Commodity Price Volatility and the Sources of Growth*

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May 1, 2014

Abstract

This paper studies the impact of the growth and volatility of commodity terms of trade (CToT) on economic growth, total factor productivity, physical capital accumulation, and human capital acquisition. We use the standard system GMM approach as well as the dynamic Common Correlated Effects Pooled Mean Group (CCEPMG) methodology for estimation to account for cross-country heterogeneity, cross-sectional dependence, and feedback effects. Using both annual data for 1970–2007 and five-year non-overlapping observations, we find that while CToT growth enhances real output per capita, CToT volatility exerts a negative impact on economic growth operating mainly through lower accumulation of physical and human capital. Productivity, however, is not affected by either the growth or the volatility of CToT. Our results also indicate that the negative growth effects of CToT volatility offset the positive impact of commodity booms. Therefore, we argue that volatility, rather than abundance *per se*, drives the "resource curse" paradox.

JEL Classifications: C23, F43, O13, O40.
Keywords: Growth, resource curse, commodity prices, volatility.

*We are grateful to Joshua Aizenman, Paul Cashin, Luis Catão, Thomas Helbling, Hashem Pesaran, Abdelhak Senhadji, Jeffrey Williamson, and participants at the RES Annual Conference 2011 and the Economic Research Forum (ERF) Regional Conference on Environmental Challenges in the MENA Region, as well as seminar participants at the University of Oxford and the International Monetary Fund for constructive comments and suggestions. We would also like to thank the Co-editor (Herman van Dijk) and three anonymous referees for most helpful suggestions. Financial support from the ERF through the 'Second Environmental Economics Research Competition for MENA' is gratefully acknowledged. The views expressed in this paper are those of the authors and do not necessarily represent those of the International Monetary Fund, IMF policy or the ERF.

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1 Introduction

This paper shows that the source of the so-called "resource curse" is the volatility in commodity prices as opposed to the abundance of the resource itself. While most studies on the resource curse paradox look at the negative growth effects of commodity abundance/dependence (particularly abundance *levels)*, they usually, with a few exceptions, overlook the *volatility* channel of impact. We argue that the volatility of Commodity Terms of Trade (CToT) should be considered in the analysis alongside the levels of resource revenues and other determinants of output per capita. This is particularly important for primary-product abundant countries, where resource revenues are highly volatile (due to exposure to global commodity market swings) and macroeconomic policies tend to be procyclical. We also study the possible growth channels through which volatility dampens growth.

Methodologically, we employ two econometric techniques: (1) the system GMM approach (a slope homogeneous panel); and (2) the dynamic Common Correlated Effects Pooled Mean Group (CCEPMG) estimator (a heterogenous panel). The former corrects for biases associated with the joint endogeneity of explanatory variables and the problems induced by unobserved country specific effects, while the latter takes account of cross-country heterogeneity and cross-sectional dependence. Accounting for these factors is particularly important in our panel data analysis as the effect of volatility on growth varies across cross-section units and depends critically on country specific factors as well as the feedback effects from determinants of GDP growth. Controlling for observed characteristics specific to countries *alone* need not ensure error cross-section independence. Neglecting such dependencies can lead to biased estimates and spurious inference, particularly given the rapid increase in world trade, international financial linkages, and exposures to global shocks.

We obtain annual data between 1970–2007 and construct a panel dataset of 118 countries. We use the annual observations for the dynamic CCEPMG approach, but we transform our time series data into at most seven non-overlapping five-year observations for the GMM estimation to filter out business cycle effects; see Aghion et al. (2009). Moreover, we make use of a country-specific commodity-price index that depends on the composition of a particular country's commodity export- and import-baskets, and investigate the impact on GDP growth of commodity terms of trade growth and volatility.

To investigate whether CToT volatility has a negative effect on growth in just primary–commodity abundant countries, we split our sample into two sets: (*a*) 62 primary commodity exporters, and (*b*) 56 other countries which have a more diversified export basket. The estimation results in both the full sample–118 countries–and the second subsample, (*b*), show that CToT volatility is not significantly related to growth. Since these countries have a more diversified basket of exports, especially manufacturing or service-sector goods, they are expected to grow faster and be better insured against price fluctuations in individual commodities. This is in contrast to the experience of the 62 primary commodity exporters, subsample (a), for which our results indicate that higher volatility of CToT harms growth. This is primarily due to price volatility, which has been intrinsic in commodity markets and rising in recent years. Our econometric results show that such volatility represents a fundamental barrier to economic prosperity, but only in commodity exporting countries.

One way to deal with the endogeneity and omitted variables concerns is to move toward a more structured growth specification that captures the mechanism of transmission from volatility to growth and the source of volatility (which can be captured well by our CToT measure due to its weak exogeneity). Having identified a negative impact of CToT volatility on GDP growth in natural resource abundant countries, we examine the channels through which this effect operates, notably physical and human capital accumulation, and Total Factor Productivity (TFP). We find that CToT volatility is associated with lower accumulation of both human and physical capital and hence lower growth. However, we cannot find a significant negative association between CToT volatility and TFP growth which is in contrast to the argument that natural resource abundant countries have fewer possibilities for technological progress.[1] This finding is important as the behavior of an economy experiencing a boom differs significantly from the standard Dutch disease in the presence of a sufficiently dynamic and knowledge-intensive natural resource sector.

Finally, while the resource curse hypothesis predicts a negative effect of commodity booms on long-run growth, our empirical findings—in line with the results reported elsewhere in the literature including Cavalcanti et al. (2011) and Esfahani et al. (2014)— show quite the contrary: an improvement in commodity terms of trade significantly raises growth. Therefore, we argue that it is volatility, rather than abundance *per se*, that drives the "resource curse" paradox. Indeed, our results confirm that the negative growth effects of CToT volatility offset the positive impact of commodity booms on real GDP per capita. Therefore, if a country can successfully manage its rents from commodity export windfalls by investing in human and physical capital, and insulating against external shocks by conducting structural reforms, it can greatly benefit from its natural resources in the long run.

The rest of the paper is set out as follows: Section 2 briefly reviews the literature; Section 3 discusses the econometric methodologies employed; Section 4 presents the main results; and Section 5 offers some concluding remarks.

[1] The exploration and production of some natural resources require the knowledge of and the access to very advanced technologies, such as the drilling and extraction of oil in deep water.

2 Literature Review

We are certainly not the first ones to emphasize the importance of volatility for economic growth. Ramey and Ramey (1995) discuss the consequences of excess volatility for long-run growth. Blattman et al. (2007) investigate the impact of terms of trade volatility on the growth performance of 35 commodity-dependent countries between 1870 and 1939. They provide evidence for the adverse effects of volatility on foreign investment and economic growth in what they call "periphery" nations. Aghion et al. (2009), using a system GMM dynamic panel data method for 83 countries over 1960–2000, show that higher levels of exchange rate volatility can stunt growth, especially in countries with relatively under-developed capital markets. Bleaney and Greenaway (2001) estimate a panel data model for a sample of 14 sub-Saharan African countries over 1980–1995 and show that growth is negatively affected by terms of trade volatility, and investment by real exchange rate instability.

Most closely related to our paper is van der Ploeg and Poelhekke (2009, 2010), who find that the volatility of unanticipated GDP per capita growth has a significant negative impact on economic growth, but the effect depends on a country's level of financial development. Our paper differs from theirs in many dimensions: first, we investigate the effects of CTOT volatility (σ_{CToT}) instead of the volatility of unanticipated GDP growth on economic activity. σ_{CToT} is a more appropriate measure to analyze the resource curse paradox as it directly affects a country's ability to extract from its resource stock and make use of the proceeds, and it is exogenously determined. Whereas the volatility of unanticipated output growth is most likely caused by factors that are not directly related to the abundance of natural resources, and is possibly endogenous. Second, our econometric methodologies are also different from theirs. They use Maximum Likelihood (ML) fixed effects panel techniques while we adopt the system GMM approach as well as a heterogeneous panel data technique— to explicitly recognize that there is a substantial degree of heterogeneity in the growth experience of different resource abundant countries. We also account for cross-country error dependencies that potentially arise from the presence of multiple unobserved common factors, and allow the individual responses to these factors to differ across countries. Third, although we do not explicitly condition the growth effects of CTOT volatility on financial development or other variables, the fixed effects in the GMM estimations, and more importantly, country-specific intercepts and different short-run slope coefficients in the CCEPMG regressions capture the effects of such variables. Fourth, we study the channels through which CToT volatility affects economic growth, while the above studies concentrate only on the overall effects of volatility on growth.

This paper is also related to a growing strand of the literature on the resource curse paradox, following Sachs and Warner (1995).[2] The empirical evidence on the resource curse paradox is mixed, with some confirming Sachs and Warner's results of the negative effect of resource abundance on economic growth, see, for instance, Bulte et al. (2005). But there is also a growing number of papers providing evidence against the resource curse paradox. Brunnschweiler and Bulte (2008) argue that the resource curse does not exist when one uses the correct measure of resource abundance (rather than dependence) in regressions.[3] Moreover, Alexeev and Conrad (2009) show that allowing for some important omitted variables, the unconditional version of the resource curse hypothesis is rejected.[4] Another empirical challenge comes from Cavalcanti et al. (2011), who use a heterogenous cointegrated panel data method for 53 oil and gas producing countries, and show that natural resource abundance *per se* is not a determinant of growth failure. The positive effect of resource abundance on both development and growth is also supported by Esfahani et al. (2014) who developed a long-run growth model for a major oil exporting economy and derived conditions under which oil revenues are likely to have a lasting impact.[5]

Another related branch of the literature investigates the channels through which natural resource abundance affects economic growth negatively. Gylfason (2001), for instance, shows that natural resource abundance appears to crowd out human capital investment with negative effects on the pace of economic activity, while Gylfason and Zoega (2006) argue that resource abundance leads to lower investment in physical capital. Finally, another line of research on resource abundance focusses on political economy considerations, see van der Ploeg (2011) for a recent survey. However, all of these studies focus on the effect of the level of resource abundance on economic growth (and its sources) and as such, they do not investigate whether there are any adverse effects of the volatility in commodity prices or resource income on GDP per capita growth.

3 The Econometric Model and Methodology

We begin with the following panel data model that can nest much of the existing work on the empirics of economic growth, from the "Barro cross-sectional regression" to the static

[2] See van der Ploeg (2011) for an extensive survey of the resource curse paradox.

[3] van der Ploeg and Poelhekke (2010) criticize the robustness of Brunnschweiler and Bulte (2008) results on econometric grounds. After addressing the identified econometric issues, they find that there is no evidence for either a curse or blessing. Furthermore, they argue that the indirect negative effect of volatility outweighs the potential positive impact (if any) of resources on growth.

[4] Collier and Goderis (2012) show that commodity booms (levels) have positive short-term effects on output growth, but conditional adverse long-term effects.

[5] See also Cashin et al. (2014) for the positive growth effects of oil shocks for major oil exporters.

and dynamic panel data techniques:

$$\begin{aligned} \Delta y_{it} &= (\phi - 1)\, y_{it-1} + \boldsymbol{\beta}' \mathbf{x}_{it} + c_{yi} + \eta_t + \varepsilon_{it}, \qquad (1) \\ \text{for } i &= 1, 2, ..., N \text{ and } t = 1, 2, ..., T \end{aligned}$$

where Δy_{it} is the growth rate of real GDP per capita in country i; and y_{it-1} is the logarithm of lagged real GDP per capita. $\mathbf{x}_{it}$ is a vector of explanatory variables; η_t is the time-specific effect; c_{yi} is the country-specific effect; and ε_{it} is the error term. Within this framework, the steady state output growth is exogenously determined by technological progress, while the speed of adjustment toward the equilibrium is a function of the determinants of steady state level of output and some initial conditions. Equation (1) allows one to study the potential determinants of steady state level of output and test the conditional convergence hypothesis in which countries converge to parallel equilibrium growth paths.

Much of the empirical growth literature is based on estimations of equation (1) using a cross-sectional approach or fixed/random effects panel estimators. Cross-sectional regressions clearly suffer from endogeneity problems as by construction, the initial level of income, y_{it-1}, is correlated with the error term, ε_{it}. This endogeneity bias is larger when considering the simultaneous determination of virtually all growth determinants, and the correlation of unobserved country-specific factors (arising from global shocks) and the explanatory variables. Traditional static panel data estimators such as fixed and random effects are not consistent either, due to the inclusion of lagged dependent variables in regressions (e.g. the initial level of GDP per capita). Specifically, the fixed effects estimator is inconsistent because it usually eliminates c_{yi} by a de-meaning transformation that induces a negative correlation between the transformed error and the lagged dependent variables of order $1/T$, which in short panels remains substantial. The assumption of a lack of correlation between c_{yi} and the explanatory variables required for random effects consistency is also violated as both Δy_{it} and y_{it-1} are functions of c_{yi}. These estimators (or their standard errors) will be biased if the errors show either heteroscedasticity or serial correlation.

We specify our growth regression dynamically and include lagged GDP per capita on the right hand side. Hence, the elimination of fixed effects from equation (1) in any standard OLS-based estimation procedure implies the violation of the orthogonality condition between the error term and explanatory variables. For this reason, we estimate this equation with the system GMM procedure and contrast it with the dynamic CCEPMG approach. It should be noted that no one estimator is perfect and each technique involves a trade-off. Estimators that effectively address a specific econometric problem may lead to a different type of bias. To deal with different types of econometric issues, and to ensure more robust results, we conduct our empirical analysis based on two estimation methods. The system GMM approach effectively deals with the endogeneity problem and country-specific fixed effects. However, it restricts all the slope coefficients to be identical across countries; assumes that the time effects are homogenous; and that the errors are cross-sectionally independent. If any of these conditions are not satisfied, the GMM method can produce inconsistent estimates of the average values of parameters; see Pesaran and Smith (1995) for more details. The time-specific heterogeneity is an underestimated but at the same time very important concern in dynamic panel data models. Country-specific time-effects can capture a number of unobservable characteristics in macroeconomic and financial applications such as (a) institutional arrangements, (b) the patterns of trade, and (c) political developments. The time-specific heterogeneity is induced by oil price shocks and/or other global common factors, which affect all countries but to different degrees. The dynamic CCEPMG methodology explained below accounts for heterogenous time effects and deals with cross-sectional dependencies effectively.

3.1 Dynamic Common Correlated Effects Pooled Mean Group (CCEPMG) Methodology

When panels of data are available, there exist a number of alternative estimation methods that vary on the extent to which they account for parameter heterogeneity. At one extreme is the Mean Group (MG) approach in which separate equations are estimated for each country and the average of estimated coefficients across countries is examined. Pesaran and Smith (1995) show that the MG method produces consistent estimates of the average of the parameters when the time-series dimension of the data is sufficiently large. At the other extreme are the traditional estimators in which dynamics are simply pooled and treated as homogeneous. Prominent examples include fixed effects (FE), random effects (RE), and generalized methods of moments (GMM). In between the two extremes is the pooled mean group (PMG) estimator of Pesaran et al. (1999) which is an intermediate case between the averaging and pooling methods of estimation, and involves aspects of both. It restricts the long-run coefficients to be homogenous over the cross-sections, but allows for heterogeneity in intercepts, short-run coefficients (including the speed of adjustment) and error variances. The PMG estimator also generates consistent estimates of the mean of short-run coefficients across countries by taking the simple average of individual country coefficients.

We make use of the PMG estimator because it offers the best available choice in terms of consistency and efficiency in our sample. Moreover, we apply the Common Correlated Effects (CCE) methodology of Pesaran (2006) to the PMG estimator to correct for the cross-sectional dependencies that arise in the error terms from unobserved global factors, since we assume that countries are affected by these shocks to varying degrees. Conditioning on observed variables (growth regressors) specific to countries alone need not ensure error cross-section independence that underlies much of the panel data literature. Neglecting such dependencies can lead to biased estimates and spurious inference, particularly given the rapid increase in world trade, international financial linkages, and exposures to common shocks.

The dynamic Common Correlated Effects PMG (CCEPMG) estimator is based on an Autoregressive Distributive Lag (ARDL) model that can be used for long-run analysis. This method avoids the need for pre-testing the order of integration given that they are valid whether the variables of interest are $I(0)$ or $I(1)$. It is also robust to omitted variables bias and simultaneous determination of growth regressors. The main requirements for the validity of this methodology are that, first, there exists a long-run relationship among the variables of interest and, second, the dynamic specification of the model is sufficiently augmented so that the regressors become weakly exogenous and the resulting residual is serially uncorrelated.

To explain the CCEPMG estimator in detail, consider the following panel $ARDL(1, ..., 1)$ model with a multifactor error structure (although the framework readily extends to higher order models):

$$y_{it} = c_{yi} + \phi_i y_{i,t-1} + \boldsymbol{\beta}'_{0i}\mathbf{x}_{it} + \boldsymbol{\beta}'_{1i}\mathbf{x}_{i,t-1} + u_{it}, \tag{2}$$

$$u_{it} = \boldsymbol{\gamma}'_i\mathbf{f}_t + \varepsilon_{it}, \tag{3}$$

$$\boldsymbol{\omega}_{it} = \begin{pmatrix} \mathbf{x}_{it} \\ \mathbf{g}_{it} \end{pmatrix} = \mathbf{c}_{\omega i} + \boldsymbol{\alpha}_i y_{i,t-1} + \Gamma'_i\mathbf{f}_t + \mathbf{v}_{it}, \tag{4}$$

where as before $i = 1, 2, ..., N$, $t = 1, 2, ..., T$, and $\mathbf{x}_{it}$ is $k_x \times 1$ vector of regressors specific to cross-section unit i at time t; c_{yi} and $\mathbf{c}_{\omega i}$ are individual fixed effects for unit i, $\mathbf{g}_{it}$ is $k_g \times 1$ vector of covariates specific to unit i (not observed in the panel data model), $k_x + k_g = k$, ε_{it} are the idiosyncratic errors, Γ_i is an $m \times k$ matrix of factor loadings ($k \geq m$), $\boldsymbol{\alpha}_i$ is a $k \times 1$ vector of unknown coefficients, and $\mathbf{v}_{it}$ is assumed to follow a general linear covariance stationary process distributed independently of ε_{it}, the idiosyncratic errors. $\mathbf{f}_t$ is an $m \times 1$ vector of unobserved common factors, which can be stationary or nonstationary; see Kapetanios et al. (2011). The source of error term dependencies across countries is captured by $\mathbf{f}_t$, whereas the impacts of these factors on each country are governed by the idiosyncratic loadings in Γ_i. The individual-specific errors, ε_{it}, are distributed independently across i and t; they are not correlated with the unobserved common factors or the regressors; and they have zero mean, variance greater than zero, and finite fourth moments. The unobserved common factors, or the heterogenous time effects, may be captured/proxied by adding cross-sectional averages of the observables to our regressions, see Pesaran (2006).

Assuming that N is sufficiently large, Chudik and Pesaran (2013) (considering the CCEMG estimator) and Chudik et al. (2013) (considering both the CCE mean group and pooled estimators) show that the unobserved common factors, $\mathbf{f}_t$, can be proxied by de-trended cross-section averages of $\mathbf{z}_{it} = (y_{it}, \mathbf{x}'_{it}, \mathbf{g}'_{it})'$ and their lags:

$$\mathbf{f}_t = \mathbf{G}\left(L\right)\widetilde{\mathbf{z}}_{wt} + O_p(N^{-1/2}), \tag{5}$$

where $\mathbf{G}\left(L\right)$ is a distributed lag function, $\widetilde{\mathbf{z}}_{wt} = \overline{\mathbf{z}}_{wt} - \overline{\mathbf{c}}_{zw}$ is a $k+1$ dimensional vector of de-trended cross-section averages, $\overline{\mathbf{z}}_{wt} = (\bar{y}_{wt}, \overline{\mathbf{x}}'_{wt}, \overline{\mathbf{g}}'_{wt})' = \sum_{i=1}^{N} w_i \mathbf{z}_{it}$ is a $k+1$ dimensional vector of cross-section averages, and $\overline{\mathbf{c}}_{zw} = \sum_{i=1}^{N} w_i \left(\mathbf{I}_{k+1} - \mathbf{A}_i\right)^{-1} \mathbf{c}_{zi}$. The weights satisfy the following normalization condition: $\sum_{i=1}^{N} w_i = 1$.

Substituting (5) into (2), we obtain

$$y_{it} = c^*_{yi} + \phi_i y_{i,t-1} + \boldsymbol{\beta}'_{0i}\mathbf{x}_{it} + \boldsymbol{\beta}'_{1i}\mathbf{x}_{i,t-1} + \boldsymbol{\delta}'_i\left(L\right)\overline{\mathbf{z}}_{wt} + \varepsilon_{it} + O_p(N^{-1/2}), \tag{6}$$

where

$$\boldsymbol{\delta}_i\left(L\right) = \sum_{\ell=0}^{\infty} \boldsymbol{\delta}_{i\ell} L^{\ell} = \mathbf{G}'\left(L\right)\boldsymbol{\gamma}_i, \tag{7}$$

and $c^*_{yi} = c_{yi} - \boldsymbol{\delta}'_i\left(1\right)\overline{\mathbf{c}}_{zw}$.

Equation (2) can be estimated using the dynamic CCEMG and CCEPMG estimators. However, for these estimators to be valid, a sufficient number of lags of cross-section averages must be included in individual equations of the panel (as we truncate the infinite polynomial distributed lag function $\boldsymbol{\delta}_i\left(L\right)$), and the number of cross-section averages must be at least as large as the number of unobserved common factors. Moreover, as always T must be large enough so that the model can be estimated for each cross-section unit.

The estimated CCEMG vector is defined as $\boldsymbol{\theta} = E(\boldsymbol{\theta}_i)$,where the individual long-run or level coefficients are

$$\boldsymbol{\theta}_i = \frac{\boldsymbol{\beta}_{0i} + \boldsymbol{\beta}_{1i}}{1 - \phi_i}. \tag{8}$$

To obtain the CCEPMG estimates, the individual long-run coefficients are restricted to be the same across countries, namely:

$$\boldsymbol{\theta}_i = \boldsymbol{\theta}, \qquad i = 1, 2, ..., N. \tag{9}$$

The dynamic CCEPMG estimator uses a maximum likelihood approach to estimate the model based on the Newton–Raphson algorithm. The lag length for the model can be determined using, for instance, the Schwarz Criterion (SBC) and the null of long-run homogeneity:

$$H_0 : \boldsymbol{\theta}_i = \left(\frac{\boldsymbol{\beta}_{0i} + \boldsymbol{\beta}_{1i}}{1 - \phi_i} \right) = \boldsymbol{\theta},$$

can be tested using the Hausman statistic for the coefficient on each of the explanatory variables and for all of them jointly.

4 Empirical Results

To empirically test the relationship between economic growth and commodity terms of trade (CToT) growth, g_{CToT}, and volatility, σ_{CToT}, we use annual data from 1970 to 2007 on: real GDP per capita, a CToT index based on the prices of 32 primary commodities, and other important determinants of growth such as trade openness, government burden, lack of price stability, and human capital. We also use a measure of export sophistication developed by Hausmann et al. (2007) in our regressions. To investigate the possible mechanisms through which CToT volatility can harm economic growth, we focus on: (i) TFP growth; (ii) physical capital accumulation; and (iii) human capital acquisition. See Table A.1 of the Data Supplement for details on the calculation and construction of these variables and sources of the data. For a list of the 118 countries in our sample, see Table A.2 of the Data Supplement available online at: http://people.ds.cam.ac.uk/km418.

4.1 System GMM Results

To filter out business cycle fluctuations and to focus on the long-run effects of CToT volatility, we follow the literature in transforming the annual series into non-overlapping five-year averages. Given the time span of our dataset (from 1970 to 2007), we construct an unbalanced panel with a maximum of seven five-yearly observations per country covering 1970-2005.

4.1.1 Volatility and Growth

We employ the system GMM estimator, but as the two-step standard errors on estimated coefficients will be biased downward in small samples like ours, we make use of Windmeijer

(2005) approach to correct for that bias. The following equation is estimated:[6]

$$\begin{aligned} g_{y,is} &= (\phi-1)\, y_{is-1} + \gamma_1 g_{CToT,is} + \gamma_2 \sigma_{CToT,is} \\ &\quad + \gamma_3 EXPY_{is} + \boldsymbol{\beta}'\mathbf{z}_{is} + c_{yi} + \eta_s + \varepsilon_{is}, \end{aligned} \tag{10}$$

where $i = 1, 2, ..., N$, and $s = 1, 2, ..., S$, in which $S = \frac{T}{5}$, with T denoting the years over 1970-2005. $g_{y,is}$ is the geometric average growth rate of real GDP per capita between dates s and $s-1$; y_{is-1} is the logarithm of real GDP per capita at the beginning of each period; $g_{CToT,is}$ is the growth rate of the CToT index; and $\sigma_{CToT,is}$ is its volatility. $EXPY_{is}$ is a measure of export diversification and $\mathbf{z}_{is}$ is a set of other control variables from the growth literature including education, trade openness, government burden, and lack of price stability. η_s is the time-specific effect; c_{yi} is the country-specific effect; and ε_{it} is the error term.

Table 1 presents the estimation results of the impact of CToT growth and volatility as well as export diversification on GDP per capita growth.[7] In regression [1.1] using the whole sample of 118 countries we observe that an increase in g_{CToT} is both growth enhancing and highly significant. On the other hand, although the coefficient of CToT volatility is negative, this is in fact insignificant. Thus, there is no evidence that volatility in commodity prices harms growth for the full sample. As we expect the growth experience of primary commodity exporters to be different from those countries that are not well endowed with a handful of primary products, we split the 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%, and the second subsample consists of the remaining 56 countries, which have a more diversified export structure.

Regression [1.2] shows the opposite significant effects of g_{CToT} and σ_{CToT} on GDP growth for the 62 primary commodity exporting countries in our sample. While commodity price booms significantly increase economic growth, volatility affects it negatively. This finding can be partly explained by the fact that fiscal and current account balances of commodity-exporting countries are affected by swings in resources revenues with destabilizing effects on the macroeconomy. The positive growth effect of g_{CToT} provides evidence against the traditional resource curse hypothesis, which argues that it is the level of resource abun-

[6] The regression specification is derived by extending the stochastic growth model with a Cobb-Douglas production function to a case where resource revenues (mainly driven exogenously by CToT fluctuations) are included as an additional factor in the capital accumulation process, see Esfahani et al. (2014) for derivations. The specification can also be derived based on a standard neoclassical growth model, in which the production function is augmented, in addition to labor and physical capital, by natural capital, see Cavalcanti et al. (2011) for derivations and proofs.

[7] The instrument set includes all regressors and all available lags. To limit the instrument count we used the "collapse" command in Stata, see Roodman (2009) for simulation results showing the superiority of this instrument set in some common applications.

Table 1: Estimates based on the System GMM Estimator and Non-overlapping Five-year Averages (1970-2005)

The Dependent Variable is the Growth Rate of :	Full Sample 118 Countries [1.1] GDP/Capita	Primary Commodity Exporters 62 Countries [1.2] GDP/Capita	[1.3] TFP	[1.4] Physical Capital	[1.5] Human Capital	Other 56 Countries [1.6] GDP/Capita
Initial "Variable", in logs	-1.204**	-0.872	-4.221***	-0.601	-0.999	-1.738***
	(0.471)	(0.688)	(0.990)	(1.020)	(0.750)	(0.546)
Commodity Terms of Trade Growth	0.240***	0.255***	0.113	0.186**	0.048	-0.156
	(0.072)	(0.078)	(0.162)	(0.093)	(0.030)	(0.469)
Commodity Terms of Trade Volatility	-0.105	-0.119**	0.006	-0.181**	-0.051*	-0.683
	(0.081)	(0.058)	(0.102)	(0.087)	(0.029)	(0.577)
Export Sophistication Measure, in logs	4.818***	2.787*	4.130***	4.979***	-0.283	3.687**
	(1.830)	(1.638)	(1.382)	(1.700)	(0.465)	(1.465)
Control variables						
Education	0.812	1.256	1.837*	-1.417	0.643***	0.054
(secondary enrollment, in logs)	(0.803)	(0.960)	(1.034)	(1.145)	(0.202)	(1.380)
Trade Openness	2.027**	2.587***	2.106	3.205**	0.442	2.142**
(trade volume/GDP, in logs)	(1.024)	(0.860)	(1.485)	(1.521)	(0.340)	(0.929)
Government Burden	-2.656**	-4.007***	-2.669	-1.160	0.643	-0.109
(government consumption/GDP, in logs)	(1.163)	(1.064)	(2.334)	(1.714)	(0.427)	(1.536)
Lack of Price Stability	-6.786***	-6.264**	-5.019*	-4.143	-0.098	-11.119***
(log [100 + inflation rate])	(2.412)	(2.485)	(2.897)	(3.375)	(0.445)	(3.773)
No. Countries/No. Observations	118/664	62/352	62/354	62/354	62/354	56/312
Specification tests (p-values)						
(a) Hansen Test	0.121	0.448	0.351	0.145	0.469	0.314
(b) Serial Correlation						
First-order	0.000	0.000	0.001	0.012	0.006	0.003
Second-order	0.199	0.252	0.569	0.110	0.533	0.674

Notes: Time and fixed effects are included in all the regressions. Standard errors are presented below the corresponding coefficients in brackets. Symbols ***, **, and * denote significance at 1%, 5%, and at 10% respectively. "Variable" is GDP per capita in regressions [1.1], [1.2], and [1.6], TFP in [1.3], Physical Capital in [1.4], and Human Capital in [1.5]. Based on two-step system GMM with Windmeijer (2005) small sample robust correction. The volatility measure is based on five year standard deviation of annual CToT growth, see the Data Supplement Section A.1 for more details. Source: Authors' estimations.

dance that affects economic growth negatively, and is in line with results obtained recently in the literature (see Section 2). The negative relationship between volatility and growth in resource-abundant countries is also documented in van der Ploeg and Poelhekke (2009), who acknowledge that the source of the resource curse is the volatility of commodity prices as opposed to resource abundance, although their empirical analysis is based on the volatility of unanticipated output growth and not of commodity prices. σ_{CToT} is a more appropriate measure to analyze the resource curse paradox as it directly affects a country's ability to extract from its resource stock and make use of the proceeds, and it is exogenously determined. Whereas the volatility of unanticipated output growth is most likely caused by factors that are not directly related to the abundance of natural resources.

To determine the overall impact of changes in CToT growth and its volatility, we calculate the average percentage effect of the two CToT variables on output per capita growth using the estimates from regression [1.2]. The overall effect is -0.312 over five years, therefore the negative growth effects of CToT volatility offset the positive impact of commodity booms, which suggests that volatility, rather than abundance per se, drives the resource curse paradox in the long run.

These results do not hold for the second subsample consisting of the remaining 56 non-resource abundant countries; see regression [1.6]. For these countries, changes in commodity prices (or their volatility) do not have any major impact on their economies. It is not trivial though that CToT growth and volatility should not have any growth effects on commodity importing countries. We would expect, for instance, an oil price shock to have a negative effect on an oil importing economy. However, these non-resource abundant countries generally have highly diversified export and import baskets, implying that the changes in commodity prices should have less effect on them as opposed to primary commodity abundant countries. This argument is also supported by observing that the coefficient of export diversification variable, $EXPY_{it}$, is significant and positive in all three regressions in Table 1. This finding suggests that diversifying away from exporting only a handful of primary commodities towards technology improving exports can significantly increase GDP growth.

Note that in all three regressions, the control variables have the expected signs and are all statistically significant except for the education variable in all regressions, and the government burden variable in [1.6]. Overall, while higher level of trade-openness is growth enhancing, price instability and government burden tend to have adverse effects on GDP growth.[8] In addition, there is evidence of income convergence across countries with the

[8] Inclusion of institutional variables does not alter our results as CToT shocks and volatility are exogenously determined and should be less vulnerable to omitted variables bias (volatility might be negatively correlated with growth because it would act as a proxy for poor governance or "extractive" institutions). Moreover, any impact of institutional quality on volatility is largely time-invariant, see Acemoglu et al.

coefficient on the lagged-dependent variable being significant for the full sample and the sample consisting of net primary commodity importers. However, this finding should be interpreted with caution as there is a large cross-country heterogeneity in our sample of 118 countries which might render the estimated coefficient on y_{is-1} biased. Finally, in all regressions, the Hansen and second order serial correlation test statistics, which examine the validity of the instruments used, are well above the conventional significance levels.

4.1.2 Volatility and the Channels Affecting Economic Growth

To determine the channel(s) through which GDP growth is negatively affected by CToT volatility in the subsample of 62 commodity exporters, we follow Beck et al. (2000) in investigating three possible sources which are acknowledged in the literature, namely, TFP, human, and physical capital investment. As before, we use the system GMM dynamic panel data approach to estimate:

$$\begin{aligned} g_{W,is} &= (\phi - 1)\, w_{is-1} + \gamma_1 g_{CToT,is} + \gamma_2 \sigma_{CToT,is} \\ &+ \gamma_3 EXPY_{is} + \boldsymbol{\beta}' \mathbf{z}_{is} + c_{yi} + \eta_s + \varepsilon_{is}, \end{aligned} \tag{11}$$

where $W = \{$TFP, or physical capital per capita, or human capital per capita$\}$; $g_{W,is}$ is the geometric average growth rate of W between dates s and $s-1$; and w_{is-1} is the logarithm of W at the beginning of each period. All other variables are as defined in equation (10).

Not surprisingly, considering the results of regression [1.3] in Table 1, we observe that human capital development and export diversification enhance TFP. However, the channel through which the CToT variables affect growth is clearly not total factor productivity, as the growth rate and the volatility of CToT are both statistically insignificant in the TFP regression. Our results suggest that commodity price booms or CToT volatility do not have an adverse impact on TFP growth. This finding contradicts the Dutch disease hypothesis, which predicts that an increase in commodity prices will lead to real exchange rate appreciation and through that a fall in output in the non-resource and more dynamic traded-goods sector, and in turn leads to a reduction of TFP and eventually the GDP growth rate (see Krugman (1987) among others). This effect would most likely be present if the revenues from primary commodities were to be intrinsically temporary, like in the Netherlands in the 1960's, but this is not the case for most of the countries in our sample, which have remained exporters of a few primary products for decades (see Esfahani et al.

(2001); hence the role of institutions are captured by fixed effects in the GMM estimations, and country-specific intercepts and different short-run slope coefficients in the CCEPMG regressions. Finally, Blattman et al. (2007) argue that the choice of which commodity to produce and export is an outcome determined by geography, factor endowments, and international demand, not institutional quality.

(2013) for more details). Thus an increase in the price of primary commodities, or its volatility, does not necessarily have negative long-run effects on TFP in these countries, as their economies would re-adjust after a shock to commodity prices.

In contrast, regression [1.4] shows that both commodity terms of trade growth and volatility have significant impacts on physical capital accumulation for primary commodity abundant countries. While a commodity price boom increases the physical capital stock, higher volatility of commodity prices significantly reduces it. Therefore, capital accumulation seems to be an important channel through which volatility affects GDP per capita growth. This result is in line with what is argued in Gylfason and Zoega (2006) and Esfahani et al. (2014) among others. A possible explanation for this finding is that economic agents tend to save less in commodity abundant countries because they perceive the revenues from primary commodity exports to be a permanent stream of future income. Another possibility is that the uncertainty arising from commodity price volatility might suppress the accumulation of physical capital by risk averse investors. Moreover, as noted by Catão et al. (2009), ToT volatility adversely affects capital accumulation and growth by raising the country's default risk, hence widening the country spreads, and lowering its borrowing capacity.

The estimation results from regression [1.5] are similar to that of regression [1.4] . They indicate that human capital accumulation is another channel through which volatility harms growth. A possible explanation for this finding is that uncertainty generally increases income inequality and leads to binding credit constraints on households with low net worth. But given that families finance their own education, higher volatility then leads to a reduction in human capital investment and thus lowers economic growth. This reduction in the growth rate of an economy due to the crowding out of human capital investment in resource abundant and/or volatile economies is also what is found in the literature. See, for example, Gylfason (2001), Aizenman and Pinto (2005), and Gylfason and Zoega (2006) among others.

Moreover, while export diversification leads to higher investment in physical capital, see regression [1.4], this effect is absent in the human capital accumulation equation, [1.5]. This result seems to suggest that for commodity abundant countries, diversification is an important mechanism that offsets the reduction in physical capital accumulation (brought about by large primary commodity export revenues) with an increase in productivity. Furthermore, the coefficients of the control variables in all three regressions generally have the expected signs, and if not, are statistically insignificant. As before, the Hansen and second order serial correlation test statistics in these three regressions confirm the validity of the instruments used and the lack of second order serial correlation in the error terms.

In line with the literature, we have defined primary commodity exporters as those countries for which the ratio of primary commodities to total exports exceeds 50%, but to make sure that this particular cut-off point is not driving our results, we also estimated all the regressions using 40% and 60% cut-off points and found the results to be robust to these changes. This is not surprising as increasing the cut-off point to 60% only reduces the sample by three countries, while reducing it to 40% increases the number of countries by six. Moreover, to make sure that our results are not driven by the way CToT volatility is measured, we estimate the conditional volatility of CToT from a GARCH(1,1) model on annual observations but averaged over the same non-overlapping five years as all other variables, and used it as our alternative measure of instability. The results echoed those obtained in Table 1. For brevity these results are not reported here but are available on request.[9]

4.2 CCEPMG Results

There are a number of advantages to using non-overlapping five-year averages, including the potential for removing business cycle fluctuations. However, the averaging itself induces a loss of information with no guarantee that the business cycle fluctuations are removed entirely. Moreover, uncertainty is best measured over the business cycle and hence, using five-year averages could underestimate the importance of volatility. Furthermore, as discussed in Section 3.1, the traditional system GMM methodology employed in Section 4.1 does not account for cross-sectional heterogeneity or residual cross-country dependencies that might be present, particularly considering the rapid increase in world trade, international financial integration of countries, and exposures to common shocks (i.e. oil price disturbances). To overcome some of these issues and also to provide robustness checks for our GMM results, we employ the dynamic CCEPMG methodology, described in Section 3.1, on annual observations from 1970 to 2007. This method allows for heterogenous error variances, short-run coefficients and intercepts while it restricts the long-run coefficients to be the same across countries. This heterogeneous treatment of short-run relationships is needed as the effect of revenue volatility on growth varies across cross-section units and depends critically on country specific factors, macroeconomic fundamentals, and institutions.

Given the requirements on time-series dimension of the panel, we include only countries for which we have at least 25 consecutive observations. In addition, and considering the results obtained in Section 4.1, we only focus on the sample of commodity exporters. This implies that our analysis will include 52 countries out of the 62 primary commodity exporters in our dataset (see Table A.2 of the Data Supplement). As data on secondary enrollment used in the GMM regressions is only available in five-year intervals, we cannot use the education

[9] We also estimated regressions [1.3]–[1.5] for the 56 net commodity-importing countries in our sample and as expected found no significant effect of g_{CToT} or σ_{CToT} on the three channels of growth described above. These results are not reported but they are available upon request.

variable in the CCEPMG estimations. This also implies that we are unable to look at the human capital accumulation channel in Section 4.2.2, and therefore we will focus on the remaining two channels of impact: TFP and physical capital investment equations.

4.2.1 Volatility and Growth

We use the dynamic CCEPMG method described in Section 3.1 to estimate the following panel $ARDL(p, q, q, ..., q)$ model:

$$y_{it} = c_{yi}^* + \sum_{l=1}^{p_i} \phi_{il} y_{i,t-l} + \sum_{l=0}^{q_i} \boldsymbol{\beta}_{il}' \mathbf{x}_{i.t-l} + \sum_{l=1}^{p_i} a_{il} \overline{y}_{t-l} + \sum_{l=0}^{q_i} \mathbf{b}_{il}' \overline{\mathbf{x}}_{t-l} + \varepsilon_{it}, \tag{12}$$

where y_{it} is the log of real GDP per capita for country i and year t, $\mathbf{x}_{it}$ is a 5×1 vector of explanatory variables, namely the growth rate of the CToT index, $g_{CToT,it}$, and its volatility, $\sigma_{CToT,it}$, and the conventional control variables: openness, government burden, and lack of price stability. $\overline{y}_t$ and $\overline{\mathbf{x}}_t$ denote the simple cross-section averages of y_{it} and $\mathbf{x}_{it}$ in year t.

The consistency and efficiency of the CCEPMG estimates rely on several conditions.[10] Firstly, the order of the ARDL process must be chosen long enough to ensure that residuals of the error-correction model are serially uncorrelated. At the same time, with a limited number of time-series observations, the ARDL order should not be overextended as this imposes excessive parameter requirements on the data. Note that the lag order is chosen on the unrestricted model, and then the homogeneity (long-run) restrictions are imposed. We try to fulfill these conditions by selecting the lag order using the Schwarz Criterion (SBC) subject to a maximum lag of two on each of the variables, in other words we set $p_i \leq 2$ and $q_i \leq 2$. Moreover, we allow the lag order selection to differ across countries.

The second condition is cross-sectional independence of the residuals ε_{it}. Cross-country dependencies arise from omitted common factors (e.g. time-specific effects or common shocks) that might influence the countries differently. We try to eliminate these common factors and to some extent satisfy the independence condition by augmenting our regressions with cross-sectional averages of the growth rates of real GDP and the CToT index. Ideally, we would also like to include the cross-sectional averages of all the variables in $\mathbf{x}_{it}$ but given that this is not possible, as we would run into lack of degrees of freedom, we choose the two variables that we believe are highly dependent across countries in our sample.

The third condition refers to the existence of a long-run relationship between our variables and requires that the coefficient on the error-correction term $(\sum_{l=1}^{p} \phi_{il} - 1)$ be negative.

[10] There is no evidence of serial correlation, non-normality, functional form misspecification, or heteroskedasticity in most of the 52 countries in the sample. The diagnostic tests are not reported here but are available upon request.

Finally, the fourth condition for the efficiency of the CCEPMG estimator is the homogeneity of the long-run parameters across countries. In addition to the dynamic CCEPMG results we also report the mean group estimates, which are averages of the individual country coefficients. We test for long-run homogeneity using the Hausman statistic for the coefficients on each of the explanatory variables and for all of them jointly based on the null of equivalence between the CCEPMG and CCEMG estimations; see Pesaran et al. (1996) for details. If we reject the null hypothesis (i.e. we obtain a probability value of < 0.05), the homogeneity assumption on long-run coefficients across countries is invalid.

Table 2 presents the dynamic CCEMG and CCEPMG estimates as well as the Hausman test statistics which is distributed as chi-squared examining panel heterogeneity. According to the Hausman statistics, the long-run homogeneity restriction is not rejected for individual parameters and jointly in all regressions. Thus, we focus on the results obtained using the CCEPMG estimator, which, given its gains in consistency and efficiency over the alternative CCEMG estimator, is more appropriate.

The results of regression [2.1] in Table 2 indicate that the error-correction coefficients, $\sum_{l=1}^{p} \phi_{il} - 1$, fall within the dynamically stable range (being statistically significant and negative), and therefore the null hypothesis of no long-run relation is rejected. This finding indicates that there is strong evidence for conditional convergence to country-specific steady states in our sample of 52 commodity exporting countries. This is in contrast to the result from regression [1.2] in Table 1, and highlights that the strict homogeneity constraints imposed in the GMM estimations are too restrictive to suggest convergence to a common steady state among all commodity exporters.

In the long run, the growth rate of GDP per capita is, as expected, negatively related to the size of government as well as the lack of price stability, and positively related to trade openness. Most importantly for our purposes, the CCEPMG estimate of the commodity terms of trade volatility is negative and statistically significant, which means that growth is adversely linked to commodity price volatility in the long run.[11] Moreover, it is still the case that our measure of resource abundance, g_{CToT}, is significantly positively related to economic growth, but its impact on real GDP per capita is smaller than that of CToT volatility. Quantitatively, the overall average negative impact of the two CToT variables on output growth is -0.09 percent per year. This finding is in line with our previous result (see Table 1) suggesting that the source of the resource curse is the volatility of commodity prices as opposed to abundance *per se*. It is also interesting that the coefficient of σ_{CToT} in [2.1] is roughly in the same magnitude as the GMM regression [1.2]. Overall, comparing the CCEMG and CCEPMG estimates, imposing long-run homogeneity reduces

[11] See Mohaddes and Pesaran (2014) for the negative effects of oil revenue volatility on the Iranian economy.

Table 2: Estimates for Primary Commodity Exporters based on Dynamic Common Correlated Effects Mean Group (CCEMG) and Pooled Mean Group (CCEPMG) Estimators and Annual Observations (1970-2007)

The Dependent Variable is the Growth Rate of:	[2.1] Output per Capita		[2.2] Total Factor Productivity		[2.3] Physical Capital	
	Dynamic CCEMG	Dynamic CCEPMG	Dynamic CCEMG	Dynamic CCEPMG	Dynamic CCEMG	Dynamic CCEPMG
Error Correction Term	-0.248***	-0.131***	-0.376***	-0.279***	-0.136***	-0.075***
	(0.037)	(0.017)	(0.045)	(0.033)	(0.022)	(0.015)
Commodity Terms of Trade Growth	0.011	0.003*	0.013	-0.012***	0.107	0.007***
	(0.133)	(0.002)	(0.033)	(0.003)	(0.129)	(0.002)
Commodity Terms of Trade Volatility	0.589	-0.034***	-0.130	0.005	-0.633	-0.018***
	(0.645)	(0.008)	(0.197)	(0.007)	(0.816)	(0.005)
Control variables						
Trade Openness	-0.004	0.249***	-0.059	0.133***	0.755	0.542***
(trade volume/GDP, in logs)	(0.464)	(0.023)	(0.288)	(0.031)	(0.486)	(0.032)
Government Burden	0.060	-0.274***	-0.362	-0.267***	4.279	0.135***
(government consumption/GDP, in logs)	(0.417)	(0.027)	(0.401)	(0.026)	(3.696)	(0.025)
Lack of Price Stability	-0.536	-0.544***	-1.359	-0.424***	-5.131*	-0.047*
(log [100 + inflation rate])	(1.033)	(0.059)	(1.984)	(0.058)	(2.791)	(0.027)
No. Countries / No. Observations	52/1813	52/1813	52/1816	52/1816	52/1819	52/1819
Specification test						
Joint Hausman Test	7.68	[$p = 0.17$]	2.31	[$p = 0.80$]	6.43	[$p = 0.27$]

Notes: All estimations include a constant country specific term. Standard errors are presented below the corresponding coefficients in brackets. Symbols ***, **, and * denote significance at 1%, 5%, and at 10% respectively. The Schwarz Bayesian Criterion (SBC) has been used to select the lag orders for each group in which the maximum lag is set to two. The p-values are presented next to the corresponding h-tests in square-brackets. The volatility measure is based on GARCH(1,1) model, see the Data Supplement Section A.1 for more details. Source: Authors' estimations.

the standard errors, increases the measured speed of adjustment and (slightly) changes the long-run estimates.[12]

4.2.2 Volatility and the Channels Affecting Economic Growth

To investigate the channels through which commodity terms of trade volatility harms output growth, we estimate the following regression for each of the 52 countries before imposing the long-run homogeneity restrictions:

$$w_{it} = c_{wi}^{*} + \sum_{l=1}^{p} \phi_{il} w_{i,t-l} + \sum_{l=0}^{q} \boldsymbol{\beta}_{il}^{\prime} \mathbf{x}_{i.t-l} + \sum_{l=1}^{p} a_{il} \overline{w}_{t-l} + \sum_{l=0}^{q} \mathbf{b}_{il}^{\prime} \overline{\mathbf{x}}_{t-l} + \varepsilon_{it}, \tag{13}$$

where w_{it} is the log of $W_{it} = \{$TFP or physical capital per capita for country i and time $t\}$; while $\overline{w}_t$ is the simple cross-sectional average of w_{it}, with all other variables as defined in equation (12). As the p-values of the Hausman tests in regressions [2.2] and [2.3] are well above the usual significance levels, we cannot reject the null hypothesis of long-run homogeneity and as such we concentrate on the CCEPMG estimates for both the TFP and the physical capital investment equations.

Regression [2.2] confirms that TFP is likely not the channel through which uncertainty in commodity prices dampens growth, as the coefficient of CToT volatility is statistically insignificant, thus supporting the results in Section 4.1.2. However, in contrast to our earlier findings using five-year averages, resource abundance measured by g_{CToT} does negatively affect TFP growth and is statistically significant. But as the overall effect of this variable on real GDP per capita growth in the long run is significantly positive, see [2.1], it must be the case that the negative impact of g_{CToT} on TFP growth is offset through other channels. Overall, there seems to be no statistical evidence that commodity booms eventually lead to lower output growth, consequently ruling out the possibility that the Dutch disease effect is operating in the countries in our sample.

Turning to the physical capital accumulation channel, regression [2.3], we observe that the results presented in Table 2 are consistent with those obtained in Table 1, as CToT growth increases the capital stock and through that enhances the growth rate of real GDP per capita. More importantly, volatility reduces physical capital accumulation; indicating that this channel is one of the most important sources through which uncertainty in commodity prices dampens output growth.

The error-correction term in regression [2.2] is in line with expectations, $\sum_{l=1}^{p} \phi_{il} - 1 < 0$,

[12] Individual country estimates are available on request, but it should be noted that they are likely to be individually less reliable given the fact that the time dimension of the panel is relatively small.

suggesting that there is some convergence towards the technological frontier across countries and thus positive knowledge spillovers. This is also true for the physical capital investment regression in [2.3]. Finally, while both government burden and lack of price stability have significantly negative effects on TFP growth, trade openness has a significant positive effect. The lack of price stability (openness) also significantly negatively (positively) affects the growth rate of physical capital stock, while government consumption boosts investment.

Thus, overall, the results of the CCEPMG estimations are in line with those obtained in Section 4.1, suggesting that commodity price volatility has a negative impact on economic growth operating through lower investment in physical capital. This result is also supported by a number of contributions in the literature, see Section 4.1.2, with emphasis on physical capital investment being the main channel through which the resource curse operates. However, the focus of those papers, as elsewhere in the resource curse literature, is on the level of the resource income, and not on the volatility effects. The importance of our empirical analysis lies in the fact that we consider both the growth rate and the volatility of resource abundance (proxied by commodity prices) in our study.

5 Concluding Remarks

This paper contributed to the literature by examining empirically the effects of commodity price booms and CToT volatility on GDP per capita growth and its sources using two econometric techniques. First, we employed a system GMM dynamic panel estimator to deal with the problems of simultaneity and omitted variables bias, derived from unobserved country-specific effects. Second, we created an annual panel dataset to exploit the time-series nature of the data and used the dynamic Common Correlated Effects Pooled Mean Group (CCEPMG) estimator to account for both cross-country heterogeneity and cross-sectional dependence which arise from unobserved common factors. The main finding was that while CToT growth enhances real output per capita, CToT volatility exerts a negative impact on economic growth operating mainly through lower accumulation of physical and human capital. Productivity, however, was not affected by either growth or volatility of CToT, which is in contrast to the argument that natural resource abundant countries have fewer possibilities for technological progress. Our results also indicated that the negative growth effects of CToT volatility offset the positive impact of commodity booms. Therefore, we argued that volatility, rather than abundance *per se*, drives the "resource curse" paradox.

An important aspect of our results was to show the asymmetric effects of CToT volatility on GDP growth in the two country groups considered. While CToT instability created a significant negative effect on output growth in the sample of 62 primary product exporters, in the case of the remaining 56 countries (or even in the full sample of 118 countries) the same pattern was not observed. One explanation for this observation is that the latter group of countries, with more diversified export structure, were better able to insure against price volatility than a sample of primary product exporters. We also offered some empirical evidence on growth-enhancing effects of export diversification, especially for countries whose GDP is highly dependent on revenues from just a handful of primary products.

The empirical results presented here have strong policy implications. Improvements in the conduct of macroeconomic policies, better management of resource income volatility, and export diversification can all have beneficial growth effects; as do policies which increase the return on investment, such as public infrastructure developments and human capital enhancing measures. Moreover, the creation of commodity stabilization funds, or Sovereign Wealth Funds in case of countries in the Persian Gulf, might be one way to offset the negative effects of commodity booms and slumps. Further research is needed in these areas as policy agenda of resource-rich economies prioritize it.

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