Data Supplement for Commodity Price Volatility and the Sources of Growth*

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May 1, 2014

*For the full version of the paper see: http://www.econ.cam.ac.uk/people/cto/km418/RMC.pdf. The dataset is available from: http://people.ds.cam.ac.uk/km418

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A Data

To empirically test the relationship between economic growth and commodity terms of trade (CToT) growth and volatility, we use annual data from 1970 to 2007 on: real GDP per capita, a CToT index based on the prices of 32 primary commodities,[1] and other important determinants of growth such as trade openness, government burden, lack of price stability, and human capital.[2] Since we are also interested in testing whether export diversification enhances growth in our sample of countries, we use a measure of export sophistication developed by Hausmann et al. (2007) in our regressions. This index measures the benefits of diversifying the economy away from primary products to manufacturing and services, and thus towards productivity-enhancing goods. For details on the construction of these variables and sources of the data used, see Table A.1.

While this paper initially investigates the economic growth effects of CToT growth and volatility for the full sample of 118 countries, it also tests whether this relationship is dependent on a country being a primary commodity exporter. As such, we split our sample into two subsets, with the first consisting of 62 primary commodity exporting countries, defining them as those for which the ratio of primary commodities to total exports exceeds 50 percent.[3] The second subsample consists of the remaining 56 countries, which have a more diversified export structure. For a complete list of all the countries, see Table A.2.

A.1 Commodity Terms of Trade

Our country-specific measure of the CToT index is from Spatafora and Tytell (2009), and is defined as:

$$CToT_{it} = \prod_j \left(\frac{P_{jt}}{MUV_t}\right)^{X_{ij}} / \prod_j \left(\frac{P_{jt}}{MUV_t}\right)^{M_{ij}}, \tag{A.1}$$

where MUV_t is a manufacturing unit value index used as a deflator, X_{ij} (M_{ij}) is the share of exports (imports) of commodity j in country i's GDP, and P_{jt} is the individual commodity price.[4] By construction, the movements in the CToT index are due to changes in commodity prices as the export and import shares are taken to be constant over time. For empirical application, we calculate X_{ij} and M_{ij} as the average value of these shares between 1970 and 2007. The CToT index allows countries to be influenced by changes in commodity prices differently, depending on the composition of their export and import baskets. This is in contrast to the "standard" commodity

[1] The commodities are: shrimp, beef, lamb, wheat, rice, corn, bananas, sugar, coffee, cocoa, tea, soybean meal, fish meal, hides, soybeans, natural rubber, hardlog, cotton, wool, iron ore, copper, nickel, aluminum, lead, zinc, tin, soy oil, sunflower oil, palm oil, coconut oil, gold, and crude oil.

[2] In the growth literature government burden is defined as the ratio of government consumption to GDP, while lack of price stability is defined as log(100 + inflation rate), see for instance Aghion et al. (2009).

[3] This ratio is calculated based on data from the United Nations Conference on Trade and Development online database using SITC 0, 1, 2, 3, 4, 68, 667, and 971.

[4] A similar measure is also used by Lee et al. (2008).

Table A.1: Definitions and Sources of Variables Used in Regression Analysis

Variable	**Definition and Construction**	**Source**
Real GDP per Capita	Ratio of GDP (in 2000 US$) to population.	Authors' construction using data from the World Bank (2010) World Development Indicators (WDI).
GDP per Capita Growth	Geometric average growth rate of real GDP per capita.	
Initial GDP per Capita	Initial value of GDP per capita in the beginning of each five-year period.	
TFP	Total factor productivity (TFP).	Authors' construction using data from Heston et al. (2009). See Section A for more details.
TFP Growth	Geometric average growth rate of TFP.	
Initial TFP	Initial value of TFP in the beginning of each five-year period.	
Physical Capital per Capita	Ratio of physical capital to population.	
Physical Capital per Capita Growth	Geometric growth rate of physical capital per capita.	
Initial Physical Capital Per Capita	Initial value of the ratio of total physical capital to total population in the beginning of each five-year period.	
Human Capital per Capita	Ratio of human capital to population.	Authors' construction using data from Barro and Lee (2010). See Section A.3 for more details.
Human Capital per Capita Growth	Geometric growth rate of human capital per capita.	
Initial Human Capital per Capita	Initial value of the ratio of total human capital to total population in the beginning of each five-year period.	
Commodity Terms of Trade Growth	Growth rate of commodity terms of trade index.	Authors' construction based on Spatafora and Tytell (2009).
Commodity Terms of Trade Volatility	Standard deviation of commodity terms of trade growth in five-year interval.	
Export Sophistication Measure	A measure of the productivity level associated with a country's specialization pattern.	Authors' construction based on Hausmann et al. (2007) and the World Bank (2010) WDI.
Education	Ratio of total secondary enrollment to the population of the age group that officially corresponds to that level of education.	Authors' construction using data from UNESCO (2010) UIS.
Trade Openness	Ratio of Exports and Imports to GDP.	Authors' construction using data from the World Bank (2010) WDI.
Government Burden	Ratio of government consumption to GDP.	
CPI	Consumer price index (2000=100) at the end of the year.	Author's calculations using data from the International Monetary Fund (2012a) World Economic Outlook.
Inflation rate	Annual percentage change in CPI.	
Lack of Price Stability	log(100+inflation rate).	

Table A.2: List of the 118 Countries in the Sample

Albania	Ecuador[1,2]	Lithuania	Sierra Leone[1,2]
Algeria[1,2]	Egypt[1,2]	Malawi[1,2]	Slovak Republic
Argentina[1,2]	El Salvador	Malaysia	Slovenia
Armenia[1]	Fiji[1,2]	Mali[1,2]	South Africa
Australia[1,2]	Finland	Mauritania[1,2]	Spain
Austria	France	Mauritius	Sri Lanka
Bahrain, Kingdom of[1]	Gabon[1,2]	Mexico	Sudan[1,2]
Bangladesh	Gambia, The[1,2]	Moldova[1]	Swaziland
Belgium	Germany	Morocco	Sweden
Benin[1,2]	Ghana[1,2]	Mozambique[1,2]	Switzerland
Bolivia[1,2]	Greece	Namibia[1,2]	Syrian Arab Republic[1,2]
Botswana[1,2]	Guatemala[1,2]	Nepal	Tajikistan[1]
Brazil	Guyana[1,2]	Netherlands	Tanzania[1]
Bulgaria	Honduras[1,2]	New Zealand[1,2]	Thailand
Burundi[1,2]	Hungary	Nicaragua[1,2]	Togo[1,2]
Cambodia	India	Niger[1,2]	Trinidad and Tobago[1,2]
Cameroon[1,2]	Indonesia[1,2]	Norway[1,2]	Tunisia
Canada	Iran, I.R. of[1,2]	Pakistan	Turkey
Central African Rep.[1,2]	Ireland	Panama[1,2]	Uganda[1]
Chile[1,2]	Israel	Papua New Guinea[1,2]	Ukraine
China, People's Rep. of	Italy	Paraguay[1,2]	United Arab Emirates[1,2]
Colombia[1,2]	Japan	Peru[1,2]	United Kingdom
Congo, Republic of[1,2]	Jordan	Philippines	United States
Costa Rica	Kazakhstan[1]	Poland	Uruguay[1,2]
Côte d'Ivoire[1,2]	Kenya[1,2]	Portugal	Venezuela, Rep. Bol.[1,2]
Croatia	Korea	Romania	Vietnam
Cyprus[1]	Kuwait[1,2]	Russia[1]	Zambia[1,2]
Czech Republic	Kyrgyz Republic[1]	Rwanda[1,2]	Zimbabwe[1,2]
Denmark	Latvia	Saudi Arabia[1,2]	
Dominican Republic	Lesotho	Senegal[1,2]	

Notes: [1] indicates that the country is a commodity exporter. Countries are classified as commodity exporters if primary commodities constitute more than 50 percent of their exports. 62 countries in the sample are primary commodity exporters and 56 are not. The 52 countries that are included in the dynamic Common Correlated Effects Pooled Mean Group (CCEPMG) analysis of Section 4.2 of the paper are denoted by [2].

price indices most commonly used in the literature, such as the "All Primary Commodities Index" in International Monetary Fund (2012b), which attaches the same weight to each country in the regression analysis. Equation (A.1) is used to construct two important variables. The first is a commodity terms of trade growth series, a proxy for resource abundance, calculated as the annual log differences in the CToT index, and the second is a measure of CToT volatility; both are explained in more detail below.

To calculate CToT growth, we first take the logarithm of (A.1)

$$\begin{aligned} \ln CToT_{it} &= \sum_j X_{ij} \ln\left(P_{jt}/MUV_t\right) - \sum_j M_{ij} \ln\left(P_{jt}/MUV_t\right) \\ &= \sum_j \left(X_{ij} - M_{ij}\right) \ln\left(P_{jt}/MUV_t\right). \end{aligned} \tag{A.2}$$

Taking the difference of (A.2), we obtain the annual growth rate of the CToT index:

$$\begin{aligned} g_{CToT,it} &= \ln CToT_{it} - \ln CToT_{it-1} \\ &= \sum_j \left(X_{ij} - M_{ij}\right) \Delta \ln\left(P_{jt}/MUV_t\right), \end{aligned} \tag{A.3}$$

which reflects the changes in the basket of real commodity prices in country i scaled by the importance of each commodity j in that economy's net exports for that particular good, $(X_{ij} - M_{ij})$.

Resource revenue (or rent), being calculated as production multiplied by price (minus marginal cost), has been used extensively in the resource curse literature as a measure of abundance. Given that production levels do not change much over time and are generally persistent, most changes in resource rents or revenues in the short-run (for instance five-years) are due to price fluctuations. Moreover, the Dutch disease phenomenon focuses on the changes in natural resource prices as the main driver of the eventual drag on TFP and output growth. Therefore, the commodity terms of trade growth considered in this paper, which is a weighted measure of changes in commodity prices, can be seen as a proxy for resource abundance, as well.

In contrast to most studies in the growth literature which employ time-invariant measures of volatility, we construct two time-varying measures. First, we consider the five year non-overlapping standard deviation of $g_{CToT,it}$:

$$\sigma_{CToT,is} = \sqrt{\frac{1}{4}\sum_{\tau=1}^{5}\left(g_{CToT,i\tau} - \overline{g_{CToT,s}}\right)^2}, \tag{A.4}$$

where $g_{CToT,i\tau}$ is the growth rate of CToT for country i in year τ within the non-overlapping five-year period $s = 1, 2, ...S$, in which $S = \frac{T}{5}$ with T denoting the years between 1970-2005, and $\overline{g_{CToT,s}} = \frac{1}{5}\sum_{\tau=1}^{5} g_{CToT,i\tau}$. The volatility of $g_{CToT,it}$, given in equation (A.4), indicates the extent to which CToT growth deviates from a given mean at any point in time. Second, as annual data on CToT volatility is required for the dynamic CCEPMG regressions, we estimate a generalized autoregressive conditional heteroscedasticity (GARCH) model using the logarithm of $CToT_{it}$. This approach estimates the "conditional variance" of the logarithm of the CToT for each year, independent of other observations. The computed variance series might yield periods with different volatility levels, and therefore a time varying measure. Specifically, we estimate the volatility of the commodity terms of trade from a GARCH(1,1) model on annual observations using a regression of the change in the logarithm of the CToT variable, $g_{CToT,it}$, on a constant (this formulation is used to avoid prejudging the issue of stationarity) as in Bleaney and Greenaway (2001) and Serven (2003):

$$\begin{aligned} g_{CToT,it} &= \ln CToT_{it} - \ln CToT_{it-1} \\ &= \kappa_0 + \xi_{it} \end{aligned}$$

$$\sigma^2_{CToT,it} = (1 - \lambda_1 - \lambda_2)\,\sigma^2_{CTOT,i} + \lambda_1 \xi^2_{it-1} + \lambda_2 \sigma^2_{it-1} \tag{A.5}$$

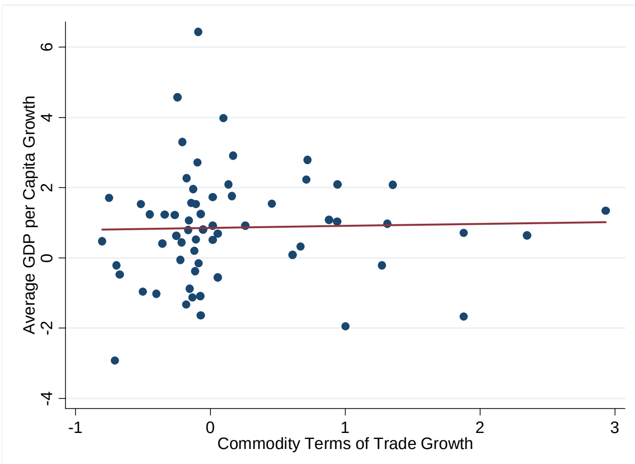
where $\xi_{it} \sim N\left(0, \sigma^2_{it}\right)$, ξ^2_{it-1} is the lagged squared error, $\sigma^2_{CToT,it}$ is the conditional variance of $g_{CToT,it}$, $\sigma^2_{CToT,i}$ is the unconditional variance, λ_1 is the ARCH parameter, and λ_2 is the GARCH parameter. We calculate CToT volatility as the square root of $\sigma^2_{CToT,it}$.[5]

The upper graphs in Figure A.1 illustrate a simple bivariate relationship between GDP per capita growth and CToT growth over the entire period 1970–2007, suggesting a mild positive correlation between these two variables for both country groups. Examining the two lower graphs, we observe that while higher CToT volatility is associated with lower GDP growth in primary commodity exporting countries, this relationship does not hold for the other subsample, which has a more diversified export structure. Overall, the results from Figure A.1 represent preliminary evidence that while commodity booms do not reduce output per capita growth (contrary to the resource curse hypothesis), the volatility of CToT stunts output growth only for primary commodity exporters. This is perhaps not surprising as those countries with a diversified basket of exports, especially manufacturing or service-sector goods, can be expected to grow faster and be better insured against price fluctuations in individual commodities.

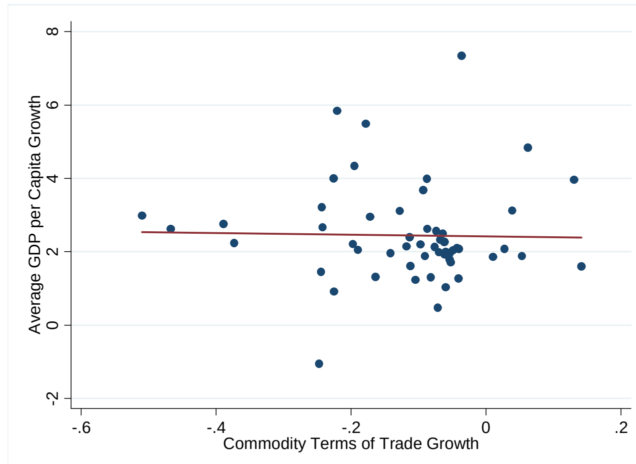
In Section 4.1 of the paper, we will add a whole range of control variables and deal with possible endogeneity problems through the system GMM approach, to investigate whether the above results survive for the full sample and the two subsamples, as suggested by Figure A.1. We will also investigate the relationship between resource abundance and/or CToT volatility with that of output growth using annual data and applying the dynamic CCEPMG methodology described in Section 4.2 of the paper. Since we also would like to investigate possible mechanisms through which CToT volatility can harm economic growth, we focus on three channels which have been widely discussed in the literature: (i) TFP growth; (ii) physical capital accumulation; and (iii) human

[5] The dynamics of the mean and variance of this measure are well-behaved.

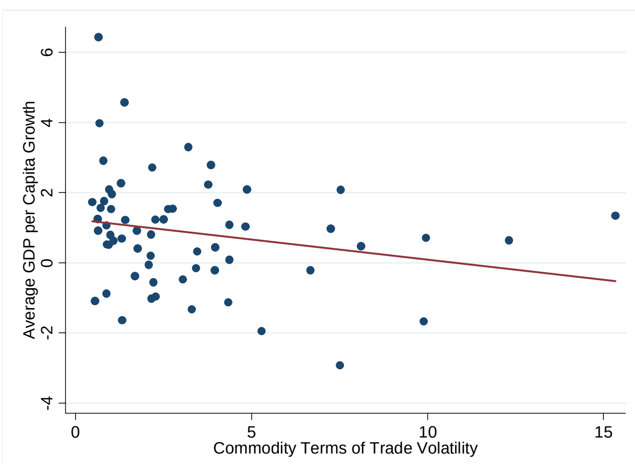
Figure A.1: Commodity Terms of Trade Growth and Volatility



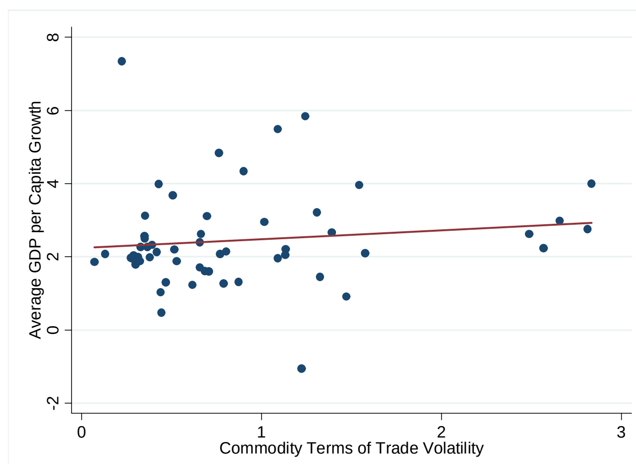
Primary Commodity Exporters (62)



All Other Countries (56)



Primary Commodity Exporters (62)



All Other Countries (56)

Notes: Average GDP per capita growth is the geometric growth rate of real per capita GDP between 1970 and 2007 and is in percent. Commodity terms of trade growth is the mean growth rate of the CToT index, defined in (A.1), over 1970 to 2007. CToT volatility is the standard deviation of the growth rate of the commodity terms of trade index and is calculated using data from 1970 to 2007. Primary commodity exporters are those countries for which the ratio of primary commodities to total exports exceed 50 percent.

capital acquisition. To do this analysis, we need to construct series for physical and human capital stocks as well as for TFP. In what follows, we briefly describe how these series are constructed.

A.2 Physical Capital Accumulation

We apply the perpetual inventory method, as in Hall and Jones (1999) for instance, to data from the Penn World Tables (PWT) 6.3; see Heston et al. (2009), to construct the series of the physical capital stock, K_{it}. We construct the initial stock of capital, K_{it_0}, for country i as:

$$K_{it_0} = \frac{I_{it_0}}{g_I + \delta}, \tag{A.6}$$

where δ is the depreciation rate, g_I is the geometric average growth rate of I_{it} between t_0 and $t_0 + 10$, and I_{it} represents gross investment and is defined as:

$$I_{it} = ki_{it} \times rgdpch_{it} \times pop_{it}, \tag{A.7}$$

in which ki_{it} measures the investment share of real GDP per capita ($rgdpch_{it}$) and pop_{it} is population. Since we have access to data on investment from 1960 for most countries, we set t_0 to this year.[6] Furthermore, we assume a depreciation rate, δ, of six percent and compute the subsequent values of the capital stock as:

$$K_{it} = (1 - \delta)K_{it-1} + I_{it}. \tag{A.8}$$

A.3 Human Capital Stock

To calculate the level of human capital stock in country i, we obtain data on the average years of schooling attained (total, primary, secondary, tertiary) in five-year intervals from the Barro and Lee Educational Attainment Dataset 2010. Since annual data is required to retrieve the human capital series, we linearly interpolate the Barro and Lee (2010) dataset. Moreover, we assume that labor is homogeneous within a country and that each unit of labor has s_{it} years of schooling (education). Therefore, the labor-augmenting human capital is given by:

$$H_{it} = e^{\psi(s_{it})}. \tag{A.9}$$

Following Psacharopoulos (1999),[7] we specify $\psi(s_{it})$ as a piecewise linear function with coefficients (returns to schooling) 0.134 for the first four years of education, 0.101 for the next four years, and 0.068 for any value of $s_{it} > 8$.[8]

[6] In those countries for which data on investment is missing in 1960, t_0 is the next available data point followed by other observations.

[7] See also Psacharopoulos and Patrinos (2004).

[8] We also constructed the human capital series by assuming that the returns to primary, secondary, and tertiary schooling is equal to 0.134, 0.101, and 0.068 per annum, but as expected, this does not lead to any

A.4 Productivity

In constructing the total factor productivity series, we follow Hall and Jones (1999) and assume that output in country i is produced according to the following constant returns to scale production function:

$$Y_{it} = K_{it}^{\alpha}(A_{it}H_{it}L_{it})^{1-\alpha}, \tag{A.10}$$

where K_{it} denotes the stock of physical capital defined in (A.8), A_{it} is a labor-augmented productivity factor, H_{it} is a measure of the average human capital of workers defined in (A.9), and L_{it} is labor input in use:

$$L_{it} = \frac{rgdpch_{it} \times pop_{it}}{rgdpwok_{it}}, \tag{A.11}$$

where as before $rgdpch_{it}$ is real GDP per capita, pop_{it} is a measure of population and $rgdpwok_{it}$ is real GDP per worker from the PWT 6.3. The capital share, α, is assumed constant across countries and set equal to 1/3.

Finally, using the data on output per worker, capital, population, and schooling, we can construct the level of total factor productivity as follows:

$$A_{it} = \frac{Y_{it}}{H_{it}L_{it}} \left(\frac{K_{it}}{Y_{it}}\right)^{-\frac{\alpha}{1-\alpha}}. \tag{A.12}$$

significant change in the series or the results.

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