Commodity Prices and Growth: Reconciling a Conundrum[1]

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Abstract

Currently, evidence on the 'resource curse' yields a conundrum. While there is much informal evidence to support the 'curse' hypothesis, time series analyses using the VAR methodology have found that increases in commodity prices significantly raise the growth of commodity exporters. We adopt co-integration methodology, enabling us to explore longer term effects than permitted using VARs, and analyze a global data set covering 1971-2004. We find sharp differences in the effects, both between the short term and the long term, and the type of commodity. For all types of commodity, the short term consequences of price booms are benign for their exporters: the direct gain from the income terms of trade is reinforced by induced growth in constant-price GDP. For agricultural commodities the output effect persists over the long term. However, for both oil and the other non-agricultural commodities, the long term effects on output are adverse and substantial. Our results thus support the 'resource curse' hypothesis, while reconciling the apparent inconsistency with results based on VARs.

Keywords: commodity prices; natural resource curse; growth

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1. Introduction

A large but predominantly informal literature suggests that there is a 'resource curse': natural resource abundant countries tend to grow slower than resource-scarce countries.[2] The theoretical literature has suggested three possible channels of transmission. First, countries with natural resources often face more volatility, especially through commodity prices. Second, increases in commodity prices can lead to Dutch Disease effects. And finally, natural resources can have adverse effects on governance.[3] In all three channels, the effect of commodity revenue windfalls is crucial. Such windfalls can occur both through the *discovery* of natural resources and through commodity *booms*.

Whereas the resource curse theory predicts a negative effect of commodity booms on growth, recent empirical studies by Deaton and Miller (1996) for Africa and Raddatz (2005) for low-income countries find quite the contrary: commodity booms significantly raise growth. The rise in African growth rates during the commodity boom that began in 2000 is clearly consistent with the results of Deaton and Miller and Raddatz. However, an acknowledged limitation of the VAR technology deployed in these studies is that it cannot address long-run effects. It is therefore possible that the positive short-run effects are offset by a subsequent resource curse beyond the horizon of the VAR approach: the post-2000 upturn would be a false dawn. In this paper we adopt cointegration methodology to analyze global data for 1971-2004 to disentangle the short and long run effects of commodity prices on growth.

The rest of this paper is structured as follows. Section 2 describes the empirical analysis, including the cointegration tests. In Section 3 we set out the results of the cointegration analysis and use them to simulate the short and long run effects of higher commodity export prices on growth in commodity-dependent economies. While the short run effects are fully consistent with those of earlier studies, we find that in the long run for oil and other non-agricultural commodities there is indeed a

[2] Sachs and Warner (1995, 1997a, b), Leite and Weidmann (1999), Auty (2001), Bravo-Ortega and De Gregorio (2001), and Sala-i-Martin and Subramanian (2003).

[3] Models of Dutch Disease were first introduced by Corden and Neary (1982) and Van Wijnbergen (1984). For the adverse effects on governance, see the rent-seeking models by Lane and Tornell (1996), Tornell and Lane (1999) and Torvik (2002).

significant and substantial resource curse. In Section 4 we test two of the transmission channels of the resource curse effect, as suggested by the theoretical literature: Dutch disease and volatility. We find that Dutch disease plays a minor role, whereas volatility may be more important. However, an implication of the result that the resource curse is confined to non-agricultural commodities, is that governance is likely to be the critical route. Typically, non-agricultural windfalls accrue predominantly to governments whereas agricultural windfalls accrue primarily to the private sector. In Section 5 we apply our results to the present commodity boom in Africa, disaggregating the accelerated growth of recent years into that attributable to the short term effects of the commodity boom and that attributable to underlying changes. Section 6 concludes.

2. The Empirical Analysis

In this section we discuss our choice of statistical technique, the variables we use in estimation, and the cointegration tests we performed. Data description and sources can be found in the Appendix.

The short-run and long-run effects of commodity export prices on GDP per capita are analyzed using the following equilibrium correction model:

$$\Delta Y_{i,t} = \alpha_i + \lambda Y_{i,t-1} + \beta_1 X_{i,t-1} + \beta_2 \Delta Y_{i,t-k} + \beta_3 \Delta X_{i,t-n} + \beta_4 S_{i,t-n} + u_{i,t} \qquad (1)$$

where $Y_{i,t}$ is log real GDP per capita in country i in year t and α_i is a country-specific fixed effect. $X_{i,t-1}$ is a vector of variables (all in logs) that is expected to affect GDP per capita both in the short run and long run. First, we include our constructed commodity export price index to test the effect of export prices. We also experiment with an oil export price index and with separate indices for oil, agricultural, and other commodities to investigate the effects of different types of commodities. In all regressions we include an oil import price index to control for the effect of oil prices on oil importing countries. In addition, we include several control variables, all taken from the empirical growth literature: i) trade openness, measured as the ratio of trade to GDP, ii) external debt to GNI, iii) inflation, measured as the consumer price index (cpi), and iv) financial development, measured as the ratio of M2 to GDP.

$S_{i,t-n}$ is a vector of control variables that is expected to have a short-run effect on growth. This vector includes indicators of civil war and coup d'etat(s). Following Raddatz (2005) we also control for several types of natural shocks, in particular geological, climatic, and human disasters. The lag order of the short-run growth determinants is denoted by $k > 0$ and $n \geq 0$. The paper's hypotheses are tested through the short-run and long-run effects of the commodity export price indices, captured within the coefficient vectors β_1 and β_3.

Our dataset consists of all countries and years for which data are available, and covers around 100 countries between 1971 and 2004. Table 1 reports summary statistics for the variables used in estimation. Next, we discuss how the commodity price indices were constructed.

Constructing commodity price indices

The commodity export price index (CEPI) was constructed using the methodology of Deaton and Miller (1996) and Dehn (2000). In particular, we collected data on world commodity prices and commodity export values for as many commodities as data availability allowed. Table 2 lists the 58 commodities in our sample. For each of the countries, we calculate the total value of commodity exports in 1990. We construct weights by dividing the individual 1990 export values for each commodity by this total. These 1990 weights are then held fixed over time and are applied to the world price indices of the same commodities to form a country-specific geometrically weighted index of commodity export prices.

When testing for the effect of commodity export prices, it is important that the commodity export price index is exogenous, i.e. not correlated with the error term in equation (1). As argued in Deaton and Miller (1996), one of the advantages of using international commodity prices is that they are typically not affected by the actions of individual countries. Also, by keeping the weights constant over time, supply responses to price changes are not included. As a result, we believe the index to be exogenous with respect to GDP or the determinants of GDP.

The oil export and oil import price indices were constructed as follows. We first collected an index of world oil prices. After taking the log of this index we interacted it with dummy variables for net oil importing countries and net oil exporting countries. This yielded two variables. The first, the oil import price index, equals the log world oil price index for net oil importers and equals zero for net oil exporters. The second, the oil export price index (OEPI), equals the log world oil price index for net oil exporters and equals zero for net oil importers.

Testing for cointegration

Using equation (1) above, the long-run equilibrium equation of log real GDP per capita can be written as follows:

$$Y_{i,t} = -\frac{1}{\lambda}(\gamma_i + \theta_1 t + \beta_1 X_{i,t} + \eta_{i,t}) \qquad (2)$$

where γ_i is a country-specific fixed effect and t is a time trend. Note that both the constant and the coefficient on the time trend are allowed to differ across countries. This follows from the fact that we left the country-specific fixed effect α_i in equation (1) unrestricted. Hence, it not only captures the country-specific constant γ_i in the levels equation (2) but also the country-specific constant in the differenced equation (1). The latter implies a country-specific linear time trend in the levels equation (2).

Equation (1) allows us to estimate the long-run relationship in equation (2) if $Y_{i,t}$ and $X_{i,t}$ are cointegrated, i.e. if $Y_{i,t}$ and $X_{i,t}$ have a common stochastic trend which is cancelled out by the linear combination. To test whether the variables do cointegrate, we first performed panel unit root tests on both the levels and the differences of the individual variables in $Y_{i,t}$ and $X_{i,t}$ and then performed a panel cointegration test. We use the panel unit root tests by Im, Pesaran and Shin (2003, IPS hereafter) and Maddala and Wu (1999). Both tests are based on augmented Dickey-Fuller (ADF) tests for the individual series in the panel. This ensures that in both tests the ADF test statistic is allowed to vary across groups, unlike for example the panel unit root test by Levin, Lin and Chu (2002). The null hypothesis is that all groups have a unit root while under the alternative one or more groups do not have a unit root. The IPS test and the Maddala and Wu test differ in that the first test is parametric and is based on the t-statistics of the individual unit root tests, whereas the second is non-parametric and is based on the p-values of the individual unit root tests. The oil export price index (OEPI) and the oil import price index are either equal to zero or equal to the world oil price index, which is not country-specific. Hence, a panel unit root test is not appropriate. Instead, we perform a Dickey-Fuller test on the log world oil price index series to test for the stationarity of the oil export and import price indices.

In order for the variables to be cointegrated, they should be integrated of order 1, that is non-stationary in levels but stationary in first differences. Panel A of Table 3 shows the results of the panel unit root tests. Most of the results confirm that the series are I(1). For the differenced series, both the IPS and the Maddala and Wu tests always reject the null that all groups have a unit root. For the oil price indices, the Dickey-Fuller test for the differences also rejects the null of a unit root. For most of the level tests, the null hypothesis that all groups have a unit root is not rejected. However, this is not always the case. The tests give mixed results for trade to gdp and the commodity export price index (CEPI), where one of the tests rejects the null and the other does not. For the oil price indices the null of a unit root is rejected, but only at the 10 percent level. Finally, both tests reject the null for the external debt to GNI variable. It is important to point out that these tests only address the null hypothesis that all series in the panel are non-stationary. Rejection of this null does not mean that all the individual series are stationary but only that at least one of the series is stationary.

We next perform a panel cointegration test, as suggested by Pedroni (1999). In particular we use the Group t-Statistic, which is analogues to the IPS test above but applied to the estimated residuals of the cointegrating regression. If the variables cointegrate, the residuals from equation (2) above should be stationary. To construct the test statistic, we proceed as suggested by Pedroni (1999). We first run the following regression for each country separately:

$$Y_t = \alpha_0 + \alpha_1 t + \alpha_2 X_t + \varepsilon_{i,t} \qquad (3)$$

where Y_t is log real GDP per capita and X_t includes the long-run GDP determinants that enter our main specification in columns (1) and (2) of Table 2A below, i.e. log trade to GDP, log external debt to GDP, log CPI, log M2 to GDP, log CEPI, and log oil import price index. This allows for country-specific fixed effects, country-specific time trends and country-specific coefficients for the long-run GDP determinants. We then collect the residuals from these regressions and run ADF regressions for each country. Following Pedroni (1999), we allow the number of lagged differences in the individual ADF regressions to differ across countries by including the lags that enter statistically significant. Finally, we calculate the average of the ADF t-statistics from these regressions, which we report in Panel B of Table 3, for both the full unbalanced sample of 96 countries and a balanced subsample of 33 countries.[4] This average is analogues to the t-bar statistic in the IPS panel unit root test. Importantly, however, the critical values for the cointegration test differ from the critical values for the IPS panel unit root test. Pedroni (1999) provides the adjusted critical values. Both the test for the balanced panel and the test for the full unbalanced panel strongly reject the null hypothesis that the residuals of the cointegrating regression are non-stationary for all groups. This supports the hypothesis that the individual series are cointegrated.

3. Estimating the Short and Long Run Effects on Growth

Table 4 reports the results of estimating equation (1) and contains four panels. Panel A shows the estimates of the long-run coefficients, corresponding to $-\frac{1}{\lambda} \bullet \beta_1$ in equations (1) and (2). Panel B reports the estimates of the short-run adjustment coefficient λ (speed of adjustment). Panel C shows the estimates of the short-run coefficients for our export price indices (β_3) and the lags of the dependent variable (β_2). Finally, panel D reports the estimates of the short-run coefficients for our

[4] The tests in Pedroni (1999) are developed for balanced panels. However, for sensitivity we also performed the procedure for our full unbalanced sample. Results are similar.

control variables (β_3 and β_4, respectively). The five columns in Table 4 correspond to five different specifications.

The first specification simply includes our commodity export price index (CEPI), entered directly. As shown in Panel A, the index is not statistically significant. However, we would expect the consequences of commodity prices to be broadly proportionate to the importance of commodity exports in GDP. Hence, in column (2) of Table 4 we add an interaction term of the commodity export price index and the ratio of commodity exports to GDP. We now find clear evidence of a long run effect. The interaction term is significant at 5 percent, consistent with the hypothesis of approximate proportionality. The sign of the coefficient is negative, consistent with a long-run 'resource curse' effect: in the long run higher export prices significantly reduce the level of constant price GDP in countries with large commodity exports. Figure 1 illustrates this effect, showing the range of dependence upon commodity exports over which the adverse effect is significant. As could be expected, countries with commodity exports close to zero percent of GDP are not affected by higher commodity prices, i.e. the elasticity of GDP per capita with respect to commodity prices is approximately zero. For higher levels of commodity exports to GDP, the elasticity turns negative. For countries with commodity exports to GDP ratios of 19 percent and higher, the negative effect is statistically significant at the 5 percent level. An example of a country that highly depends on its commodity exports is Zambia. In 1990 Zambia's commodity exports represented 35 percent of its GDP. The results in Figure 1 therefore predict a long-run elasticity of -0.47. In other words, a 10 percent increase in the price of Zambian commodity exports leads to a 4.7 percent lower long-run level of GDP per capita. These results clearly suggest the existence of a long-run "resource curse". We should note that a reduction in constant-price GDP is not the same as a reduction in real income. The higher export price directly raises real income for a given level of output and this qualitatively offsets the decline in output. The magnitude of this benefit from the terms of trade follows directly from the change in the export price and the share of exports in GDP. Thus, in the example of Zambia above, the terms of trade gain directly raises income by 3.5 percent of GDP for given output. Even so, this is less than the decline in output of 4.7 percent, so that the resource curse ends up reducing both output and income relative to counterfactual.

We next investigate whether this adverse long-run effect is common to all the commodities in our index. Economically the most important commodity in the index is oil. We replace our general commodity export price index (CEPI) by our oil export price index (OEPI). Column (3) shows the results when we repeat the specification of column (1), simply entering the oil export price index directly. As shown in panel A, the level of the index is again statistically insignificant. As before, we next investigate whether the long-run effect of higher commodity export prices is proportionate to the value of oil exports. Hence, in column (4) of Table 4 (panel A) we add an interaction term of the oil export price index and the net oil exports to GDP ratio. We now find strong evidence that oil exports have a long-run effect, the interaction term entering significant at 1 percent. The sign of the coefficient is negative, consistent with the hypothesis of an 'oil curse'.

To investigate the commodity decomposition further, in column (5) of panel A we decompose the general commodity export price index CEPI into three sub-indices: one for oil only (OEPI), one for agricultural commodities only (A-CEPI), and one for non-oil, non-agricultural commodities only (NONA-CEPI).[5] The results for the oil export price index, OEPI, are similar to the results in column (4). The direct effect of the index is statistically insignificant, whereas its interaction with the level of net oil exports to GDP enters negative and is again significant at 1%. In Figure 2, Panel A, we again illustrate the range of oil exports over which the effect is significant. For levels of net oil exports to GDP above 13 percent, the effect of higher oil prices is negative and statistically significant: an increase in the oil price negatively affects long-run GDP per capita. The effect is substantial. For a country like Nigeria, which has net oil exports of 34 percent of GDP, the results predict a long-run elasticity of -0.50. In other words, a 10 percent increase in the price of oil leads to a 5.0 percent lower long-run level of Nigerian GDP per capita. For a country like Angola, with net oil exports of 64 percent of GDP, the effect is even more severe: a 10 percent increase in the price of oil leads to a 9.9 percent lower level of GDP per capita.

[5] The indices A-CEPI and NONA-CEPI were constructed in the same way as the general index CEPI. For A-CEPI we used the commodities in panel B of Table 2, whereas for NONA-CEPI we used the commodities in panel A of Table 2, except for oil. To ensure that the sample is identical to the sample in columns (1) and (2), we exclude commodities with incomplete time series.

We next investigate the effect of the non-oil, non-agricultural commodities. The direct effect of this export price index, NONA-CEPI, is again statistically insignificant while its interaction with the ratio of non-oil, non-agricultural exports to GDP is statistically significant at 10%[6]. The sign of the coefficient is again negative, suggesting that the "resource curse" effect is not confined to oil but also applies to other non-agricultural commodities. Panel B of Figure 2 illustrates the range over which the effect is significant, namely once these exports exceed 5 percent of GDP. In this range an increase in non-oil, non-agricultural commodity export prices leads to lower long-run levels of per capita GDP. Examples of countries that depend on this class of export commodities, are Bolivia (10% of GDP), Mauritania (22% of GDP), and Zambia (34% of GDP). For Mauritania, the results in panel B of Figure 2 predict a long-run elasticity of -0.80. In other words, a 10 percent increase in the price of non-oil, non-agricultural commodities, causes an 8.0 percent lower level of per capita GDP.

Finally we investigate the effect of agricultural commodity export prices. As previously, the direct effect of the index, A-CEPI, is not statistically significant. Now, however, the interaction term of A-CEPI with the ratio of agricultural exports to GDP is also insignificant and indeed enters positive. This suggests that higher agricultural export prices are not a 'curse' analogous to non-agricultural commodities: on the contrary, they are more likely than not to be beneficial. The absence of any "resource curse" effect for agriculture is illustrated in panel C of Figure 2. The contrast between the effects of the agricultural and non-agricultural commodities offers a clue as to the routes by which the latter are having adverse effects. We return to this issue after discussing the other results.

Having discussed the long-run effects of commodity prices, we now turn to the other variables in our model. To save space, we only discuss the results in column (1). First, all of the other long-run determinants enter with the expected signs. Trade to GDP enters with a positive sign and is statistically significant at the 1% level, indicating that more open countries tend to have higher long-run GDP levels. External debt enters negative and significant at the 5% level, indicating that fiscal imprudence has a negative long-run effect on GDP. The consumer price index enters with the negative

[6] When running the specification in column (5) without the agricultural index A-CEPI, the interaction term of NONA-CEPI with the NONA exports to GDP ratio is negative and significant at 5 percent.

sign, suggesting that countries with historically high levels of inflation have lower long-run GDP levels. However, this coefficient is not statistically significant so should be viewed with caution. The same goes for the ratio of M2 to GDP, which enters with a positive sign, indicating that more financially developed countries tend to have higher long-run GDP levels.

Panel B shows the short-run adjustment coefficient that corresponds to the speed of adjustment to long-run equilibrium. Lagged GDP per capita enters negative and is statistically significant at the 1% level. The size of the coefficient suggests that the speed of adjustment (i.e., the proportion of the deviation from steady state that is corrected) is 6.5 percent per year.

Having considered the long-run effects we now turn to the short-run effects. Column (1) in panel C reports the short-run coefficients of our commodity export price index and lagged growth. The results show that the contemporaneous as well as the first three lags of the change in the log commodity export price index enter positive and significant at 10 percent or higher, suggesting that an increase in the growth rate of export prices has a positive short-run effect on GDP growth. Figure 3 illustrates this effect by showing the impulse response function of an increase in the growth rate of commodity export prices. The effect of a 10 percentage points increase in prices cumulates to almost 0.5 percentage point of GDP growth after year t+3. The positive short-run effect of commodity export prices is consistent with the findings in Deaton and Miller (1996) and Raddatz (2005).[7] In addition to the effect of export prices, column (1) in panel C shows the coefficients of the lags of the dependent variable GDP growth. We find that the first lag is most important as it enters positive and significant at 1 percent. The fourth lag enters negative and significant at 5 percent, suggesting that there is some degree of mean reversion in the growth rate of GDP.

Panel C, column (3), reports the short-run coefficients of the oil export price index. The results show that the contemporaneous as well as the first four lags of the change in the log oil export price index enter positive, suggesting that an increase in the

[7] Raddatz (2005) documents that a 14 percent increase in commodity export prices results in a 0.9 percent increase in GDP after four years. Our estimated effect is very similar although slightly smaller. It should be noted that Raddatz does not distinguish between short-run and long-run effects of commodity prices.

growth rate of oil export prices has a positive short-run effect on GDP growth in oil exporting countries. However, the effect is only statistically significant in the same year as the shock. Figure 4 illustrates the short-run effect of higher oil prices by showing the impulse response function of an increase in the growth rate of oil export prices. The effect is very similar to the general effect of higher commodity export prices. A 10 percentage points increase in the oil price cumulates to almost 0.5 percentage points higher GDP growth after year t+3.

Thus, the short-run dynamics of a commodity boom are quite contrary to the long-run effects. Further, the short run effects on output are reinforced by the direct gain in income through the improvement in the terms of trade, so that real incomes rise strongly.

We next discuss the short-run effects of the control variables that were part of the cointegrating vector (column (1) in panel D). Again, the openness indicator has the strongest impact on per capita GDP, with up to three lags entering positive and statistically significant at 10 percent or higher, suggesting that changes in openness have a positive impact on growth in the following three years. Changes in inflation have a negative effect on growth in the following year but this effect is reversed in the third year after the shock. External debt and financial development do not seem to have short-run effects on growth. A change in the oil price has a negative effect on growth in oil importing countries in the same year and the three subsequent years, although this effect is only statistically significant (at 10 percent) in the first year after the shock.[8]

The coefficients for the short-run control variables are reported in the remainder of panel D. The two political shocks, coups and civil war, have large adverse effects on growth. A coup appears to cut growth by around 2.8 percentage points in the year of the coup. The negative impact of civil war is estimated to be somewhat smaller, 2.0 percentage points, which is roughly consistent with the findings in Collier (1999) who documents a growth loss during war of 2.2 percentage points. We investigated whether this effect changes during the war but found that this is not the case.

[8] Even though the oil import price index is not significant for lags beyond 1, we include these lags because the commodity export price index also has up to four lags.

We find mixed evidence of the importance of natural disasters for growth, although they may, of course, have serious implications for other dimensions of wellbeing. Geological shocks significantly reduce growth by around 1 percentage point in the same year and by another 1 percentage point in year t+2. Climatic shocks have no significant effect in the year of the shock but in the subsequent three years there is a gain of around 0.5 percentage points growth. That climatic shocks actually augment growth may be due to donor responses. Humanitarian shocks do not appear to have significant growth effects.

4. Decomposing the Long Run Effects

The literature offers three candidate explanations for the resource curse effect: Dutch disease, the mismanagement of volatility, and adverse effects on governance. Since the responses appropriate for overcoming the resource curse differ radically as between these routes, their relative magnitude is evidently of importance. In this section we test for the importance of the first two explanations.[9]

Dutch Disease

We first explore the possibility that the long-run negative effect reflects the occurrence of Dutch Disease effects. The windfall of export revenue leads to a real exchange rate appreciation and a loss of international competitiveness in the commodity exporting country. As a result, output in the tradables sector declines and, under some circumstances, this had adverse effects on GDP due to externalities. To test for the importance of this channel, we add an index of real exchange rate overvaluation to the specification in column (5) of Table 4.[10] If the negative long-run effect of non-agricultural commodity export prices works *through* their impact on the

[9] The availability of governance data is rather limited compared to the scope of our sample.
[10] We now exclude the agricultural commodity export price index and its interaction with agricultural exports, as it has proven to be unimportant. However, the results below for the Dutch Disease channel also go through if we include the agricultural index. The same holds when we use the specification with the general commodity price index, CEPI, in column (2) of Table 5. Results are available upon request.

real exchange rate, then the interaction effect of the export price indices should disappear once we control for exchange rate overvaluation.

The exchange rate overvaluation index enters negative and is statistically significant at 5 percent, suggesting that, consistent with Dutch disease, an overvalued exchange rate indeed has a negative effect on long-run GDP per capita.[11] However, the magnitude of the Dutch disease effect is quite modest. It is depicted in Figure 5 which shows the effects of oil prices and non-oil, non-agricultural export prices. Each panel shows two lines. The solid lines denote the interaction effects when we do *not* control for exchange rate overvaluation. These effects are based on the specification in column (5) of Table 4 without the agricultural price index, but applied on a slightly smaller sample for which we have real exchange rate overvaluation data. The dashed lines show the interaction effects once we do control for exchange rate overvaluation, using the same sample. Hence, the differences between the solid and the dashed lines represent the proportions of the resource curse effects that are due to Dutch Disease.
As can be seen, adding the real exchange rate overvaluation index shifts the lines upwards, suggesting that part of the negative effects of the export prices works through the Dutch Disease channel. However, the effect is small: the shift only captures a small proportion of the total effects.

Volatility

We next investigate the role of volatility. Commodity booms are typically not permanent and prices tend to show at least some degree of mean reversion over time. As a result, countries that have experienced one or more commodity export price boom will typically also have faced higher volatility of export prices. Therefore, it might be that it is not the commodity booms by themselves that affect long-run GDP but rather the higher volatility that accompanies them.

The case-study literature on the resource curse points to post-boom crises as being the key episodes during which growth suffers. To an extent, this can be contrasted with the Dutch disease effect which hypotheses a continuous rather than episodic reduction

[11] To save space, we do not report the results of this regression.

in growth rates. We investigate whether the statistical pattern is consistent with an episodic account of the resource curse. We first divide the observations in our sample into two groups. The first group, group I, includes the countries for which the non-agricultural commodity exports to GDP ratio is above the sample median, hence the "commodity-dependent" countries. The second group, group II, includes the countries for which the non-agricultural commodity exports to GDP ratio is below the sample median. The mean growth rate of group II is 0.25 percentage points higher than the mean growth rate of group I, which is consistent with a resource curse effect. We next investigate whether this difference in the mean growth rate is due to episodes of extreme negative growth. We construct two series. For the first series we take the growth rate of group II and substract the difference between the mean growth rates of groups I and II (0.25 %). Hence, this series has the *mean* of group I but the *distribution* of group II. The second series equals the growth rates of group I. Hence, this series has the *mean* and the *distribution* of group I. We next construct frequency distributions for both series and then substract the first series from the second, i.e. we take the difference between the group I frequency distribution and the group II frequency distribution. If group I suffers more frequently from negative growth outliers, this should show in the series. Panel A of Figure 6 shows this difference in frequency distributions. As can be seen from the left half of the graph, group I does indeed suffer more frequently from negative growth episodes. We calculate how much of the difference in the mean growth rates of group I and II can be explained by these outliers. We define the extreme negative growth outliers as those observations of log GDP per capita below -3 percentage points (-0.03 on the horizontal axis). We then multiply the differences in this part of the distribution by the changes in log GDP per capita (growth) and sum them. The resulting difference in growth is -0.20 percentage points. Hence, of the total difference in mean growth rates of commodity dependent and non-commodity dependent of 0.25 percentage point, about 0.20 percentage point is explained by negative growth outliers.

These negative outliers only reflect volatility if they correspond to different countries in individual years rather than to the same countries for several years of persistently low growth. To distinguish between these two cases, we perform a second procedure. We first take the mean growth rates of individual countries over time and then divide the sample again into a group with lower-than-median mean growth and a group with higher-than-median mean growth. We apply the same procedure as before, which gives us the difference in the frequency distributions of *country mean* growth rates. If the negative growth outliers above correspond to several years of persistently low growth for the same countries, then this should show in the difference between the frequency distribution of the commodity dependent group of countries and the non-commodity dependent group of countries. This difference is illustrated in panel B of Table 6. As can be seen from the graph, commodity dependent countries do not experience more cases of persistently low growth rates than non-commodity dependent countries. As a result, we can conclude that the negative outliers above do in fact reflect volatility rather than persistently low growth 'disasters'.

However, this does not imply that 80% of the resource curse is *explained* by volatility. First, the resource curse is considerably more severe than the 0.25 percentage point lower growth of the commodity-exporting group of countries, because the counterfactual should surely be that their favourable resource endowment should be advantageous rather than simply neutral. Second, it is in one sense unsurprising that the commodity-exporting countries should have more volatile growth, with high prices causing booms and low prices causing slumps. The mere fact of severe slumps does not necessarily indicate that volatility is the problem. It may be entirely appropriate for a commodity-exporting economy to suffer slumps if by doing so it is able to harness supra-normal growth during booms. Our accounting exercise is better seen as a test which might potentially have refuted volatility as an explanation, had we found that the resource-dependent countries did not suffer more severe slumps.

Governance

There are no long time series on governance, and a formal test of its effects is beyond the scope of this paper. However, our results do point indirectly to governance as being critical in the explanation of the resource curse. This is because of the sharp distinction we have found between the agricultural and non-agricultural commodities. The export of both agricultural and non-agricultural commodities generates Dutch disease, and the prices of both are volatile, so neither explanation of the resource curse would predict this sharp difference. By contrast, it is predicted if governance is the route through which the resource curse operates.

The distinction between agricultural and non-agricultural commodities corresponds to whether or not the activity generates rents. Agricultural commodities can be produced in many different locations and so competitive entry will drive profits to normal levels. The rents on land used for export crops should therefore be no higher than that used for other crops, once allowance is made for differences in investment, such as the planting of trees. In contrast, the non-agricultural commodities are all extractive, the feasibility of production being dependent upon the presence of the resource in the ground. Hence, the extractive industries all generate rents as a matter of course. Rents can be taxed without driving the activity away. Thus, whereas the revenues from agricultural exports accrue as incomes to private factors of production, much of the revenues from the non-agricultural commodities accrue as rents to government. Here lies an important potential difference: governance is bound to matter for non-agricultural commodities because government is directly responsible for spending the income. Not only is governance intrinsically important, but it is liable to be worse. For example, both Acemoglu et al. (2002) and Tornell and Lane (1999) propose routes by which rents from extractive exports would generate a 'curse'.

5. The Current Commodity Boom: A Simulation

Recently a number of African countries have begun to grow markedly more rapidly than for the preceding two decades. An important issue is the extent to which this marks underlying improvements in policies and governance, versus the short term effects of commodity booms which we have suggested are likely to turn sour. We therefore apply our estimation results to simulate the effects of the current upturn in commodity prices on growth in those Sub-Saharan African countries that have substantial exports of oil or other non-agricultural commodities. We include all countries for which either oil or other non-agricultural commodity exports to GDP exceed 5%, a group of 14 countries.[12] We construct an oil export price index and an aggregate index for non-oil, non-agricultural, commodities specific to this group of countries, using the procedure described previously. Both indices are shown in Figure 7, panel A. Oil prices rose sharply between 1998 and 2000, and increased even more

[12] Angola, Cameroon, Democratic Republic of Congo, Republic of Congo, Equatorial Guinea, Gabon, Guinea, Liberia, Mauritania, Namibia, Nigeria, Sudan, Togo, and Zambia.

during the period from 2003 until 2006. Non-oil, non-agricultural export prices were relatively stable before 2003 but also increased sharply between 2003 and 2006.

We next simulate the short-run effects of the commodity boom. In particular, we rerun the specification in column (5) of Table 4 but without the agricultural commodity export price index and with separate short-run effects for oil and non-oil, non-agricultural commodity export prices. We then use the estimated coefficients from the regression and the log changes in the indices to calculate the short-run effects on growth. We abstract from the lagged effects of any pre-1999 shocks and assume that export prices remain at their current levels until 2010. This assumption is evidently not a forecast, but merely a neutral stance from which to investigate the likely short and long term consequences of the current boom. Finally, to generate a counterfactual, we benchmark against the assumption that export prices would have remained constant at their 1998 levels.

The results are illustrated in Figure 7, panel B. The actual growth rate of this group of countries has indeed accelerated substantially, as depicted in the panel. Weighted by GDP, the average per capita growth rate in 2005 was 4.5%, and over the entire post-1998 period it was 2.29%. How much of this is accounted for by the commodity boom? The solid line shows the predicted short-run effect of the export price shocks on growth in the 14 African countries. The two peaks correspond to the two episodes of price increases in panel A. The effects are substantial. In both 2000 and 2001, as well as during 2005, 2006, and 2007, the predicted growth effect exceeds 2% points. The cumulative predicted effect on growth over the same period as actual observed growth is 1.18%. Hence, our estimate of the underlying growth rate of this group of economies, abstracting from the commodity boom is 1.1%. This is indeed a little higher than in previous decades, but it is evidently considerably lower than global growth and so implies that the tendency for Africa to diverge from the rest of the world economy has not fundamentally been arrested. On our assumption that global prices will remain constant at their 2005 level, Africa's currently high growth rates persist until 2009 and then collapse. Hence, it may not be until 2010 that it will become evident whether Africa's underlying growth has indeed been decisively raised.

Evidently, although the above simulation has applied our model to the issue of short term growth, the more important implication of the model is for the long term. We now simulate the long-run effect of the present commodity boom on this group of countries. Using the aggregate log changes in both price indices between 1999 and 2006, and the aggregate shares of both commodity groups in GDP, our simulation results suggest that the current commodity boom will in the long run lower per capita constant-price GDP by 26.0 percent. We should stress that this does not imply a decline in living standards, since the output decline is mitigated by the direct contribution of the improved income terms of trade. However, such a major contraction in output would imply that, far from accelerating, African long term growth would decelerate.

6. Conclusion

We have found that for non-agricultural commodities, price booms have strong short-term effects on output, but adverse long-term effects. This has three important implications. The first is a vindication of the 'resource curse' literature. However, we reject the conventional attribution of the resource curse to Dutch disease: it explains only a small part of the overall adverse effect. The most likely explanation appears to be connected with governance. This is an inference from our result that the adverse effect is confined to the non-agricultural commodities. Whereas agricultural commodity booms accrue predominantly to farmers, those for non-agricultural commodities accrue predominantly to government.

The second implication concerns the recent acceleration of growth rates observed in Africa. Our simulation suggests that around half of current growth in the commodity-exporting economies is attributable to the short term effects of the commodity boom, leaving a residual of underlying growth that remains very low.

The final implication is that the current commodity boom is, if past behaviour is repeated, likely to have strongly adverse long term effects, so that the current acceleration in growth rates is particularly misleading. However, if our tentative diagnosis of the root cause of the resource curse as being due to errors in governance is correct, then this dire prognosis may be avoidable. The resource curse would not be a quasi-mechanistic consequence of a market process such as Dutch disease, but the result of contingent political processes.

Table 1: Summary Statistics

	Obs	Mean	St dev	Min	Max
GDP per capita (log)	2418	6.84	1.11	4.31	9.17
Trade to GDP (log)	2405	4.07	0.56	1.84	5.43
External debt to GNI (log)	2416	3.89	0.81	0.12	7.10
CPI (log)	2410	2.60	4.10	-26.84	7.00
M2 to GDP (log)	2416	3.31	0.55	1.41	5.02
CEPI (log)	2220	4.67	0.33	3.27	6.18
Commodity exports to GDP (%)	2418	9.03	8.68	0	44.61

OEPI (log)	2418	1.07	1.87	0	4.96
Net oil exports to GDP (%)	2418	3.64	10.68	0	87.86
Oil import price index (log)	2418	3.24	1.88	0	4.96
Δ GDP per capita (log)	2418	0.01	0.05	-0.36	0.30
Δ Trade to GDP (log)	2405	0.01	0.14	-1.20	1.40
Δ External debt to GNI (log)	2416	0.04	0.21	-1.38	1.60
Δ CPI (log)	2410	0.18	0.38	-0.12	5.48
Δ M2 to GDP (log)	2416	0.02	0.13	-1.31	1.53
Δ CEPI (log)	2209	-0.01	0.18	-0.81	1.03
Δ OEPI (log)	2418	0.01	0.13	-0.68	0.93
Δ Oil import price index (log)	2418	0.02	0.22	-0.68	0.93
Coup d'etat	2418	0.03	0.18	0	2
Civil war	2418	0.09	0.29	0	1
Geological shocks	2418	0.05	0.23	0	2
Climatic shocks	2418	0.26	0.51	0	3
Humanitarian shocks	2418	0.02	0.16	0	2

Notes: This table reports summary statistics for all observations used in estimation.

Table 2: List of commodities

Panel A: Non-agricultural commodities				
Aluminum	Gasoline	Natural gas	Phosphatrock	Uranium
Coal	Ironore	Nickel	Silver	Urea
Copper	Lead	Oil	Tin	Zinc
Panel B: Agricultural Commodities				
Bananas	Fish	Oliveoil	Rice	Sunfloweroil
Barley	Fishmeal	Oranges	Rubber	Swinemeat

Beef	Groundnuts	Palmkerneloil	Shrimp	Tea
Butter	Groundnutoil	Palmoil	Sisal	Timber
Cocoabeans	Hides	Pepper	Sorghum	Tobacco
Coconutoil	Jute	Potash	Soybeans	Wheat
Coffee	Lamb	Poultry	Soybeanmeal	Wool
Copra	Linseedoil	Plywood	Soybeanoil	
Cotton	Maize	Pulp	Sugar	

Table 3: Panel unit root and panel cointegration tests

Panel A: Panel unit root tests

	Im, Pesaran, Shin (IPS)		Maddala and Wu	
	Levels	*Differences*	*Levels*	*Differences*
GDP per capita (log)	-2.31	-4.00***	75.80	327.47***
Trade to GDP (log)	-1.69	-5.97***	113.83***	1004.47***
External debt to GNI (log)	-1.85**	-3.13***	108.82***	233.60***

CPI (log)	-1.47	-1.81**	61.74	92.60**
M2 to GDP (log)	-1.63	-2.88***	52.00	222.87***
CEPI (log)	-2.38***	-3.07***	48.92	249.65***
	Dickey-Fuller			
	Levels	*Differences*		
OEPI (log)	-2.63*	-6.14***	-	-
Oil import price index (log)	-2.63*	-6.14***	-	-
Panel B: Pedroni panel cointegration test (based on IPS)				
	Full sample (unbalanced)		Subsample (balanced)	
Group t-Statistic	-4.70***		-4.52***	

Notes: Table 3 reports test statistics for panel unit root and panel cointegration tests. The test statistics correspond to the t-bar statistic in Im, Pesaran, and Shin (2003), the Fisher χ^2 test statistic in Maddala and Wu (1999), and the statistic $Z^*_{t\,N,T}$ divided by N in Pedroni (1999). The choice of lag order in the panel unit root tests was based on a pooled (augmented) Dickey-fuller regression with fixed effects, except for the oil export and import price indices, for which we ran an ordinary (augmented) Dickey-Fuller test. The number of lags is 1, 0, 2, 4, 2, 4, 0, and 0 for GDP per capita, trade to GDP, external debt to GNI, CPI, M2 to GDP, CEPI, OEPI, and the oil import price index, respectively. Since equation (2) includes a time trend, we also include a time trend in the panel unit root test for GDP per capita (results are similar if we exclude the trend). *, ** denote significance at the 5% and 1% levels, respectively.

Table 4: Estimation results

	(1)	(2)	(3)	(4)	(5)
Panel A:Estimates of long-run coefficients					
Trade to GDP (log)	0.342***	0.352***	0.355***	0.359***	0.362***
	(0.104)	(0.109)	(0.103)	(0.104)	(0.106)
External debt to GNI (log)	-0.074**	-0.070*	-0.018	-0.024	-0.065
	(0.036)	(0.037)	(0.039)	(0.040)	(0.041)
CPI (log)	-0.006	-0.005	0.001	0.001	-0.003
	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
M2 to GDP (log)	0.061	0.082	0.080	0.082	0.064

	(1)	(2)	(3)	(4)	(5)
	(0.093)	(0.097)	(0.087)	(0.089)	(0.098)
CEPI (log)	-0.144	0.042			
	(0.199)	(0.150)			
CEPI (log) * Commodity exports to GDP		-0.015**			
		(0.006)			
OEPI (log)			-0.098	0.049	0.052
			(0.087)	(0.096)	(0.095)
OEPI (log) * Net oil exports to GDP				-0.013***	-0.016***
				(0.004)	(0.004)
NONA-CEPI (log)					-0.030
					(0.100)
NONA-CEPI (log) * NONA-exports to GDP					-0.035*
					(0.018)
A-CEPI (log)					0.042
					(0.133)
A-CEPI (log) * A-exports to GDP					0.012
					(0.017)
Oil import price index (log)	-0.056	-0.076	-0.108*	-0.107*	-0.105
	(0.062)	(0.064)	(0.062)	(0.062)	(0.066)
Observations	2169	2169	2418	2418	2169
Number of countries	100	100	115	115	100
R-squared within	0.16	0.16	0.15	0.16	0.17

Notes: The dependent variable is the first-differenced log of real GDP per capita in year t. CEPI is the commodity export price index, OEPI is the oil export price index, NONA-CEPI is the commodity export price index when excluding oil and agricultural commodities. A-CEPI is the commodity export price index when including agricultural commodities only. All regressions include country-specific fixed effects. Robust standard errors are clustered by country and are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Estimation results (cont'd)

	(1)	(2)	(3)	(4)	(5)
Panel B: Estimate of short-run adjustment coefficients					
GDP per capita (log)$_{t-1}$	-0.065***	-0.064***	-0.060***	-0.059***	-0.064***
	(0.010)	(0.009)	(0.008)	(0.008)	(0.009)
Panel C: Estimates of short-run coefficients: commodity prices, oil prices, and GDP					
Δ (CEPI (log))$_t$	0.016**	0.016**			0.017**
	(0.008)	(0.008)			(0.008)
Δ (CEPI (log))$_{t-1}$	0.027***	0.025***			0.023***

	(0.009)	(0.009)			(0.008)
Δ (CEPI (log))$_{t-2}$	0.017**	0.015*			0.013*
	(0.008)	(0.008)			(0.008)
Δ (CEPI (log))$_{t-3}$	0.009*	0.009*			0.008
	(0.005)	(0.005)			(0.005)
Δ (CEPI (log))$_{t-4}$	0.007	0.007			0.006
	(0.006)	(0.006)			(0.005)
Δ (OEPI (log))$_{t}$			0.021**	0.021**	
			(0.009)	(0.009)	
Δ (OEPI (log))$_{t-1}$			0.019	0.020	
			(0.012)	(0.012)	
Δ (OEPI (log))$_{t-2}$			0.009	0.010	
			(0.009)	(0.009)	
Δ (OEPI (log))$_{t-3}$			0.008	0.009	
			(0.007)	(0.007)	
Δ (OEPI (log))$_{t-4}$			0.002	0.003	
			(0.008)	(0.008)	
Δ (GDP per capita (log))$_{t-1}$	0.139***	0.136***	0.162***	0.160***	0.135***
	(0.036)	(0.036)	(0.034)	(0.033)	(0.035)
Δ (GDP per capita (log))$_{t-2}$	-0.038	-0.042	-0.022	-0.025	-0.043*
	(0.026)	(0.026)	(0.025)	(0.025)	(0.026)
Δ (GDP per capita (log))$_{t-3}$	0.059*	0.053*	0.055*	0.051*	0.053*
	(0.030)	(0.031)	(0.029)	(0.030)	(0.030)
Δ (GDP per capita (log))$_{t-4}$	-0.058**	-0.061**	-0.041**	-0.043**	-0.062***
	(0.023)	(0.024)	(0.021)	(0.021)	(0.023)

Notes: The dependent variable is the first-differenced log of real GDP per capita in year t. CEPI is the commodity export price index and OEPI is the oil export price index. All regressions include country-specific fixed effects. Robust standard errors are clustered by country and are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Estimation results (cont'd)

	(1)	(2)	(3)	(4)	(5)
Panel D: Estimates of short-run coefficients: control variables					
Δ Trade to GDP (log)$_{t-1}$	0.019*	0.019*	0.021**	0.021**	0.019*
	(0.011)	(0.011)	(0.011)	(0.010)	(0.011)
Δ Trade to GDP (log)$_{t-2}$	0.022**	0.022**	0.020**	0.020**	0.022**
	(0.009)	(0.010)	(0.009)	(0.009)	(0.010)
Δ Trade to GDP (log)$_{t-3}$	0.018**	0.017**	0.016**	0.016**	0.018**
	(0.008)	(0.008)	(0.007)	(0.007)	(0.008)

Δ Ext. debt to GNI (log)$_{t-1}$	0.002	0.001	-0.000	-0.001	-0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Δ CPI (log)$_{t-1}$	-0.011**	-0.011**	-0.011***	-0.011***	-0.010**
	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)
Δ CPI (log)$_{t-2}$	-0.003	-0.003	-0.001	-0.001	-0.004
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Δ CPI (log)$_{t-3}$	0.009*	0.009*	0.001	0.000	0.009**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)
Δ M2 to GDP (log)$_{t-1}$	-0.002	-0.002	0.002	0.002	-0.001
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)
Δ Oil im. pr. index (log)$_{t}$	-0.004	-0.004	-0.003	-0.003	-0.005
	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)
Δ Oil im. pr. index (log)$_{t-1}$	-0.008*	-0.008*	-0.002	-0.002	-0.006
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Δ Oil im. pr. index (log)$_{t-2}$	-0.007	-0.007	-0.003	-0.003	-0.006
	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)
Δ Oil im. pr. index (log)$_{t-3}$	-0.004	-0.004	-0.001	-0.001	-0.004
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Δ Oil im. pr. index (log)$_{t-4}$	0.006	0.006	0.008**	0.008**	0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Coup$_{t}$	-0.028***	-0.027***	-0.025***	-0.025***	-0.027***
	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)
War$_{t}$	-0.020***	-0.019***	-0.019***	-0.019***	-0.020***
	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)
Geological shock$_{t}$	-0.012**	-0.012**	-0.013**	-0.013**	-0.013**
	(0.006)	(0.006)	(0.005)	(0.005)	(0.006)
Geological shock$_{t-1}$	0.000	0.000	0.002	0.002	-0.000
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Geological shock$_{t-2}$	-0.009***	-0.010***	-0.008**	-0.008**	-0.011***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)

Notes: The dependent variable is the first-differenced log of real GDP per capita in year t. All regressions include country-specific fixed effects. Robust standard errors are clustered by country and are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

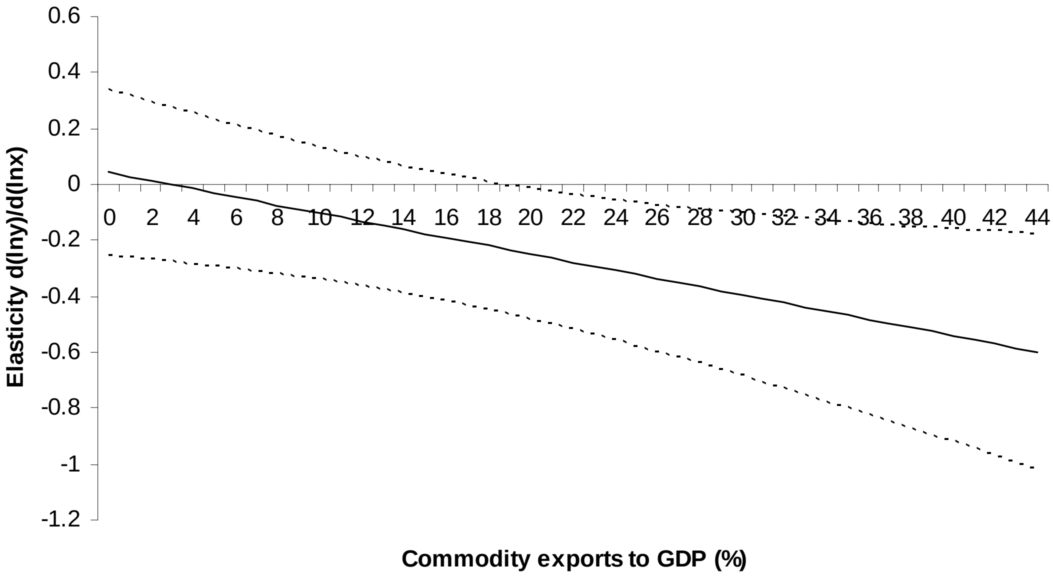
Table 4: Estimation results (cont'd)

	(1)	(2)	(3)	(4)	(5)
Panel D (cont'd): Estimates of short-run coefficients: control variables					
Climatic shock$_{t}$	-0.001	-0.001	-0.002	-0.002	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Climatic shock$_{t-1}$	0.004**	0.004**	0.003	0.003	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Climatic shock$_{t-2}$	0.005**	0.005**	0.004**	0.004**	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)

Climatic shock$_{t-3}$	0.007***	0.007***	0.007***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Humanitarian shock$_t$	-0.006	-0.006	-0.006	-0.006	-0.006
	(0.009)	(0.009)	(0.010)	(0.010)	(0.009)

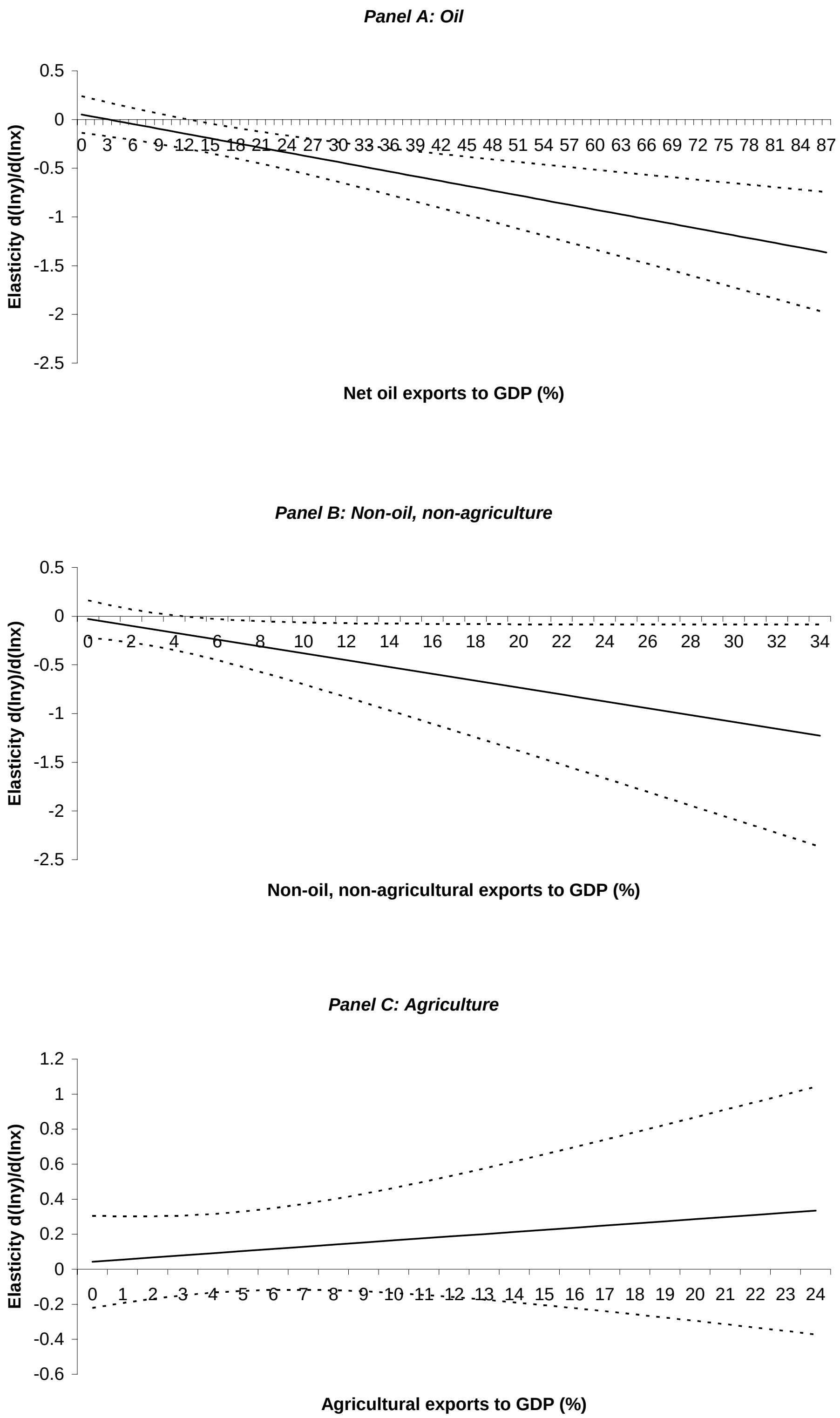
Notes: The dependent variable is the first-differenced log of real GDP per capita in year t. All regressions include country-specific fixed effects. Robust standard errors are clustered by country and are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Figure 1 The long-run effect of commodity export prices on gdp per capita

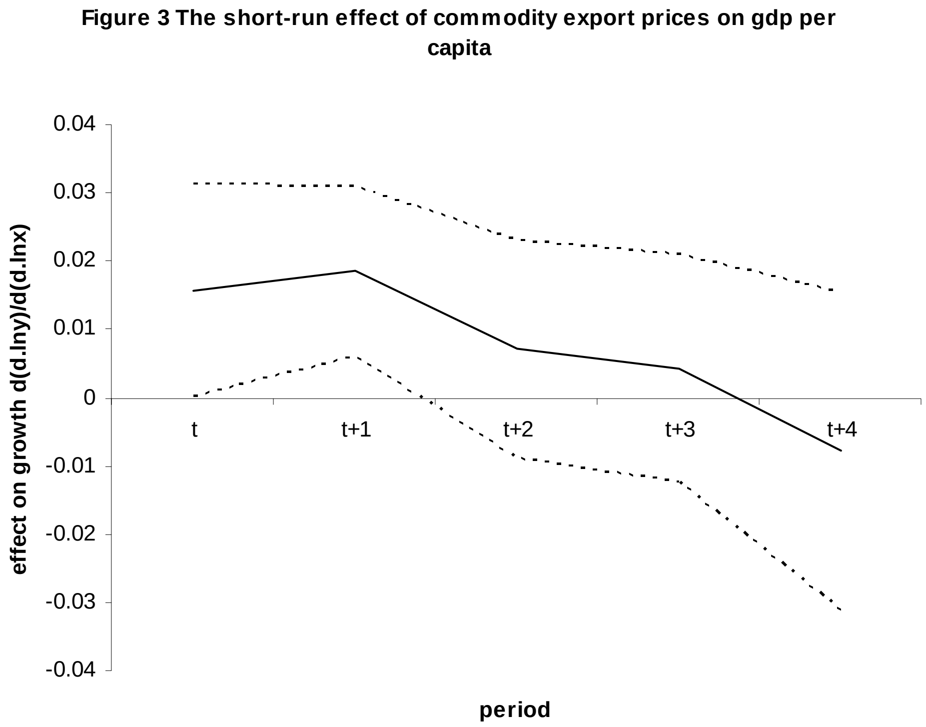


Notes: Figure 1 is based on the estimation results in panel A of Table 4 (column (2)). The solid line denotes the elasticity of gdp per capita with respect to commodity export prices. The dashed lines illustrate the 95% confidence interval. The range of values on the horizontal axis corresponds to the range of values in our sample.

Figure 2 The long-run effect of oil, non-oil non-agricultural, and agricultural commodity export prices on gdp per capita

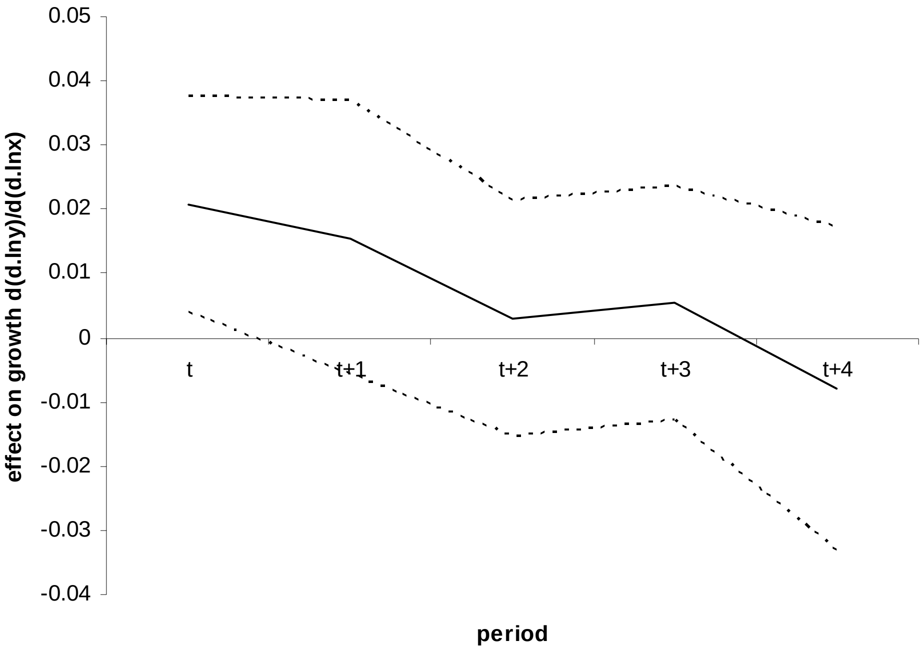


Notes: Figure 2 is based on the estimation results in panel A of Table 4 (column (5)). The solid line denotes the elasticity of gdp per capita with respect to the three indices. The dashed lines illustrate the 95% confidence interval. The range of values on the horizontal axes corresponds to the range of values in our sample.



Notes: Figure 3 is based on the estimation results in panel C of Table 4 (column (1)). The solid line denotes the impulse response function of a shock to the commodity export price index in period t. A value of 0.015 on the vertical axis implies that a 10 percentage point increase in the growth rate of commodity export prices leads to a 0.15 percentage point increase in the gdp per capita growth rate. The dashed lines illustrate the 95% confidence interval.

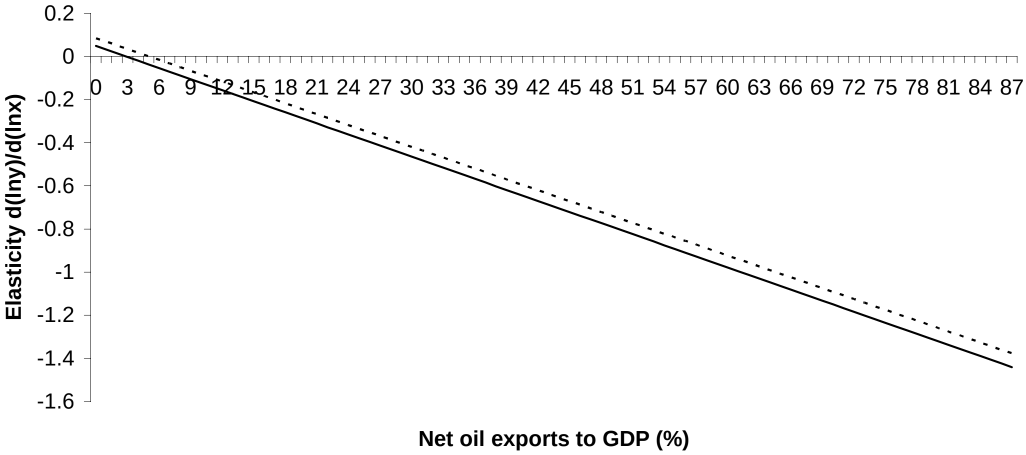
Figure 4 The short-run effect of oil export prices on gdp per capita



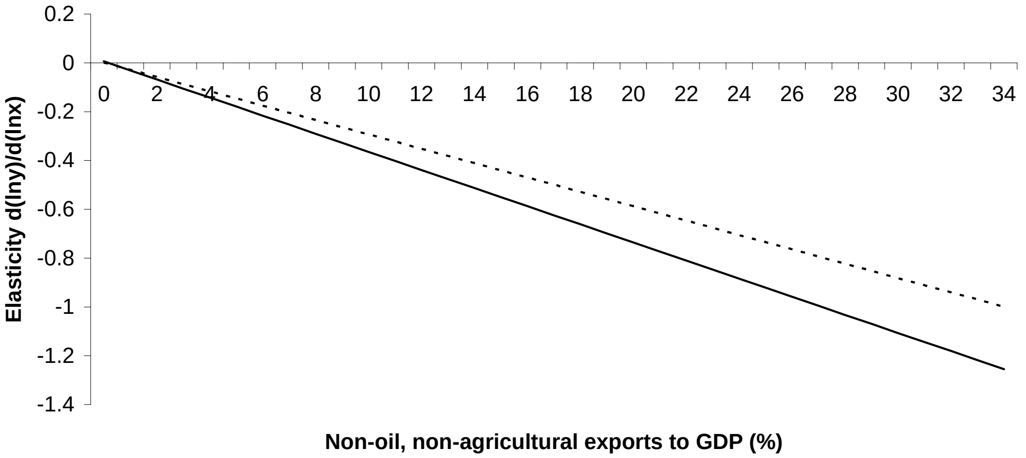
Notes: Figure 4 is based on the estimation results in panel C of Table 4 (column (3)). The solid line denotes the impulse response function of a shock to the oil export price index in period t. A value of 0.02 on the vertical axis implies that a 10 percentage point increase in the growth rate of oil export prices leads to a 0.20 percentage point increase in the gdp per capita growth rate. The dashed lines illustrate the 95% confidence interval.

Figure 5 The Dutch Disease channel of the resource curse

Panel A: Oil



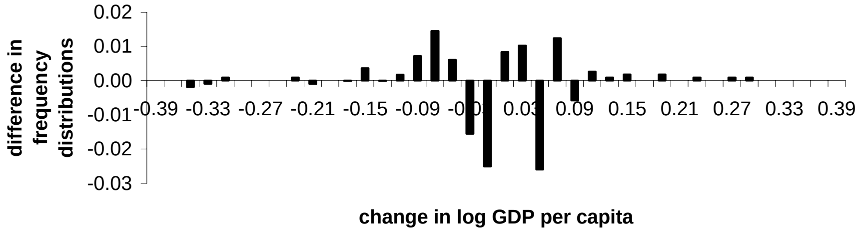
Panel B: Non-oil, non-agriculture



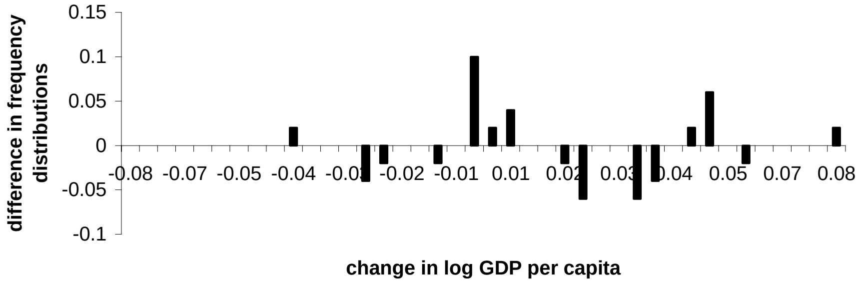
Notes: Figure 5 is based on estimation results from the specification in column (5) of Table 4, without the agricultural commodity price index and its interaction term. Both the solid line and the dashed line denote the elasticity of gdp per capita with respect to the two indices. The solid lines refer to the specification without the indicator of exchange rate overvaluation, whereas the dashed lines refer to the specification with the indicator of exchange rate overvaluation.

Figure 6: The volatility channel of the resource curse

Panel A: All country-year growth observations



Panel B: Mean country growth observations only

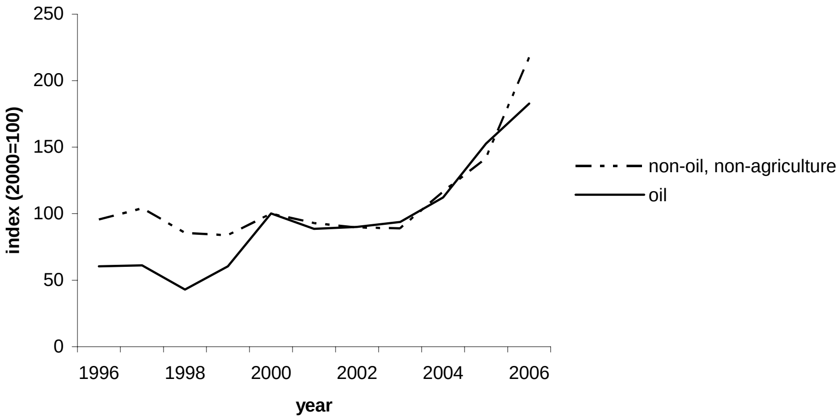


Notes: Panel (A) shows the difference between the frequency distribution of GDP growth for countries with non-agricultural commodity exports *above* the median (group I) and the frequency distribution of GDP growth for countries with non-agricultural commodity exports *below* the median (group II). Group II has a higher average growth rate and so we substracted the difference in average growth rates between the two groups (0.25 %) from the GDP growth series for group II. As a result, this series has the distribution of group II and the mean of group I. This ensures that panel A only reflects differences in the distributions and not in the means of the series. Positive values in panel A indicate that the countries in group I have relatively more observations in the corresponding GDP growth categories on the horizontal axis than countries in group II. Positive values towards the lower end of the values on the horizontal axis therefore indicate that commodity-dependent countries (group I) more often experience episodes of severe negative growth.

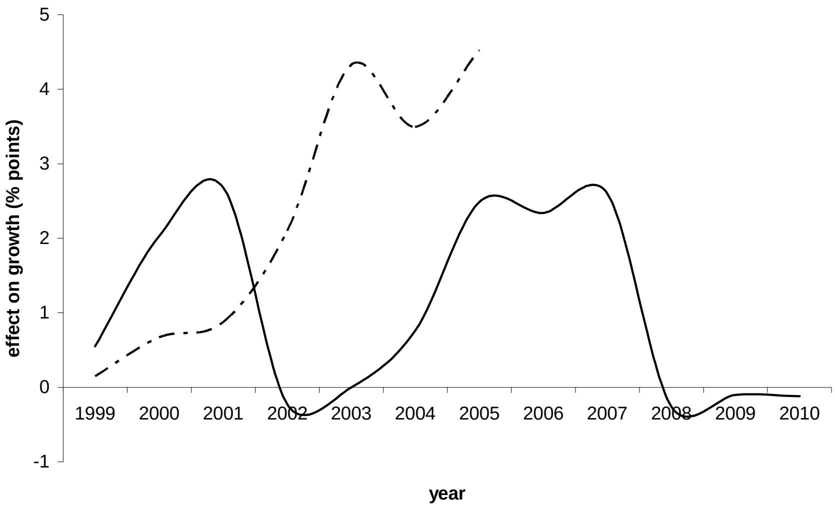
Panel (B) shows the difference between the frequency distribution of *country mean* GDP growth for countries with non-agricultural commodity exports *above* the median (group 1) and the frequency distribution of *country mean* GDP growth for countries with non-agricultural commodity exports *below* the median (group 2). Group 2 has a higher average growth rate and so we substracted the difference in average growth rates between the two groups (0.15 %) from the GDP growth series for group 2. As a result, this series has the distribution of group 2 and the mean of group 1. This ensures that panel B only reflects differences in the distributions and not in the means of the series. Positive values in panel B indicate that group 1 has relatively more observations in the corresponding GDP growth categories on the horizontal axis than group 2. Positive values towards the lower end of the values on the horizontal axis therefore indicate that the number of countries that experiences persistently low growth 'disasters' is higher for the group of commodity-dependent countries than for the group of non commodity-dependent countries.

Figure 7: A simulation of the short-run effects of the current commodity boom on growth in Africa's commodity exporting countries

Panel A: Export price indices



Panel B: Predicted effects on growth (solid line) and actual growth rates (dashed line)



Notes: Panel A shows the aggregate export price indices for the non-agricultural commodity exporting group of Sub-Saharan African countries (Angola, Cameroon, Congo Democratic Republic, Congo Republic, Equatorial Guinea, Gabon, Guinea, Liberia, Mauritania, Namibia, Nigeria, Sudan, Togo, and Zambia). The solid line in panel B shows the results of a simulation of the short-run effects of the current commodity boom on aggregate GDP per capita growth in this group of countries. The simulation was based on the estimation results from a regression similar to the specification in column (5) of Table 4 but without the agricultural commodity export price index and with separate short-run effects for oil and non-oil, non-agricultural commodity export prices. As input for the export indices, we use the export price indices in panel A.

The dashed line in panel B shows the average actual GDP per capita growth rate of the 14 countries, weighted by real GDP.

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Appendix

This appendix provides the data sources for the variables used in estimation.

Real GDP per capita

GDP per capita in constant 2000 US dollars, taken from the World Development Indicators.

Commodity export price index

Commodity export values for 1990 are from the UNCTAD Commodity Yearbook 2000 and the United Nations International Trade Statistics 1993 and 1994. Quarterly world commodity price indices are taken from the IMF's International Financial Statistics (series 76, except for butter and coal where we use series 74). Four commodity price series (coal, plywood, silver, and sorghum) had several short gaps in the early sample periods. Following Dehn (2000), we filled these gaps by holding the price constant at the value of the first available observation. Four price series (palmkerneloil, bananas, tobacco, and silver) had 1, 2, or 3 missing quarterly values in the middle of the series. Again following Dehn (2000) these gaps were filled by linear interpolation. Price series with larger gaps were not adjusted. However, where gaps would cause missing export price index observations in countries for which this commodity was relatively unimportant (share of exports in total commodity exports smaller than 10%), these price series were left out of the index.

The geometrically weighted commodity export price index was first calculated on a quarterly basis and deflated by the export unit value, taken from the IMF's International Financial Statistics (series 74..DZF). We then calculated the annual averages.

Commodity exports to GDP (%)

Commodity export values for 1990 are from the UNCTAD Commodity Yearbook 2000 and the United Nations International Trade Statistics 1993 and 1994. GDP is in current US dollars for 1990, taken from the World Development Indicators.

Oil import price index and oil export price index

The index of world oil prices was taken from the IMF's International Financial Statistics (series 00176AADZF) and is a spot price index of the average world price of crude petroleum. The dummy variables for net oil importing and net oil exporting countries are based on net oil imports in 2001. We defined net oil imports as crude oil imports plus total imports of refined petroleum products minus crude oil exports minus total exports of refined petroleum products, all taken from the Energy Information Administration's International Energy Annual 2002. Since these components are expressed in thousands of barrels per day, we multiplied them by 365 times the 2001 average weekly world oil price per barrel, also taken from the Energy Information Administration. If net oil imports are positive, the dummy for net oil importing countries is 1, otherwise it is zero. If net oil imports are negative, the dummy for net oil exporting countries is 1, otherwise it is zero.

Net oil exports to GDP (%)

Net oil exports are defined as minus net oil imports, where net oil imports consist of net crude oil imports plus net imports of refined petroleum products, all taken from the Energy Information Administration's International Energy Annual 2002 and expressed in current US dollars using the procedure described under the previous item. GDP is in current US dollars for 2001, taken from the World Development Indicators.

Trade openness

Trade (% of GDP): the sum of exports and imports of goods and services measured as a share of GDP, taken from the World Development Indicators.

External debt

Total external debt to gross national product, taken from Global Development Finance.

Inflation

Consumer price index (2000=100), taken from World Development Indicators.

Financial development

Money and quasi money (M2) as % of GDP, taken from World Development Indicators.

Civil war

Dummy variable: 1 for civil war, 0 otherwise, taken from Gleditsch (2004) and available at http://weber.ucsd.edu/~kgledits/expwar.html.

Coup d'etat

The number of extraconstitutional or forced changes in the top government elite and/or its effective control of the nation's power structure in a given year, taken from Banks' Cross-National Time-Series Data Archive and available at http://www.scc.rutgers.edu/cnts/about.cfm. Unsuccessful coups are not counted.

Geological, climatic, and human disasters

Geological disasters include earthquakes, landslides, volcano eruptions, and tidal waves. Climatic disasters include floods, droughts, extreme temperatures, and wind storms. Human disasters include famines and epidemics. In order to identify disasters that could affect a country's macroeconomic performance, we construct each of the three variables as the annual number of episodes that qualify as large disasters according to the criteria established by the International Monetary Fund (IMF, 2003). A large disaster affects at least 0.5% of the population, or causes damage of at least 0.5% of GDP, or causes at least 1 death per 10000 people. Data are taken from the WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED) and are available at www.em-dat.net.

UNCTAD commodity price index

Commodity price index that includes a wide range of commodities: (i) food and tropical beverages, (ii) vegetable oilseeds and oils, (iii) agricultural raw materials, and (iv) ores, minerals, and metals (source: Commodity Price Statistics, United Nations Conference on Trade and Development (UNCTAD)). The index was first deflated by the export unit value, taken from the IMF's International Financial Statistics (series 74..DZF). Then we constructed the annual averages of the monthly deflated index.

UNCTAD oil price index

Crude petroleum index based on the average of Dubai, United Kingdom Brent and West Texas Intermediate crude prices, reflecting relatively equal consumption of medium, light and heavy crudes worldwide. (source: Commodity Price Statistics, United Nations Conference on Trade and Development (UNCTAD)). The index was first deflated by the export unit value, taken from the IMF's International Financial Statistics (series 74..DZF). Then we constructed the annual averages of the monthly deflated index.