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OxCarre Research Paper

No. 2008-03

Volatility and the Natural Resource Curse

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VOLATILITY AND 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. 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

JEL code: C12, C21, C23, F43, G20, O11, O41, Q32

Revised 28 February 2009

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* University of Oxford. Also affiliated with University of Amsterdam, CEPR and CESifo. This work is supported by the BP funded Oxford Centre for the Analysis of Resource Rich Economies and is a revised version of CEPR Discussion Paper 6513.
** De Nederlandsche Bank, Amsterdam and European University Institute, Florence.
§ We thank the referees, Rob Alessie, Anindya Banerjee, Benedikt Goderis and Tony Venables for helpful comments on an earlier version. We also benefited from comments received during presentations at Glasgow University, Napels University, the 2007 OxCarre Launch Conference, the Royal Economic Society 2008 Annual Meeting and De Nederlandsche Bank.

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 greater 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] In a cross-

[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. A critique of Ramey and Ramey (1995) may be that the

section of 91 countries 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 dependence 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 give evidence against the conventional interpretation of the natural resource curse following from Sachs and Warner (1997ab, 2001) and many others.[2] Brunnschweiler and Bulte (2008) found that, using resource abundance (i.e., stocks of natural resource wealth) rather than resource dependence (i.e., natural resource exports as a percentage of GDP) as an explanatory variable, leads to a positive rather than a negative effect of resources on growth. In a similar vein, 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.

To motivate our multivariate econometric tests for the importance of volatility for the resource curse, we first present some telling stylized facts and partial correlations for the period 1970-2003 in Figures 1–3 and Table 1:

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observed negative effect of volatility on growth may be driven by the stark contrast between developed countries with low volatility and developing countries with high volatility. To the extent that our results allow for a richer set of controls in the growth equation and, more importantly, try to simultaneously explain the volatility of unanticipated output growth with institutional, geographical and economic variables, our results are less susceptible to this critique.

[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.

- 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 simple correlation while Ramey and Ramey (1995) show that this also holds after controlling for initial income per capita, population growth, human capital and physical capital.
- Second, developing countries have 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%-points. Most striking is that Sub-Saharan Africa and the Middle East & North Africa have 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 more volatile. Countries in the bottom quartile of financial development have a standard deviation of annual growth in GDP per capita 2 %-points 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. 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 %-points. Figure 2 also indicates that resource-rich countries have greater macroeconomic volatility. 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. 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 %-points lower than countries that are more than 359 kilometres from the nearest waterway. Empirical work also finds that remote countries are more likely to have undiversified exports and to experience greater volatility in output growth (Malik and Temple, 2006). Since Figure 1 indicates that the negative correlation between volatility and growth in income per capita is not much different for landlocked countries, the

disappointing growth performance of landlocked countries may be due to their higher volatility rather than being landlocked.

Although these stylized facts are suggestive, we perform a proper multivariate econometric analysis and control for all potential factors affecting the rate of economic growth.

Several papers have looked closer at the sources of volatility. The sophisticated statistical decomposition analysis performed in Koren and Tenreyro (2007) sheds light on why poor economies are more volatile than rich economies. They suggest four reasons why poor countries are much more volatile than rich countries: they specialize in more volatile sectors; specialize in fewer sectors; experience more frequent and more severe aggregate shocks (e.g., from macroeconomic policy); and their macroeconomic fluctuations 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.

Our multivariate econometric analysis provides complementary evidence on the factors affecting volatility by focusing on one of the most volatile sectors: natural resources. We argue that crucial and strongly related sources of macroeconomic volatility and poor growth performance are natural resource dependence, but also lack of a sophisticated financial system 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 less diversified and vulnerable to volatile world commodity prices. Natural resource revenues tend to be 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). Furthermore, the relatively high macroeconomic volatility

in developing countries induces relatively high welfare cost of consumption volatility and the welfare cost of removing this volatility may exceed the welfare gain from a permanent additional percentage point of growth (Pallage and Robe, 2003).

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 Appendices 1 and 2 describe 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 3. Section 5 uses our core estimates to compare resource-rich and landlocked Africa with a sample of South-East Asian countries. Section 6 concludes.

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

2.1. Economic arguments

Aghion, et al. (2006) show that with macroeconomic volatility driven by nominal exchange rate movements, firms are more likely to hit liquidity constraints and thus cannot afford to innovate which depresses growth, especially in economies with poorly developed financial institutions.[3] 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. 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.

[3] It is assumed that the price level is determined by the nominal exchange rate (the law of one price), nominal wages are pre-set not knowing the realization of the price level, the production function is of the Cobb-Douglas variety, the cumulative density function of liquidity shocks is concave, and firms maximize profits and can only innovate if they have enough cash (profits plus resource revenue) to cope with adverse liquidity shocks. With higher profits or resource revenues and a more developed financial system, more firms are more able to overcome liquidity shocks and thus the probability of innovation is higher. It can then be shown that moving from a peg to a float curbs innovation and growth.

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 greater 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.[4] 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 the traded sector is heavily dependent on natural resources and not very diversified (Hausmann and Ribogon, 2002). Shocks to the demand for non-traded goods and services – associated with shocks to natural resource income – are then not

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

accommodated by movements in the allocation of labour but by expenditure 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 in both the short and the 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 for diversified countries like Mexico or Indonesia or naturally specialized countries such as some Gulf States. Unfortunately, resource-rich economies are often specialized in production of natural resources 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 lose 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. Perhaps encouraged by the Prebisch hypothesis (the secular decline of world prices of primary exports), some developing countries have promoted state-led industrialization through prolonged import substitution to avoid resource dependency. These policies may also have been a reaction to the appreciation of the real exchange rate and decline of the traded manufacturing sectors caused by natural resource dependence. Once natural resource income has ceased, policies often 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. Case studies suggest that during the 1970s and 1980s many oil windfalls could have been put to better use (Gelb, 1988).

Political scientists have also argued that states adopt and maintain sub-optimal policies, and have studied the resource curse in great detail (e.g., 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. Of course, some of these choices may well be rational when leaders have short-term horizons due to political instability or other reasons (Caselli and Cunningham, 2009).

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 robust. They show that, once resource abundance (proxied by a measure of natural resource wealth) 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. Resource abundance is measured as the net-present value of natural capital in USD per capita in 1994, including subsoil assets, forest resources, protected areas, and agricultural land, with a constant discount factor of 4%. Since this measure makes several assumptions about the valuation of resources and has a limited time span, we feel that our approach is better served by the actual export revenue received on world markets. The latter is reported since 1970. The drawback on the other hand is that it does not measure how many resources a country has, but only its dependence on resources. Dependence is however the main channel through which our story runs. The literature uses the words dependence and abundance interchangeably, but we will refer to dependence as the export value of resources as a share of GDP, and abundance as the net present value of natural capital.

Sachs and Warner find for a wide range of control variables that natural resource dependence harms 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). Furthermore, growth seems to be higher in countries with 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 with a ratio of natural resource exports to GDP of 40 percent 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 robust to including other important determinants of economic growth. 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.

In the remainder of this paper we provide our empirical evidence on volatility and the resource curse. Table 3 in section 4.1 then yields our core estimates of volatility on growth and we establish that the direct effect of natural resources on growth is positive while the indirect effect through volatility is negative. Section 4.1 also probes deeper into the causes of macroeconomic volatility. We also show that the negative indirect effect of volatility is especially strong in highly volatile countries. Section 4.2 discusses the empirical effects of the volatility of various commodity resource shares on volatility on unanticipated growth and thus on growth performance. Table 4 in section 4.3 extends the analysis further and estimates the effects of ethnic fractions and of various current account and capital restrictions on volatility and thus growth.

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 must be given 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 3). 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. We have also estimated all our regressions with year dummies included in the annual growth equation, but this does not yield substantially different results. The countries used in our sample for the core regressions are reported in Appendix 1 while the data are described in Appendix 2.

4.1. Volatility is the key channel for the 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 3 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 poor countries catching 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 volatility of unanticipated output growth, because

[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.

resource dependence enters the volatility equation in a non-linear way as described in equation (A2).[6] We thus see that the total effect of resource dependence on growth is given by a direct effect (measured by the relevant parameter in θ and an indirect effect through volatility, measured by the relevant term in $\frac{1}{2}\lambda\sigma_i\gamma$). Natural resource dependence is thus, due to the indirect effect, a curse for 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. More open and financially developed countries are expected to be more stable and grow faster even if they export many resources. We see from Figure 5 that for the less volatile OECD (including Norway) and South-East Asia, 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.

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 looked for an exogenous variable that strongly predicts the investment share, but does not affect growth or correlate with other important unobserved characteristics. We instrumented 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).[7] 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.[8] We also include two geographical variables: whether a country is

[6] 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.

[7] 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.

[8] 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.

landlocked or not, and a climate variable. Our results (available on request) show that all our effects are qualitatively robust to this IV strategy, also if we additionally control for the possibility that fractionalization affects growth directly through the general quality of bureaucracy and corruption.[9] .

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 exports 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.

4.2. Volatility of commodity export shares and macroeconomic volatility

With regression 6a as the benchmark, regression 6b in Table 3 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 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 3 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 7a 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 7b 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 7c 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

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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.

[9] As measured in the International Country Risk Guide (PRS Group, 2006).

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 significant interaction between financial development and *initial* point-source resource dependence in the variance equation, regression 7d suggests that well-functioning capital markets 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 even when controlling for terms-of-trade shocks.

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

Table 4 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 8a 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 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 8b shows that ethnic polarization is no longer important once volatility of export shares of point-source and diffuse resources, and volatility of 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 4 also tests for the impact of economic restrictions to examine whether financial and trade liberalization boosts or depresses growth. Grilli and Milesi-Ferretti (1995) found no significant effect on growth but discuss their benefits for reducing capital flow volatility and facilitating stabilization policies. They may be important omitted variables in our variance equation. We therefore replace the single openness dummy with four dichotomous measures of

restrictions from the Annual Report on Exchange Arrangements and Restrictions (IMF, 2006). These include for example limits on repatriation of profits, exchange rate controls and restrictions on international payment. Regression 9a 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 high resource dependence. Capital account restrictions may thus curb volatility and boost growth, especially in resource-rich countries.[10] Access to international capital markets may be pro-cyclical, which may 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 9a 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 these exchange controls curb volatile capital in- and outflows. Regression 9b drops the interaction terms but includes the volatility of revenues, government spending and terms-of-trade shocks as explanatory variables in the variance equation, but this does not change the effect of the four restrictions.

5. Accounting for Growth Performance: Africa versus South-East Asian Countries

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 core equation 6a of Table 3. It is insightful to compare the African countries with some fast-growing resource-poor South-East Asian countries (including some South-East Asian countries)[11], since they have similar starting positions (in 1970). We therefore compare in Table 5 resource-rich and landlocked Africa with the South-East Asian Sample. 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 South-East Asian countries, they grow faster and catch up, everything else equal. We see from the top panel of Table 5 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 South-East Asian countries becomes 1.31%-point. Now if those African countries had

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

[11] The South-East Asian countries in our sample are South Korea, Malaysia, Philippines and Thailand

invested as much in physical and human capital as their South-East Asian counterparts, 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 South-East Asian sample, Africa would gain yet another 0.43%-point annual growth. These three factors combined yield an extra growth bonus 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 their South-East Asian counterparts: 2.98%-point extra growth per annum! The main reasons for the high volatility of resource-rich Africa are their heavy dependence on resources (increasing volatility by 0.41%-point, translating into a 0.52%-points loss in growth), lack of openness (1.71%-point), under-developed financial markets (0.58%-points) and distance from waterways (1.07%-point).[12]

The bottom panel of Table 5 compares landlocked Africa with the South-East Asian countries in our sample. 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 South-East Asian countries. Accounting for landlocked Africa being more dependent on resources than the South-East Asian countries, 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 South-East Asian countries 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 South-East Asian countriesa 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 South-East Asian countries 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 South-East Asian countries. 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.

[12] 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.

6. Concluding Remarks

We have shown that the resource curse 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 is a curse. This is not limited to oil-exporters, 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 fuelled by resource wealth, and current account restrictions increase 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 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. It is increasingly realised that large external shocks, volatile macroeconomic policies, microeconomic rigidities and weak institutions induce substantial income volatility in many developing countries, which imposes significant welfare losses for risk-averse individuals (e.g., Loayza et al., 2007). Future research should thus be focused on ways on how to cope with such volatility and manage the associated risks. Future work might 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.

References

Aghion, P. and G. Saint Paul (1998). On the virtues of bad times, Macroeconomic Dynamics, 2, 3, 322-344.

Aghion, P., G.-M. Angeletos, A. Banerjee and K. Manova (2005). Volatility and growth: credit constraints and productivity-enhancing investments, Working Paper 11349, NBER, Cambridge, Ma.

Aghion, P., P. Bacchetta, R. Rancière and K. Rogoff (2006). Exchange rate volatility and productivity growth: the role of financial development, Discussion Paper No. 5629, CEPR, London.

Aizenman, J. and N. Marion (1991). Policy uncertainty, persistence and growth, Review ofInternational Economics, 1, 2, 145-163.

Aizenman, J. and N. Marion (1999). Volatility and investment: interpreting evidence from developing countries, Economica, 66, 157-179.

Alesina, A., A. Devleeschauwer, W. Easterly, S. Kurlat and R. Wacziarg (2003). Fractionalization, Journal of Economic Growth, 8, 155-194.

Alexeev, M. and R. Conrad (2005). The elusive curse of oil, Working Paper SAN05-07, Terry Sandford Institute of Public Policy, Duke University, Durham.

Barro, R.J. and J.-W. Lee (2000). International data on educational attainment: updates and implications, Working Paper No. 42, Centre for International Development, Harvard University.

Bernanke, B.S. (1983). Irreversibility, uncertainty and cyclical investment, Quarterly Journal of Economics, 98, 1, 85-106.

Bertola, G. (1994). Flexibility, investment, and growth, Journal of Monetary Economics, 34, 2, 215-238.

Black, F. (1987). Business Cycles and Equilibrium, Basil Blackwell, New York.

Blattman, C., J. Hwang and J.G. Williamson (2007). Winners and losers in the commodity lottery: The impact of terms of trade growth and volatility in the Periphery 1870-1939, Journal of Development Economics, 82, 156-179.

Bloom, D.E. and J. Sachs (1998). Geography, demography, and economic growth in Africa, Brookings Papers on Economic Activity, 2, 207-295.

Brunnschweiler, C. and E.H. Bulte (2008). The natural resource curse revised and revisited: A tale of paradoxes and red herrings, Journal of Environmental Economics and Management, 55, 3, 248-264.

Cameron, A.C. and P.K. Trivedi (2005). Microeconometrics: Methods and Applications, Cambridge University Press, New York.

Caselli, F. and T. Cunningham (2009). Leader behavior and the natural resource curse, Oxford Economic Papers, this issue.

Céspedes and R. Sahay (2002). Keyens, cocoa, and copper: In search of commodity currencies, Working Paper WP/02/223, International Monetary Fund, Washington, D.C.

Deaton, A. (1999). Commodity prices and growth in Africa, Journal of Economic Perspectives, 13, 3, 23-40.

Ding, N. and B.C. Field (2005). Natural resource abundance and economic growth, Land Economics, 81, 3, 496-502.

Dixit, A. and R. Rob (1994). Switching costs and sectoral adjustments in general equilibrium with uninsured risk, Journal of Economic Theory, 62, 1, 48-69.

Easterly, W., M. Kremer, L. Pritchett and L.H. Summers (1993). Good policy or good luck? Country growth performance and temporary shocks, Journal of Monetary Economics, 32, 459-483.

Easterly, W. and R. Levine (1997). Africa's growth tragedy: policies and ethnic divisions, Quarterly Journal of Economics, 12, 1203-1250.

Edwards, J.A. (2007). Dynamics of the cross-country growth/volatility relationship, Global Economy Journal, 7, 2, 4.

Elbers, C., J.W. Gunning and B. Kinsey (2007). Growth and risk: Methodology and Micro Evidence, The World Bank Economic Review, 21, 1, 1-20.

Fatás, A. and I. Mihov (2005). Policy volatility, institutions and economic growth, Discussion Paper No. 5388, CEPR, London.

Flug, K., A. Splilimbergo and E. Wachtenheim (1999). Investment in education: do economic volatility and credit constraints matter?, Journal of Development Economics, 55, 2, 465-481.

Gallup, J.L, J.D. Sachs and A. Mellinger (1999). Geography and economic development, Working Paper No. 1, Centre for International Development, Harvard University.

Gelb, A. (1988) (ed.), Oil Windfalls: Blessing or Curse?, Oxford University Press, Oxford.

Grilli, V. and G.M. Milesi-Ferretti, (1995). Economic effects and structural determinants of capital controls, IMF Staff Papers 42, 3, 517–551.

Gylfason, T., T.T. Herbertsson and G. Zoega (1999). A mixed blessing: natural resources and economic growth, Macroeconomic Dynamics, 3, 204-225.

Hausmann, R. and R. Ribogon (2002). An alternative interpretation of the 'resource curse': theory and policy implications, Working Paper No. 9424, NBER, Cambridge, MA.

Hausmann, R., U. Panizza and R. Rigobon (2004). The long-run volatility puzzle of the real exchange rate, Working Paper No. 10751, NBER, Cambridge, MA.

Herbertsson, T.T., M. Skuladottir and G. Zoega (2000). Three symptoms and a cure: A contribution to the economics of the Dutch Disease, Discussion Paper No. 2364, CEPR, London.

Heston, A., R. Summers and B. Aten (2006). Penn World Table 6.2, Center for International Comparisons of Production, Income and Prices, University of Pennsylvania.

Imbs, J. (2006). Growth and volatility, Journal of Monetary Economics, 54, 7, 1848-1862.

International Monetary Fund (2006, and earlier). Annual Report on Exchange Arrangements and Restrictions, International Monetary Fund, Washington, D.C.

Koren, M. and S. Tenreyro (2007). Volatility and Development, Quarterly Journal of Economics, 122, 1, 243-287.

Kose, M.A., E.S. Prasad and M.E. Torrones (2003). Financial integration and macroeconomic volatility, IMF Staff Papers, 50, 119-142.

Kose, M.A., E.S. Prasad and M.E. Torrones (2006). How do trade and financial integration affect the relationship between growth and volatility?, Journal of International Economics, 69, 176-202.

Loayza, N.V., R. Rancière, L. Servén and J. Ventura (2007). Macroeconomic volatility and welfare in developing countries: an introduction, World Bank Economic Review, 21, 3, 343-357.

Malik, A. and J. Temple (2006). The geography of output volatility, Journal of Development Economics, forthcoming.

Mansoorian, A. (1991). Resource discoveries and 'excessive' external borrowing, Economic Journal, 101, 1497-1509.

Martin, P. and C.A. Rogers (2000). Long-term growth and short-term economic instability, European Economic Review, 44, 359-381.

Mirman, L.J. (1971). Uncertainty and optimal consumption decisions, Econometrica, 39, 179-185.

Montalvo, J.G. and M. Reynal-Querol (2005a). Ethnic diversity and economic development, Journal of Development Economics, 76, 293-323.

Montalvo, J.G. and M. Reynal-Querol (2005b). Ethnic polarization, potential conflict, and civil wars, American Economic Review, 95, 797-816.

Pallage, S. and M.A. Robe (2003). On the welfare cost of economic fluctuations in developing countries, International Economic Review, 44, 2, 677-698.

Pagan, A.R. (1984). Econometric Issues in the Analysis of Regressions with Generated Regressors, International Economic Review, 25(1), 221-247.

Pindyck, R.S. (1991). Irreversibility, uncertainty, and investment, Journal of Economic Literature, 129, 3, 1110-1148.

Political Risk Services Group, (2006). International Country Risk Guide, East Syracuse, NY.

Ramey, G. and V.A. Ramey (1991). Technology commitment and the cost of economic fluctuations, Working Paper No. 3755, NBER, Cambridge, MA.

Ramey, G. and V.A. Ramey (1995). Cross-country evidence on the link between volatility and growth, American Economic Review, 85, 5, 1138-1151.

Rose, A.K. and M.M. Spiegel (2007). International financial remoteness and macroeconomic volatility, Journal of Development Economics, forthcoming.

Ross, M.L. (1999). The political economy of the resource curse, World Politics, 51, 297-322.

Sachs, J.D. and A.M. Warner (1995 and revised 1997a). Natural resource abundance and economic growth, in G. Meier and J. Rauch (eds.), Leading Issues in Economic Development, Oxford University Press, Oxford.

Sachs, J.D. and A.M. Warner (1997b). Fundamental sources of long-run growth, American Economic Review, Papers and Proceedings, 87, 2, 184-188.

Sachs, J.D. and A.M. Warner (2001). The curse of natural resources, European Economic Review, 45, 827-838.

Stock, J.H. and M. Yogo (2002). Testing for weak instruments in linear IV regression, Technical Working Paper 284, NBER, Cambridge, MA.

UNCTAD (2007). Commodity price statistics, United Nations Conference on Trade and Development, New York, NY.

Wacziarg, R. and K.H. Welch (2008). Trade liberalization and growth: new evidence, World Bank Economic Review, 22, 2, 187-231.

World Bank (2006). World Development Indicators, World Bank, Washington, D.C.

World Bank (2007). Adjusted Net Savings Data, Environmental Economics and Indicators, World Bank, Washington, D.C.

Appendix 1: Countries Included in our Core Estimates

Algeria	France	Pakistan
Argentina	Ghana	Panama
Australia	Greece	Peru
Austria	Guatemala	Philippines
Belgium	Honduras	Portugal
Benin	India	Senegal
Bolivia	Ireland	Spain
Brazil	Israel	Sri Lanka
Cameroon	Italy	Sweden
Canada	Japan	Switzerland
Central African Republic	Jordan	Thailand
Chile	Korea, Rep.	Togo
Colombia	Malawi	Trinidad and Tobago
Congo, Dem. Rep.	Malaysia	Tunisia
Congo, Rep.	Mali	Turkey
Costa Rica	Mexico	United Kingdom
Denmark	Netherlands	United States
Ecuador	New Zealand	Uruguay
Egypt, Arab Rep.	Nicaragua	Venezuela, RB
El Salvador	Niger	Zambia
Finland	Norway	

Appendix 2: 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).	PRS Group (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)
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 3: Econometric methodology

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

$$\Delta \log(y_{it}) = \lambda \sigma_i + \mathbf{X}_{i70}\boldsymbol{\theta} + \mathbf{Z}_{i70}\boldsymbol{\beta} + \varepsilon_{it}, \quad \sigma_i^2 = \exp(\mathbf{Z}_{i70}\boldsymbol{\gamma} + c) \quad \text{and}$$

$$\varepsilon_{it} \sim N(0, \sigma_i^2), \quad i = 1,..,N, \quad t = 1,..,T.$$

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. Average volatility σ_i is assumed constant over time, but differs for each country depending on the initial country characteristics captured in $\mathbf{Z}_{i70}$. We also allow for *direct* effects of these variables on growth ($\boldsymbol{\beta}$). We estimate parameters $\{\lambda, \boldsymbol{\theta}, \boldsymbol{\gamma}, c$ and $\boldsymbol{\beta}\}$ by maximizing the log-likelihood function. The error terms are assumed to be uncorrelated across countries.

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

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

Region	Yearly real GDP per capita growth rate		Export Value Share of GDP: Fuels, Ores & Metals		Agricultural Raw Materials, Foods		All Resources		Government Share	Financial Development
	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	5.82	41.41
Sub-Saharan Africa (SSA)	0.47	6.52	9.60	3.97	10.24	3.60	19.65	5.66	4.76	17.44
East Asia & Pacific (EAP)	2.47	5.00	6.81	3.45	10.04	3.11	16.71	5.49	2.72	51.77
Latin America & Caribbean (LAC)	1.47	4.54	4.99	2.64	9.66	3.70	14.59	5.34	3.98	34.87
South Asia (SA)	2.41	4.41	0.52	0.42	4.25	1.55	4.77	1.83	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	2.52	22.70
Western Europe (WE)	2.35	2.33	2.71	1.00	5.20	0.95	7.86	1.60	1.53	76.08
North America (NA)	2.09	1.90	2.90	0.52	2.99	0.45	5.88	0.85	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	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	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	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	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	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	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.

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: 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)	(6b)	(7a)	(7b)	(7c)	(7d)	(7e)
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

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

Table 4: Ethnic Tensions, Economic Restrictions and the Resource Curse

Ethnic tensions	(8a)	(8b)
Annual growth equation		
1st lag GDP per capita growth	0.219***	0.229***
	(0.028)	(0.027)
Average investment share of GDP 70-03	0.053**	0.069***
	(0.026)	(0.026)
Average population growth rate 1970-2003	-0.451***	-0.244
	(0.153)	(0.160)
log per capita GDP 1970	-0.013***	-0.010***
	(0.002)	(0.002)
Human capital 1970	0.001**	0.001
	(0.001)	(0.001)
Volatility (σ_i)	**-0.686*** **	**-0.320*** **
	(0.212)	**(0.121)**
Initial point-source resources 70	0.019	0.008
	(0.037)	(0.028)
Financial development 1970	-0.014**	-0.007
	(0.005)	(0.005)
Sachs Warner updated openness dummy 70	-0.002	0.002
	(0.004)	(0.003)
Ethnic Polarization	0.002	-0.003
	(0.004)	(0.004)
Constant	0.143***	0.098***
	(0.023)	(0.014)
Variance equation		
Initial point based resources 70	-4.785***	-1.348**
	(0.395)	(0.542)
Initial diffuse resources 70	0.863	0.213
	(0.611)	(0.523)
Initial financial development 1970	-1.140***	-0.683***
	(0.113)	(0.095)
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**
	(0.000)	(0.000)
Ethnic Polarization	0.402***	0.056
	(0.088)	(0.127)
Point-source export share volatility 70-03		8.834***
		(1.327)
Diffuse export share volatility 70-03		5.827**
		(2.601)
Government share volatility 70-03		8.725***
		(2.072)
sd TOT index growth		4.537***
		(0.483)
Constant	-6.406***	-7.491***
	(0.043)	(0.034)
*Point-source resources 70 * Eth. Pol.*	8.536***	
	(0.369)	
Observations	2084	2084
Log likelihood	3748.2	3840.1
Countries	62	62

Economic Restrictions	(9a)	(9b)
Annual growth equation		
1st lag GDP per capita growth	0.220***	0.228***
	(0.028)	(0.029)
Average investment share of GDP 70-03	0.077***	0.081***
	(0.018)	(0.019)
Average population growth rate 70-03	-0.426***	-0.394***
	(0.130)	(0.114)
log per capita GDP 1970	-0.012***	-0.010***
	(0.002)	(0.002)
Human capital 1970	0.002***	0.001*
	(0.001)	(0.001)
Volatility (σ_i)	**-0.490*** **	**-0.337*** **
	(0.153)	**(0.114)**
Initial point-source resources 70	0.064***	0.037**
	(0.021)	(0.019)
Financial development 1970	-0.012**	-0.006
	(0.005)	(0.005)
Current Account Restrictions (yes=1)	0.004*	0.002
	(0.002)	(0.002)
Capital Account restrictions (yes=1)	-0.005*	-0.003
	(0.003)	(0.003)
Constant	0.125***	0.105***
	(0.017)	(0.012)
Variance equation		
Initial point based resources 70	5.314***	0.016
	(0.340)	(0.455)
Initial diffuse resources 70	2.082**	0.121
	(0.862)	(0.878)
Initial financial development 1970	-1.232***	-0.582***
	(0.197)	(0.132)
Distance to nearest navigable river or coast	0.001***	0.000
	(0.000)	(0.000)
Ethnic Polarization	0.965***	0.296***
	(0.122)	(0.058)
Point-source export share volatility 70-03		7.811***
		(0.542)
Diffuse export share volatility 70-03		10.504***
		(1.118)
Government share volatility 70-03		3.752*
		(2.179)
sd TOT index growth		4.166***
		(0.322)
Constant	-7.303***	-7.813***
	(0.027)	(0.048)
Multiple Exchange Practices (yes=1)	-0.759***	-0.438**
	(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	2013	2013
Log likelihood	3622.6	3707.2
Countries	60	60

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

Table 5: Counterfactual Experiments for Resource-Rich and Landlocked Africa

Resource-Rich Africa versus South-East Asian		sample mean	South-East Asia	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, and Zambia. The South-East Asian countries in our sample are South Korea, Malaysia, Philippines and Thailand. The calculations are based on regression (6a). The effect of each variable on the growth rate (or on volatility) is measured as the effect of changing the respective variable to the sample mean level of the South-East Asian countries, while keeping all other variables constant.

Landlocked Africa versus South-East Asia		sample mean	South-East Asia	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 and Zambia. South-East Asian countries are South Korea, Malaysia, Philippines and Thailand. The calculations are based on regression (6a). The effect of each variable on the growth rate (or on volatility) is measured as the effect of changing the respective variable to the sample mean level of South-EastAsia, while keeping all other variables constant.

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

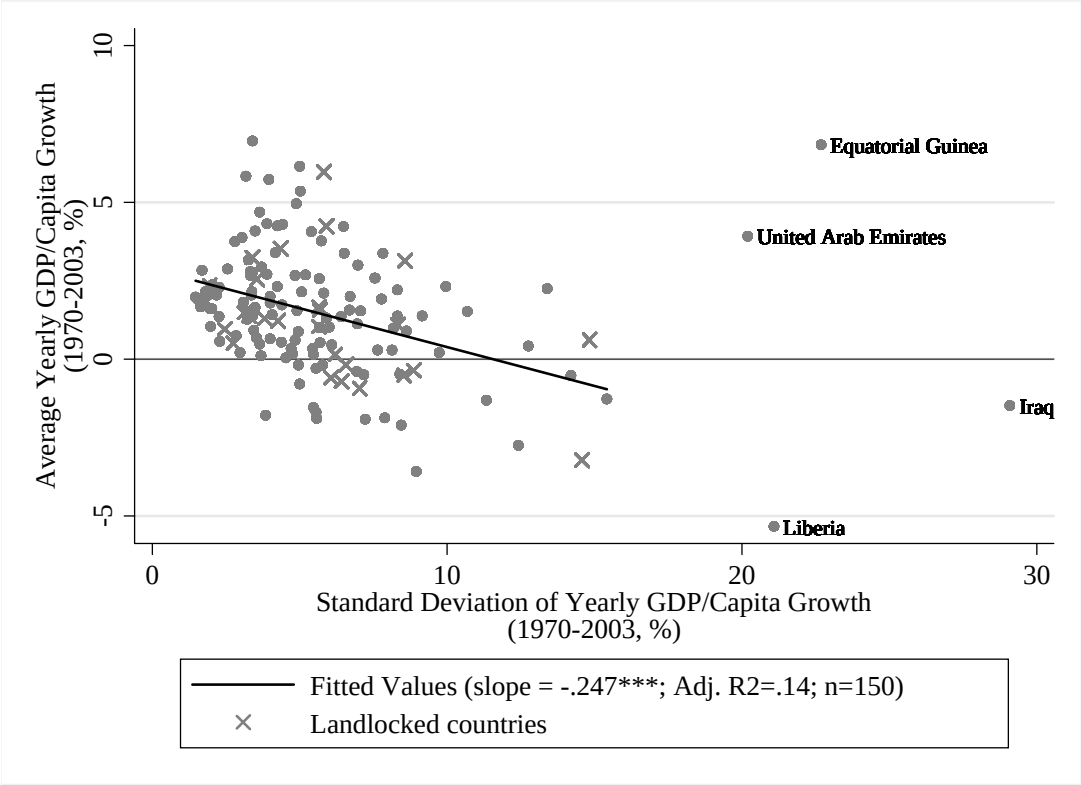
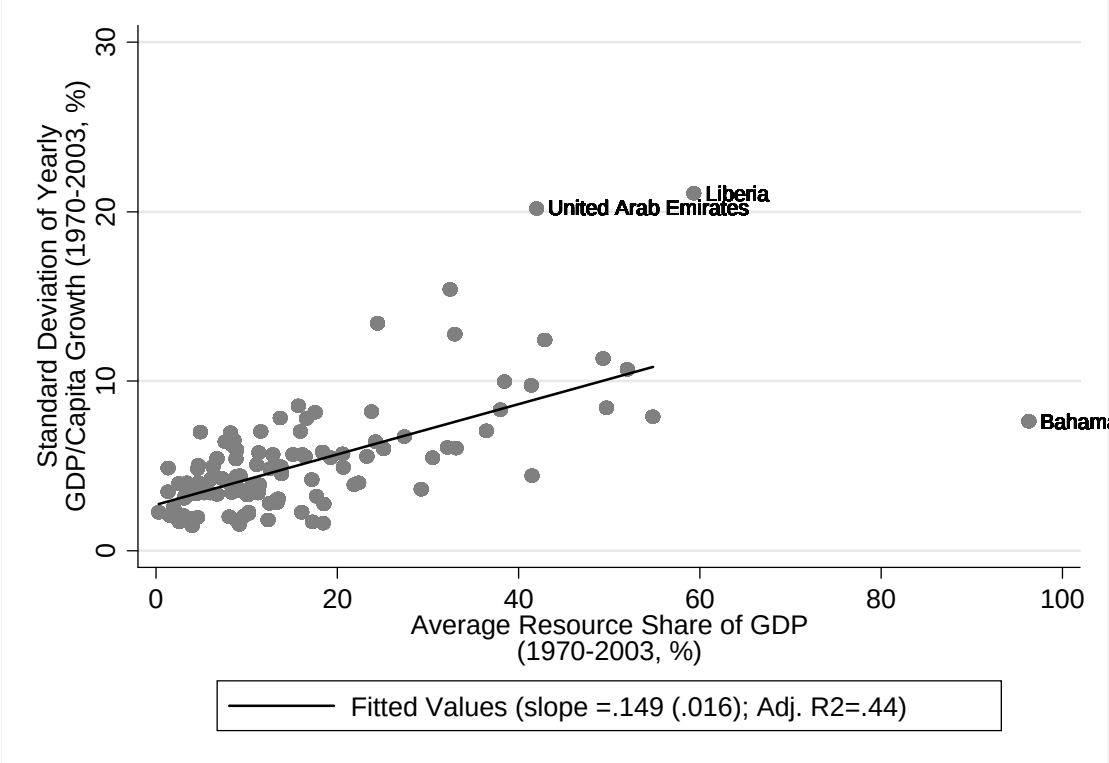
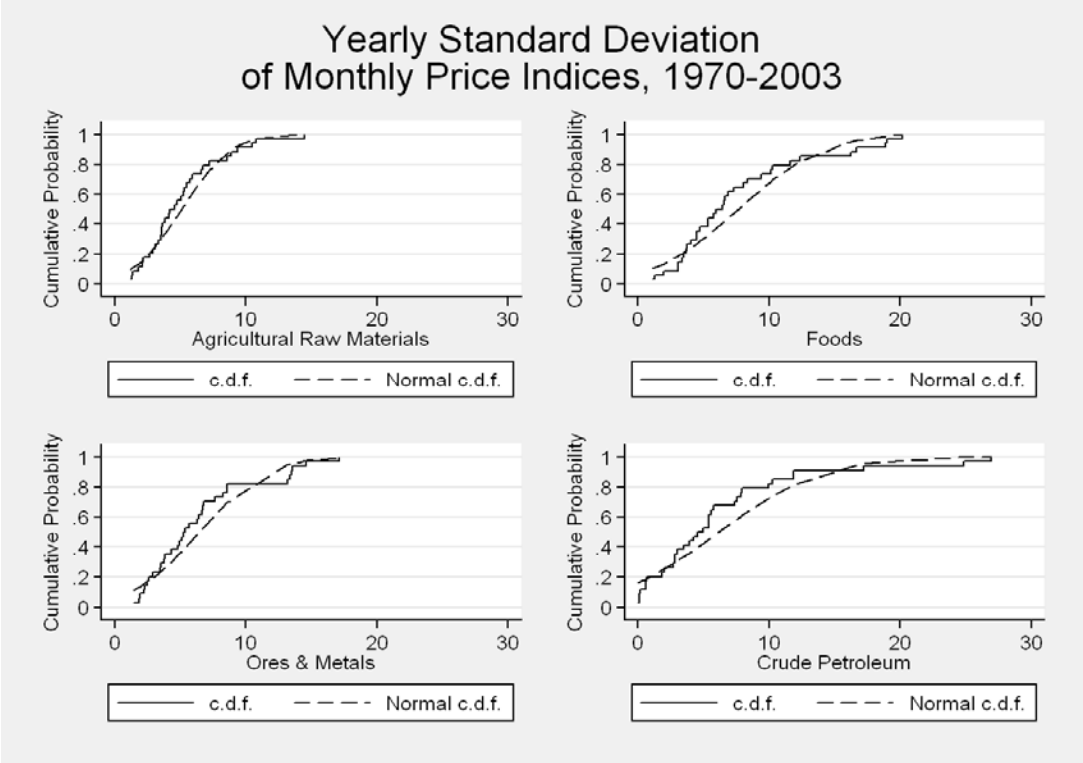


Figure 2: Resource-Rich Economies Are More Volatile



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

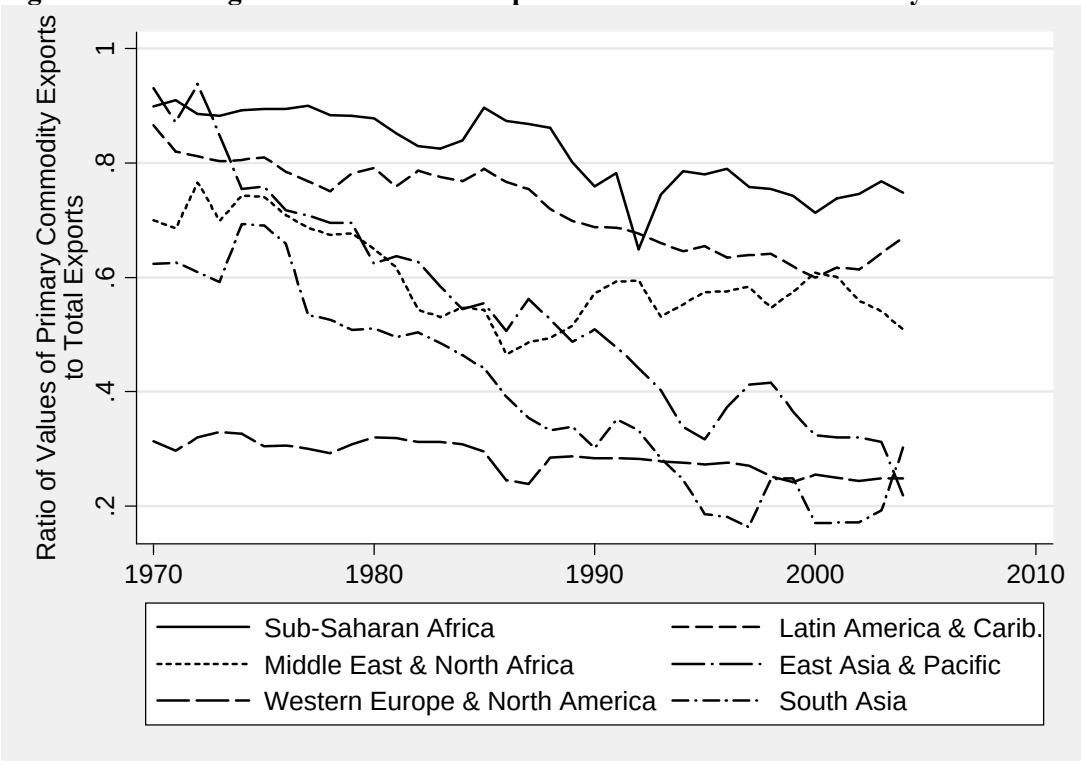
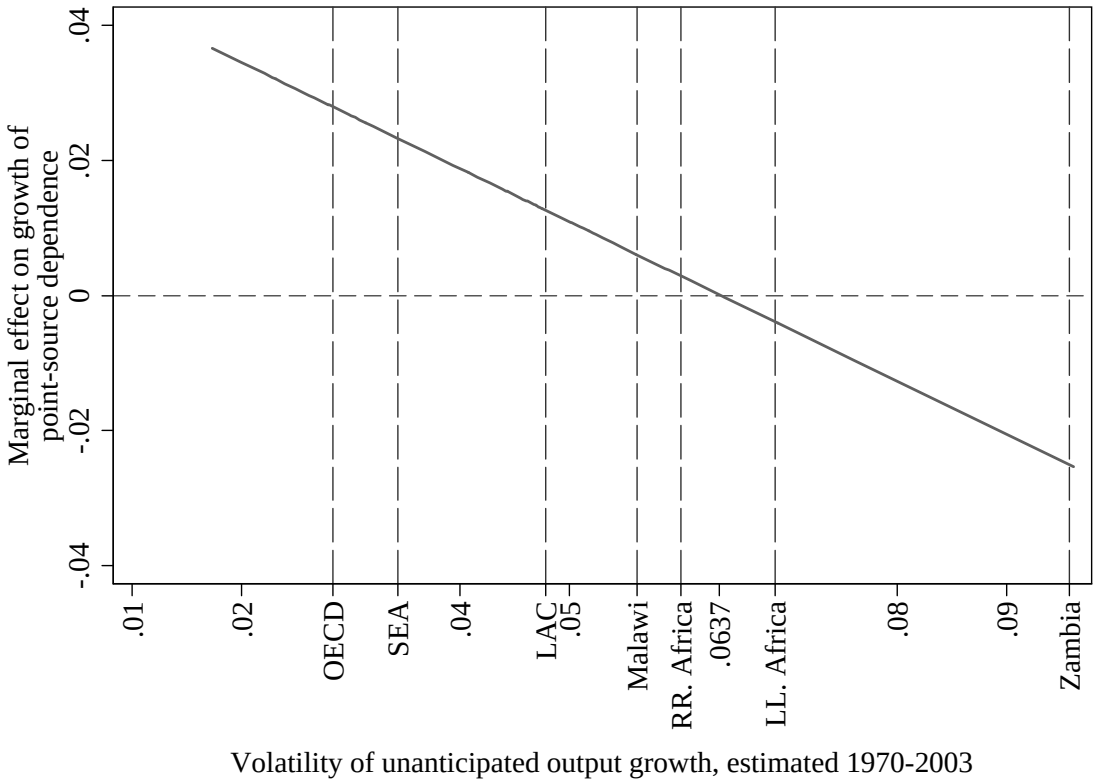


Figure 5: Marginal Effect of Point-Source Resource Dependence on Growth



Note: RR. Africa = resource-rich Africa; LL. Africa = Landlocked Africa; SEA = South-East Asia, corresponding to Table 7. Based on regression 6a of Table 4.