VOLATILITY HARMS GROWTH

New Perspectives on the Natural Resource Curse

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Abstract

We provide cross-country evidence that rejects the traditional interpretation of the natural resource curse. First, growth depends negatively on volatility of unanticipated output growth independent of initial income, investment, human capital, trade openness, natural resource dependence and population growth. Second, the direct *positive* effect of resources on growth is swamped by the indirect *negative* effect through volatility. Third, with well developed financial sectors, the resource curse is less pronounced. Fourth, landlocked countries with ethnic tensions have higher volatility and lower growth. Fifth, restrictions on the current account raise volatility and depress growth whereas capital account restrictions lower volatility and boost growth. We also present IV-estimates to correct for the endogenous nature of investment rates. Our key message is thus that volatility is a quintessential feature of the resource curse.

Keywords: volatility, growth, resource curse, financial development, openness, landlocked, ethnic tensions, restrictions on current and capital account

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1. Introduction

The key determinants of economic growth highlighted in the empirical literature – institutions, geography and culture – show far more persistence than the growth rates they are supposed to explain (Easterly, et al, 1993). One candidate to explain the volatility of growth in income per capita is the volatility of commodity prices. This includes not only oil, but also for example grain and coffee prices. What commodity prices lack in trend, they make up for in volatility (Deaton, 1999). A recent detailed examination of the growth performance of 35 countries during the historical period 1870-1939 led to the following conclusions (Blattman, Hwang and Williamson, 2007). Countries that specialize in commodities with substantial price volatility have more volatility in their terms of trade, enjoy less foreign direct investment and experience lower growth rates than countries that specialize in commodities with more stable prices or countries that are industrial leaders. Countries in the periphery with volatile commodity prices and undiversified economies fall behind in economic development. Also, the long-run volatility of the real exchange rate of developing countries is approximately three times bigger than that of industrialized countries (Hausmann, et al, 2004). Another study employs data for 83 countries over the period 1960-2000 and also finds robust evidence for a strong and negative link between real exchange rate volatility and growth performance after correcting for initial output per worker, enrolment in secondary education, trade openness, government consumption, inflation and even banking or currency crises (Aghion, et al, 2006). Furthermore, the adverse effect of exchange rate volatility on growth is weaker for countries with well developed financial systems.

The pioneering work of Ramey and Ramey (1995) takes a different tack. It investigates the link between volatility of unanticipated output growth (rather than volatility of the terms of trade) and growth performance. It uses the Heston-Summers data to provide cross-country evidence for a negative link between volatility and mean growth rates controlling for initial income, population growth, human capital and physical capital. Interestingly, this study finds evidence for this negative link regardless of whether one includes the share of investment in national income or not. It also estimates the relationship between volatility and growth in a panel model that controls for both time and country fixed effects. To allow for the time-varying nature of volatility, a measure of government spending volatility is used that is correlated with volatility of output across both time and countries. The negative link between volatility and growth seems robust to a large set of conceivable controls that vary with time period or country.[1] Another study

[1] However, Imbs (2007) shows that growth and volatility correlate positively across sectors. Within the context of a mean-variance portfolio setup, it is understandable that volatile sectors command higher investment rates and thus higher growth rates.

shows for a cross-section of 91 countries that policy variability in inflation and government spending exerts a strong and negative impact on growth (Fatás and Mihov, 2005).

Our main objective is to extend Ramey and Ramey (1995) by allowing for the *direct* effect of natural resource abundance on growth and, more importantly, the *indirect* effect of natural resources on growth performance via volatility. We thus follow Blattman, Hwang and Williamson (2007) and allow for the role of natural resources in macroeconomic volatility. We allow natural resources, financial development, openness and distance from waterways to be the underlying determinants of volatility. These variables affect the volatility of the real exchange rate and thus also GDP growth.

Another objective is to provide evidence against the conventional interpretation of the natural resource curse following from the work of Sachs and Warner (1997ab, 2001) and many others.[2] In line with Brunnschweiler and Bulte (2008), we find that the *direct* effect of natural resources on growth performance may well be positive. However, we take the argument further and establish that the *indirect* effect of natural resources on growth via the volatility channel is negative. We thus test whether any adverse *indirect* effect of natural resources on growth performance via volatility of unanticipated output growth dominates any *direct* effect of natural resource abundance on economic growth. Inspired by Aghion, et al (2006), we test whether the adverse effect of natural resources on volatility and growth is weakened if there are well developed financial institutions. We also test whether being landlocked, ethnic tensions and restrictions on the current account boost volatility and curb growth and whether restrictions on the capital account and exchange controls reduce volatility and boost growth. To avoid omitted variable bias, we control for initial income per capita, population growth, investment rates and primary schooling.

Our econometric tests for the importance of volatility for the paradox of plenty are motivated by Figures 1–3 and by the data on average yearly growth and its standard deviation by country groups for the period 1970-2003 presented in Table 1. These data suggest five stylized facts that are essential for a new and improved understanding of the natural resource curse:

- First, volatile countries with a high standard deviation of yearly growth in GDP per capita have on average lower growth in GDP per capita. Figure 1 illustrates this partial correlation while Ramey and Ramey (1995) show that this relationship holds even after controlling for initial income per capita, population growth, human capital and physical capital.

[2] The windfall resource revenues lead to appreciation of the real exchange rate and decline of the non-resource export sectors. If there is substantial loss in learning by doing in the non-resource export sectors, there will be a fall in total factor productivity growth as in Sachs and Warner (1995). Natural resources may also invite rapacious rent seeking and thus hamper growth.

- Second, developing countries have much more volatile output growth than developed countries. Whereas Western Europe and North America have a standard deviation of, respectively, 2.33 and 1.90 %-points of yearly growth in GDP per capita, the figures for Asia are 4.4 to 5 %-points and for Latin America & Caribbean 4.54%-point. Most striking is that Sub-Saharan Africa and the Middle East & North Africa have the highest volatility. Their standard deviations of average growth in GDP per capita are, respectively, 6.52 and 8.12 %-points.
- Third, countries with poorly developed financial systems are much more volatile. Countries in the bottom quartile of financial development have a standard deviation of annual growth in GDP per capita 2 %-point higher than those in the top quartile. North America and Western Europe have well developed financial systems while Eastern Europe & Central Asia and especially South Asia and Middle East & North Africa have poor functioning financial systems. Resource-rich and landlocked economies have less developed financial systems than resource-poor countries.
- Fourth, countries that depend a lot on natural resources are much more volatile than countries without natural resources. Countries with a share of natural resource exports in GDP greater than 19% (the top quartile) have a staggeringly high standard deviation of output growth of 7.37 %-points. For countries with a natural resource exports share of less than 5 per cent of GDP (the bottom quartile), the figure is only 2.83 %-point. Figure 2 also indicates that resource-rich countries have bigger macroeconomic volatility than resource-poor countries. Figure 3 shows that world commodity prices are extremely volatile and are the main reason why natural resource export revenues are so volatile. Crude petroleum prices are more volatile than food prices and ores & metals prices. Volatility of agricultural raw material prices is less, but still substantial. Monthly price deviations of 10%-points from their base level (year 2000) are quite normal.
- Fifth, landlocked countries suffer much more from volatility than countries with easy access to waterways. Indeed, countries that are less than 49 kilometres from the nearest waterway have a standard deviation of growth in GDP per capita that is 1.6 %-point lower than countries that are more than 359 kilometres from the nearest waterway. Empirical work also finds that remote countries have less access to markets, less diversified exports and greater volatility of output growth (Malik and Temple, 2006). Interestingly, Figure 1 reveals that that the negative correlation between volatility and growth in income per capita does not seem to be much different for landlocked countries. This suggests that the disappointing growth performance of many landlocked countries seems to be due to their higher volatility.

Although these stylized facts are suggestive, they are merely partial correlations and do not permit any causal evidence. Hence, we perform a proper multivariate econometric analysis and control for all potential factors affecting the rate of economic growth. We also face the thorny issue of the endogenous nature of explanatory variables.

The sophisticated statistical decomposition analysis performed in Koren and Tenreyro (2007) suggests four possible reasons why poor countries are so much more volatile than rich countries: poor countries specialize in more volatile sectors; poor countries specialize in fewer sectors; poor countries experience more frequent and more severe aggregate shocks (e.g., from macroeconomic policy); and macroeconomic fluctuations in poor countries are more highly correlated with the shocks of the sectors they specialize in. The evidence suggests that, as countries develop their economies, their productive structure shifts from more to less volatile sectors. Also, the degree of specialization declines in early stages of development and increases a little in later stages of development. Furthermore, the volatility of country-specific macroeconomic shocks falls with development. This decomposition analysis sheds interesting light on why poor economies are more volatile than rich economies. Our multivariate econometric analysis provides complementary evidence on the factors affecting volatility.

We argue that crucial and strongly related sources of macroeconomic volatility and poor growth performance are lack of a sophisticated financial system, natural resource dependence, and whether a country is landlocked or not. We also provide evidence that economic restrictions and ethnic tensions play a role. Landlocked countries with a large dependence on natural resources are typically not very diversified and vulnerable to volatile world commodity prices.Natural resource revenues tend to be very volatile (much more so than GDP), because the supply of natural resources exhibits low price elasticities of supply. Furthermore, as documented in Bloom and Sachs (1998) and indicated by Figure 4, Sub-Saharan Africa is most vulnerable to volatility of commodity prices as it depends so much on natural resources. Dutch Disease effects may also induce real exchange rate volatility and thus a fall in investment in physical capital and learning, and further contraction of the traded sector and lower productivity growth (e.g., Gylfason, et al, 1999; Herbertsson, et al, 2000). Volatile resource revenues are disliked by risk-averse households. The welfare losses induced by consumption risk are tiny compared with those resulting from imperfect financial markets. However, a recent dynamic stochastic general equilibrium study of Zimbabwe highlights the incompleteness of financial markets and suggests that the observed volatility in commodity prices depresses capital accumulation and output by about 40 percent (Elbers, et al, 2007).

Our paper gives a prominent role to the quality of financial markets in understanding how the volatility of commodity prices and natural resource export revenues might depress growth. We adapt the liquidity shock arguments put forward by Aghion, et al (2006). Effectively, larger natural resource revenues make it easier to overcome negative liquidity shocks. We thus show that more volatile commodity prices will harm innovation and growth.

Section 2 discusses why volatility may harm output growth, especially in countries with poor financial systems. Since there are also theoretical reasons for volatility to boost growth, the issue needs to be settled empirically. Section 3 gives cross-country evidence which shows that the traditional estimates of the natural resource curse are not robust, where Appendix 1 describes the data that we have used in our estimates. Section 4 presents our cross-country estimates on the determinants of volatility and the effect of volatility on economic growth where our econometric methodology is set out in Appendix 2. Section 5 uses our preferred estimates to do a counterfactual experiment comparing resource-rich and landlocked Africa with the Asian Tigers. Section 6 concludes.

2. Why Might the Volatility of Natural Resource Revenues Hamper Growth?

2.1. Economic arguments

Aghion, et al (2006) shows that macroeconomic volatility driven by nominal exchange rate movements may stunt innovations and thus depress growth in economies with poorly developed financial institutions and nominal wages not reacting immediately to changes in prices. We adopt this argument to show that volatility in natural resource revenues, induced by volatility in primary commodity prices, curbs growth in economies with badly functioning financial systems. Let the law of one price hold, so that the price level P_t simply tracks the nominal exchange rate S_t. In other words, $P_t = S_t P_t^*$ where the foreign price level P_t^* is normalized to unity. Nominal wages are pre-set not knowing the realization of the price level, that is $W_t = \phi A_t \, E[P_t] = \phi A_t \, E[S_t]$, where A_t denotes productivity and $\phi < 1$ is a constant. Output follows from the production function $Y_t = A_t \sqrt{l_t}$, where l_t denotes employment. Profits are $\pi_t \equiv A_t S_t \sqrt{l_t} - \phi A_t \, E[S_t] \, l_t$. The value of innovations the next period is $V_{t+1} = V P_{t+1} A_{t+1}$, where next period's productivity is given by $A_{t+1} = \gamma A_t$ with $\gamma > 1$ if entrepreneurs have sufficient funds to innovate and $A_{t+1} = A_t$ otherwise. Firms have sufficient funds (profits plus resource revenues Q_t) to innovate if they have enough cash flow to cope with adverse liquidity shocks, i.e., $\mu (\pi_t + S_t Q_t) > z P_t A_t$ where μ is a measure of financial development and z is a random liquidity shock. If liquidity shocks z are i.i.d. across firms with cumulative density function $F(z)$, the probability of innovation is given by:

(1) $$\rho_t = \mathrm{F}\left(\frac{\mu\left(\pi_t + S_t Q_t\right)}{S_t A_t} \right).$$

Higher profits or natural resource revenues and a more developed financial system imply that more firms are able to overcome liquidity shocks and thus that the probability of innovation is higher. Profit maximization yields the following levels of employment and profits:

(2) $$l_t = \left(\frac{S_t}{2\phi \mathrm{E}[S_t]} \right) \quad \text{and} \quad \pi_t = \left(\frac{A_t S_t^2}{4\phi \mathrm{E}[S_t]} \right),$$

so that higher productivity, a lower expected price level (i.e., a lower wage) and a higher realized price level boost profits. The probability of innovation is thus given by:

(3) $$\rho_t = \mathrm{F}\left(\mu \left[\left(\frac{S_t}{4\phi \mathrm{E}[S_t]} \right) + \left(\frac{Q_t}{A_t} \right) \right] \right).$$

The rate of economic growth increases with the expected probability of innovation:

(4) $$g_t \equiv \frac{\mathrm{E}[A_{t+1}] - A_t}{A_t} = (\gamma - 1)\mathrm{E}[\rho_t] = (\gamma - 1)\mathrm{E}\left[\mathrm{F}\left(\mu \left[\left(\frac{S_t}{4\phi \mathrm{E}[S_t]} \right) + \left(\frac{Q_t}{A_t} \right) \right] \right) \right].$$

Aghion, et al (2006) makes the assumption that the cumulative density function F(.) is concave, so that $\mathrm{E}[\mathrm{F}(c)] \leq \mathrm{F}(\mathrm{E}[c])$. The cumulative density functions of standard deviations of commodity prices given in Figure 3 are indeed concave (and close to the normal cumulative density functions). It follows that more exchange rate volatility stunts innovations and curbs growth, especially if the degree of financial development is weak. Moving from a peg to a float thus leads to a lower rate of economic growth. Here we are more interested in the effect of commodity prices on growth performance: *A high and stable level of resource revenues eases liquidity constraints and thus boosts innovations and economic growth. However, for a given expected level of natural resource revenues, more volatility in commodity prices and resource revenues harms innovation and growth, especially if financial development is weak.*

IMF data on 44 commodities and national commodity export shares and monthly indices on national commodity export prices for 58 countries during 1980-2002 indicate that real

commodity prices affect real exchange rate volatility (Cashin, et al, 2002). Since we have seen that real exchange rate uncertainty exacerbates the negative effects of domestic credit market constraints, this gives another reason why volatility of commodity prices curbs economic growth. Also, many resource-rich countries suffer from poorly developed financial systems and financial remoteness and thus suffer from bigger macroeconomic volatility (Aghion, et al, 2006; Rose and Spiegel, 2007). Given the high volatility of primary commodity prices and resource revenues and thus of the real exchange rate of many resource-rich countries, we expect resource-rich countries with poorly developed financial systems to have poor growth performance.

With complete financial markets, long-term investment is counter-cyclical and mitigates volatility. However, if firms face tight credit constraints, investment is pro-cyclical and amplifies volatility. Of course, there may be other reasons why volatility may depress economic growth (Aghion, et al, 2005). Learning by doing and human capital accumulation is increasing and concave in the cyclical component of production (Martin and Rogers, 2000). In that case, long-run growth should be negatively related to the amplitude of the business cycle.[3] This explanation does not require uncertainty and holds for predictable shocks as well. With irreversible investment, increased volatility holds back investment and thus depresses growth (Bernanke, 1983; Pindyck, 1991; Aizenman and Marion, 1991). The costs of volatility come from firms making uncertainty-induced planning errors (Ramey and Ramey, 1991). These costs arise if it is costly to switch factors of production between sectors (Bertola, 1994; Dixit and Rob, 1994). However, if firms choose to use technologies with a higher variance and a higher expected return (Black, 1987) or if higher volatility induces more precautionary saving and thus more investment (Mirman, 1971), there may be a *positive* link between volatility and growth. If the activity that generates productivity growth is a substitute to production, the opportunity cost of productivity enhancing activities is lower in recessions and thus volatility may boost growth (Aghion and Saint Paul, 1998). Ultimately, the question of whether anticipated or unanticipated volatility harms or boosts growth thus needs to be settled empirically.

In economies where only debt contracts are available and bankruptcy is costly, the real exchange rate becomes much more volatile if there is specialization in traded goods and services and the non-resource traded sector is small (Hausmann and Ribogon, 2002). Shocks to the demand for non-traded goods and services – associated with shocks to natural resource income – are then not accommodated by movements in the allocation of labour but by expenditure

[3] They find that for industrialized countries and European regions a higher standard deviation of growth and of unemployment tends to depress growth rates.

switching. This demands much higher relative price movements. Due to bankruptcy costs, interest rates increase with relative price volatility. This causes the economy to specialize away from non-resource traded goods and services, which is inefficient. The less it produces of these goods and services, the more volatile the economy becomes and the higher the interest rate has to be. This causes the sector to shrink further until it vanishes. Others stress that resource revenues are used as collateral and encourage countries to engage in 'excessive' borrowing at the expense of future generations, which can harm the economy both in short and long run (Mansoorian, 1991).

Volatility is bad for growth, investment, income distribution, poverty and educational attainment (e.g., Ramey and Ramey, 1995; Aizenman and Marion, 1999; Flug et al, 1999). To get round such natural resource curses, the government could resort to stabilization and saving policies and improve the efficiency of financial markets. It also helps to have a fully diversified economy, since then shocks to non-traded demand can be accommodated through changes in the structure of production rather than expenditure switching. This is relevant for inefficiently specialized countries such as Nigeria and Venezuela, but less so for diversified countries like Mexico or Indonesia or naturally specialized countries such as some Gulf States. Unfortunately, resource-rich economies are often specialized in resource production and thus tend to be more volatile.

2.2. Political arguments

Natural resource bonanzas reduce critical faculties of politicians and induce a false sense of security. This can lead to investment in 'white elephant' projects, bad policies (e.g., import substitution or unsustainable budgetary policies), and favours to political clientele, which cannot be financed once resource revenues dry up. Politicians loose sight of growth-promoting policies, free trade and 'value for money' management. During commodity booms countries often engage in exuberant public spending as if resource revenues last forever. This carries the danger of unsustainable spending programmes, which need to be reversed when global commodity prices collapse and revenues dry up. Encouraged by the Prebisch hypothesis (i.e., the secular decline of world prices of primary exports), many developing countries have made the mistake of trying in vain to promote state-led industrialization through prolonged import substitution using tariffs, import quota and subsidies for manufacturing in an attempt to avoid resource dependency. These policies may have been a reaction to the appreciation of the real exchange rate and the decline of the traded manufacturing sectors caused by natural resource dependence. The natural resource wealth may thus have prolonged bad policies, which eventually had to be reversed. The resulting

policy-induced volatility harms growth and welfare. Table 1 indicates that resource-rich countries indeed have a relatively high volatility in the national income share of government.

Political scientists have also argued that states adopt and maintain sub-optimal policies (Ross, 1999). Cognitive theories blame policy failures on short-sightedness of state actors, who ignore the adverse effects of their actions on the generations that come after the natural resource is exhausted, thus leading to myopic sloth and exuberance. These cognitive theories highlight a get-quick-rich mentality among businessmen, a boom-and-bust psychology among policy makers, and abuse of resource wealth by privileged classes, sectors, client networks and interest groups.

3. Is the Traditional Natural Resource Curse a Red Herring?

Ding and Field (2005), Alexeev and Conrad (2005) and Brunnschweiler and Bulte (2008) demonstrate that the natural resource curse as estimated by Sachs and Warner (1995, 1997ab, 2001) is not very robust. They show that, once resource abundance (proxied by a measure of natural resource wealth[4]) rather than resource dependence (the average 1970-80 national income share of natural resource exports) is used, the effect of natural resources on growth performance is positive and thus the resource curse disappears. Sachs and Warner find for a very wide range of control variables that natural resources harm growth during the years 1970-90 even after allowing for the effects of geography and quality of institutions. Table 2 re-estimates the Sachs and Warner regressions with more recent data for the period 1970-2003. Instead of the average budget balance as in Sachs and Warner (1997b), we use the average investment share which captures both public and private investment. The first regression indicates that growth performance is better in countries that are poor, open to international trade, have small population growth rates and a long life expectancy (as a proxy for human capital) and a superior rule of law. Countries that are poor grow faster than rich countries (i.e., there is conditional convergence), especially if they are open to international trade. Investment does not seem to be a statistically significant determinant of economic growth. The main point is that the first regression also indicates that, even allowing for all of these determinants of growth, there is a strong negative effect of resources on the average annual growth in income per capita. A country whose natural resource exports constitute 40 percent of national income seems to enjoy 1%-point growth per annum less than a country which does not export natural resources. This is a substantial effect and has been coined the *natural resource curse*. However, we find that this type of evidence for the natural resource curse is not very robust to including other important determinants of economic growth.

[4] The net-present value of natural capital in USD per capita in 1994, including subsoil assets, forest resources, protected areas, and agricultural land.

For example, after adding the standard deviation of actual annual growth in GDP per capita for the 33 year period as an additional explanatory variable, the effect of natural resources on growth performance vanishes. In this sense, the natural resource curse is indeed a red herring.

4. Is Volatility the Quintessential Feature of the Natural Resource Curse?

Having rejected the traditional resource curse and the implied negative effect of resource dependence on economic growth, it could be that resource dependence affects growth through other channels. For example, resource dependence may erode the quality of institutions or the legal system and thus hamper growth. Or resource dependence may lower human capital formation or physical investment and thus dampen growth prospects. However, the stylized facts discussed in the introduction and the second regression in Table 2 suggest that natural resources seem to play a key role in understanding macroeconomic volatility and growth prospects. We therefore estimate growth regressions simultaneously with regressions explaining volatility of unanticipated growth in income per capita (see Appendix 2). Once account is taken of the *negative* effect of cross-country variations in volatility on the rate of economic growth, the level of resource dependence may exert a *positive* effect on growth.[5] From a policy perspective, it is important to know whether any *negative indirect* effect of natural resources on growth performance via volatility of unanticipated output growth dominates any *positive direct* effect of resource dependence on growth, and whether the adverse effects are weakened if there are well developed financial institutions. Furthermore, we test whether landlocked countries experience higher volatility and lower growth. To get meaningful results, we control for initial income per capita, population growth, investment rates and primary schooling on growth.

4.1. Volatility harms growth especially in Africa

Cross-country empirical evidence on how much volatility of unanticipated output per capita growth depresses average annual growth in GDP per capita is presented in Table 3. Our benchmark is regression 1. The positive coefficients on the average investment share and initial human capital suggest countries that invest a lot in physical and human capital enjoy a higher growth rate in income per capita, albeit that the coefficient on human capital is not very significant. Similarly, countries with very high population growth rates tend to have worse

[5] As already mentioned in section 3, If the explanatory variable is natural resource *abundance* (proxied by natural resource wealth per capita) rather than natural resource *dependence*, there appears to be a positive effect on growth performance. From our point of view, this does not seem surprising as natural resource wealth is much less volatile than natural resource export revenues and more likely to boost the rate of economic growth.

growth performance. And, of course, the significant negative coefficient on initial GDP per capita indicates that poor countries which start off with a low level of income per capita catch up and grow faster ceteris paribus (i.e., conditional convergence). Our benchmark regression indicates that volatility of unanticipated output growth negatively affects growth in GDP per capita. This confirms for our sample the results of Ramey and Ramey (1995). Regression 2 indicates that there is evidence for serial correlation in growth in income per capita. We then examine what the influence may be of natural resource exports or natural resource rents on growth performance. Regression 3 tests whether there is any evidence for a natural resource curse along the lines of Sachs and Warner (1995, 1997a, 2001).[6] We only find support for a negative coefficient for point-source natural resource dependence on economic growth.[7] In contrast to much of the existing empirical literature, financial development, openness to international trade[8] and various interaction terms are statistically insignificant explanatory factors of cross-country variations in growth in GDP per capita. One possible explanation of this is that the effects of these variables are picked up by the effect of volatility on growth performance. We return to that in section 4.2.

In order to get an initial understanding of the sources and origins of volatility, regression 4 explains volatility by regional dummies instead of country dummies. Interesting is that Sub-Saharan African and to a lesser extent the Middle-East and North Africa are much more volatile and thus suffer much more from bad growth prospects. If Sub-Saharan Africa would have the same volatility as East Asia and the Pacific, its average annual growth rate would be 0.96%-point higher.[9] Regression 4 also indicates that, controlling for all traditional factors explaining cross-country differences in growth performance, there is no evidence of a traditional resource curse: point-source and diffuse natural resource exports as a percentage of GDP are insignificant.[10] However, regression 5 does indicate that the GDP share point-source natural resource *rents* (i.e., net of exploration costs)[11] does exert a negative effect on growth in GDP per capita even after allowing for the effects of volatility on growth. Regression 5 also shows significant interaction terms of natural resource rents with openness and financial development at the 1%-level. This

[6] To allow for the fact that the errors in our explanation of growth in GDP per capita are not independent within countries, we cluster the standard errors by country in regression 2 and all further regressions.
[7] These include oil, gas, ores and minerals, which are typically produced in concentrated locations.
[8] We use the openness variable of Sachs and Warner (1997a) as expanded by Wacziarg ad Welch (2003). Instead of 'years open to trade' we use initial openness to minimize reverse causality concerns.
[9] $0.96\% = -0.243 * \sqrt{\exp(-7.788)} * \left\{ \sqrt{\exp(1.010)} - \sqrt{\exp(2.557)} \right\}$
[10] Diffuse natural resources include agricultural raw materials and foods such as livestock, coffee, bananas or tobacco, which typically are produced throughout the country.
[11] The resource rents data are not necessarily superior, since extraction costs are available for much fewer countries than resource revenues and are often proxied by regional/continental rather than local costs. Rents data have the further drawback that they are available for a smaller sample and only for point-source resources.

suggests that the resource curse is less pronounced for countries open to international trade and with well functioning financial systems. For very open countries with a high degree of financial development, the resource curse can even be turned into a blessing.

Clearly, the regional dummies use more aggregate information than the country dummies. The resulting omitted variable bias biases the coefficient on volatility upwards, since it forces countries within each region to have similar volatility. It is therefore important to try to explain why some countries are more volatile than other countries.

4.2. Opening the black box: Volatility is the key channel for the natural resource curse

To better understand the effects of natural resource dependence on growth, we need to dig deeper into the determinants of volatility. Regression 6a in Table 4 does exactly that. It still finds that investment in physical and human capital boost economic growth while population growth depresses growth in income per capita. There is also again evidence for conditional convergence, so that poor countries catch up. Interestingly, there is now evidence of a significant *positive* direct effect of point-source natural resource export revenue on economic growth. There is no evidence for a significant effect of openness on growth. There is evidence for a significant direct effect of financial development on economic growth, but unfortunately it is negative. More important, volatility of unanticipated growth exerts a powerful and negative effect on growth in GDP per head. As expected, volatility itself increases with the GDP share of point-source resources but not significantly with the GDP share of diffuse resources. Volatility also decreases with the degree of financial development and openness of a country to international trade, which supports the hypothesis put forward by Aghion et al (2006) and Rose and Spiegel (2007). In line with Malik and Temple (2006), we find that volatility increases with the distance from navigable coast or rivers, which is their strongest geographical predictor of output volatility.

Figure 5 calculates on the basis of regression 6a the marginal effect of resource dependence on growth. This effect depends on the volatility of unanticipated output growth, because resource dependence enters the volatility equation in a non-linear way as described in equation (A2).[12] Natural resource dependence is thus a curse for very volatile countries, but a boon for countries with relatively stable unanticipated output growth. In fact, if σ exceeds 0.064 (i.e. 2*0.05/(1.621*0.971)), resource dependence curbs growth and otherwise it boosts growth. Very open and financially developed countries are expected to be more stable and grow faster

[12] Ramey and Ramey (1995) have used the same specification. We also tried the logarithm of the variance in the mean equation, but this gave a much worse fit. The exponential specification forces volatility to take on positive values only.

even if they export many resources. We see from Figure 5 that for the less volatile OECD (including Norway) and Asian Tigers, resource dependence is a boon for growth, while for volatile landlocked Africa (especially Zambia) a curse. For resource-rich Africa the positive direct effect of resource dependence is more or less cancelled out by the indirect effect through volatility. However, this is a best-case scenario based on a weakly significant direct positive effect. In later regressions we find a *negative* direct effect of resource dependence on growth, in which case the line in Figure 5 shifts down such that the curse is apparent for more regions and countries. The resource curse is always more severe for more volatile countries.

4.3. Dealing with endogeneity of investment shares

Growing countries attract more investment, so the direction of causality may go either way. Even though we control for openness and financial development, we probably do not capture enough of the institutional effects on growth and investment. We therefore look for an exogenous variable that strongly predicts the investment share, but does not affect growth or correlate with other important unobserved characteristics. We choose to instrument the investment share with an index of ethno-linguistic fractionalization. This index measures the probability that two randomly selected individuals from a given country will not belong to the same ethnic group (Montalvo and Reynal-Querol, 2005a).[13] The rationale is that trust, ability to communicate and social cohesion are essential prerequisites for successful investment. Fractionalized countries have lower levels of trust, more corruption, less transfers, subsidies and political rights (Alesina et al, 2003). These factors should lower the investment rate, since they increase uncertainty about returns and expropriation.[14] We also assume that ethno-linguistic fractionalization is randomly 'assigned' to countries and mostly historically determined. Countries should also not have systematically different growth rates depending on their degree of ethnic fractionalization. We suspect that this is the case given the very different growth experiences of countries among the top-ten of ethnic fractionalization, i.e., Canada, Senegal, India and Mali. In the bottom-ten of least fractionalized countries are Norway, Japan, Tunisia, and Greece. We also include two geographical variables:

[13] They base their data on the World Christian Encyclopedia. They argue that fractionalization is a poor predictor of civil war compared to ethnic polarization. We are therefore more confident that there is no effect of fractionalization on growth via the link of conflicts.

[14] Montalvo and Reynal-Querol (2005b) argue that ethnic *polarization* affects investment but not growth, while fractionalization affects growth directly as in Easterly and Levine (1997), but not investment. However, these growth regressions do not control for population growth or volatility. If we run regression 6a with ethnic fractionalization and polarization using their ethnicity data, we find no growth effects of these two variables. Adding polarization to the first stage yields no effect of polarization, but still gives a significant negative effect of fractionalization on investment. Taking the effect of volatility into account seems to have important effects on the link between ethnicity and growth, and should be seen as complementary. Regressions available on request.

whether a country is landlocked or not, and a climate variable. Investment opportunities may be lower if it is more difficult for a country to diversify and export. Alesina et al (2003) also find strong correlations between ethno-linguistic fractionalization and geographical variables. This allows us to isolate the effect of fractionalization on investment and most importantly to conduct a Hansen over-identification test for exogeneity of the instruments.

Regressions (6b), (6c), and (6d) of Table 3 report the first and two second stages of this IV exercise and confirm the detrimental effect of volatility on growth. Regression (6c) uses all the instruments in the first stage, while (6d) uses only the ethno-linguistic fractionalization index, for reasons explained below. Although the positive effect of the investment share on growth is now larger, the qualitative results are similar to the ML estimates presented in regression (6a). An interesting feature of the second-stage regressions (6c) and (6d) is that the (weak) evidence for a positive direct effect of natural resources on growth has disappeared. The first stage (6b) of the IV regressions shows a large and significant positive correlation between natural resource dependence and the investment share. We cannot claim that this corresponds to a causal effect, but it further explains the positive (although insignificant) direct effect of natural resource dependence on growth after controlling for volatility.

These conclusions are supported by several statistical tests which measure the quality of the IV-strategy. The first stage (6b) confirms that ethno-linguistic fractionalization has a strong negative effect on the investment share. The F-test on the excluded instruments is unfortunately below 9.08 (5% critical value for three instruments) which means that the relative bias of using these instruments is larger than 10 percent of the inconsistency of regression 6a. This means that there is still some bias in the equation (Stock and Yogo, 2002). However, if we repeat the IV regressions with only ethnic fractionalization in column (6d) we achieve an F-test value of 11.85. Ethnic fractionalization is therefore a strong predictor of investment. Using only this instrument improves the precision of several important estimates (first-stage not reported). On the other hand, using all three instruments allows us to test for their exogeneity because in this case the equation is over-identified. The Hansen test[15] is passed with confidence in column (6b) and implies that our instruments are exogenous.[16]

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[15] Robust to heteroskedasticity and autocorrelation.

[16] A complicating factor is that the predicted investment share in regression 6c is a *generated regressor* (Pagan, 1984), which causes standard errors to be too small (although coefficients are consistently estimated). A common solution is to *block bootstrap* the standard errors, which resamples every replication from within each cluster (each country) to allow errors to be correlated within countries, but independent between countries. Since it is very difficult to achieve convergence of the log likelihood function for every replication, we use the fact that *block bootstrapping* is asymptotically equivalent to panel robust sandwich standard errors (Cameron and Trivedi, 2005). The latter correction of the standard errors is what we use in

4.4. Natural resource rents, volatility and growth

Our regressions 6 quantify the effects of the GDP share of natural resource exports on volatility and growth, but it seems relevant to also take account of production costs of extracting natural resources and furthermore assess the robustness of the interaction terms with resource dependence in the annual growth equation. Regressions 7 therefore present the corresponding ML and IV estimates with the GDP share of natural resource rents as an explanatory variable. Again, growth performance is negatively affected by volatility of unanticipated output growth even after allowing for the positive effect of investment shares and the negative effect of population growth and initial income per capita on growth performance. Also, the direct effects of natural resource rents on growth are statistically significant and negative (but insignificant once we allow for the endogeneity of investments). The interaction terms with financial development and openness are significant and positive (also once we allow for endogenous investments). This indicates that natural resource rents boost growth provided countries are open and financially developed. The negative coefficients on openness and financial development itself may reflect conditional convergence: countries that were rich in 1970 also tended to be open and financially developed. Figure 6 shows that for already moderate degrees of financial development the marginal effect of the rent share on growth is positive rather than negative. Resource dependence has a positive effect on growth in open economies and a negative effect for closed economies. Hence, countries that are open to international trade and have a high degree of financial development turn the resource curse into a blessing.

Turning to the determinants of volatility, we see that the GDP share of point-source resource rents and the distance from the navigable coast or rivers have a significant positive effect on volatility and thus a negative effect on growth. Diffuse resource export revenues do not seem to impact volatility and growth. Still, there is a significant negative effect of openness and financial development on volatility of unanticipated output growth and thus a positive effect on growth.

Unfortunately, our set of instruments does not perform as well when we use resource rents which is reflected in large standard errors in regression 7c and only a weakly significant effect of the ethno-linguistic fractionalization index in the first stage regression 7b, even though the Hansen test supports our claim that the instruments are exogenous. The F-test in the first-stage is also very small and remains small in regression 7d where only the investment share is used.

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all regressions, including 6c, to allow for within-country correlation of the errors. We can therefore directly interpret the results.

However, qualitatively the estimates are very similar in nature to the regressions where resource export revenues were used.

Summing up and probing deeper into the determinants of volatility, we find that countries that are closed to international trade, have badly functioning financial markets, are landlocked and have a high share of natural resource rents have higher volatility in unanticipated growth in output per capita and therefore worse growth prospects. These results suggest, in contrast to the previous literature, that volatility of commodity prices is a key feature of the resource curse.

4.5. Impact of volatility of various commodity export shares on macroeconomic volatility

With regression 6a as the benchmark, regression 6e in Table 5 tries to see if the marginal effect of initial resource dependence on volatility is weaker if a country starts off from a higher level of financial development as well. This seems not to be the case. However, it is more likely that financial services give countries the means to deal with the large world price shocks and will reduce the effect of resource wealth fluctuations on output volatility. Financial development may limit the pass-through of volatile resource income into general output volatility through insurance and easing of borrowing constraints. The second half of Table 5 therefore focuses on ML estimates of regressions with *fluctuations* in the GDP shares of resource exports as an additional explanatory variable in the variance equation. Since resource quantities are relatively inelastic, most of the revenue movement will originate in world prices. Regression 9a indicates that adding the volatility of the GDP share of both point-source and diffuse resources to the variance equation significantly helps to explain the volatility of unanticipated output growth. Regression 9b indicates that, inspired by Fatás and Mihov (2005), adding the volatility of the GDP share of government spending (capturing policy shocks and spending bonanzas following windfall revenues) also significantly improves our estimate of the volatility of unanticipated growth. Furthermore, regression 9c shows that especially the volatility of the food export share, the volatility of the fuel export share and the volatility of the ores & metals export share contribute to the volatility of unanticipated output growth. The volatility effect of natural resources is thus not limited to oil-producing countries, but also includes for example copper, coffee, banana and tobacco exporters. The qualitative results of the estimated equation for annual growth are not much affected, except that the estimated negative effect of volatility of unanticipated output growth on mean annual growth is almost three times smaller and closer to the black-box estimate with individual country dummies (despite being much more parsimonious).

Although we did not find evidence for a significant interaction term between financial development and *initial* point-source resource dependence in the variance equation, we find in

regression 9d that well-functioning capital markets greatly reduce the effect that *shocks* in the resource share have on volatility. Consistent with the model of section 2, a stable share of natural resources in GDP does not increase volatility by itself, but rapid fluctuations in the share through prices create liquidity constraints and harm growth. Financial development gives a country the means to deal with sudden changes in resource revenues. This holds even after we control for terms-of-trade shocks.

4.6. Impact of ethnic tensions and economic restrictions on volatility and growth

Table 6 presents some further refinements and robustness tests of our results. Since ethnic polarization as defined by Montalvo and Reynal-Querol (2005b) is a good predictor of civil conflict, it may also be a good predictor of volatility. We want to check whether resources still have an independent effect on volatility when we allow for an effect of ethnic polarization. Furthermore, this measure takes its highest value if a country is equally divided into two groups. Such a situation may increase instability if natural resources are present as well. Regression 10a indicates indeed that ethnic polarization significantly improves the estimate of the volatility of unanticipated output growth, but does not have an independent direct effect on growth. The interaction term shows that there is also a significant positive interaction with resource dependence: the more polarized a country, the more resources lead to volatile economies through conflict and rent-seeking government policy. Regression 10b shows that ethnic polarization is no longer important once the volatility of the export shares of point-source and diffuse resources, and the volatility of the GDP share of government spending are used as explanatory variables of volatility. Resources are not necessarily bad, but anything that magnifies already volatile prices, such as public spending booms and busts (possibly related to civil strife), seems to harm long-run growth prospects.

Table 6 also tests for the impact of economic restrictions to examine whether financial and trade liberalization boosts or depresses growth. We replace the single openness dummy with four measures of restrictions from the Annual Report on Exchange Arrangements and Restrictions (IMF, 2006). Regression 11a indicates that capital account restrictions have a somewhat negative *direct* impact on growth. However, this is swamped by the negative effect of capital account restrictions on volatility and thus the positive effect on growth, especially for countries with a high degree of natural resource dependence. Capital account restrictions may thus help to curb volatility and increase growth performance, especially in resource-rich

countries.[17] Access to international capital markets may have a pro-cyclical element, which tends to generate higher output volatility especially in resource-rich, developing economies. Current account restrictions have no significant direct effect on growth, but do contribute to volatility especially in resource-rich countries and thus hamper growth. Regression 11a also indicates that the surrender of export receipts is associated with higher volatility and lower growth. Multiple exchange practices lower volatility and increase growth, since they are a form of exchange control and curb volatile capital in- and outflows. Regression 11b drops the interaction terms and includes the fluctuations in revenues and government spending as well as terms-of-trade shocks. The effect of the four restrictions is qualitatively unchanged.

5. Accounting for Growth Performance: Africa versus the Asian Tigers

To get a feeling for what our estimates of the determinants of growth in GDP per capita imply in practice, it is interesting to perform some counterfactual exercises. We perform these exercises based on our preferred equation 6a of Table 4. It is insightful to compare the African countries with the Asian Tigers[18], since they have similar starting positions (in 1970). We therefore compare in Table 7 resource-rich and landlocked Africa with the Asian Tigers. Resource-rich countries are those in the global top 25 and natural resource exports valuing on average more than 17.31% of GDP during 1970-2003. Since the resource-rich countries of Africa were poorer in 1970 than the Asian Tigers, they grow faster and catch up, everything else equal. We see from the top panel of Table 7 that this growth differential amounts to 0.87%-point per year (the difference in initial GDP per capita times the coefficient). Allowing for the positive *direct* growth effects of higher natural resource dependence in Africa, we see that the growth differential with the Tigers becomes 1.31%-point. Now if those African countries would invest as much in physical and human capital as the Asian Tigers, they would add a further 0.65%- and 0.46%-points, respectively to their annual growth rate. If resource-rich Africa's population growth rate were to be reduced in line with the Tigers, Africa would gain yet another 0.43%-point annual growth. These three factors combined yield an extra bonus to potential growth of 1.54%-point. However, the key message is how much potential growth is lost due to the high volatility of unanticipated output growth in resource-rich Africa compared with the Asian Tigers: a whopping 2.98%-point extra growth per annum! The main reasons for the high volatility of these resource-rich countries in Africa compared with the Asian Tigers are their heavy dependence on natural resources

[17] Kose et al (2003) find that increased gross financial flows and absence of capital account restrictions lead to an increase in the relative volatility of consumption.

[18] The Asian Tigers in our sample are: South Korea, Malaysia, Philippines and Thailand

(increasing volatility by 0.41%-point, translating into a 0.52%-point loss in growth, their lack of openness (1.71%-point), their badly developed financial markets (0.58%-point) and their distance from navigable waterways (1.07%-point).[19]

The bottom panel of Table 7 compares landlocked Africa with the Tigers. The results are similar, although the prospects of these countries are perhaps even more miserable. Still, as landlocked Africa starts off from a worse starting position than resource-rich Africa, it catches up more quickly and thus grows 1.41%-point faster than the Tigers. Accounting for landlocked Africa being more dependent on resources than the Tigers, would raise this growth differential to 1.74%-point. Now bringing mainly investment in physical and human capital but also population growth in line with the Tigers would add an extra 1.47%-point growth per annum. This offers some hope. However, if landlocked Africa were to be able to bring down its volatility of unanticipated output in line with that of the Tigers, it would boost growth by a further 1.97%-point per annum. The potential growth bonus is thus 3.44%-point. If this were feasible, landlocked Africa's negative growth differential with the Tigers of -3.82%-points could have been reduced to a little as -0.38%-points. The countries Malawi and Zambia are resource rich *and* landlocked. They also have relatively high volatility and poorly developed financial systems. Not surprisingly, they have a lot to gain.

We conclude that a big push to economic growth occurs if the volatility of unanticipated output growth in Africa is brought down to the level of the Asian Tigers. The big contributing factors to Africa's volatility are its volatile stream of mainly point-source natural resource revenues, its lack of fully developed financial markets and openness to international trade, and its disadvantages of being relatively more landlocked than the Asian Tigers.

6. Concluding Remarks

We have shown that the curse of natural resources is foremost a problem of volatility. The high volatility of world prices of natural resources causes severe volatility of output per capita growth in countries that depend heavily on them. The resulting volatility of unanticipated output growth has a robust negative effect on long-run growth itself and can therefore rightly be coined a curse. This is not limited to oil-producing countries, but also applies to exporters of copper, coffee, foods, etc. which include many of the world's worst performing countries. Also, ethnic tensions, which are often literally fuelled by resource wealth, and current account restrictions increase

[19] Each number is obtained by keeping all other variables constant and using the country's value for the respective variable. The effect on growth is then calculated using the coefficient on volatility in the mean equation. They therefore reflect the growth effect of changing only one variable to the country's 1970 level.

volatility. The latter effect is especially strong in resource-rich countries. Government spending bonanzas after windfall resource revenues also increase volatility to the detriment of growth, because revenue drops inevitably follow.

Volatility can fortunately be substantially reduced provided that countries have a sound financial system to cope with large and sudden fluctuations in resource income. Fewer capital account restrictions, openness and physical access to world trade also lower volatility. Countries can turn the curse even into a blessing, because we find evidence for a positive direct effect of natural resource dependence on growth after controlling for volatility. The key to a turn-around for many resource-rich countries is financial development, ensuring openness and mitigating the effect of being landlocked, because the *indirect negative* effect of resource dependence on growth, via volatility, is much larger than any *direct positive* effect. While it may be difficult to lower price volatility of resources themselves, it should be feasible to deal with volatility in a more efficient way. A special issue of the World Bank Economic Review (e.g., Loayza et al., 2007) also recognizes that volatility of many developing countries results from large external shocks, volatile macroeconomic policies, microeconomic rigidities and weak institutions impose welfare losses for risk-averse individuals. Future research should be focused on ways on how to cope with such volatility and manage the associated risks. Future work should also investigate ways to overcome the political temptations of short-run resource wealth to create the financial and political institutions needed to reduce volatility, soften the impact of volatility on growth and prevent poverty.

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Appendix 1: Description of the Cross-Country Data

VARIABLE NAME	DEFINITION	SOURCE
GDP/capita growth rate	Annual ln difference in real GDP per capita, Laspeyres; Averages are taken by country across the given period and annual growth rates.	PWT 6.2 from Heston et al (2006)
Investment share of GDP	Gross fixed capital formation as % of GDP	PWT 6.2 from Heston et al (2006)
Average population growth rate	Ln difference in total population	PWT 6.2 from Heston et al (2006)
log per capita GDP	Ln real GDP per capita	PWT 6.2 from Heston et al (2006)
Human capital	Average schooling years in the population (age 25+)	Barro & Lee (2000)
Rule of Law 1984	A country's score on the law and order index in 1984 (first year available).	IMF (2006)
Total resources	The sum of point-source resources and diffuse resources.	WDI (2006)
Point-source resources	F.o.b. value of exported fuels + ores & metals as a percentage of GDP	WDI (2006)
Diffuse resources	F.o.b. value of exported foods and agricultural raw materials as a percentage of GDP	WDI (2006)
Fuels	F.o.b. value of exports as a percentage of GDP. Corresponds to SITC section 3 (mineral fuels).	WDI (2006)
Ores & Metals	F.o.b. value of exports as a percentage of GDP. Commodities in SITC divisions 27, 28, and 68 (nonferrous metals).	WDI (2006)
Agricultural Raw Materials	F.o.b. value of exports as a percentage of GDP. Corresponds to SITC section: 2 (crude materials except fuels) excluding divisions 22, 27 (crude fertilizers and minerals excluding coal, petroleum, and precious stones), and 28 (metalliferous ores and scrap).	WDI (2006)
Foods	F.o.b. value of exports as a percentage of GDP. Commodities in SITC sections: 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal and vegetable oils and fats) and SITC division 22 (oil seeds, oil nuts, and oil kernels).	WDI (2006)
Resource rents	(total sale value – total production costs)/GDP, current US$ for bauxite, copper, nickel, tin, zinc, lead, phosphates, iron ore, silver, gold (ores); brown coal, hard coal, oil, natural gas (fuels)	World Bank (2007) and WDI (2006)
Monthly world commodity prices	Monthly averages of free-market price indices for all food, agricultural raw materials, minerals, ores & metals, crude petroleum (average of Dubai/Brent/Texas equally weighted). Base year 2000 = 100.	UNCTAD, 2007
Financial development	Domestic credit to private sector (% of GDP)	WDI (2006)
Sachs Warner updated openness dummy	open to trade = 1	Wacziarg & Welch (2003)
Fraction of years open to trade	number of total years open to trade divided by years in sample	Wacziarg & Welch (2003)
Landlocked dummy	=1 if a country has no access to sea	Gallup et al (1999)
% population in temperate climate zone	% 1995 pop in Koeppen-Geiger temperate zones (Cf+Cs+Df+DW)	CID, General Measures of Geography, 2007
Distance to nearest navigable river or coast	minimum distance in km, fixed effect	CID, General Measures of Geography, 2007
Life expectancy 1970	Life expectancy at birth	WDI (2006)
Ethnic Polarization	Index of ethno-linguistic polarization (0: many small groups, to 1: two large groups)	Montalvo & Reynal-Querol (2005)
Ethnic Fractionalization	Index of ethno-linguistic fractionalization (0 to 1), the probability that two randomly selected individuals from a given country will not belong to the same ethnic group.	Montalvo & Reynal-Querol (2005)
Multiple Exchange Practices	dummy, yes = 1	IMF (2006)
Current Account Restrictions	dummy, yes = 1	IMF (2006)
Capital Account Restrictions	dummy, yes = 1	IMF (2006)
Surrender of Export receipts	dummy, yes = 1	IMF (2006)
Government spending volatility	standard deviation of yearly share of government expenditure of GDP	PWT 6.2 from Heston et al (2006)
sd ToT index growth	standard deviation of yearly terms-of-trade index growth rate, where the terms-of-trade index is defined as the value of total exports over total imports	PWT 6.2 from Heston et al (2006)

Appendix 2: Econometric methodology

We use a dataset with *N* countries and a sample period of *T* years. Ramey and Ramey (1995) specify the following econometric model for growth in GDP per capita:

$$\text{(A1)} \qquad \Delta \log(y_{it}) = \lambda \sigma_i + \mathbf{X}_{i70}\boldsymbol{\theta} + \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, \sigma_i^2), \quad i = 1,...,N, \quad t = 1,..,T,$$

where y_{it} is GDP per capita in country *i* for year *t*, σ_i is the standard deviation for country *i* of the error term ε_{it}, $\mathbf{X_{i70}}$ is a vector of control variables for country *i* and year 1970, and $\boldsymbol{\theta}$ is a vector of coefficients assumed to be constant across countries. The errors ε_{it} are the deviations of growth from the predicted values based on the controls. The variances of these errors do not depend on time, but do vary for each country. The standard controls included in $\mathbf{X_{i70}}$ are initial log of GDP per capita, average share of investment in GDP, initial human capital (proxied by average years of schooling for those older than 25 years in 1970 taken from Barro and Lee (1993)) and average annual rate of population growth over the sample period. Ramey and Ramey (1995) then find statistically significant estimates for λ of -0.211 for a sample of 92 countries and -0.385 for the OECD countries. There is thus a negative relationship between volatility and conditional growth performance. In terms of the estimated magnitude of the economic impact of a one standard deviation change in the variable, volatility ranks third after the investment share and initial income per capita in the sample of 92 countries and second after initial income per capita for the OECD sample. Following on from Ramey and Ramey (1995), we will also test whether natural resource dependence, openness and financial development exert additional effects on growth.

We also probe into the black box of (A1) and try to explain volatility (i.e., the standard deviation of the yearly error in the growth equation) in terms of degree of financial development, resource dependence, and the distance from navigable river or coast. We collect these variables affecting volatility in the vector $\mathbf{Z}_{i70}$ and estimate the cross-country regressions:

$$\text{(A2)} \qquad \Delta \log(y_{it}) = \lambda \sigma_i + \mathbf{X}_{i70}\boldsymbol{\theta} + \mathbf{Z}_{i70}\boldsymbol{\beta} + \varepsilon_{it}, \quad \sigma_i^2 = \exp(\mathbf{Z}_{i70}\boldsymbol{\gamma} + c) \quad \text{and}$$
$$\varepsilon_{it} \sim N(0, \sigma_i^2), \quad i = 1,..,N, \quad t = 1,..,T.$$

Average volatility σ_i is assumed constant over time, but different for each country depending on the initial country characteristics captured in $\mathbf{Z}_{i70}$. If countries are similar in terms of the $\mathbf{Z}_{i70}$, they are also predicted to have similar volatility. The vector of parameters $\boldsymbol{\gamma}$ measures the average

cross-country effect of factors like resource dependence, financial development and distance from waterways on volatility. We also allow for *direct* effects of these variables on growth (**β**).

We estimate parameters {λ, **θ**, **γ**, c and **β**} of (A2) by maximizing the log-likelihood function:

(A3) $$L = -\frac{NT}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log\left(\boldsymbol{\Sigma}_t\right) - \frac{1}{2}\sum_{t=1}^{T}\boldsymbol{\varepsilon}_t\boldsymbol{\Sigma}_t^{-1}\boldsymbol{\varepsilon}_t,$$

where the covariance matrix is defined by $\boldsymbol{\Sigma}_{t,ii} = \sigma_i^2 = \exp(\mathbf{Z}_{i70}\boldsymbol{\gamma} + c), i = 1,..,N, t = 1,..,T,$ and $\boldsymbol{\Sigma}_{t,ij} = 0, i \neq j, t = 1,..,N$ and $\boldsymbol{\varepsilon}_t \equiv (\varepsilon_{1t},..,\varepsilon_{Nt})'$ with $\varepsilon_{it} \equiv \Delta\log(y_{it}) - \lambda\sigma_i - \mathbf{X}_{i70}\boldsymbol{\theta} - \mathbf{Z}_{i70}\boldsymbol{\beta}, t = 1,..,T.$

The method of econometric estimation is analogous to that of an autoregressive conditional-heteroskedasticity in mean (ARCH-M) estimation (Engle, Lilien, Robins, 1987). The variances are conditional, but time invariant. The error terms are assumed to be uncorrelated across countries.[20]

Table 1: Growth, Volatility, Financial Development and Resources in World

Regional Characteristics (%, 1970-2003, at least 10 observations per country)

Region	Yearly real GDP per capita growth rate		Export Value Share of GDP						Rent Share of GDP		Government Share	Financial Development
			Fuels, Ores & Metals		Agricultural Raw Materials, Foods		All Resources		Fuels, Ores & Metals			
	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	sd	mean
Middle East & North Africa (MENA)	1.18	8.12	22.24	9.30	2.51	1.52	24.75	9.07	26.98	11.20	5.82	41.41
Sub-Saharan Africa (SSA)	0.47	6.52	9.60	3.97	10.24	3.60	19.65	5.66	5.79	3.76	4.76	17.44
East Asia & Pacific (EAP)	2.47	5.00	6.81	3.45	10.04	3.11	16.71	5.49	4.44	2.44	2.72	51.77
Latin America & Caribbean (LAC)	1.47	4.54	4.99	2.64	9.66	3.70	14.59	5.34	6.31	3.26	3.98	34.87
South Asia (SA)	2.41	4.41	0.52	0.42	4.25	1.55	4.77	1.83	1.31	0.96	2.98	17.33
Eastern Europe & Central Asia (ECA)	2.56	4.34	2.07	0.66	3.50	1.03	5.57	1.54	2.23	1.23	2.52	22.70
Western Europe (WE)	2.35	2.33	2.71	1.00	5.20	0.95	7.86	1.60	0.55	0.52	1.53	76.08
North America (NA)	2.09	1.90	2.90	0.52	2.99	0.45	5.88	0.85	3.41	1.85	1.60	109.36
1st q. Av. Fin. Development (<=16.2)	0.70	6.40	9.71	4.23	7.64	3.00	17.06	5.52	5.14	2.95	4.64	10.38
4th q. Av. Fin. Development (>=52.9)	2.32	4.40	4.68	2.29	5.28	1.78	9.89	3.45	4.99	2.62	3.03	80.92
1st q. Av. Resource Dep. (<=6.1)	2.73	2.83	1.17	0.48	2.23	0.64	3.41	0.93	1.65	1.11	2.38	64.96
4th q. Av. Resource Dep. (>=19.3)	1.08	7.37	23.22	10.00	11.62	3.59	34.67	10.85	14.10	6.47	4.72	25.47
1st q. Distance to waterway (<=49km)	1.76	8.12	6.72	3.41	8.22	2.65	24.75	9.07	6.03	2.50	5.82	41.41
4th q. Distance to waterway (>=359km)	1.46	6.52	8.22	3.68	8.59	3.43	19.65	5.66	8.99	4.75	4.76	17.44

Note: *Means* are cross-country averages of country average growth rates or variable shares between 1970 and 2003. *Standard deviations (sd)* are the average cross-country standard deviations of country yearly growth rates or variable shares over the corresponding period.

[20] Allowing for non-zero covariances as in Cermeño and Grier (2005) would increase the number of parameters to be estimated too much to be identified for the large country panel we work with.

Table 2: Does the Traditional Natural Resource Curse Really Exist?

Dependent Variable (constant 2000 international dollars, PWT 6.2)	average GDP growth per capita 1970-2003	
	(1)	(2)
Annual growth Equation		
Total resources 1970	**-0.027****	**-0.012**
	(0.013)	**(0.013)**
Initial log per capita GDP	-0.012***	-0.010**
	(0.004)	(0.004)
Fraction of years open to trade	0.151***	0.177***
	(0.040)	(0.038)
Initial GDP/capita * fraction years open	-0.017***	-0.021***
	(0.005)	(0.005)
Average investment share of GDP	0.041	0.041
	(0.030)	(0.028)
Rule of Law 1984	0.004**	0.004**
	(0.001)	(0.001)
Average yearly growth GDP per capita 60-70	-0.013	0.008
	(0.072)	(0.067)
Distance to nearest navigable river or coast	-0.000	-0.000
	(0.000)	(0.000)
Fraction of population in temperate climate	0.003	0.006
	(0.005)	(0.005)
Life expectancy 1970	0.001**	0.001*
	(0.000)	(0.000)
Average population growth rate 1970-2003	-0.524**	-0.470**
	(0.251)	(0.233)
Human capital 1970	0.001	0.001
	(0.001)	(0.001)
Standard deviation of GDP/capita growth		**-0.292*** **
		(0.099)
Constant	0.061**	0.057**
	(0.026)	(0.024)
Observations	58	58
R-squared	0.75	0.79
Countries	58	58

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Volatility Harms Growth but the Resource Curse is not Cast in Stone

Dependent Variable	yearly GDP growth per capita 1970-2003				
(constant 2000 international dollars, PWT 6.2)	(1)	(2)	(3)	(4)	(5)
Annual growth equation			**Resource Export Revenues**		**Resource Rents**
Average investment share of GDP	0.108***	0.079***	0.063***	0.053***	0.083***
	(0.012)	(0.013)	(0.013)	(0.017)	(0.020)
Average population growth rate 1970-2000	-0.472***	-0.337***	-0.411***	-0.460***	-0.624***
	(0.118)	(0.103)	(0.127)	(0.158)	(0.141)
Initial log per capita GDP	-0.012***	-0.009***	-0.011***	-0.012***	-0.010***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Initial human capital 1970	0.001*	0.001**	0.001*	0.001**	-0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)
Volatility (σ_i)	**-0.110****	**-0.089****	**-0.126****	**-0.243****	**-0.240*****
	(0.049)	(0.043)	(0.058)	(0.113)	(0.087)
1st lag GDP per capita growth		0.264***	0.264***	0.240***	0.207***
		(0.028)	(0.032)	(0.028)	(0.031)
Initial point-source resources			-0.071**	-0.035	
			(0.035)	(0.041)	
Point based rent share					-0.202***
					(0.044)
Initial diffused resources			-0.000	0.010	0.033**
			(0.018)	(0.020)	(0.014)
Initial financial development			-0.003	-0.001	-0.007**
			(0.006)	(0.005)	(0.003)
Sachs Warner updated openness dummy			0.001	0.002	0.002
			(0.003)	(0.004)	(0.002)
Initial point-source resources * openness			0.003	0.012	
			(0.086)	(0.073)	
Point-source rent share * openness					0.177**
					(0.085)
Initial point res. * Fin. Dev.			0.280	0.181	
			(0.215)	(0.191)	
Point-source rent share * Fin. Dev.					0.745***
					(0.182)
Constant	0.110***	0.084***	0.100***	0.117***	0.106***
	(0.011)	(0.012)	(0.012)	(0.014)	(0.011)
Variance equation					
Sub-Saharan Africa				2.557***	2.618***
				(0.207)	(0.224)
Middle-East & North Africa				1.708***	1.675***
				(0.258)	(0.305)
Latin America & Caribbean				1.583***	1.561***
				(0.176)	(0.178)
Eastern Europe & Centra Asia				1.410***	1.350***
				(0.036)	(0.050)
East Asia & Pacific				1.010***	0.852***
				(0.195)	(0.221)
South Asia				0.444**	0.356**
				(0.182)	(0.165)
Western Europe				0.192	0.256
				(0.153)	(0.163)
North America				Reference region (least volatile)	
Constant	-3.823***	-3.947***	-6.630***	-7.788***	-7.747***
	(0.118)	(0.011)	(0.024)	(0.033)	(0.041)
Country dummies in variance eq.	yes	yes	yes	no	no
Observations	3448	3437	2185	2185	2014
Log likelihood	5898.5	5997.9	4226.6	4017.1	3759.4
Countries	103	103	65	65	60

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Regressions 2-5 use clustered standard errors, by country.

Table 4: Volatility is the Quintessential Feature of the Natural Resource Curse

Dependent Variable	yearly GDP growth per capita 1970-2003	*Average investment share GDP 1970-2003*	Yearly GDP growth per capita 1970-2003		yearly GDP growth per capita 1970-2003	*Average investment share GDP 1970-2003*	yearly GDP growth per capita 1970-2003	
(constant 2000 international dollars, PWT 6.2)	(6a) ML	(6b) 1st stage	(6c) IV-ML	(6d) IV-ML	(7a) ML	(7b) 1st stage	(7c) IV-ML	(7d) IV-ML
Annual growth equation	**Resource Export Revenues**				**Resource Rents**			
Average investment share of GDP '70-'03	0.045*		*0.119***	*0.113**	0.094***		*0.137***	*0.151***
	(0.025)		*(0.056)*	*(0.061)*	(0.019)		*(0.066)*	*(0.071)*
1st lag GDP per capita growth	0.221***	*0.053***	0.215***	0.215***	0.205***	*0.068****	0.203***	0.201***
	(0.025)	*(0.021)*	(0.027)	(0.026)	(0.027)	*(0.024)*	(0.028)	(0.029)
Average population growth rate 1970-2003	-0.478***	*0.258*	-0.457***	-0.460***	-0.692***	*-0.236*	-0.612***	-0.607***
	(0.144)	*(0.832)*	(0.162)	(0.157)	(0.105)	*(0.964)*	(0.142)	(0.142)
log per capita GDP 1970	-0.014***	*-0.026***	-0.013***	-0.013***	-0.012***	*-0.021*	-0.012***	-0.012***
	(0.002)	*(0.012)*	(0.003)	(0.002)	(0.002)	*(0.015)*	(0.003)	(0.003)
Human capital 1970	0.002**	*0.012****	0.001	0.001	0.000	*0.012****	-0.000	-0.000
	(0.001)	*(0.003)*	(0.001)	(0.001)	(0.000)	*(0.004)*	(0.001)	(0.001)
Volatility (σ_i)	**-0.971****		**-0.897***	**-0.937****	**-0.843*****		**-1.069***	**-1.055*****
	(0.378)		**(0.508)**	**(0.415)**	**(0.286)**		**(0.584)**	**(0.378)**
Point-source resources 1970	0.050*	*0.242****	0.033	0.036				
	(0.030)	*(0.039)*	(0.041)	(0.027)				
Point-source rent share 1970					-0.188***	*0.543***	-0.120	-0.132
					(0.051)	*(0.229)*	(0.116)	(0.085)
Sachs Warner updated openness dummy 70	-0.006	*0.058****	-0.010	-0.010*	-0.009**	*0.052***	-0.014*	-0.015**
	(0.005)	*(0.018)*	(0.008)	(0.005)	(0.004)	*(0.022)*	(0.007)	(0.006)
Point-source rent share * openness 70					0.208**	*-0.032*	0.198*	0.201**
					(0.101)	*(0.064)*	(0.102)	(0.099)
Financial development 1970	-0.018**	*0.067**	-0.021**	-0.021***	-0.027***	*0.066**	-0.031***	-0.031***
	(0.007)	*(0.037)*	(0.009)	(0.007)	(0.007)	*(0.035)*	(0.010)	(0.006)
Point-source rent share * Fin. Dev. 70					0.948***	*-0.311*	0.572***	0.601***
					(0.144)	*(1.691)*	(0.207)	(0.179)
Constant	0.170***	*0.313****	0.151***	0.157***	0.149***	*0.281***	0.162***	0.158***
	(0.030)	*(0.090)*	(0.046)	(0.032)	(0.021)	*(0.116)*	(0.043)	(0.035)
Landlocked dummy		*-0.012*				*-0.007*		
		(0.013)				*(0.012)*		
% Population in Temperate Climate Zone		*0.002*				*0.004*		
		(0.026)				*(0.032)*		
Ethnic Fractionalization Index		*-0.073****				*-0.059**		
		(0.026)				*(0.035)*		
Variance equation								
Point-source resources 1970	1.621***		1.655	1.657**				
	(0.589)		(1.386)	(0.657)				
Point-source rent share 1970					2.449***		2.568	2.575**
					(0.935)		(1.723)	(1.272)
Diffuse resources 1970	0.801		0.982	0.980	0.154		0.260	0.261
	(0.514)		(1.952)	(0.711)	(0.783)		(0.626)	(0.649)
Financial development 1970	-1.290***		-1.299***	-1.300***	-1.423***		-1.430***	-1.430***
	(0.072)		(0.457)	(0.184)	(0.209)		(0.092)	(0.167)
Sachs Warner updated openness dummy 70	-0.693***		-0.681***	-0.682***	-0.709***		-0.717***	-0.717***
	(0.160)		(0.129)	(0.182)	(0.242)		(0.149)	(0.085)
Distance to nearest navigable river or coast	0.001***		0.001***	0.001***	0.001***		0.001**	0.001***
	(0.000)		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)
Constant	-6.100***		-6.118***	-6.117***	-5.974***		-5.958***	-5.959***
	(0.062)		(0.278)	(0.070)	(0.054)		(0.059)	(0.073)
F-stat. on excl. instruments		*6.46*		*11.85*		*2.44*		*5.65*
Hansen overidentification J-statistic (p-value)		*0.126*		*n.a.*		*0.366*		*n.a.*
Country dummies in variance eq.								
Observations	2084	2084	2084	2084	1980	1980	1980	1980
R2	.	0.72	.	.	.	0.67	.	.
Log likelihood	3732.3	3927.4	3732.6	3731.9	3584.0	3538.4	3576.2	3576.4
Countries	62	62	62	62	59	59	59	59

Robust and clustered standard errors by country. *** p<0.01, ** p<0.05, * p<0.1. Columns 6d and 7d use only Ethnic Fractionalization Index as an IV.

Table 5: Effects of Various Commodity Exports on Volatility and Growth

Dependent Variable	yearly GDP growth per capita 1970-2003		yearly GDP growth per capita 1970-2003				
(constant 2000 international dollars, PWT 6.2)	(6a)	(6e)	(9a)	(9b)	(9c)	(9d)	(9e)
Annual growth equation							
1st lag GDP per capita growth	0.221***	0.220***	0.232***	0.230***	0.230***	0.226***	0.226***
	(0.025)	(0.025)	(0.026)	(0.027)	(0.027)	(0.027)	(0.028)
Average investment share of GDP '70-'03	0.045*	0.045*	0.063**	0.065**	0.063**	0.065**	0.074***
	(0.025)	(0.025)	(0.025)	(0.026)	(0.026)	(0.026)	(0.026)
Average population growth rate 1970-2003	-0.478***	-0.478***	-0.461***	-0.346**	-0.343**	-0.358**	-0.307**
	(0.144)	(0.145)	(0.133)	(0.152)	(0.149)	(0.139)	(0.147)
log per capita GDP 1970	-0.014***	-0.014***	-0.012***	-0.011***	-0.010***	-0.011***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Human capital 1970	0.002**	0.002**	0.001*	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Volatility (σ_i)	**-0.971****	**-1.022*****	**-0.427*****	**-0.350****	**-0.334****	**-0.426*****	**-0.388*****
	(0.378)	**(0.297)**	**(0.129)**	**(0.141)**	**(0.148)**	**(0.148)**	**(0.127)**
Point based resources 1970	0.050*	0.054*	0.014	0.008	0.005	0.018	0.016
	(0.030)	(0.028)	(0.023)	(0.023)	(0.029)	(0.023)	(0.022)
Financial development 1970	-0.018**	-0.018***	-0.010*	-0.008	-0.008	-0.009	-0.007
	(0.007)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Sachs Warner updated openness dummy 70	-0.006	-0.007*	0.001	0.002	0.003	0.001	0.001
	(0.005)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	0.170***	0.174***	0.121***	0.107***	0.106***	0.115***	0.104***
	(0.030)	(0.027)	(0.018)	(0.018)	(0.019)	(0.019)	(0.015)
Variance equation							
Initial point-source resources 1970	1.621***	2.125***	-0.426	-0.720	-0.493	-0.563	-1.247***
	(0.589)	(0.596)	(0.488)	(0.634)	(0.645)	(0.862)	(0.337)
Initial diffuse resources 1970	0.801	0.807	-0.897***	-0.133	-1.076	0.167	0.483
	(0.514)	(0.497)	(0.323)	(0.638)	(0.974)	(0.430)	(0.378)
Initial financial development 1970	-1.290***	-1.266***	-1.063***	-0.858***	-0.842***	-0.754***	-0.594***
	(0.072)	(0.121)	(0.136)	(0.096)	(0.226)	(0.166)	(0.153)
Sachs Warner updated openness dummy 1970	-0.693***	-0.700***	-0.467***	-0.536***	-0.487**	-0.545***	-0.215**
	(0.160)	(0.160)	(0.180)	(0.174)	(0.207)	(0.164)	(0.095)
Distance to nearest navigable river or coast	0.001***	0.001***	0.001***	0.001***	0.001***	0.000**	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Financial development * point based share		-2.780					
		(2.049)					
Point-source export share volatility 70-03			9.303***	9.528***		15.837***	14.491***
			(0.774)	(1.286)		(1.141)	(0.588)
Diffuse export share volatility 70-03			10.907***	3.899*		1.841*	3.737***
			(1.491)	(2.004)		(1.047)	(1.377)
Government share volatility 70-03				10.525***	10.406***	9.786***	8.372***
				(1.179)	(3.260)	(2.709)	(1.510)
Agricultural R.M. resource share volatility 70-03					0.631		
					(3.023)		
Foods resource share volatility 70-03					10.916***		
					(1.690)		
Ores & metals resource share volatility 70-03					6.626***		
					(2.543)		
Fuels resource share volatility 70-03					9.513***		
					(1.719)		
Financial development * point based volatility						-34.343***	-29.620***
						(6.542)	(3.295)
sd ToT index growth							4.321***
							(0.181)
Constant	-6.100***	-6.093***	-6.517***	-6.751***	-6.826***	-6.711***	-7.401***
	(0.062)	(0.067)	(0.030)	(0.035)	(0.057)	(0.075)	(0.020)
Observations	2084	2084	2084	2084	2084	2084	2084
Log likelihood	3732.3	3732.5	3792.2	3814.4	3815.2	3819.0	3842.8
Countries	62	62	62	62	62	62	62

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6: Ethnic Tensions, Economic Restrictions and the Resource Curse

Ethnic tensions	(10a)	(10b)	**Economic Restrictions**	(11a)	(11b)
Annual growth equation			**Annual growth equation**		
1st lag GDP per capita growth	0.219***	0.229***	1st lag GDP per capita growth	0.220***	0.228***
	(0.028)	(0.027)		(0.028)	(0.029)
Average investment share of GDP 70-03	0.053**	0.069***	Average investment share of GDP 70-03	0.077***	0.081***
	(0.026)	(0.026)		(0.018)	(0.019)
Average population growth rate 1970-2003	-0.451***	-0.244	Average population growth rate 70-03	-0.426***	-0.394***
	(0.153)	(0.160)		(0.130)	(0.114)
log per capita GDP 1970	-0.013***	-0.010***	log per capita GDP 1970	-0.012***	-0.010***
	(0.002)	(0.002)		(0.002)	(0.002)
Human capital 1970	0.001**	0.001	Human capital 1970	0.002***	0.001*
	(0.001)	(0.001)		(0.001)	(0.001)
Volatility (σ_i)	**-0.686*** **	**-0.320*** **	**Volatility (σ_i)**	**-0.490*** **	**-0.337*** **
	(0.212)	**(0.121)**		**(0.153)**	**(0.114)**
Initial point-source resources 70	0.019	0.008	Initial point-source resources 70	0.064***	0.037**
	(0.037)	(0.028)		(0.021)	(0.019)
Financial development 1970	-0.014**	-0.007	Financial development 1970	-0.012**	-0.006
	(0.005)	(0.005)		(0.005)	(0.005)
Sachs Warner updated openness dummy 70	-0.002	0.002	*Current Account Restrictions (yes=1)*	0.004*	0.002
	(0.004)	(0.003)		(0.002)	(0.002)
Ethnic Polarization	0.002	-0.003	*Capital Account restrictions (yes=1)*	-0.005*	-0.003
	(0.004)	(0.004)		(0.003)	(0.003)
Constant	0.143***	0.098***	Constant	0.125***	0.105***
	(0.023)	(0.014)		(0.017)	(0.012)
Variance equation			**Variance equation**		
Initial point based resources 70	-4.785***	-1.348**	Initial point based resources 70	5.314***	0.016
	(0.395)	(0.542)		(0.340)	(0.455)
Initial diffuse resources 70	0.863	0.213	Initial diffuse resources 70	2.082**	0.121
	(0.611)	(0.523)		(0.862)	(0.878)
Initial financial development 1970	-1.140***	-0.683***	Initial financial development 1970	-1.232***	-0.582***
	(0.113)	(0.095)		(0.197)	(0.132)
Sachs Warner updated openness dummy 70	-0.624***	-0.187			
	(0.097)	(0.139)			
Distance to nearest navigable river or coast	0.001***	0.000**	Distance to nearest navigable river or coast	0.001***	0.000
	(0.000)	(0.000)		(0.000)	(0.000)
Ethnic Polarization	0.402***	0.056	Ethnic Polarization	0.965***	0.296***
	(0.088)	(0.127)		(0.122)	(0.058)
Point-source export share volatility 70-03		8.834***	Point-source export share volatility 70-03		7.811***
		(1.327)			(0.542)
Diffuse export share volatility 70-03		5.827**	Diffuse export share volatility 70-03		10.504***
		(2.601)			(1.118)
Government share volatility 70-03		8.725***	Government share volatility 70-03		3.752*
		(2.072)			(2.179)
sd TOT index growth		4.537***	sd TOT index growth		4.166***
		(0.483)			(0.322)
Constant	-6.406***	-7.491***	Constant	-7.303***	-7.813***
	(0.043)	(0.034)		(0.027)	(0.048)
*Point-source resources 70 * Eth. Pol.*	8.536***		*Multiple Exchange Practices (yes=1)*	-0.759***	-0.438**
	(0.369)			(0.186)	(0.178)
			Current Account Restrictions (yes=1)	0.426***	0.511***
				(0.105)	(0.069)
			Capital Account restrictions (yes=1)	-0.294***	-0.311***
				(0.045)	(0.070)
			Surrender of Export receipts (yes=1)	0.384***	0.242***
				(0.081)	(0.082)
			*Cur. Acc. Restrictions * Point Resources 70*	4.877***	
				(1.080)	
			*Cap. Acc. Restrictions * Point Resources 70*	-2.508***	
				(0.634)	
Observations	2084	2084	Observations	2013	2013
Log likelihood	3748.2	3840.1	Log likelihood	3622.6	3707.2
Countries	62	62	Countries	60	60

Robust and clustered (by country) standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Counterfactual Experiments for Resource-Rich and Landlocked Africa

Resource-Rich Africa versus the Asian Tigers		sample mean	Asian Tigers	Resource-rich Africa	Difference	on volatility	on yearly GDP/capita growth rate
GDP per capita growth		1.49%	4.04%	0.25%	-3.79%		
Mean equation							
1st lag GDP per capita growth	0.221***	1.48%	4.00%	1.07%	-2.94%		0.65%
Average investment share of GDP 1970-2003	0.045*	17.26%	24.45%	14.96%	-9.50%		0.43%
Average population growth rate 1970-2003	-0.478***	1.72%	1.86%	2.75%	0.89%		0.43%
Initial log per capita GDP 1970	-0.014***	8.362	7.747	7.129	-0.619		-0.87%
Initial human capital 1970	0.002**	4.140	4.049	1.476	-2.574		0.46%
Volatility (σ_i)	-0.971**	4.04%	3.43%	6.02%	2.59%		2.98%
Initial point-source resources 1970	0.050*	4.35%	4.32%	13.13%	8.80%		-0.44%
Initial financial development 1970	-0.018**	29.07%	26.89%	14.43%	-12.47%		-0.22%
Variance equation							
Initial point-source resources 1970	1.621***	4.35%	4.32%	13.13%	8.80%	-0.41%	0.52%
Initial diffuse resources 1970	0.801	7.27%	11.08%	10.52%	-0.56%	0.01%	-0.02%
Initial financial development 1970	-1.290***	29.07%	26.89%	14.43%	-12.47%	-0.47%	0.58%
Sachs Warner updated openness dummy 70	-0.693***	0.374	0.746	0	-0.746	-1.37%	1.71%
Distance to nearest navigable river or coast	0.001***	277.763	90.902	552.571	461.669	-0.86%	1.07%
Estimated volatility		4.04%	3.43%	6.02%	2.59%		
Countries		62	4	6			

Note: Resource-rich African counties are: Algeria. Congo. Rep.. Ghana. Malawi. Togo. Zambia. Asian Tigers are: South Korea. Malaysia. Philippines and Thailand.

Landlocked Africa versus the Asian Tigers		sample mean	Asian Tigers	Landlocked Africa	Difference	on volatility	on yearly GDP/capita growth rate
GDP per capita growth		1.49%	4.04%	0.22%	-3.82%		
Mean equation							
1st lag GDP per capita growth	0.221***	1.48%	4.00%	0.50%	-3.51%		0.78%
Average investment share of GDP 1970-2003	0.045*	17.26%	24.45%	12.13%	-12.32%		0.56%
Average population growth rate 1970-2003	-0.478***	1.72%	1.86%	2.57%	0.71%		0.34%
Initial log per capita GDP 1970	-0.014***	8.362	7.747	6.744	-1.004		-1.41%
Initial human capital 1970	0.002**	4.140	4.049	0.874	-3.176		0.57%
Volatility (σ_i)	-0.971**	4.04%	3.43%	6.88%	3.45%		1.97%
Initial point-source resources 1970	0.050*	4.35%	4.32%	10.97%	6.65%		-0.33%
Initial financial development 1970	-0.018**	29.07%	26.89%	12.05%	-14.84%		-0.27%
Variance equation							
Initial point-source resources 1970	1.621***	4.35%	4.32%	10.97%	6.65%	-0.36%	0.45%
Initial diffuse resources 1970	0.801	7.27%	11.08%	7.99%	-3.09%	0.09%	-0.11%
Initial financial development 1970	-1.290***	29.07%	26.89%	12.05%	-14.84%	-0.63%	0.78%
Sachs Warner updated openness dummy 70	-0.693***	0.374	0.746	0	-0.746	-1.56%	1.95%
Distance to nearest navigable river or coast	0.001***	277.763	90.902	979.419	888.516	-1.76%	2.19%
Estimated volatility		4.04%	3.43%	6.88%	3.45%		
Countries		62	4	5			

Note: Landlocked Africa are: Central African Republic. Malawi. Mali. Niger. Zambia. Asian Tigers are: South Korea. Malaysia. Philippines and Thailand.

Figure 1: Volatility Correlated with Low Growth in GDP per Capita

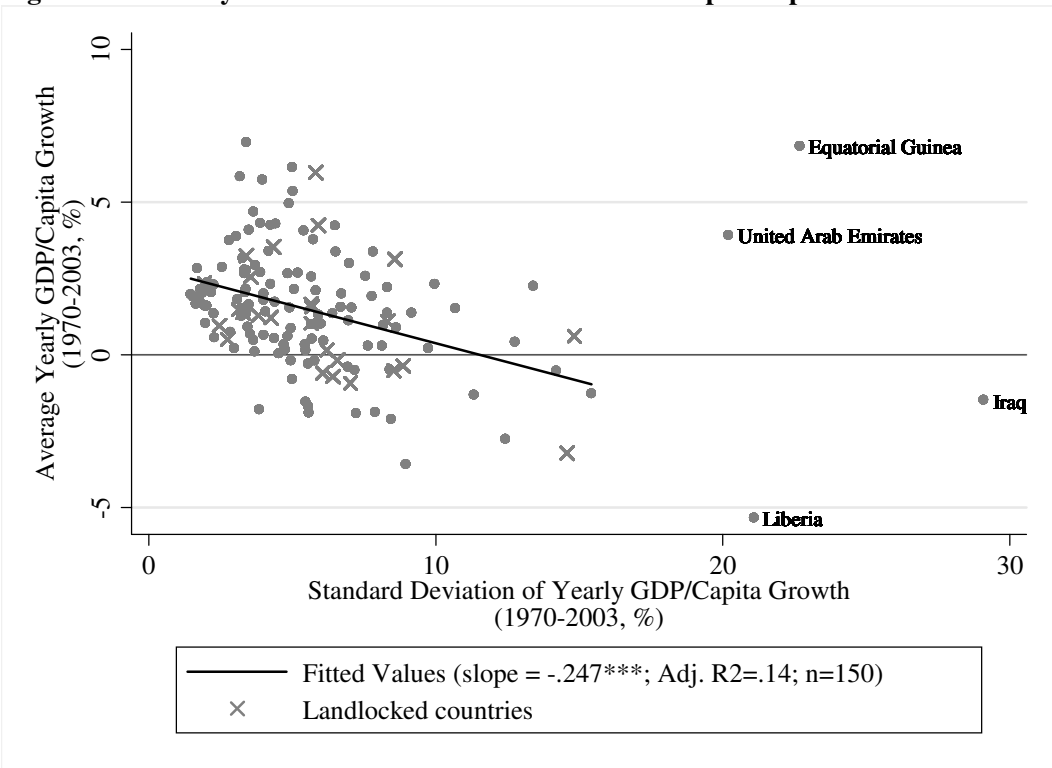
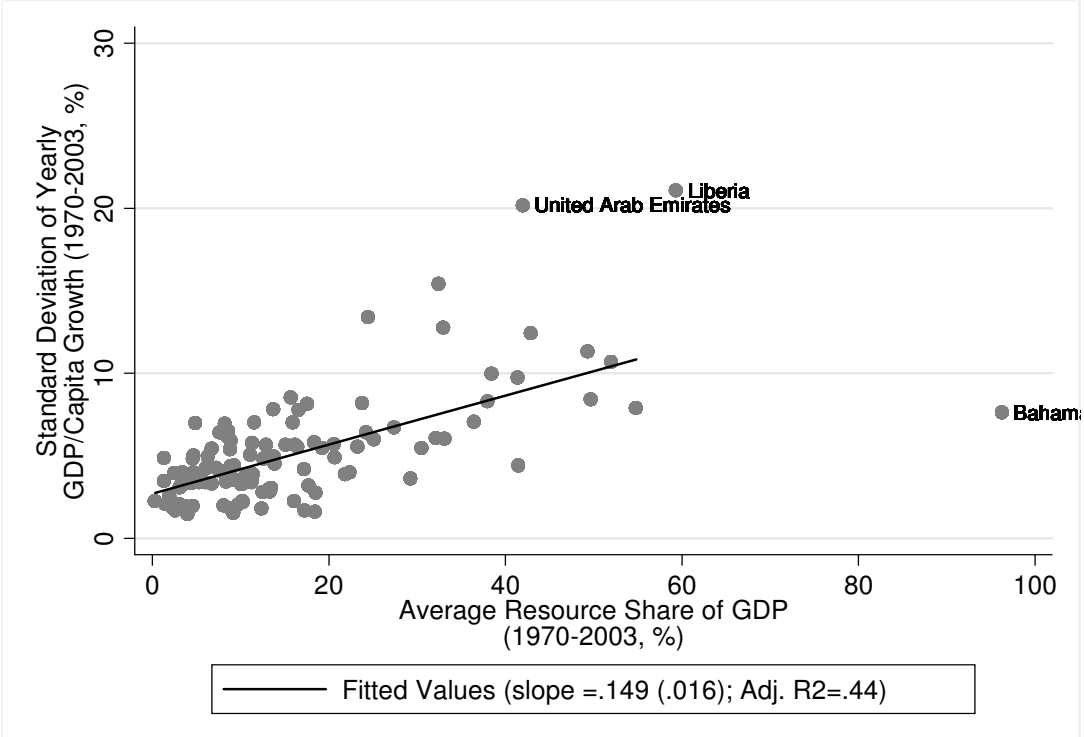
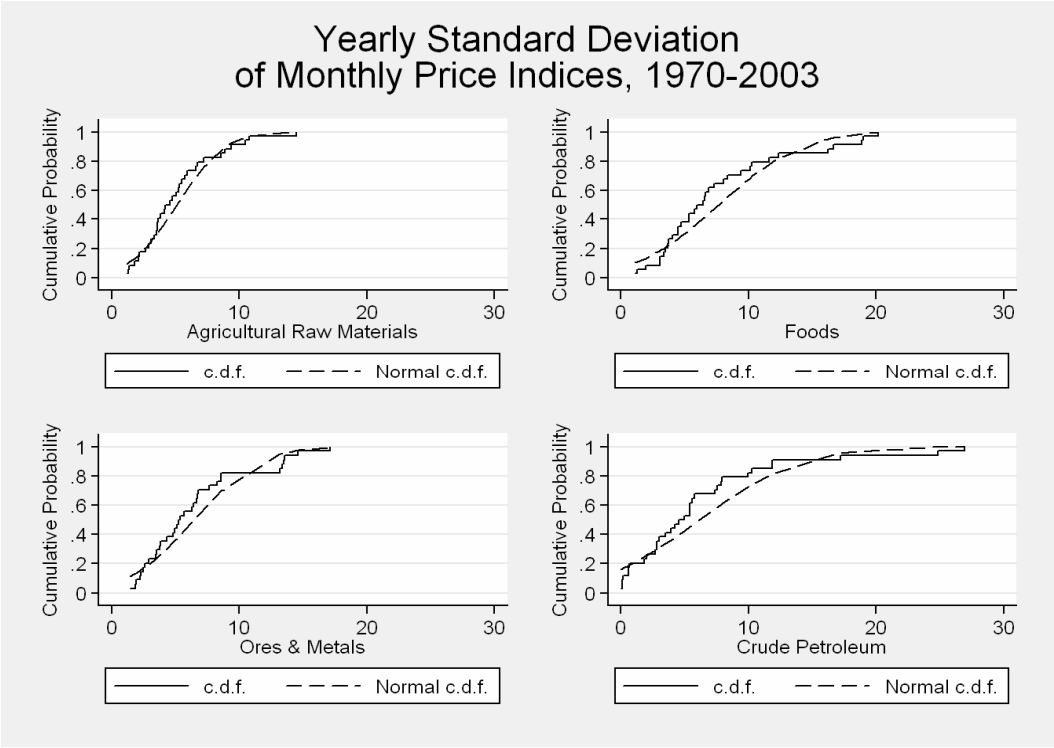


Figure 2: Resource-Rich Economies Are More Volatile



Note: Resource share measures the total of food, agricultural raw materials, mining and fuel export revenue, as a percentage of GDP, average over the period 1970-2003.

Figure 3: Cumulative density function of volatility of commodity prices



Note: The x-axis measures the yearly standard deviation of the monthly price index levels

Figure 4: Declining Natural Resource Dependence in the Global Economy

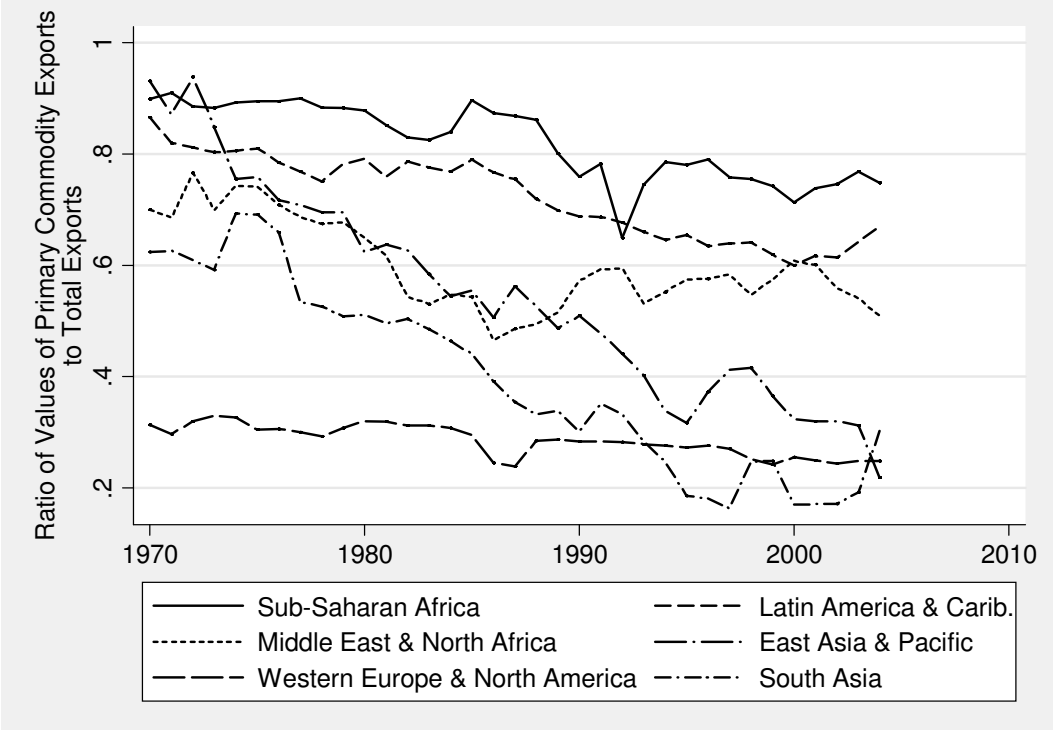
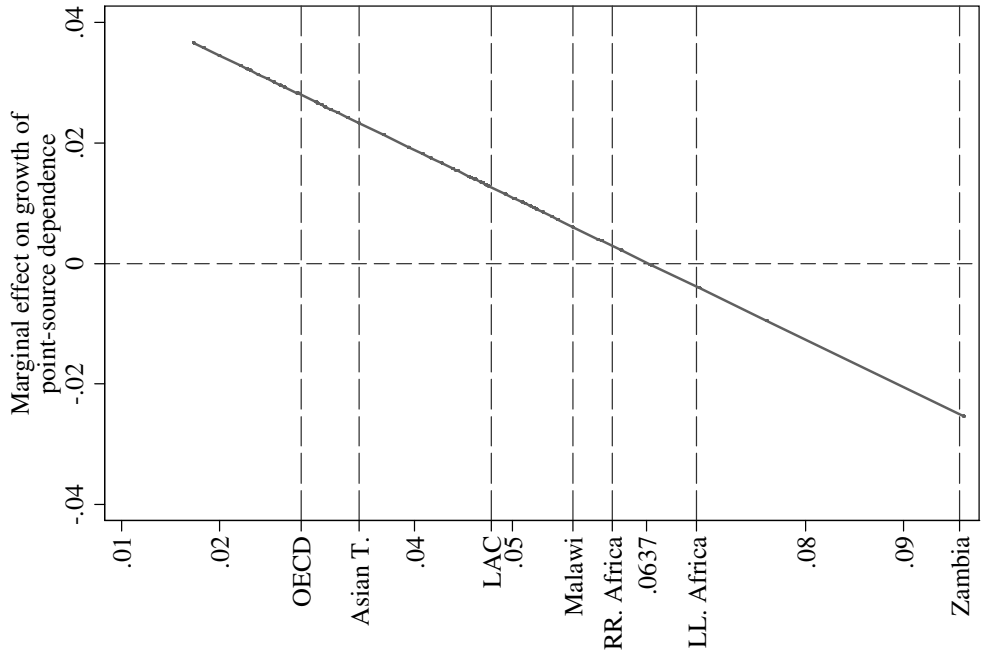
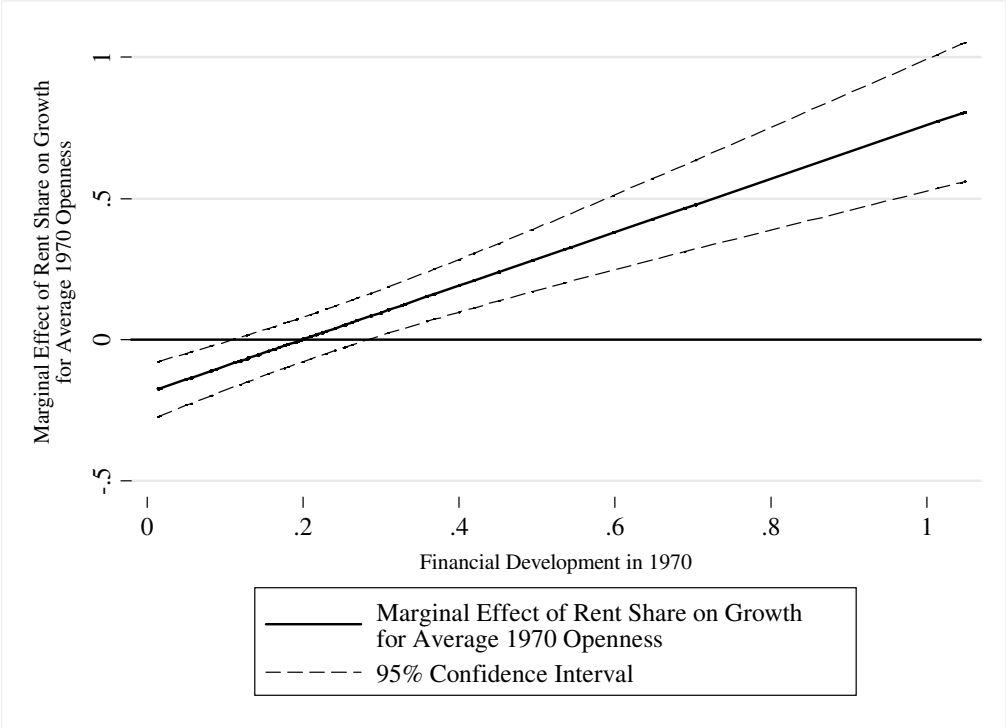


Figure 5: Marginal Effect of Point-Source Resource Dependence on Growth



Note: RR. Africa = resource-rich Africa; LL. Africa = Landlocked Africa; Asian T. = Asian Tigers, corresponding to Table 7. Based on regression 6a of Table 4.

Figure 6: Marginal Effect of GDP Share of Resource Rents on Growth



Note: Based on regression 7a of Table 4.