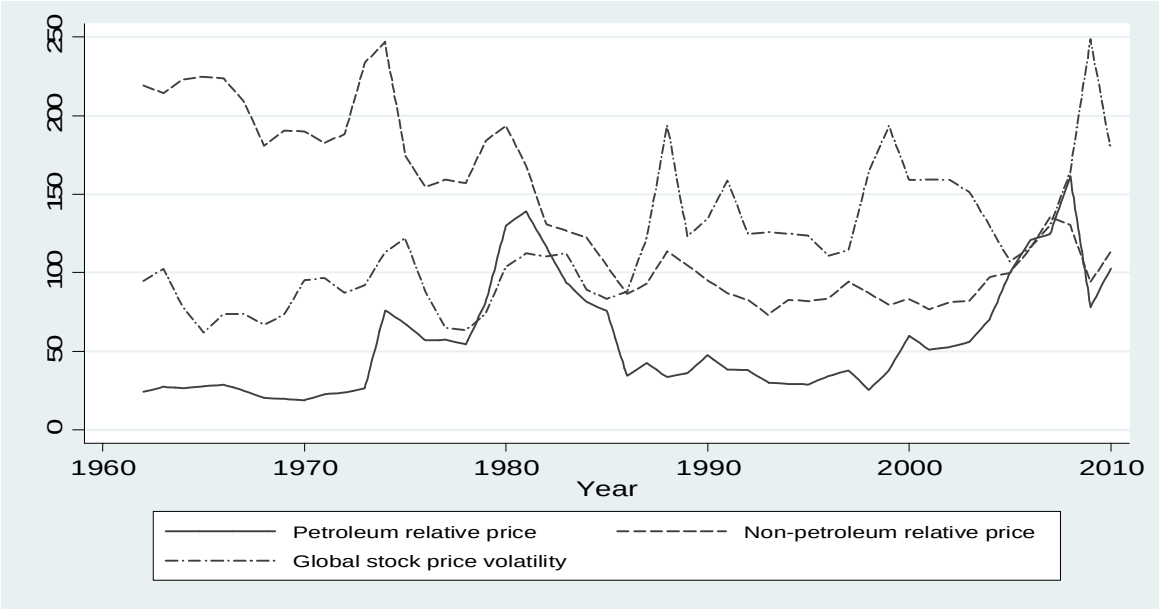


Table B.1. Westerlund panel cointegration test

Panel	Gt	Ga	Pt	Pa	p*
Whole sample	-1.598	-3.174	-12.342	-2.485	2.92
	(7.530)	(10.833)	(5.436)	(7.633)	
	1.000	*1.000*	*1.000*	*1.000*	
Non-petroleum exporters	-1.667	-1.633	-4.954	-2.550	3.94
	(3.457)	(6.270)	(3.841)	(3.780)	
	1.000	*1.000*	*1.000*	*1.000*	
Non-petroleum importers	-2.689	-6.892	-6.750	-4.798	2.17
	(-1.081)	(3.358)	(2.183)	(2.522)	
	0.140	*1.000*	*0.986*	*0.994*	
Petroleum exporters	-0.494	-0.499	-5.713	-0.918	4.37
	(8.907)	(7.087)	(3.371)	(4.822)	
	1.000	*1.000*	*1.000*	*1.000*	
Petroleum importers	-1.603	-3.860	-6.222	-3.880	1
	(3.635)	(4.895)	(2.433)	(2.951)	
	1.000	*1.000*	*0.993*	*0.998*	

Notes: p* is the number of lags included in the error correction equations (determined by AIC) with a maximum lag length of 5. Z-value is (in parentheses) and the *p*-value is in italics. We allow above for a constant but no deterministic trend in the cointegration relationship.

Table B.2. Stock price volatility correlation with commodities' relative prices. Positively correlated commodities in bold

Commodity	Correlation	Mean	Std. Dev.
Aluminium	-0.597	0.149	0.393
Bananas	-0.494	0.128	0.322
Beef	-0.675	0.301	0.501
Cocoa beans	-0.532	0.410	0.553
Coconut oil	-0.601	0.407	0.584
Coffee	-0.714	0.470	0.625
Copper	-0.415	-0.018	0.559
Cotton	-0.710	0.669	0.544
Crude petroleum	**0.258**	-0.742	0.597
Fish meal	-0.585	0.430	0.627
Gold	**0.314**	-0.087	0.389
Hardwood	-0.224	0.082	0.234
Hides	-0.494	0.243	0.277
Iron	-0.298	-0.025	0.737
Lamb	-0.621	0.018	0.297
Lead	-0.424	0.050	0.530
Maize	-0.628	0.627	0.538
Nickel	-0.149	-0.316	0.423
Palm oil	-0.574	0.574	0.574
Rice	-0.500	0.403	0.510
Rubber	-0.575	0.164	0.517
Shrimp	-0.554	0.414	0.324
Soybean meal	-0.590	0.461	0.474
Soybean oil	-0.589	0.467	0.482
Soybeans	-0.625	0.532	0.524
Sugar	-0.467	0.622	0.481
Sunflower oil	-0.529	-0.191	0.469
Tea	-0.573	0.276	0.458
Tin	-0.544	0.256	0.579
Wheat	-0.610	0.451	0.492
Wool	-0.538	0.257	0.435
Zinc	-0.642	0.484	0.486
Non-petroleum prices	-0.608		

Notes: Commodity prices are relative to MUV. The last two columns show some summary statistics, mean and standard deviation, for each commodity price. Non-petroleum prices is the unweighted average of non-petroleum commodity prices.

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