Child Mortality, Commodity Price Volatility and the Resource Curse

Abstract

Given many developing economies depend on primary commodities, the fluctuations of commodity prices may imply significant effects for the wellbeing of children. To investigate, this paper examines the relationship between child mortality and commodity price movements as reflected by country-specific commodity terms-of-trade. Employing a panel of 69 low and lower-middle income countries over the period 1970-2010, we show that commodity terms-of-trade volatility increases child mortality in highly commodity-dependent importers suggesting a type of 'scarce' resource curse. Strikingly however, good institutions appear able to mitigate the negative impact of volatility. The paper concludes by highlighting this tripartite relationship between child mortality, volatility and good institutions and posits that an effective approach to improving child wellbeing in low to lower-middle income countries will combine hedging, import diversification and improvement of institutional quality.

Keywords: Low and lower-middle income countries, commodity prices, terms-of-trade, institutions, resource curse, child mortality.

1. Introduction

The Millennium Development Goals (MDG) of the United Nations targeted a reduction by two thirds, between 1990 and 2015, in the global under-five mortality rate. The latest report (UN, 2015) states 'Every day in 2015, 16,000 children under five continue to die, mostly from preventable causes. Child survival must remain the focus of the post-2015 development agenda.' In 2015, there were a shocking 6 million deaths of under-fives worldwide, of which 3 million occur in Sub-Saharan Africa (86 deaths per 1000 live births) and 1.8 million in Southern Asia (50 deaths per 1000 live births); compare these mortality rates with the 6 deaths per 1000 live births in developed countries. The same regions appear to be commodity-dependent low and lower-middle income countries, see Figure 1. This suggests a link between commodity-dependence and child mortality, the subject of investigation in this paper.

[Insert Figure 1 about here]

Specifically, we study the impact of the growth and volatility of commodity prices on child mortality and, in doing so, extend previous work examining (i) the relationship between economic growth and natural resource endowments (e.g., Sachs and Warner, 2001) – the so-called resource curse and (ii) the linkages between such endowments and serious health conditions (de Soysa and Gizelis, 2013, 2016; Sterck, 2016). Our focus on young children has a twofold rationale: firstly, improving child survival rates in the developing world is of the utmost importance as recognised by the UN and secondly, children are particularly vulnerable to diseases and other health risks related to either the quality of nutrition, or the quality of life more generally (see Galiani *et al*., 2005), both of which can be partially traced back to the global commodity market.

Surprisingly, the relationship between commodity prices and child mortality remains underexplored in the extant literature, although a plethora of signs point to a potential link:

for example, booms in food prices are theorised to lead to malnutrition (Christian, 2010; Darnton-Hill and Cogill, 2010), and more broadly, commodity prices affect macroeconomic conditions (Céspedes and Velasco, 2014), which in turn determine infant mortality rates (Baird *et al*., 2011). The few exceptions include Miller and Urdinola (2010) who examine the case of Columbia using three episodes of sharp coffee price movements in 1975, 1985 and 1989-90. More recently, Lee *et al*. (2015) employing a panel method over the period 2001-2011, suggest that food price inflation impacts developing country infant mortality. However, in a wider context, the literature reports that both the level (or growth) and the volatility of macroeconomic variables can affect economic growth and other measures of welfare (Mendoza, 1997; Blattman *et al.*, 2007; Ramey and Ramey, 1995; Van der Ploeg and Poelhekke, 2009; Bansal *et al.*, 2014). Our paper adopts the methodological approach of this latter literature to investigate the determinants of infant mortality, and in particular focuses on the role of the global commodity market. Section 2 explains our theoretical framework in more depth.

To isolate the specific effect of commodity trade, we examine for the first time the effect of 'commodity terms-of-trade' (CTOT) on child mortality in a large panel of poor developing countries. CTOT is a country-specific index that allows us to account for the effect of a number of commodities simultaneously. This index reflects an individual country's position in the commodity market by measuring national commodity trade structures; therefore movements in global commodity prices differently affect CTOT across countries (Spatafora and Tytell, 2009, Ricci *et al.*, 2013, and Cavalcanti *et al.*, 2014). Since we are interested in evaluating the effect of commodity prices on child mortality, the CTOT index is preferred to the traditional TOT because the latter includes not only primary commodities but also manufactured and high value-added goods. Some recent studies reveal that the CTOT index exhibits a significant impact on economic growth (Spatafora and Tytell,

2009, and Cavalcanti *et al.*, 2014) and the real exchange rate (Aizenman *et al.*, 2012, and Ricci *et al.*, 2013).

We consider a sample of 69 low and middle-low income countries over the period 1970-2010. Of these, 25 countries are net commodity exporters and 44 are net commodity importers. To assess the impact of the degree of commodity dependence, we compare these groups with two smaller sub-samples consisting of the most commodity-dependent countries. Panel least-squares estimations show the main driver through which commodity prices can affect child mortality is their volatility, not the growth rate. As an explanation for the latter, we show that the CTOT of developing countries exhibits either no or weak trend, an outcome consistent with the observations of Harvey *et al.* (2010) for individual long-run commodity prices and Blattman *et al.* (2007) for countries' TOT. Subsequently, we demonstrate that the volatility effect operates primarily in heavily commodity-dependent importers. These countries tend to suffer from higher levels of commodity volatility than heavily commodity-dependent exporters. This not only illustrates the adverse impact of high commodity dependence on child survival but also reveals a 'scarce' resource curse. In other words, the typical resource curse applies where countries have an abundance of a natural resource, whereas volatility is particularly harmful when countries have a lack of essential resources and are forced to import them. Importantly we show that good institutions, for example as proxied by political regime data, can shield importers from the detrimental effects of volatility.

Given the aforementioned consequences of volatility, using financial hedging and reducing commodity dependence through import substitution and/or diversification of the commodity basket in commodity-importing nations, appears critical to decreasing child mortality. Improving the quality of institutions must also be a priority. The rest of the paper is set out as follows. Section 2 discusses the theoretical framework whilst section 3 presents the

methodology. Section 4 includes discussion of the data sources and sample construction whilst section 5 presents the empirical results and their interpretation. Finally, section 6 concludes.

2. Theoretical Framework

Several channels transmit changes in global commodity prices to child mortality rates, and these are schematically represented in Figure 2, and discussed below. We distinguish here between channels that rely on the level of commodity prices (e.g. food price inflation), and those triggered by their volatility (representing the uncertainty of future price movements).

[Insert Figure 2 about here]

2.1. Level view

There are major reasons to expect that a range of commodity prices are critical for child survival. Firstly and despite a lack of empirical work (Lee *et al*., 2016), booms in food prices are often theorised to be related to increased malnutrition and consequently considered a major cause of child mortality (e.g., Christian, 2010; Darnton-Hill and Cogill, 2010). This is included within the *cost channel* of Figure 2, which represents the effect of a range of global and domestic commodity prices, including food and energy, on the costs of running the household, and thus decisions with regard to food consumption and healthcare. This argument is consonant with the micro-model by Strulik (2004) who explains the expenditure-mortality nexus at a household level by separating "controllable" factors of infant mortality (e.g, household expenditure on nutrition and healthcare) from those beyond a family's control (e.g. state-funded healthcare support).

Secondly, given many developing countries specialize in trading primary commodities, their economies are vulnerable to movements in the global commodity price

level (Céspedes and Velasco, 2014). This would affect the country's GDP, and subsequently government income, and the general quality of public health-related services provided in the country, which would, in turn, affect child mortality rates. This is depicted the *government channel* in Figure 2 and corresponds to the "uncontrollable" (by the household) mortality rate in Strulik's (2004) model.

Thirdly, one can argue that in commodity-dependent countries much household income would depend on global commodity prices, via its effect on employment in the relevant sectors (e.g., see Miller and Urdinola, 2010). A change in the level of commodity prices can thus be transmitted to child mortality rates through the *income channel* in Figure 2. For example, a steep fall in the price of coffee may see declining employment in the agricultural sector, loss of household income, reduced calorie intake by a household's children and increased child mortality. Again, this view supports the hypothesis that a range of commodity prices, and not solely food, affect child mortality rates in commodity-dependent countries, entering the household decision-problem either as a disposable income component, or as expenditures.

2.2. Volatility view

The above discussion reflects the plausible *level* effects of commodity prices on child survival. However, the *volatility* of such prices may also have significant effects; after all commodity prices are acknowledged to be particularly volatile, increasing the risks around prospective revenues and costs (see Harvey *et al*., in press). Additional macroeconomic uncertainty can delay or limit capital investment by commodity producers and healthcare investment by their related governments, ultimately reducing future growth and increasing poverty (see, *inter alia*, Blattman *et al*., 2007 and Poelhekke and van der Ploeg, 2009). We

refer to the effect on private investment as the *investment channel* in Figure 2 and allow effect of uncertainty on government investment to be mediated via the *government channel*.

Of course, the uncertainty resulting from commodity price volatility is also likely to change the behaviour of households. For example, they may attempt to partially offset future changes in household income or expenditures by creating reserves (i.e., savings), or by cross-subsidizing between households (e.g., arrangements for informal group childcare to free up mothers' time for work; see, Blau and Robins, 1988 and Doiron and Kalb, 2005). However, these precautionary arrangements (illustrated by the *precautionary channel* in Figure 2) divert funds from being spent on health and good quality food. Besides, frequent, persistent and/or large commodity prices shocks may overwhelm household reserves and prevent efficient cross-subsidization, which cannot always be quickly arranged.

2.3 Net exporters versus net importers

It is important to see how the five channels above (cost, government, income, investment and precautionary) operate for net commodity exporters and importers. For net exporting countries, a significant portion of GDP is directly commodity-derived (Sinnott, 2009, Medina, 2010, and Murphy *et al.*, 2010), implying falls in prices may raise child mortality via the government channel and the income channel (vice versa for price increases). On the other hand, for large net importers of commodities like energy and food, falls in such prices may lessen child mortality via the same channels, as well as the cost channel. Therefore, from the perspective of the level of commodity prices, their movements would have different directional effects on the child mortality in net exporters and importers.

By contrast, an increase in volatility will have similarly detrimental effects on child mortality for both net importers and exporters. For example, with higher volatility of energy, exporters will be less sure of their future revenues, and this would reduce investments, while

importers would be less sure of future costs, with the same effect on investment. Although the directional effect on child mortality via the investment and the precautionary channels will be the same, the magnitude will depend on individual country circumstances.

2.4. Role of institutions

An important country consideration are its institutions. Given the "uncontrollable" mortality rate is a function of country healthcare provision, institutional quality (e.g., the quality of those government institutions with responsibility for decisions regarding healthcare) will determine the system's effectiveness in mitigating any negative effects of commodity price movements. Indeed, studies such as Atkinson and Hamilton (2003) and Van der Ploeg (2011) already suggest that good institutions play an essential role in economies deriving positive benefits from resource income. Measures of institutional quality include direct measures of corruption or type of political regime, such as whether a specific regime is considered a democracy or autocracy. This is because first, corrupt institutions foster rent-seeking and unproductive 'white elephant' investments (Chowdhury, 2004, Dietz *et al.*, 2007 and Van der Ploeg, 2011) and are often associated with autocracies; and second, autocracies tend to resist modernisation policies such as industrialisation (Acemoglu *et al.*, 2001, Dietz *et al.*, 2007, and Cuberes and Jerzmanowski, 2009), which reduce commodity dependence and lessen its adverse consequences for economic performance and child survival.

2.5. Hypotheses

From our theoretical framework we can formulate four main hypotheses. First, a range of commodity prices, and not solely food, affect child mortality rates in commodity-dependent countries. Second, level changes in commodity prices can have different directional effects on net exporters and importers. Third, commodity price volatility raises the rate of infant

mortality unambiguously across net exporters and importers, although the magnitude of the effect will depend on country circumstances. Fourth, better institutions reduce the adverse effect of commodity price volatility on child mortality.

3. Methodology

To assess the relationship between economic conditions and the child mortality rate, the literature (see, *inter alia*, Pritchett and Summers, 1996; Ruhm, 2000; Gerdtham and Ruhm, 2006; and Gonzalez and Quast, 2011) has estimated the following equation:

$$MR_{it} = \alpha + \beta_1 E_{it} + \beta_2 X_{it} + \eta_i + \delta_t + \varepsilon_{it} \quad (1)$$

where MR_{it} is the logarithm of mortality rate on the *i*th cross-sectional unit at time *t*, E_{it} represents the macroeconomy, proxied by either the unemployment rate or GDP per capita, X_{it} is a set of control variables, δ_t is a time-specific effect which represents child mortality determinants that vary uniformly across countries over time (for example, medical technologies) and η_i is a country-specific effect which captures the factors that differ across countries but are time-invariant (such as climate or culture). Finally, ε_{it} is the error term.

There are some key econometric issues raised by past empirical studies regarding the estimation of child mortality determinants in (1). The first issue is the incidental association caused by excluded variables that affect both the mortality rate and economic activity. Dealing with the effect of excluded variables that are constant over time is possible by estimating either fixed-effects (with country-specific effects) or first-differenced models (see Pritchett and Summers, 1996 and Ross, 2006).

The second issue relates to the downward trend of the child mortality rate over time due to global factors such as health improvements. More specifically, recent medical discoveries and the spread of low-cost health interventions address health problems and lessen child mortality. The empirical neglect of these improvements can generate misleading results since

any reduction of child mortality could wrongly be attributed to other variables such as GDP growth or democracy (Ross, 2006). Including the time-specific effect in estimated models captures any universal trend.

A third issue notes that equation (1) requires considerable independent variation of explanatory variables over time. Other panel studies that have considered this requirement include Ruhm (2000) and Gonzalez and Quast (2011) using data from states from within one country or Gerdtham and Ruhm (2006), examining data from OECD countries that might be considered integrated. Our data appears to satisfy the condition as CTOT fluctuations suggest enough independent variation across countries in our sample (e.g., the estimated correlation coefficients between our measures of CTOT were generally low - see section 4.2). Notably, trade structures differ significantly across countries and these structures determine CTOT responses to global commodity price changes. Additionally, although we also decompose the sample into exporters and importers, these sub-groups are still heterogeneous as the export/import composition varies across countries.

The final econometric issue refers to the inability of annual observations to appropriately capture the medium and long-term effects of explanatory variables on a dependent variable (Blattman *et al*., 2007 and Cavalcanti *et al.*, 2014). Thus, and as is common in the economic growth literature, we transform the annual series into non-overlapping five-year averages with a maximum of eight observations per country. The five-year averages (i) allow us to define volatility as the standard deviation of CTOT growth within each five-year window (ii) are typically considered reasonable to smooth out business cycle fluctuations and (iii) are also useful given the persistence of commodity price shocks is rather high (see Harvey *et al*., 2010; indeed, Modified Dickey-Fuller unit root tests on our annual log level CTOT data show that the overwhelming majority of countries cannot reject the null of a unit root – see section 4.2).

Taking into account the above issues and any non-stationary behaviour (see section 4.1 and 4.2 for unit root tests), we estimate the following first-difference model instead of (1):

$$\Delta MR_{is} = \alpha + \beta_1 \Delta CTOT_{is} + \beta_2 CTOTv_{is} + \beta_3 \Delta X_{is} + \delta_s + \varepsilon_{is} \quad (2)$$

where the subscript 's' represents one of the five-year averages, s = 1, 2,… S, with S = T/5, and T denoting the years between 1970 and 2010. ΔMR_{is} is therefore the first-difference of the logarithm of under-five mortality rate in the ith country in the sth observation and $\Delta CTOT_{is}$ and $CTOTv_{is}$ refer to CTOT growth and CTOT volatility respectively. ΔX_{is} is a set of control variables (all in first-differences of the logarithm) including: the gross primary school enrolment ratio to control for the tendency of education to reduce mortality, the share of the population aged 0–4 and share of the population aged 65 and older to control for the age of the population, democracy dummies and domestic credit to private sector relative to GDP to control for institutional quality and financial development respectively, and GDP per capita growth to control for economic conditions (see Pritchett and Summers, 1996, Ruhm, 2000 and Gonzalez and Quast, 2011). Finally, the δ_s term is a time-specific effect and ε_{is} is the error term.

Work examining infant mortality like Pritchett and Summers (1996) also employ first-differences; this is typically part of a strategy to mitigate artificiality in child mortality data. The use of a growth-type model also allows more ready comparisons with the recent economic growth literature (see, for example, Easterly, 1999, and Younger, 2001). We also adopt the approach of Pritchett and Summers (1996) by estimating the model with and without GDP per capita growth. GDP per capita growth is one of the possible factors through which commodity price volatility can affect child mortality. Both models lead to qualitatively the same results and thus only results that include GDP per capita growth are shown. Finally note that following others (see Arezki and Brückner, 2012, Cuberes and Jerzmanowski, 2009

and Iyigun and Owen, 2004), we estimate (2) with panel least squares and cluster-robust standard errors at the country level to control for autocorrelation and/or heteroskedasticity.

To extend the analysis to investigate whether the effect of CTOT growth on the first-difference of mortality rate is conditional on the degree of commodity dependence, we also estimate (2) over a sub-sample that includes the most commodity-dependent countries in our dataset. Finally, to see whether institutional quality plays a role, we estimate the following model:

$$\Delta MR_{is} = \alpha + \beta_1 \Delta CTOT_{is} + \beta_2 (CTOTv \times IQ_H)_{is}$$
$$+\beta_3 (CTOTv \times IQ_L)_{is} + \beta_4 \Delta X_{is} + \delta_s + \varepsilon_{is} \quad (3)$$

where $(CTOTv \times IQ_H)_{is}$ and $(CTOTv \times IQ_L)_{is}$ are the interactions between CTOT volatility and proxies for high (IQ_H) and low (IQ_L) institutional quality. To briefly summarise the overall empirical strategy, regression (2) is estimated for the entire sample and the results compared with those of the highly commodity-dependent sample, whilst regression (3) is estimated for highly commodity-dependent sample only. Appropriate robustness checks are also carried out in section 5.

4. Data

4.1 Child mortality

An annual series of the under-five mortality rate, over the 1970–2010 period, is obtained from the UN Inter-Agency Group for Child Mortality Estimation (IGME, includes the United Nations Children's Fund, the World Health Organization, the World Bank and the United Nations Population Division). This series measures the probability per 1,000 that a new-born baby will die before reaching the age of five. The data is constructed from such sources as vital registration (VR) systems, sample vital registration (SVR) systems, surveys and censuses, and is available for almost all countries over a long period. It thus serves our goals

better than the survey datasets employed by some child mortality studies such as Ruhm (2000), Miller and Urdinola (2010) and Kudamatsu (2012), which have limited country coverage, particularly for developing nations. Additionally, surveys often present discrepancies (Pritchett and Summers, 1996) and national survey data, especially for authoritarian nations, is subject to falsification by the reporting of lower than actual child mortality rates (Ross, 2006). Pritchett and Summers (1996) employ an earlier version of the IGME dataset, although they recognise that the interpolation and extrapolation techniques used in construction can potentially make some of the variation over time in reported series artificial. Recently these techniques have been improved to represent, with more flexibility, the changes in child mortality over time (see Alkema and New, 2014). In any case, the data is constructed using a variety of sources which helps limit the effect of any falsified reports. During the later results section, we control for the common determinants of child mortality and show their effects are consistent with the extant literature, suggesting that our findings are not biased by using the IGME dataset.

To examine the order of integration of the logarithm of our mortality rate (MR_{it}) and its first difference (ΔMR_{it}), we carry out Fisher-type and IPS panel unit root tests with and without trend. Table A1 in the online Appendix [INSERT LINK TO ONLINE FILE A] shows the logarithm of our mortality rate is I(1) at the 5% level of significance whilst its first difference is I(0). For other evidence of non-stationary mortality rates see Caporale and Gil-Alana (2015).

4.2 Commodity terms-of-trade

The commodity terms-of-trade (CTOT) index, outlined in Spatafora and Tytell (2009), comprises 32 commodities and has been recently used by Cavalcanti *et al.* (2014). We

employ an extended version, constructed by Nikola Spatafora (n.d) and based on 46 annual commodity prices from 1970. It is defined as follows:

$$CTOT_{it} = \prod_j \left(\frac{P_{jt}}{MUV_t}\right)^{X_{ij}} / \prod_j \left(\frac{P_{jt}}{MUV_t}\right)^{M_{ij}} \quad (4)$$

where P_{jt} is the price of commodity *j* in year *t*, MUV_t is the manufacturing unit value index in year *t* used as a deflator, and *Xij (Mij)* is the share of exports (imports) of commodity *j* in country *i*'s GDP. Spatafora's weights are time-averaged over the period 1988-2010 and therefore changes in CTOT occur solely in response to commodity price fluctuations. For clarification, taking the logarithm of (4) gives:

$$lnCTOT_{it} = \sum_j (X_{ij} - M_{ij}) \ln(P_{jt}/MUV_t) \quad (5)$$

The above equation (5) shows that CTOT reflects the country-specific dimension of global commodity prices since the composition of a country's net export $(X_{ij} - M_{ij})$ determines the response of national CTOT to changes in relative prices (P_{jt}/MUV_t). CTOT growth is the first difference of CTOT (in logs) and CTOT volatility is the five-year standard deviation of CTOT growth (for similar approach, see, for instance, Mendoza, 1997; Blattman *et al*., 2007; and Cavalcanti *et al.*, 2014).

The export and import shares of individual commodities used to construct the CTOT index are taken from the United Nations' COMTRADE database whilst the source of commodity prices is the IMF Commodity Price System database. The MUV data are obtained from UNCTAD's Handbook of Statistics database and the IMF's World Economic Outlook database.

To examine both the persistence of commodity price shocks and the order of integration issues, we apply the Modified Dickey–Fuller unit root test to annual data of the log level of CTOT for all individual countries (using constant with trend models and using AIC to determine the appropriate lag length). The results in Table A2 of the online Appendix

[INSERT LINK TO ONLINE FILE A] show that the vast majority of countries (i.e., 63 countries out of 69 at the 5% level of significance) cannot reject the null of a unit root. This is strong evidence that commodity price shocks present high persistence. Please note that the results without trend provide analogous findings. In the same table, the Modified Dickey–Fuller unit root test without trend for the first difference of log CTOT (i.e., growth) shows I(0) series for 66 out of 69 countries. Moreover, the test with trend suggests CTOT growth is I(0) for all countries. Using pairwise correlation coefficients we also confirm that CTOT growth exhibits considerable independence of across countries (see Table A3 of the online Appendix [INSERT LINK TO ONLINE FILE A]).

4.3 Institutional quality, democracy and other variables

As proxies for institutional quality we use (a) data on whether a country is a democracy or autocracy and (b) a distribution of resources index. The source of annual democracy data is Cheibub *et al*. (2010). Democracy is a dummy variable coded 1 for a democratic political regime that matches all the following conditions: the effective executive and legislature are elected (either directly or indirectly), the existence of parties outside the governing party, the existence of multiple parties within the legislature, the alternation rule is not violated, and the incumbents (person, party, military hierarchy) do not unconstitutionally close the lower house of the national legislature and rewrite the rules in their favour (for more details see Cheibub *et al*., 2010).

The distribution of resources index measures the extent to which resources such as healthcare, education, water and housing are distributed in society and is constructed by the Varieties of Democracy (V-Dem) Institute at the University of Gothenburg (see Sigman and Lindberg, 2015, and Lindberg *et al*., 2014). The index itself exists in a range between 0 and 1 where values close to 1 represent an equal distribution and 0, an entirely unequal distribution

of resources. Sigman and Lindberg (2015) suggest that a more equal distribution of resources helps underpin "egalitarian" democracy by allowing more individuals to participate effectively in the political arena.

The source of our measures of financial development (i.e., domestic credit to private sector relative to GDP) and gross primary education enrolment ratio (a percentage of the population of official primary education age) is the World Bank's Development Indicators dataset. The GDP per capita source is Heston *et al.* (2012) (see Penn World Table Version 7.1). Finally, the demographic characteristics data (i.e., percentage of population under 5 and percentage of population over 65) are obtained from the UN Population Division.

Overall, we collect data for 69 countries classified by World Bank as low- and lower-middle-income economies. In total, there are 84 countries allocated to these classifications by the World Bank, however not all countries could be included in our dataset due to availability limitations. We focus on low- to lower-middle-income countries because many of their children consume at or below the subsistence level, making them more vulnerable to commodity price fluctuations. Additionally, focusing on countries with reasonably homogenous economic outcomes allows us to avoid certain selection bias issues. For example, Ross (2006) attributes the positive effect of democracy on the reduction of child mortality, reported by studies such as Zweifel and Navia (2000), Lake and Baum (2001) and Boix (2003) to the sample omission of autocracies with good economic and social achievements whilst including democracies with similarly records. The imposed homogeneity of poor economic outcomes in our study mitigates this particular selection bias.

We decompose the countries selected into commodity exporters and importers, unlike Cavalcanti *et al*. (2014) who decompose countries into exporters and other countries, in order to investigate commodity export dependence. If we crudely classify exporters (importers) as countries with positive (negative) net commodity exports to GDP, our full sample of 69

countries can be separated into two samples of 25 exporters and 44 importers (see section A.4. in the online Appendix [INSERT LINK TO ONLINE FILE A] for a list of countries). Of course, such a demarcation rule doesn't tell us about the magnitude of commodity dependence. The World Economic Outlook (2012) defines commodity exporters as countries with a share of net commodity exports to total goods exports exceeding 10 percent. Taking into account that the CTOT index does not include all commodities and that GDP is used as the denominator, we surmise that in our case a 7 percent threshold seems appropriate and leads to a reasonable number of countries in the highly commodity dependent sub-samples. Specifically, commodity exporters (importers) are defined as countries with the ratio of net commodity exports to GDP that exceeds 7 (-7) percent, resulting in highly commodity-dependent subsamples containing 16 exporter and 19 importer countries. In the following results section, we compare the results of these latter sub-samples with those of the full sample demarcation to highlight the effects of commodity dependence.

5. Empirical results

5.1 Investigating the child mortality and CTOT relationship

Table 1 presents summary statistics of our variables for commodity exporters and importers in both the full and highly commodity-dependent samples.

[Insert Table 1 about here]

Given we have selected low- to lower-middle-income countries, it is unsurprising that annual GDP per capita is low for both exporters and importers, across the full and highly commodity-dependent samples. Moreover, there is a reasonable similarity in summary statistics across the samples, confirming the approximate homogeneity of selected countries. On the other hand, CTOT appears more volatile for importers than exporters (the standard

deviation of CTOT level for heavily commodity-dependent exporters is 76.41, whereas for importers it is 85.67. Carrying out an *F*-test of their equality results in a *p*-value of 0.001). This suggests that commodity price movements within our sample present the potential to be more harmful for importers than exporters. We shall return to this later.

[Insert Table 2 about here]

Table 2, columns 1 and 2, presents the results of estimating (2) for our full sample. Firstly, results indicate that the effect of CTOT growth on the first-difference of infant mortality rates is statistically insignificant for both exporters and importers. This extends the findings of Turnovsky and Chattopadhyay (2003) and Blattman *et al.* (2007) who show that TOT growth is also insignificant for investment and GDP growth, respectively. Blattman *et al.* rationalise their result by suggesting that TOT exhibit weak trend. To investigate the trend of CTOT for both exporters and importers, we pre-test using panel unit-root tests and then estimate the appropriate trend function (see section A.5, tables A5 and A6, in the online Appendix [INSERT LINK TO ONLINE FILE A], for methodology and results). The findings provide evidence of no trend for commodity exporters and a small, negative trend for commodity importers. This suggests the argument of Blattman *et al.* (2007) holds in a CTOT context: the relatively small magnitude of CTOT over our sample period providing an explanation of the insignificant effect of CTOT growth on child mortality.

Turning to the other moment of CTOT in Table 2, columns 1 and 2, the effect of CTOT volatility is also statistically insignificant. It would appear that at this level of stratification, where we haven't separated out heavily commodity-dependent countries, volatility cannot yet be shown to affect mortality. However, the coefficients of the control variables are typically consistent with the empirical and theoretical literature, confirming the validity of IGME's child mortality data. For example, GDP per capita growth significantly decreases child mortality across all categories, supporting previous studies (Pritchett and Summers, 1996,

Cutler *et al.*, 2002, Bhalotra, 2010, and Baird *et al.*, 2011) that demonstrate the role of income in reducing child mortality in poor countries. Strikingly, the significant and mortality-reducing effect of democracy illustrates the role that institutional quality may play in welfare, particularly in low- to lower-middle-income countries. As noted previously, democracies are theorised to produce superior welfare outcomes to autocracies by producing more public goods and progressive income distributions (Zweifel and Navia, 2000, Lake and Baum 2001, Boix, 2003, and Kudamatsu, 2012). This result is in stark contrast to influential work such as Ross (2006) who suggests democracy does not matter for child mortality. Similarly to Ross (2006) our study employs country-level data, however, the finding that democracy reduces child mortality also draws support from the micro evidence of Kudamatsu (2012). His paper compares the survival of babies from the same mother, pre- and post- the arrival of democracy in sub-Saharan Africa, suggesting that democratisation improves wellbeing via changed public health policies. The difference in our study is the explicit focus on low to low-middle income countries where it would appear that political regime becomes an important determinant. Finally, other control variables such as education and development characteristics also tend to present the expected signs. For instance, education and financial development are negatively signed even when they are not significant.

To explore the relationship between child mortality and CTOT in more depth, Table 2, columns 3 and 4, presents the results of estimating (2) for our heavily commodity-dependent samples where only exporters (importers) countries with the ratio of net commodity exports to GDP that exceeds 7 (-7) percent are included. As suggested in the second hypothesis, columns 3 and 4 in Table 2 show that the signs of the coefficients attached to CTOT growth are different for commodity-dependent net importers and exporters; however, given the statistical insignificance, within our estimation framework these are not important effects. A striking difference is that CTOT volatility is now strongly significant at the 1 percent level

for importers, lending support to our third hypothesis outlined in Section 2. Specifically, the positive coefficient here suggests increases in commodity terms-of-trade volatility lead to increases in country child mortality. Why might the significance of this result not carry over to exporter countries in our sample?

[Insert Figure 3 about here]

Figure 3 provides a possible explanation, graphically illustrating that CTOT level and CTOT growth are more volatile for commodity importers than exporters as also earlier reported in the summary statistics of Table 1. Additionally, an F-test for the equality of the standard deviations of CTOT growth for heavy exporters and importers gives a p-value of 0.002, rejecting equivalence. It is this higher instability of importers' CTOT in our sample that makes their children more vulnerable to the identified harmful effect of commodity price volatility. These findings extend our understanding of the adverse outcomes of volatility and reinforce work by Blattman *et al.* (2007) and Van der Ploeg and Poelhekke (2009) suggesting that any adverse effect is stronger in commodity-dependent, highly volatile countries.

We found in earlier results that as a control variable, democracy plays an important role in reducing child mortality in low to lower-middle income countries. Might a deeper, tripartite relationship exist between child mortality, volatility and a proxy for institutional quality, political regime? To investigate, we estimate (3) for our highly commodity-dependent subsamples, explicitly modelling the interactions between democracy (i.e., IQ_H) and CTOT volatility, and autocracy (i.e., IQ_L) and CTOT volatility. Another approach would be to analyze separate samples of autocratic and democratic countries. Results produced are qualitatively similar to those using the interaction methodology.

[Insert Table 3 about here]

Table 3, columns 1 and 2, shows that the interaction variable (i.e., CTOT volatility × political regime) is only significant for autocracies. This may indicate that the higher institutional

quality as proxied by democratic governance, lowers infant mortality in commodity-dependent countries by mitigating the adverse effect of volatility. Notably though, the magnitudes of the coefficients for autocracy and democracy interaction variables (i.e., 5.887** and 6.901 respectively) are not dissimilar and a test for equality cannot be rejected (i.e., *p*-value of 0.482). This suggests further investigation is required to ascertain the role of institutional quality.

Other measures of institutional quality may be more appropriate. In particular, the estimations above employ the democracy data from Cheibub *et al*. (2010), where we have transformed the annual frequency into five-year period averages by selecting the modal value for each of those five-year periods. A more suitable approach might be to employ the modal value for whole sample period. This helps us address the issue raised in the literature (see *inter alia*, Roland, 2004) that institutions may change at a slower rate than political regimes.

Table 3, columns 3 and 4, re-estimates (3) for our highly commodity-dependent subsamples but now the political regime for each country is indicated by a single modal value for the whole sample period. Again, the interaction variable (i.e., CTOT volatility × political regime) is only significant for autocracies. However, this time the magnitudes of the coefficients for autocracy and democracy interaction variables (i.e., 7.145*** and -2.386 respectively) are of different sign and a test for equality can be clearly rejected (i.e., *p*-value of 0.011). This offers evidence that high institutional quality inhibits the negative effects of commodity price fluctuations on infant mortality, as posited in our fourth hypothesis from Section 2.

5.2 Decomposing volatility

To shed light on possible channels by which volatility impacts infant mortality, we decompose countries' CTOT into energy and non-energy CTOT. Note that the non-energy

basket for heavily commodity-dependent importers mainly consists of food commodities (see Figure 4) whilst heavily commodity-dependent exporters are relatively better diversified. We examine this dichotomy because (i) previous work suggests a linkage between food prices and child mortality, (ii) data availability (see Section 4.2) dictates the split between energy and non-energy commodities, and (iii) although underexplored, a prima facie case could be made that energy price movements are likely to be crucial to welfare measures such as child mortality (in particular, one might consider the growing influence of the energy-food nexus.)

[Insert Figure 4 about here]

[Insert Table 4 about here]

Table 4 presents the results of estimating (2) for our heavily commodity-dependent samples, where we employ the growth and volatility of both energy and non-energy CTOT as explanatory variables. Energy volatility is significant and positively signed for importers only, whereas CTOT non-energy volatility is insignificant, supporting our first hypothesis from Section 2. Note that the sign and significance of our control variables remains similar when comparing Table 4 with columns 3 and 4 in Table 2. Overall, this is suggestive that energy commodities dominate the volatility effect caused by CTOT. In other words, it would therefore appear as if movements in global food commodity prices are subordinate to those of energy when considering the impact on child mortality.

5.3. Robustness

5.3.1. Top quartile of countries ranked by magnitude of CTOT volatility

In the above analysis we have distinguished between exporters, importers and commodity dependence when examining the effect of CTOT volatility. However, it follows that if the volatility channel is important, it will show clearly in samples that contain countries that present the largest volatility. Therefore, in a robustness check for the mortality-volatility

relationship, we estimate (2) for a sample that contains the top quartile of countries when they are ranked by the magnitude of CTOT volatility.

[Insert Table 5 about here]

Table 5 shows the relevant results and again demonstrates the significance of CTOT volatility. Overall then, our analysis suggests that fluctuations in commodity terms-of-trade are an important determinant for child mortality in low- to lower-middle-income countries. Specifically, greater volatility *ceteris paribus* leads to an increase in the infant mortality rate and this occurs particularly where volatility is already relatively large. Policy advice would include improving the quality of institutions and diversifying the trade portfolio to smooth the time series of net exports.

5.3.2. Using different thresholds

Until now we have defined heavily commodity-dependent exporters (importers) as countries with the ratio of net commodity exports to GDP that exceeds 7 (-7) percent, resulting in subsamples containing 16 exporter and 19 importer countries. The threshold is chosen so we can examine heavily commodity-dependent countries but still have a sufficient number of countries to allow for appropriate econometric testing. If we choose a much lower threshold (e.g., 3% and -3%) one might expect a priori that the *t*-statistic of importer CTOT volatility in regression (2) to indicate insignificance. This is because we are now including more countries that are less commodity-dependent and therefore less likely to be sensitive to commodity price movements.

[Insert Table 6 about here]

We re-estimate (2) for 3% and -3% and indeed, this is what is found (see Table 6). However, when we estimate regression (2) for other high thresholds (i.e., 6% and -6%, 8% and -8%) the

t-statistics of importer CTOT volatility become significant at conventional levels (also see Table 6).

5.3.3. Using another measure of institutional quality

Estimating regression (3) for our heavily commodity-dependent subsamples and using the democracy data from Cheibub *et al*. (2010) as a proxy for institutional quality, Table 3, columns 3 and 4, revealed previously that the interaction variable (i.e., CTOT volatility × political regime) is only significant for autocracies. In this section, we now use the distribution of resources index constructed by the Varieties of Democracy (V-Dem) Institute at the University of Gothenburg (see section 4.3) as another proxy for institutional quality. Table 3, columns 5 and 6, shows the estimation of (3) with this proxy. Here we operationalize the index by calculating its average value for each five-year period and then generating a dummy equal to 1 if the average is in top Quartile (i.e., a fair distribution of resources) and 0 otherwise (i.e., a poor distribution of resources). Interestingly, in Table 3, the results in columns 5 and 6, are analogous to those in columns 3 and 4. The interaction variable (i.e., CTOT volatility × distribution of resources) is only significant for the poor distribution of resources. Indeed, the magnitude of the coefficients for poor and fair distribution interaction variables (i.e., 8.134*** and -4.653 respectively) are of different sign and a test for equality can be clearly rejected (i.e., *p*-value of 0.006). This provides further evidence that good institutional quality mitigates the adverse effects of commodity price movements on infant mortality rates.

6. Conclusion

This study sheds a new light on the relationship between child mortality and commodity prices by investigating theoretically and empirically the political and economic aspects that

may influence any association. Our theoretical framework posits four hypotheses: (1) food prices are not the only commodity price that affects child mortality rates in commodity-dependent countries; (2) level changes in commodity prices can have different directional effects on net exporters and importers, (3) commodity price volatility adversely affects the rate of infant mortality; (4) better institutions limit this effect.

Employing a sample of 69 low and lower-middle income countries over the period of 1970-2010, we find that the volatility of the country-specific commodity terms-of-trade index (CTOT) links global commodity prices with child mortality in commodity-dependent countries, in line with our third hypothesis. These volatility effects dominate the level effects posited in our second hypothesis. The resource curse literature traditionally focuses on commodity-dependent exporters, but the curse in our paper affects mainly highly commodity-dependent importers, thus giving a resource-scarcity aspect to the curse. The differential effects on exporters and importers appear to be largely due to the higher CTOT volatility of importers and their sensitivity to energy price volatility, consistent with our first hypothesis. In turn, this is related to the better diversification of exporters and consequently, a relative lack of sensitivity to volatile energy prices.

From a policy perspective, our findings highlight the importance of reducing commodity terms-of-trade volatility, especially for commodity-importing nations. To circumvent the harmful effect of commodity price volatility on child mortality, financial hedging of energy imports can clearly play an important role. For example, the Reserve Bank of India recently suggested the country hedges its oil imports (Reuters, 2014). Although requiring longer-term planning, reducing commodity-dependence by shifting toward import substitution and/or increasing domestic energy production, and developing manufacturing and services sectors should also help avoid the curse we discuss in this paper.

Improving the quality of institutions is another option for domestic policymakers. Our model proxies institutional quality by using data on democracy and fair distribution of resources; results reveal better institutions lower child mortality by explicitly moderating the adverse effect of CTOT volatility, as posited by the fourth hypothesis. Strikingly, there appears to be a tripartite relationship between child mortality, volatility and good institutions in commodity-dependent countries. A strategic combination of hedging, diversification and improvement of institutional quality appears likely to be the most effective approach to improving child wellbeing in low- to lower-middle-income countries.

There are several avenues for future work. For example, the CTOT measure used in this paper relies on time-averaged export and import weights and therefore reflects movements in commodity prices only. However, the child mortality effects of variations in CTOT due to changes in the share of exports and imports might also be significant; analysing those would require the construction of a new variable. Moreover, data quality and availability meant a maximum sample of 69 low and middle-income countries could be used in this paper. Recent improvements in data quality are likely to lead to larger samples in the future.

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Tables

Table 1

Summary statistics

	Obs.	Mean	S.D.	Obs.	Mean	S.D.
	Full sample					
	Commodity exporters			Commodity importers		
Mortality under 5	992	129.496	68.519	1703	123.707	74.515
CTOT level	1000	129.074	70.144	1760	154.020	80.610
GDP per capita	960	1710.26	977.023	1601	1819.40	1444.574
Financial development	831	18.876	14.438	1384	19.241	12.088
Primary education enrolment	858	85.064	27.931	1435	82.444	30.123
Population over age 65	1000	3.420	0.784	1760	4.014	2.277
Population under age 5	1000	16.629	2.549	1760	15.807	3.598
	Heavily-dependent					
	Commodity exporters			Commodity importers		
Mortality under 5	632	133.564	72.165	708	110.106	75.935
CTOT level	640	123.556	76.411	760	148.597	85.671
GDP per capita	600	1977.31	889.986	623	1899.60	1367.860
Financial development	537	18.642	12.012	503	19.371	13.994
Primary education enrolment	550	85.286	27.492	552	80.678	31.318
Population over age 65	640	3.386	0.649	760	4.669	3.170
Population under age 5	640	16.643	2.295	760	14.849	4.298

Notes: Heavily commodity-dependent countries have a ratio of net commodity exports to GDP that exceeds 7 (-7) percent.

Table 2

Child mortality, CTOT growth and volatility, 1970-2010.

	(1)	(2)	(3)	(4)
	Full sample		Commodity-dependent	
	Commodity exporters Cluster SE	Commodity importers Cluster SE	Commodity exporters Cluster SE	Commodity importers Cluster SE
CTOT growth	-0.151	-0.517	-0.955	0.956
	(2.021)	(2.026)	(2.557)	(3.382)
CTOT volatility	-0.0323	0.411	0.487	6.006***
	(1.949)	(1.567)	(1.884)	(1.966)
Democracy dummy	-0.870*	-1.046**	-0.750	-0.988
	(0.463)	(0.417)	(0.566)	(0.726)
GDP per capita growth	-24.84***	-20.23***	-20.72***	-13.43**
	(4.095)	(5.002)	(4.939)	(5.985)
Δ(Primary education enrolment ratio)	-9.906***	-0.984	-14.62**	6.905
	(3.513)	(3.407)	(5.365)	(4.493)
Δ(Financial development)	-2.075*	-0.865	-3.624***	-3.830**
	(1.180)	(1.170)	(1.144)	(1.685)
Δ(Population over age 65)	14.11	-24.31*	16.78	-19.34
	(16.25)	(12.11)	(17.87)	(17.83)
Δ(Population under age 5)	43.76***	-21.70*	52.24***	-1.392
	(10.40)	(12.05)	(16.09)	(11.24)
Constant	-1.324**	-1.365**	-1.583**	-3.413***
	(0.550)	(0.614)	(0.604)	(0.551)
Year dummy	Y	Y	Y	Y
Observations /Country	164/25	269/44	104/16	97/19
Adjusted R^2	0.332	0.238	0.329	0.247

Notes. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the first-difference of the logarithm of under-five mortality rate. Heavily commodity-dependent countries have a ratio of net commodity exports to GDP that exceeds 7 (-7) percent.

Table 3

Child mortality, CTOT growth and volatility/regime interaction effect for heavily commodity-dependent countries, 1970-2010

	(1)	(2)	(3)	(4)	(5)	(6)
	5-year democracy		Modal democracy		Distribution of resources	
	Commodity exporters Cluster SE	Commodity importers Cluster SE	Commodity exporters Cluster SE	Commodity importers Cluster SE	Commodity exporters Cluster SE	Commodity importers Cluster SE
CTOT volatility × autocracy	0.906	5.887**	1.601	7.145***		
	(1.835)	(2.143)	(2.332)	(1.679)		
CTOT volatility × democracy	-2.449	6.901	0.882	-2.386		
	(6.224)	(6.432)	(3.844)	(3.112)		
CTOT volatility × poor distribution of resources					1.247	8.134***
					(1.607)	(1.885)
CTOT volatility × fair distribution of resources					2.659	-4.653
					(10.29)	(3.967)
CTOT growth	-1.234	0.902	-0.541	-0.0115	-1.093	2.291*
	(2.746)	(3.398)	(2.488)	(3.702)	(1.275)	(1.115)
Democracy dummy	-0.351	-1.120	-0.786	1.202	0.586	1.816
	(0.973)	(1.520)	(1.160)	(0.702)	(1.809)	(2.421)
GDP per capita growth	-20.33***	-13.37**	-14.28**	-8.191	-20.54***	-9.093**
	(4.860)	(6.170)	(5.955)	(7.314)	(5.011)	(4.252)
Δ(Primary education enrolment ratio)	-13.94**	6.800	-11.02**	-3.606	-12.16**	0.139
	(5.433)	(4.776)	(4.882)	(4.541)	(4.848)	(5.761)

Δ(Financial development)	-3.600***	-3.860**	-7.387***	-4.810**	-4.902***	-4.843***
	(1.182)	(1.723)	(2.317)	(2.091)	(0.917)	(1.404)
Δ(Population over age 65)	17.21	-18.92	6.014	-32.44	0.570	-20.47
	(18.67)	(18.50)	(17.41)	(27.72)	(13.05)	(17.08)
Δ(Population under age 5)	53.20***	-1.162	17.27	3.815	40.74***	0.673
	(16.85)	(11.81)	(25.99)	(15.62)	(12.97)	(11.04)
Constant	-1.737**	-3.389***	-1.706	-4.184***	-1.732**	-4.146***
	(0.632)	(0.563)	(0.986)	(0.542)	(0.601)	(0.722)
Year dummy	Y	Y	Y	Y	Y	Y
F-test	0.592	0.482	0.878	0.011	0.891	0.006
Observations /Country	104/16	97/19	90/15	84/19	16/104	18/94
Adjusted R^2	0.323	0.238	0.304	0.171	0.341	0.320

Notes. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heavily commodity-dependent countries have a ratio of net commodity exports to GDP that exceeds 7 (-7) percent. *F*-test is the *p*-value of a test of equality between the coefficients on the interaction terms (i.e., $H_0: \beta_2 = \beta_3$) in (3). The dependent variable is the first-difference of the logarithm of under-five mortality rate. "5-year democracy" – democracy/autocracy variable computed as the modal value of the corresponding index in each 5-year period. "Modal democracy" – democracy/autocracy variable computed as the modal value of the corresponding index over the whole period 1970-2010. "Distribution of resources" – the model with institutional quality proxied by the distribution of resources index.

Table 4

Child mortality, growth and volatility of energy CTOT and non-energy CTOT in heavily commodity-dependent countries, 1970-2010

	(1) Commodity exporters Cluster SE	(2) Commodity importers Cluster SE
Non-Energy TOT volatility	-2.145	0.0438
	(4.694)	(4.686)
Energy TOT volatility	1.418	11.01***
	(2.602)	(2.197)
Non-Energy TOT growth	-1.070	6.618
	(2.943)	(4.967)
Energy TOT growth	-1.550	2.656
	(2.848)	(2.803)
Democracy dummy	-0.783	-1.338*
	(0.598)	(0.723)
GDP per capita growth	-21.09***	-18.61***
	(5.052)	(6.067)
Δ(Primary education enrolment ratio)	-14.24**	0.448
	(5.382)	(7.215)
Δ(Financial development)	-3.651***	-5.255
	(1.162)	(3.510)
Δ(Population over age 65)	18.09	-17.44
	(16.86)	(19.64)
Δ(Population under age 5)	53.48***	2.846
	(16.20)	(14.05)
Constant	-1.548*	-2.991***
	(0.802)	(0.786)
Year dummy	Y	Y
Observations	104	76
Adjusted R^2	0.318	0.243

Notes. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heavily commodity-dependent countries have a ratio of net commodity exports to GDP that exceeds 7 (-7) percent. The dependent variable is the first-difference of the logarithm of under-five mortality rate.

Table 5

Child mortality, CTOT growth and volatility for countries with top quartile CTOT volatility

1970-2010

	(1) Rest of sample Cluster SE	(2) Top Quartile Cluster SE
CTOT growth	-0.740	3.353
	(1.590)	(2.386)
CTOT Volatility	-0.960	5.104*
	(1.567)	(2.700)
GDP per capita growth	-0.812**	-1.922**
	(0.322)	(0.818)
Democracy dummy	-24.26***	-14.35*
	(3.452)	(8.201)
Δ(Financial development)	-8.175***	6.943
	(2.739)	(5.217)
Δ(Primary education enrolment ratio)	-1.205	-1.588
	(1.139)	(1.683)
Δ(Population over age 65)	-14.20	26.44
	(10.03)	(29.57)
Δ(Population under age 5)	9.172	-49.39***
	(7.832)	(16.54)
Constant	-1.091**	-2.210*
	(0.517)	(1.251)
Year dummy	Y	Y
Observations /Country	331/52	102/17
Adjusted R^2	0.278	0.285

Notes. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the first-difference of the logarithm of under-five mortality rate.

Table 6

Child mortality, CTOT growth and volatility with different thresholds, 1970-2010

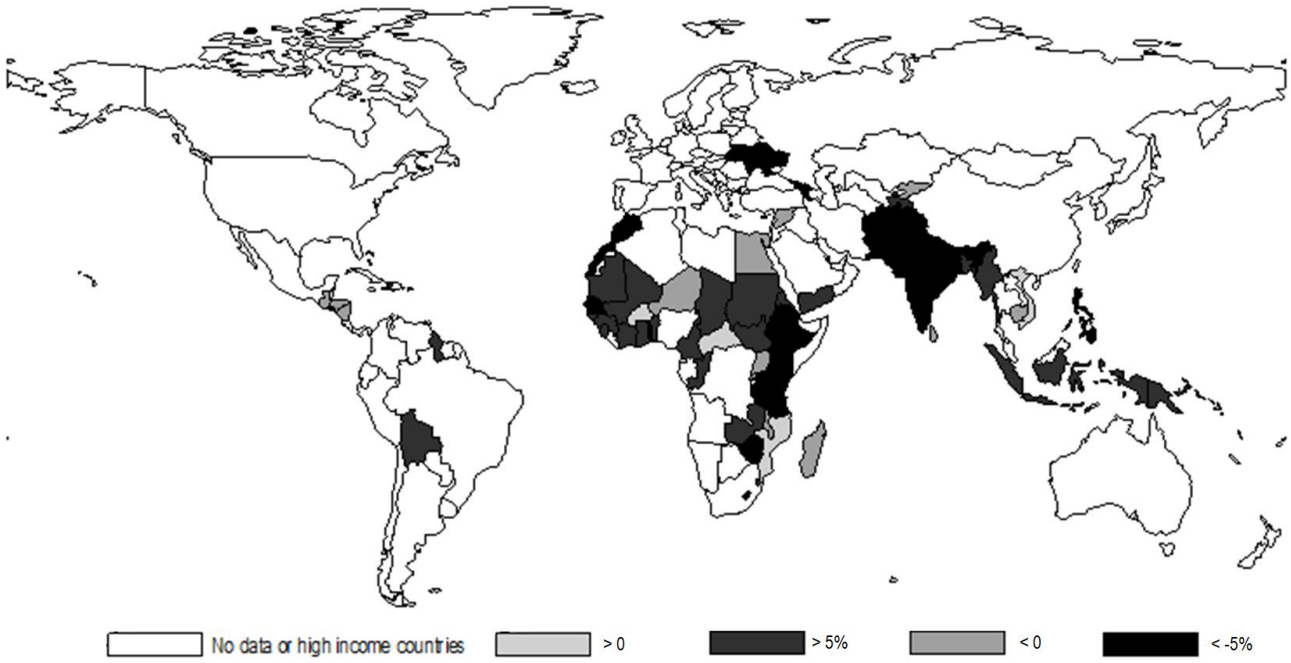
Threshold	3%		6%		8%	
	(1)	(2)	(3)	(4)	(5)	(6)
	Exporters	Importers	Exporters	Importers	Exporters	Importers
	Cluster SE	Cluster SE	Cluster SE	Cluster SE	Cluster SE	Cluster SE
CTOT growth	-0.559	0.400	-1.092	0.681	-1.682	0.490
	(2.160)	(1.823)	(2.443)	(1.900)	(2.568)	(4.124)
CTOT volatility	0.971	1.548	0.660	3.589*	1.222	4.205**
	(1.551)	(1.531)	(1.693)	(2.059)	(2.618)	(1.807)
Democracy dummy	-0.574	-0.668	-0.756	-0.627	-0.773	-1.151
	(0.448)	(0.492)	(0.528)	(0.707)	(0.599)	(1.175)
GDP per capita growth	-20.67***	-12.00**	-19.68***	-12.21*	-22.27***	-9.516
	(3.463)	(5.594)	(3.885)	(5.948)	(5.176)	(7.867)
Δ(Primary education enrolment ratio)	-11.03***	1.827	-13.98**	4.196	-11.70*	5.219
	(3.142)	(3.350)	(5.275)	(4.104)	(5.489)	(7.353)
Δ(Financial development)	-1.758	-3.486***	-2.745*	-4.005**	-3.608**	-2.938
	(1.035)	(1.209)	(1.318)	(1.605)	(1.416)	(1.756)
Δ(Population over age 65)	6.671	-20.29	6.643	-18.03	14.51	-25.47
	(14.06)	(15.33)	(17.83)	(16.45)	(16.72)	(19.38)
Δ(Population under age 5)	42.67***	-3.131	45.62***	-1.703	53.62***	-14.08
	(11.27)	(11.13)	(12.61)	(10.55)	(15.66)	(12.01)
Constant	-1.682***	-1.960***	-1.667***	-2.806***	-1.850*	-3.199***
	(0.524)	(0.694)	(0.570)	(0.602)	(0.886)	(0.695)
Year dummy	Y	Y	Y	Y	Y	Y
Obs./country	143/22	146/27	114/18	103/20	92/14	71/14
Adjusted R^2	0.319	0.200	0.314	0.210	0.300	0.166

Notes. Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the first-difference of the logarithm of under-five mortality rate.

FIGURES

Figure 1

Commodity dependence of low and lower-middle income countries (average net commodity export to GDP, 2005-10)



Note. For sources of data, see Section 4.

Figure 2

Transmission channels of the effects of movements in commodity prices on child mortality.

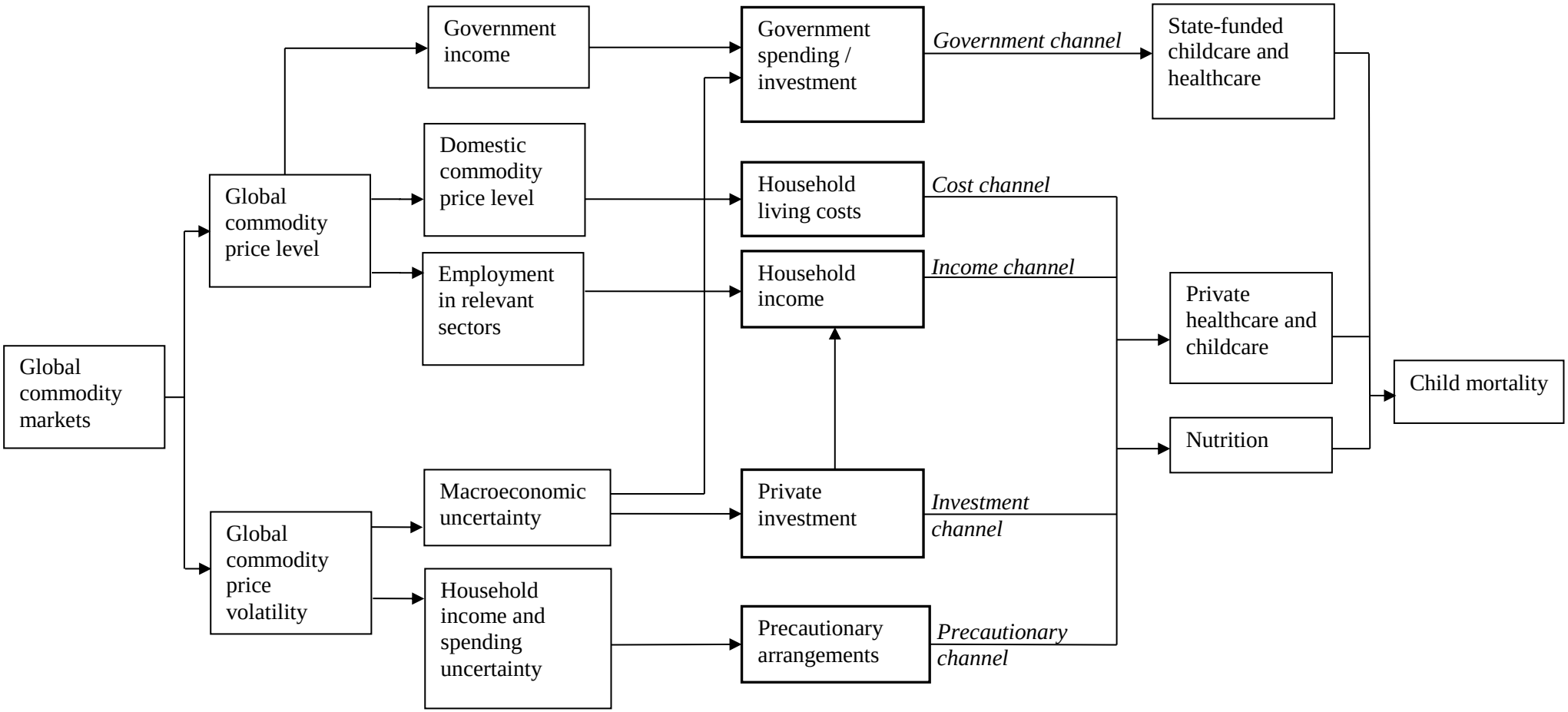


Figure 3

CTOT level and growth over time for heavily commodity-dependent exporters and importers

(net exports to GDP above 7% and below -7% respectively)

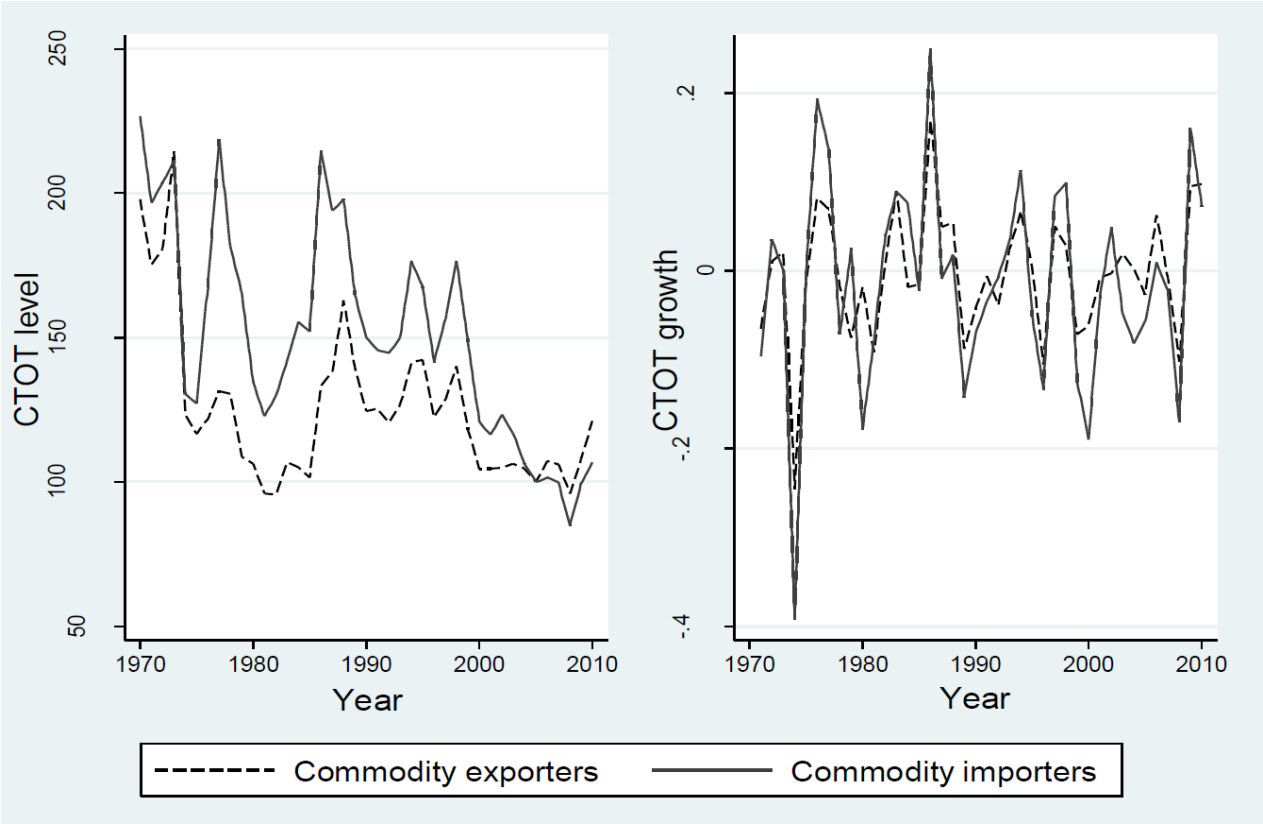
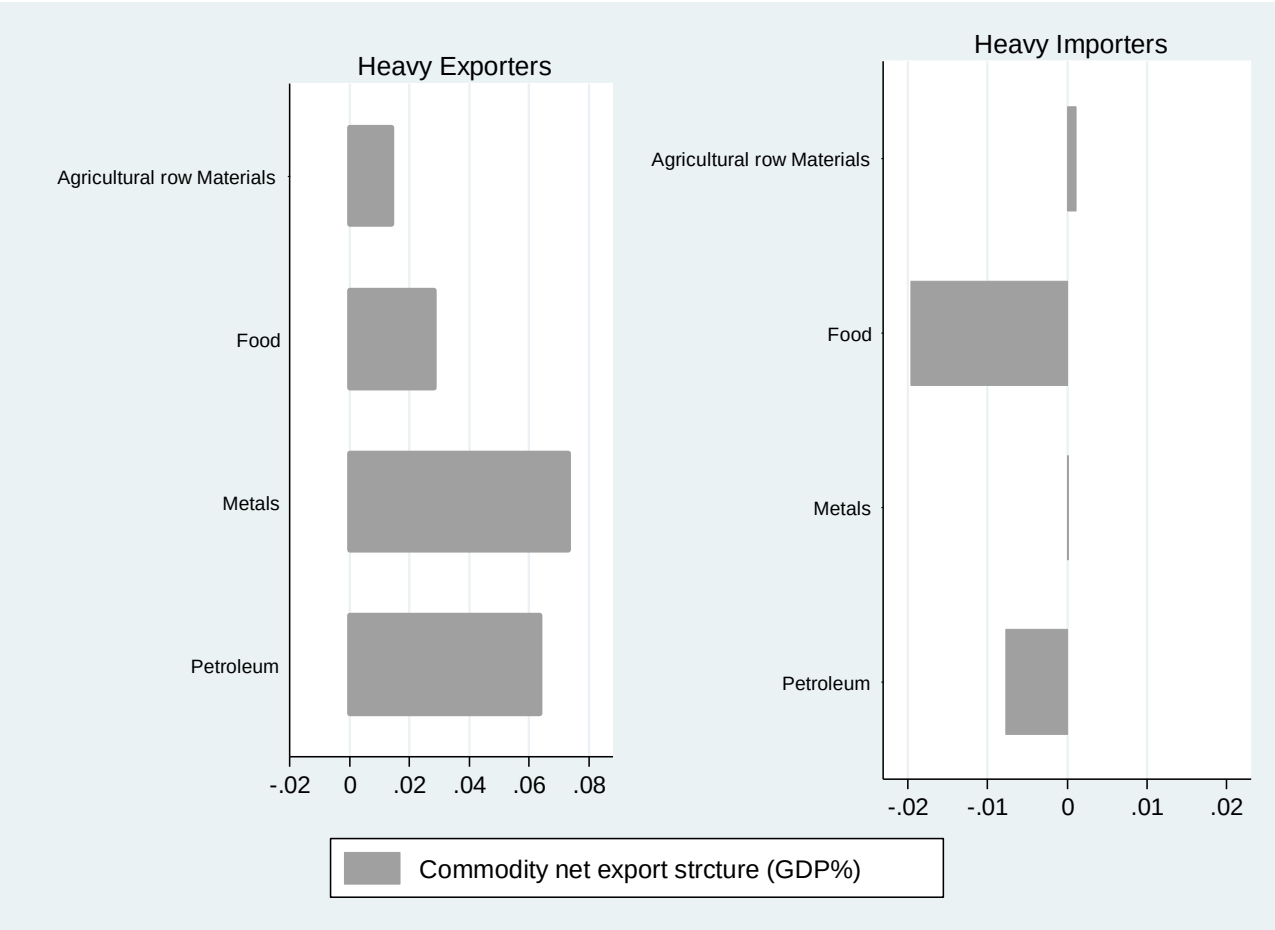


Figure 4

Structure of net commodity export of heavily commodity-dependent countries

(net exports to GDP above 7% and below -7% respectively)



Appendix A

A.1. Panel unit root tests for child mortality

Table A1

Panel unit root tests

Series	*t*-Statistic	*p*-value	L
IPS test			
Child mortality *without trend*	0.10	0.84	2.01
Child mortality *with trend*	-1.49	0.68	1.88
Child mortality growth	-5.07	0.00	1.78
Fisher test			
Child mortality *without trend*	-1.24	0.11	3
Child mortality *with trend*	-1.30	0.10	3
Child mortality growth	-5.25	0.00	3

Notes: *p* value represents the probability that the null hypothesis is true. L represents the (average) lag length.

A.2 Modified Dickey–Fuller unit root tests for CTOT level and growth

Table A2

Modified Dickey–Fuller unit root test

	CTOT Level		CTOT growth	
Country	Test statistic	lag	Test statistic	lag
Afghanistan	-2.768	1	-4.894***	1
Armenia	-2.135	1	-2.688***	1
Bangladesh	-1.117	1	-3.567***	1
Benin	-2.396	1	-4.404***	1
Bhutan	-1.373	1	-1.835	2
Bolivia	-1.894	1	-3.589***	1
Burkina Faso	-2.385	1	-4.441***	1
Burundi	-2.662	1	-4.008***	1
Cabo Verde	-1.717	1	-4.3***	1
Cameroon	-4.372**	1	-4.822***	1
Central African Republic	-1.859	1	-3.862***	1
Comoros	-2.546	1	-3.751***	1
Congo, Rep.	-1.87	1	-4.157***	1
Cote d'Ivoire	-3.135	1	-3.924***	1
Djibouti	-1.743	1	-3.833***	1
Egypt, Arab Rep.	-1.72	1	-3.804***	1
El Salvador	-2.593	1	-4.053***	1
Eritrea	-1.366	1	-3.835***	1
Ethiopia	-2.594	1	-3.953***	1
Gambia, The	-1.251	1	-4.952***	1
Georgia	-2.387	1	-3.543***	1
Ghana	-3.641**	1	-4.128***	1
Guatemala	-2.217	1	-3.971***	1
Guinea	-2.528	1	-4.385***	1
Guinea-Bissau	-4.112***	1	-5.032***	1
Guyana	-2.188	1	-4.154***	1

Honduras	-2.28	1	-3.982***	1
India	-1.928	1	-3.646***	1
Indonesia	-1.791	1	-2.941***	1
Kenya	-2.16	1	-3.344***	1
Kyrgyz Republic	-2.186	1	-5.352***	1
Lesotho	-2.177	1	-3.815***	1
Madagascar	-1.936	1	-4.066***	1
Malawi	-1.886	1	-4.848***	1
Mali	-2.257	1	-4.78***	1
Mauritania	-0.732	1	-3.215***	1
Moldova	-2.208	1	-4.41***	1
Mongolia	-1.891	1	-1.439	2
Morocco	-1.829	1	-4.408***	1
Mozambique	-2.141	1	-4.602***	1
Nepal	-1.629	1	-3.884***	1
Nicaragua	-2.281	1	-4.19***	1
Niger	-2.425	1	-4.43***	1
Nigeria	-1.552	1	-3.79***	1
Pakistan	-1.851	1	-3.491***	1
Papua New Guinea	-2.605	3	-2.453**	2
Paraguay	-2.053	1	-3.892***	1
Philippines	-2.007	1	-3.689***	1
Rwanda	-3.29*	2	-3.571***	1
Samoa	-1.743	1	-4.651***	1
Sao Tome and Principe	-4.392***	1	-4.139***	1
Senegal	-0.624	2	-2.014***	2
Sierra Leone	-2.45	1	-3.873***	1
Solomon Islands	-3.718**	1	-4.85***	1
Sri Lanka	-2.106	1	-3.043***	1
Sudan	-1.868	1	-4.042***	1
Swaziland	-4.645***	8	-4.82***	1
Syrian Arab Republic	-1.684	1	-3.267***	1
Tajikistan	-2.734	1	-4.486***	1

Tanzania	-1.969	1	-4.351***	1
Timor-Leste	-2.402	1	-3.932***	1
Togo	-2.256	1	-4.607***	1
Uganda	-2.632	1	-3.977***	1
Ukraine	-2.443	1	-4.83***	1
Vanuatu	-2.222	1	-4.527***	1
Vietnam	-3.094	1	-5.172***	1
Yemen, Rep.	-1.769	1	-3.907***	1
Zambia	-1.662	1	-1.256	2
Zimbabwe	-2.123	1	-4.242***	1

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

A.3. Average pairwise correlation coefficient for CTOT growth

Table A3

Average pairwise correlation coefficient

Sample	*Correlation coefficient*
Annual data: Full sample	0.298
Annual data: All exporters	0.204
Annual data: All importers	0.348
Annual data: Heavy exporters	0.109
Annual data: Heavy importers	0.331
5-year obs: Full sample	0.262
5-year obs: All exporters	0.194
5-year obs: All importers	0.295
5-year obs: Heavy exporters	0.109
5-year obs: Heavy importers	0.264

A.4. List of Countries

Table A4

Commodity Exporters (25 countries)	Commodity Importers (44 countries)
Bolivia*	Afghanistan*[a]
Burundi [a]	Armenia*
Cameroon*	Bangladesh
Congo, Rep.*	Benin
Cote d'Ivoire*	Bhutan*
Ghana	Burkina Faso
Guinea*	Cabo Verde* [a]
Guyana*	Central African Rep.
Honduras [a]	Comoros [a]
Indonesia	Djibouti*
Mali*	Egypt, Arab Rep.
Mauritania*	El Salvador
Mongolia* [a]	Eritrea* [a]
Mozambique	Ethiopia [a]
Nigeria*	Gambia, The*
Papua New Guinea*	Georgia*
Paraguay* [a]	Guatemala
Sudan	Guinea-Bissau
Syrian Arab Rep.*	India
Tajikistan*	Kenya
Uganda [a]	Kyrgyz Rep.
Vietnam	Lesotho*
Yemen, Rep.*	Madagascar
Zambia*	Malawi
Zimbabwe	Moldova*
	Morocco*
	Nepal*
	Nicaragua [a]
	Niger [a]
	Pakistan

	Philippines
	Rwanda [a]
	Samoa*
	Sao Tome and Principe* [a]
	Senegal*
	Sierra Leone* [a]
	Solomon Islands*
	Sri Lanka
	Swaziland [a]
	Tanzania
	Timor-Leste* [a]
	Togo
	Ukraine*
	Vanuatu

Note. * refers to highly commodity-dependent exporters/importers. [a] refers to the top quartile of countries when they are ranked by the magnitude of CTOT volatility.

A.5. Trend tests for CTOT

To test for a panel unit root, we employ Levin–Lin–Chu (LLC) panel test and the Im–Pesaran–Shin (IPS) panel test. Based on these unit root test results, we estimate CTOT trend as follows:

If $lnCTOT_{it}$ is stationary, we estimate the following TS model:

$$lnCTOT_{it} = \alpha + \beta_i Trend_{it} + \eta_i + \varepsilon_{it}. \quad \text{(A1)}$$

Otherwise, if $lnCTOT_{it}$ is non-stationary, we estimate the following DS model:

$$\Delta lnCTOT_{it} = \beta_i + \varepsilon_{it} \quad \text{(A2)}$$

where $Trend_{it}$ is a time trend, η_i is the country-specific effect and ε_{it} is the error term. The error terms are clustered at the country level to account for the possibility of correlated disturbances within each country. β_i represents the trend coefficient in both TS and DS models.

Table A5 gives the results of both LLC and IPS unit root tests. The results show that both tests reject the null hypothesis of a unit-root (all series contain a unit root) in CTOT level in favour of the alternative that some series are stationary, for both exporters and importers. Of course, given the individual unit root tests in Table A2, this result does not come as a surprise.

Estimates of the TS model (A1) are shown in the top section of Table A6 and illustrate that commodity importers, but not exporters, present a significant trend. However, this trend looks small at approximately -0.010. As robustness check, we estimate the DS model (A2) for all sub-groups and the results (see the bottom section of Table A6) support the TS model findings of a small trend for importers and no trend for exporters.

Table A5

Panel unit root tests

Series	t-Statistic	*p* value	L
LLC test			
All commodity exporters	-2.370***	0.009	1.96
All commodity importers	-6.679***	0.000	2.16
Heavy commodity exporters	-1.542*	0.061	1.94
Heavy commodity importers	-5.183***	0.000	2.42
IPS test			
All commodity exporters	-3.598***	0.000	1.96
All commodity importers	-6.347***	0.000	2.16
Heavy commodity exporters	-2.659***	0.004	1.94
Heavy commodity importers	-4.824***	0.000	2.42

Notes. *t* statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01. L is the lag average used for the ADF regressions performed in computing the test statistic (chosen by AIC). The method proposed in Levin, Lin, and Chu (2002) has been used to estimate the long-run variance of each panel's series with maxlags $= 3.21T^{1/3}$. Therefore since T=41, the maxlags is 11. For the benchmark samples, commodity exporters (importers) are the countries with positive (negative) net commodity exports to GDP. The sub-samples include only highly commodity-dependent exporters (importers) where net exports to GDP exceed 7 (-7) percent.

Table A6

Trend tests

	(1) All commodity exporters	(2) All commodity importers	(3) Heavily-dependent commodity exporters	(4) Heavily-dependent commodity importers
Trend	-0.005	-0.013***	-0.002	-0.010**
	(-1.52)	(-5.79)	(-0.38)	(-2.70)
Constant	4.852***	5.200***	4.720***	5.098***
	(74.61)	(113.18)	(52.92)	(68.38)
Obs./countries	1025/25	1804/44	656/16	779/19
Constant	-0.006	-0.015***	-0.003	-0.013***
	(-1.36)	(-4.65)	(-0.46)	(-3.25)
Obs./countries	1000/25	1760/44	640/16	760/19

Notes. *t* statistics in parentheses, * p<0.10, ** p<0.05, *** p<0.01. The sub-samples include only heavily commodity-dependent exporters (importers) where net exports to GDP exceed 7 (-7) percent