European University Institute

Department of Economics

EUI Working Papers

ECO 2007/36

Volatility, Financial Development and the Natural Resource Curse

Frederick van der Ploeg and Steven Poelhekke

EUROPEAN UNIVERSITY INSTITUTE
DEPARTMENT OF ECONOMICS

Volatility, Financial Development and the Natural Resource Curse

FREDERICK VAN DER PLOEG

and

STEVEN POELHEKKE

EUI Working Paper **ECO** 2007/36

ISSN 1725-6704

Printed in Italy
European University Institute
Badia Fiesolana
I – 50014 San Domenico di Fiesole (FI)
Italy

http://www.eui.eu/
http://cadmus.eui.eu/

VOLATILITY, FINANCIAL DEVELOPMENT AND THE NATURAL RESOURCE CURSE

Frederick van der Ploeg* and Steven Poelhekke** [§]

Abstract

Cross-country evidence is presented on resource dependence and the link between volatility and growth. First, growth depends negatively on volatility of unanticipated output growth independent of initial income per capita, the average investment share, initial human capital, trade openness, the national income share of natural resource exports and population growth. Second, the adverse effect of resources on growth operates primarily through higher volatility. The positive effect of resources on growth is *positive*, but can be 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 lead to higher volatility and lower growth, but capital account restrictions lower volatility and boost growth. These effects are especially strong in resource-rich countries. We also present IV-estimates to correct for the endogenous nature of investment rates and panel estimates to allow for possible changes in explanatory variables over time. Our key message is 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

September 2007

Address for correspondence:

European University Institute, Badia Fiesolana, Via dei Roccettini 9
I-50014 San Domenico di Fiesole (FI), Italy
rick.vanderploeg@eui.eu; steven.poelhekke@eui.eu

* European University Institute, Florence, Oxcarre, Oxford University, University of Amsterdam.
** European University Institute, Florence.
[§] We thank Rob Alessie and Anindya Banerjee for helpful discussions.

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 (Haussmann, 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 (2006) 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 on macroeconomic volatility. We allow natural resources, financial development, openness and distance from waterways to be the underlying determinants of volatility. They may be viewed as exogenous proxies for the volatility of the real exchange rate and thus of GDP growth. We also shed new light on the evidence for the resource curse given by Sachs and Warner (1997) and many others.[2] Our objective is to test whether any adverse *indirect* effect of natural resources on growth performance via volatility of unanticipated output growth dominates any adverse *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 on growth.

Our econometric tests on 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.
- Second, developing countries suffer much more from volatility in 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

[2] The windfall resource revenues lead to appreciation of the real exchange rate and a 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.

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 %-point. 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 raw agricultural product 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).

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 complimentary 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. Countries with a large dependence on natural resources and that are landlocked are typically not very diversified and vulnerable to highly 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 reasons for volatility to boost growth, the issue needs to be settled empirically. Section 3 discusses our econometric methodology for the cross-country and the panel estimates. Section 4 presents our cross-country estimates and section 5 our panel

estimates. Section 6 uses our preferred estimates to perform a counterfactual experiment comparing resource-rich and landlocked Africa with the Asian Tigers. Section 7 concludes.

2. Why Volatility of Natural Resource Revenues Might 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 holds, 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 $W_t = \phi A_t \mathrm{E}[P_t] = \phi A_t \mathrm{E}[S_t]$, 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 $\pi_t \equiv A_t S_t \sqrt{l_t} - \phi A_t \mathrm{E}[S_t] l_t$. 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 $\mathrm{F}(z)$, the probability of innovation is given by:

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

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:

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

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 E[F(c)] ≤ F(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 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

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

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 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. Estimation Methodology

3.1. Cross-country estimation

Consider 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:

$$\Delta \log(y_{it}) = \lambda \sigma_i + \mathbf{X}_{i70}\boldsymbol{\theta} + \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, \sigma_i^2), \quad i = 1,...,N, \quad t = 1,..,T, \tag{5}$$

where y_{it} is GDP per capita in country *i* for year *t*, σ_i is the standard deviation for country *i* of the residuals 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 residuals ε_{it} are the deviations of growth from the predicted values based on the controls. The variances of these residuals 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 magnitude of the economic impact, 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. 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 (5) 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, 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:

$$\Delta \log(y_{it}) = \lambda \sigma_i + \mathbf{X}_{i70}\boldsymbol{\theta} + \mathbf{Z}_{i70}\boldsymbol{\beta} + \varepsilon_{it}, \quad \sigma_i^2 = \exp(\mathbf{Z}_{i70}\boldsymbol{\gamma} + c) \quad \text{and} \tag{6}$$

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

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 across-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 ($\boldsymbol{\beta}$).

We estimate parameters $\{\lambda, \boldsymbol{\theta}, \boldsymbol{\gamma}, c \text{ and } \boldsymbol{\beta}\}$ of (6) by maximizing the likelihood function:

$$L = -\frac{NT}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}\log\left(\boldsymbol{\Sigma}_t\right) - \frac{1}{2}\sum_{t=1}^{T}\boldsymbol{\varepsilon}_t\boldsymbol{\Sigma}_t^{-1}\boldsymbol{\varepsilon}_t, \tag{7}$$

where the covariance matrix is defined by $\mathbf{\Sigma_{t,ii}} = \sigma_i^2 = \exp(\mathbf{Z}_{i70}\boldsymbol{\gamma} + c), i = 1,..,N, t = 1,..,T,$ and $\mathbf{\Sigma_{t,ij}} = 0, i \neq j, t = 1,..,N$ and $\boldsymbol{\varepsilon}_\mathbf{t} \equiv (\varepsilon_{1t},..,\varepsilon_{Nt})'$ 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 uncorrelated across countries.[4]

3.2. Panel estimation

Ramey and Ramey (1995) argue that government spending affects volatility of output across time and countries. They first estimate country-specific forecasting equations for growth in government spending that include a constant, two lags of the log of GDP per capita, two lags of the log of government spending per capita, a quadratic time trend, a post-1973 trend, and a dummy for the post-1973 period. They then use ML to estimate the following equations linking squared innovations to government spending and output-innovation volatility to growth:

(8) $\Delta\log(y_{it}) = \lambda\,\sigma_{it} + \boldsymbol{\theta}\,\mathbf{X_{it}} + \varepsilon_{it}, \quad \varepsilon_{it} \sim \mathrm{N}(0,\, \sigma_i^2), \;\; \sigma_{it} = \alpha_0 + \alpha_1\,\mu_{it}^2, \;\; i = 1,..,I, \;\; t = 1,..,T,$

where μ_{it}^2 is the square of the estimated residual for country i in year t from the forecasting equations for government spending. Regression (8) contains also time and country fixed effects. Government spending is effectively used to obtain a statistical estimate of volatility that varies both over time and across countries. The estimate for λ is similar for the sample of 92 countries (namely, – 0.178), but the estimate for the OECD sample is much higher (i.e., – 0.949). Countries with higher innovation variances thus have lower mean conditional growth rates.

In our empirical work, we allow natural resource dependence to be included in $\mathbf{Z_{it}}$ as an explanatory variable of economic growth and as a determinant of volatility. We thus estimate:

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

$\mathbf{Z_{it}}$ now includes time-varying data on financial development, resource dependence, etc, which also allows volatility to vary over time. The panel should give us a more efficient estimate and

[4] 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.

allows us to control for unobserved fixed effects. The initial year will no longer be 1970, but changes every five years. As various countries become open with time, this allows us to address the question whether countries as a consequence become less volatile. In contrast, the cross-section estimate address the related question whether countries which were open in 1970 were less volatile. Furthermore, we can factor out the effect of unobserved fixed effects on growth. To do this, we apply the within-transformation (subtracting the mean of each variable over time per country from itself) on all variables and re-estimate the panel with ML. Since the mean of a fixed effect is itself, the fixed effects cancel out. The coefficients can then be interpreted as the effect of a change in the variable relative to its country-mean over time.

4. Cross-Country Evidence

The stylized facts discussed in the introduction suggest that natural resources play a key role in understanding macroeconomic volatility and growth prospects. 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 adverse *negative indirect* effect of natural resources on growth performance via volatility of unanticipated output growth dominates any adverse *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. Explaining volatility by country and regional dummies

Table 2 provides cross-country empirical evidence on how much volatility of unanticipated output per capita growth depresses average annual growth in GDP per capita. The appendix gives the definition of all the variables and their source of origin. 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 growth performance. And, of course, the significant negative coefficient on

[5] In fact, if the explanatory variable is natural resource *abundance* (proxied by natural resource wealth) rather than natural resource *dependence*, there appears to be a positive effect on growth performance (e.g., Ding and Field, 2005; Alexeev and Conrad, 2005; Brunnschweiler and Bulte, 2007). 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.

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). Regression 1 is our benchmark regression, which 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). However, regression 2 indicates that there is some evidence for serial correlation in the errors. Regression 3 tests whether there is any evidence for a natural resource curse along the lines of Sachs and Warner (1995). We only find support for a negative coefficient for point-source natural resource dependence on economic growth.[6] In contrast to much of the existing empirical literature, financial development, openness to international trade[7] and various interactions terms are 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 block 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 a half percentage point higher. 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 as the share of point-source or diffuse natural resource exports in total exports is insignificant.[8] However, regression 5 does indicate that point-source natural resource rents (i.e., net of exploration costs)[9] 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 with openness and financial development at the 1%-level. This 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 block dummies leave out information that is in the country dummies. The resulting omitted variable bias is why the coefficient on volatility is bigger, since it forces countries within each region to have similar volatility.

---

[6] These include oil, gas, ores and minerals, which are typically produced in concentrated locations.
[7] We use the openness variable of Sachs and Warner (1997) as expanded by Wacziarg ad Welch (2003).
[8] Diffuse natural resources include agricultural raw materials and foods such as livestock, coffee, bananas or tobacco, which typically are produced throughout the country.
[9] 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.

4.2. Opening the black box: Underlying determinants of volatility and 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 and allows for an autoregressive error structure. 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 resources 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 and to a lesser extent 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 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 the standard deviation of unanticipated output growth impacts the mean equation while the variance equation explains the logarithm of the variance of unanticipated output growth.[10] 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*0.063/(1.581*1.247), resource dependence curbs growth and otherwise it boosts growth. 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. In later regressions we find a *negative* direct effect of resource dependence on growth, in which case the line in Figure 5 lies below the horizontal axis. The resource curse is then more severe for more volatile countries.

[10] 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.

4.3. Dealing with the endogenous nature of investment shares

Growing countries attract more investment, which may reverse the direction of causality. Even though we control for openness and financial development, we may 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 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).[11] 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.[12] 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. Among the least fractionalized 10 countries are Norway, Japan, Tunisia, and Greece. We also include two geographical variables: 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 moreover to conduct a Sargan over-identification test for exogeneity of the instruments.

Regressions 6b and 6c of Table 3 report the first and second stage of this IV regression and confirm the detrimental effect of volatility on growth. Although the positive effect of investment shares on growth are now bigger, the qualitative results are similar to the ML estimates presented in regression 6a. The first stage confirms that ethno-linguistic

[11] Montalvo and Reynal-Querol (2005a) 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.

[12] 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. We return to this issue in section 4.5.

fractionalization has a strong effect on the investment share. The degree to which a country is landlocked also affects the investment share, but only if we do not cluster standard errors by country (which allows for autocorrelation within countries). The F-test on the excluded instruments is much larger than 10, which means that our specification does not suffer from weak instrument bias (Stock and Yogo, 2002). This also greatly lowers any bias from a direct correlation with growth. The Sargan tests are also passed with confidence and imply that our instruments are exogenous. The first stage of the IV regressions show a significant positive correlation with natural resource dependence and the investment share. We cannot claim that this is causal, but it further explains the positive effect of resource dependence on growth after controlling for volatility.

4.4. Natural resource rents, volatility and growth

Our estimates 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. 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. Financial development and openness now have a negative direct effect on growth, but the interaction terms with natural resource rents are significant and positive. For the lowest degree of financial development, the net effect of the GDP share of resource rents on growth is negative (i.e., –0.143 for the IV estimates) for countries closed to international trade, but positive (i.e., +0.090) for countries open to international trade. If countries have higher degrees of financial development, the marginal effect of resource rents on growth may be positive even for closed economies.

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. In contrast, regression 7 shows a significant negative effect of openness and financial development on volatility of unanticipated output growth and thus a positive effect on growth. Regression 8 drops diffuse resources in the variance equation and obtains similar results as regression 7a. Figure 6 is based on regression 8 and shows that for already moderate degrees of financial development the marginal effect of the rent share on growth in the mean equation 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. Regression 6d in Table 4 adds an interaction term between financial development and point-source resource dependence. As expected, the volatility effect of natural resource dependence is less pronounced if a country is more financially developed, although this interaction term is not well determined.

Probing deeper into the determinants of volatility, we thus 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. Resource Share Volatility, Ethnic Tensions and Economic Restrictions

With regression 6a as the benchmark, the second half of Table 4 gives ML estimates of regressions with volatility of GDP shares of resource exports as an additional explanatory variable in the variance equation. 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 also significantly improves our estimate of the volatility of unanticipated growth. Furthermore, regression 9c shows that especially the volatility of food export share, the volatility of fuel export share and the volatility of ores & metals export share contribute to the volatility of unanticipated output growth. The volatility effect of natural resources is not limited to oil-producing countries, but also includes for example copper, coffee, banana and tobacco exporters. The qualitative results of the estimated mean equation are not much affected, except that the estimated negative effect of volatility on growth is almost three times smaller and quite close 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 *changes* in the resource share have on volatility. Consistent with the model of section 2, a stable share of resources in GDP does not increase volatility by itself, rather 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.

Table 5 presents some further 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. Regression 10a indicates indeed that ethnic polarization significantly improves the estimate of the volatility of unanticipated output growth, but regression 10b shows that this is no longer the case 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. This is not so surprising, since ethnic polarization may be an exogenous proxy for the somewhat endogenous volatilities of resource export and government spending shares.

Table 5 also tests for the impact of economic restrictions to examine whether financial liberalization boosts or depresses growth. Regression 11a indicates that capital account restrictions have a significant 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.[13] 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 surrender of export receipts are 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 indicates that, as before, the volatility of the GDP shares of point-source and diffuse natural resource exports and the volatility of the GDP share of government spending boost volatility of unanticipated output growth and thus depress growth in GDP per capita.

5. Panel Evidence

Table 6 reports our panel estimates of the effects of volatility, natural resource dependence, financial development and openness as well as investment rates, schooling, population growth and initial income per capita on growth in GDP per capita. Regressions 12 report the estimates where the independent variables are five-yearly means while regression 13 and 14 report results where independent variables are five-yearly initial values. The growth rate varies every year and the unanticipated yearly shocks to growth are used to calculate the volatility. All regressions

[13] 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.

indicate that investment rates have a significant positive effect on growth and that population growth and initial income per capita have a significant negative effect on growth in GDP per capita. Human capital only has a significant positive effect on growth in regressions 12a, 13a and 14a, which is not so surprising as human capital does not change much and its effects are picked up by the fixed effects in regressions 12b, 13b and 14b. Regressions 12a and 13a also show a significant negative effect of volatility of unanticipated output growth on growth performance, but the fixed effects regressions 12b and 13b do not. If volatility in a country has increased over time relative to the average volatility, this has not affected growth significantly. Apparently, there is not enough time variation in volatility to distinguish it from country fixed effects.[14] In the mean regressions openness and natural resources do not significantly impact growth. Since they do not change much, they may be picked up by the fixed effects. The variance equations of regressions 12a and 13a indicate that volatility increases with point-base resource dependence and to a lesser extent with diffuse resource dependence. Through this channel resource dependence has a negative impact on growth. We also confirm that a high degree of financial development, openness and distance to navigable coast or rivers lead to less volatility and thus to more growth.

Given increased globalization and financial integration, it is interesting to examine whether the adverse effect of volatility on growth has diminished in recent years (cf., Kose et al, 2006). Regressions 14a and b therefore repeat regression 13a and b for the years 1990-2003. We find a negative but less significant adverse effect of volatility on growth within this sub-sample. However, after controlling for fixed effects in regression 14b, we find that this effect turns positive, albeit that it is not very significant. We conclude that after 1990 the significant effect of volatility on growth has disappeared. Despite the short time span, we find the usual effects of resource dependence and financial development.

6. 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 3. It is insightful to compare the African countries with the Asian Tigers, since they have similar starting positions. 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 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

[14] However, using a rolling windows methodology, there is some evidence that the effect of volatility of annual output growth on growth in GDP per capita varies over time (Edwards, 2007).

grow faster and catch up. We see from the top panel of Table 7 that this growth differential amounts to 1.12%-point per year. Allowing for the positive *direct* growth effects of higher natural resource dependence in Africa, we see that the growth differential with the Tigers becomes 1.67%-point. Now if those African countries would invest as much in physical and human capital as the Asian Tigers, they would add a further 0.59%- and 0.58%-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 0.56%-point annual growth. These three factors combined yield an extra bonus to potential growth of 1.73%-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 3.23%-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 (0.48%-point), their lack of openness (1.70%-point), their badly developed financial markets (0.58%-point) and their distance from navigable waterways (1.09%-point). Annual growth could thus in total be raised by as much as 4.96%-point. The growth differential with the Tigers could thus have been boosted from 1.67%- to 6.63%-points per year, which is a huge amount.

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 1.82%-point faster than the Tigers. Accounting for landlocked Africa being more dependent on resources than the Tigers, would raise this growth differential to 2.24%-point. Now bringing mainly investment in physical and human capital but also population growth in line with the Tigers would add an extra 1.94%-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 4.30%-point per annum. The potential growth bonus is thus 6.24%-point. If this were feasible, landlocked Africa's growth differential with the Tigers could have been boosted from 2.24%- to 8.48%-points per annum. The countries Malawi and Zambia are resource rich *and* landlocked. They also have relatively high volatility and poorly developed financial systems. Not surprisingly, they can boost their annual growth differential with the Tigers from, respectively, 3.12%- and 4.46%-points to 7.94%- and 12.88%-points.

We conclude that the 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.

7. 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 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. Future research should focus on 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 of International 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.

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 (2007). The natural resource curse revised and revisited: A tale of paradoxes and red herrings, Journal of Environmental Economics and Management, to appear.

Cashin, P., L. 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.

Cermeño, R. and K. Grier, (2005), "Conditional Heteroskedasticity and Cross-Sectional Dependence in Panel Data: An Empirical Study of Inflation Uncertainty in the G7 countries." In: *Contributions in Economic Analysis*, Badi H. Baltagi, Ed., North-Holland.

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.

Engle, R.F., D.M. Lilien and R.P. Robins (1987). Estimating time varying risk premia in the term structure: the Arch-M Model", Econometrica, 55, 391-407.

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.

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.

Haussmann, 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, mimeo., HEC Lausanne.

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.

Malik, A. and J. Temple (2006). The geography of output volatility, Discussion Paper No. 5516, CEPR, London.

Mansoorian (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.

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.

Newbery, D. and J. Stiglitz (198?). Theory of Commodity Price Stabilization, Oxford University Press, Oxford.

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

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, Discussion Paper no. 6301, CEPR, London.

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 1997). Natural resource abundance and economic growth, in G. Meier and J. Rauch (eds.), Leading Issues in Economic Development, Oxford University Press, Oxford.

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. Welsch (2003). Trade liberalization and growth: new evidence, Working Paper No. 10152, NBER, Cambridge, MA.

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.

Data Appendix

VARIABLE NAME	DEFINITION	SOURCE
GDP/capita growth rate	Ln difference in real GDP per capita, Laspeyres	PWT 6.2 from Heston et al (2006)
Average 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 total population	Barro & Lee (2000)
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)
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
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	yes = 1	IMF (2006)
Current Account Restrictions	yes = 1	IMF (2006)
Capital Account Restrictions	yes = 1	IMF (2006)
Surrender of Export receipts	yes = 1	IMF (2006)

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.

Table 2: Natural Resource Curse and Regional Volatility

Dependent Variable	yearly GDP growth 1970-2003	yearly GDP growth 1970-2003	yearly GDP growth 1970-2003	yearly GDP growth 1970-2003	yearly GDP growth 1970-2003
(constant 2000 international dollars, PWT 6.2)	(1)	(2)	(3)	(4)	(5)
Mean equation	**Resource Export Revenues**				**Resource Rents**
Average investment share of GDP 1970-2003	0.108***	0.109***	0.088***	0.074***	0.105***
	(0.012)	(0.017)	(0.023)	(0.026)	(0.023)
Average population growth rate 1970-2003	-0.472***	-0.464***	-0.571**	-0.625***	-0.794***
	(0.118)	(0.157)	(0.222)	(0.196)	(0.212)
log per capita GDP 1970	-0.012***	-0.012***	-0.015***	-0.016***	-0.013***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.002)
Human capital 1970	0.001*	0.001	0.001*	0.001*	-0.000
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Volatility (σ_i)	**-0.110****	**-0.112***	**-0.171***	**-0.319****	**-0.312****
	(0.049)	**(0.066)**	**(0.099)**	**(0.133)**	**(0.133)**
Point-source resources 1970			-0.090**	-0.039	
			(0.040)	(0.038)	
Point-source rent share 1970					-0.236***
					(0.082)
Diffuse resources 1970			0.001	0.014	0.044**
			(0.023)	(0.023)	(0.017)
Financial development 1970			-0.003	-0.000	-0.008
			(0.006)	(0.005)	(0.006)
Sachs Warner updated openness dummy 70			0.001	0.002	0.002
			(0.005)	(0.005)	(0.003)
Point based resources * openness 70			0.020	0.030	
			(0.090)	(0.065)	
Point-source rent share * openness 70					0.207***
					(0.064)
Point-source resources * Fin. Dev. 70			0.335	0.194	
			(0.219)	(0.186)	
Point-source rent share * Fin. Dev. 70					0.886***
					(0.316)
Constant	0.110***	0.111***	0.136***	0.153***	0.134***
	(0.011)	(0.015)	(0.022)	(0.021)	(0.017)
1st Lag Error (ε)		0.272***	0.273***	0.248***	0.220***
		(0.017)	(0.021)	(0.018)	(0.018)
2nd Lag Error (ε)		0.030*	0.002	-0.010	-0.006
		(0.018)	(0.023)	(0.020)	(0.020)
Variance equation					
Sub-Saharan Africa				2.579***	2.648***
				(0.154)	(0.156)
Middle-East & North Africa				1.726***	1.701***
				(0.161)	(0.164)
Latin America & Caribbean				1.596***	1.571***
				(0.154)	(0.155)
Eastern Europe & Centra Asia				1.429***	1.372***
				(0.272)	(0.271)
East Asia & Pacific				1.024***	0.865***
				(0.160)	(0.160)
South Asia				0.439**	0.359*
				(0.195)	(0.197)
Western Europe				0.212	0.279*
				(0.155)	(0.154)
North America				Reference region (least volatile)	
Constant	-3.823***	-3.961***	-6.629***	-7.803***	-7.763***
	(0.118)	(0.119)	(0.192)	(0.150)	(0.150)
Country dummies in variance eq.	yes	yes	yes	no	no
Observations	3448	3448	2186	2186	2014
Log likelihood	5898.5	6020.2	4227.3	4017.6	3758.2

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

Table 3: Underlying Determinants of Volatility and the Natural Resource Curse

Dependent Variable	yearly GDP growth 1970-2003	*Average investment share GDP 1970-2003*	yearly GDP growth 1970-2003	yearly GDP growth 1970-2003	*Average investment share GDP 1970-2003*	yearly GDP growth 1970-2003	yearly GDP growth 1970-2003
(constant 2000 international dollars, PWT 6.2)	(6a) Arch	(6b)† 1st stage	(6c) IV-Arch	(7a) Arch	(7b)† 1st stage	(7c) IV-Arch	(8) Arch
Mean equation	**Resource Export Revenues**			**Resource Rents**			
Average investment share of GDP '70-'03	0.063**		0.149**	0.118***		*0.172***	0.123***
	(0.026)		(0.066)	(0.026)		*(0.075)*	(0.022)
Average population growth rate 1970-2003	-0.634***	0.213	-0.609***	-0.887***	*-0.299*	-0.785***	-0.784***
	(0.144)	(0.835)	(0.145)	(0.147)	*(0.965)*	(0.172)	(0.141)
log per capita GDP 1970	-0.018***	-0.027**	-0.017***	-0.015***	*-0.022*	-0.016***	-0.013***
	(0.003)	(0.012)	(0.003)	(0.003)	*(0.015)*	(0.003)	(0.002)
Human capital 1970	0.002***	0.013***	0.001	0.000	*0.012***	0.000	0.000
	(0.001)	(0.003)	(0.001)	(0.001)	*(0.004)*	(0.001)	(0.001)
Volatility (σ_i)	**-1.247*****		**-1.170*****	**-1.078*****		**-1.328*****	**-0.351***
	(0.360)		**(0.367)**	**(0.399)**		**(0.425)**	**(0.184)**
Point-source resources 1970	0.063**	0.242***	0.042				
	(0.025)	(0.039)	(0.029)				
Point-source rent share 1970				-0.223**	*0.531***	-0.143	-0.233**
				(0.108)	*(0.233)*	(0.107)	(0.108)
Financial development 1970	-0.023***	0.067*	-0.027***	-0.033***	*0.066**	-0.038***	-0.022***
	(0.007)	(0.037)	(0.008)	(0.008)	*(0.035)*	(0.009)	(0.005)
Sachs Warner updated openness dummy 70	-0.009	0.059***	-0.013**	-0.011*	*0.052***	-0.018**	0.000
	(0.006)	(0.018)	(0.007)	(0.007)	*(0.022)*	(0.008)	(0.003)
Point-source rent share * openness 70				0.243***	*-0.028*	0.233***	0.286***
				(0.081)	*(0.063)*	(0.084)	(0.106)
Point-source rent share * Fin. Dev. 70				1.154***	*-0.234*	0.683**	1.024***
				(0.309)	*(1.708)*	(0.282)	(0.319)
Constant	0.219***	0.322***	0.197***	0.192***	*0.293***	0.205***	0.135***
	(0.035)	(0.090)	(0.041)	(0.036)	*(0.116)*	(0.042)	(0.025)
1st Lag Error (ε)	0.224***		0.224***	0.211***		0.219***	0.186***
	(0.017)		(0.017)	(0.018)		(0.017)	(0.014)
2nd Lag Error (ε)	-0.002		-0.004	0.001			
	(0.019)		(0.019)	(0.019)			
Landlocked dummy		-0.013			*-0.008*		
		(0.013)			*(0.012)*		
% Population in Temperate Climate Zone		0.002			*0.004*		
		(0.026)			*(0.032)*		
Ethnic Fractionalization Index		-0.074***			*-0.061**		
		(0.026)			*(0.035)*		
Variance equation							
Point based resources 1970	1.581***		1.617***				
	(0.205)		(0.206)				
Point based rent share 1970				2.325***		2.435***	8.096***
				(0.651)		(0.635)	(0.247)
Diffuse resources 1970	0.765**		0.964***	0.165		0.290	
	(0.368)		(0.372)	(0.372)		(0.364)	
Financial development 1970	-1.290***		-1.302***	-1.405***		-1.410***	-1.663***
	(0.092)		(0.099)	(0.097)		(0.098)	(0.083)
Sachs Warner updated openness dummy 70	-0.689***		-0.676***	-0.711***		-0.715***	-0.475***
	(0.048)		(0.049)	(0.048)		(0.048)	(0.043)
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)
Constant	-6.097***		-6.115***	-5.980***		-5.969***	-6.171***
	(0.066)		(0.067)	(0.069)		(0.067)	(0.036)
Cragg-Donald F-stat. on excl. instruments		*134.3*			*71.4*		
Hansen overidentification J-statistic (p-value)		*0.152*			*0.376*		
Country dummies in variance eq.	no		no	no		no	no
Observations	2084	2084	2084	1980	*1980*	1980	2311
R2		0.72			*0.67*		
Log likelihood	3729.1		3728.9	3580.6		3572.8	3970.1

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

† Robust and clustered standard errors by country. Landlocked is also significant if standard errors are not clustered.

Table 4: Effects of GDP Shares of Natural Resources on Volatility and Growth

Dependent Variable	yearly GDP growth 1970-2003		yearly GDP growth 1970-2003			
(constant 2000 international dollars, PWT 6.2)	(6a)	(6d)	(9a)	(9b)	(9c)	(9d)
Mean equation						
Average investment share of GDP '70-'03	0.063**	0.062**	0.086***	0.089***	0.086***	0.088***
	(0.026)	(0.026)	(0.025)	(0.025)	(0.025)	(0.025)
Average population growth rate 1970-2003	-0.634***	-0.633***	-0.622***	-0.459**	-0.451**	-0.472***
	(0.144)	(0.143)	(0.146)	(0.178)	(0.179)	(0.171)
log per capita GDP 1970	-0.018***	-0.018***	-0.015***	-0.014***	-0.014***	-0.014***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Human capital 1970	0.002***	0.002***	0.002**	0.001	0.001	0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Volatility (σ_i)	**-1.247*** **	**-1.290*** **	**-0.565** **	**-0.457** **	**-0.443** **	**-0.541*** **
	(0.360)	**(0.366)**	**(0.233)**	**(0.186)**	**(0.183)**	**(0.187)**
Point based resources 1970	0.063**	0.066***	0.018	0.009	0.007	0.022
	(0.025)	(0.024)	(0.026)	(0.022)	(0.023)	(0.022)
Financial development 1970	-0.023***	-0.023***	-0.013**	-0.011**	-0.011**	-0.011**
	(0.007)	(0.007)	(0.006)	(0.005)	(0.005)	(0.005)
Sachs Warner updated openness dummy 70	-0.009	-0.009	0.000	0.003	0.004	0.002
	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)
Constant	0.219***	0.223***	0.159***	0.139***	0.138***	0.148***
	(0.035)	(0.035)	(0.026)	(0.022)	(0.023)	(0.022)
1st Lag Error (ε)	0.224***	0.223***	0.238***	0.241***	0.241***	0.236***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
2nd Lag Error (ε)	-0.002	-0.003	-0.005	-0.021	-0.021	-0.021
	(0.019)	(0.019)	(0.020)	(0.021)	(0.021)	(0.021)
Variance equation						
Initial point based resources 1970	1.581***	1.986***	-0.499*	-0.796***	-0.569*	-0.647**
	(0.205)	(0.703)	(0.287)	(0.281)	(0.319)	(0.295)
Initial diffuse resources 1970	0.765**	0.774**	-1.023*	-0.261	-1.220**	0.025
	(0.368)	(0.368)	(0.548)	(0.554)	(0.583)	(0.555)
Initial financial development 1970	-1.290***	-1.270***	-1.059***	-0.860***	-0.843***	-0.758***
	(0.092)	(0.098)	(0.099)	(0.106)	(0.107)	(0.114)
Sachs Warner updated openness dummy 1970	-0.689***	-0.695***	-0.461***	-0.527***	-0.476***	-0.537***
	(0.048)	(0.048)	(0.054)	(0.055)	(0.064)	(0.055)
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)
Financial development * point based share		-2.215				
		(3.387)				
Point based export share volatility 70-03			9.349***	9.572***		15.601***
			(0.492)	(0.460)		(1.646)
Diffuse export share volatility 70-03			11.451***	4.433*		2.463
			(2.235)	(2.438)		(2.450)
Government share volatility 70-03				10.830***	10.669***	10.136***
				(1.095)	(1.220)	(1.062)
Agricultural R.M. resource share volatility 70-03					0.799	
					(2.128)	
Foods resource share volatility 70-03					11.650***	
					(3.466)	
Ores & metals resource share volatility 70-03					6.695***	
					(2.240)	
Fuels resource share volatility 70-03					9.555***	
					(0.474)	
Financial development * point based volatility						-32.786***
						(8.938)
Constant	-6.097***	-6.093***	-6.521***	-6.763***	-6.839***	-6.725***
	(0.066)	(0.066)	(0.076)	(0.080)	(0.085)	(0.080)
Observations	2084	2084	2084	2084	2084	2084
Log likelihood	3729.1	3729.3	3789.5	3812.6	3813.5	3816.8

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

Table 5: Ethnic Tensions, Economic Restrictions and the Resource Curse

Ethnic tensions	(10a)	(10b)	**Economic Restrictions**	(11a)	(11b)
Mean equation			**Mean equation**		
Average investment share of GDP 70-03	0.070**	0.088***	Average investment share of GDP 70-03	0.106***	0.114***
	(0.029)	(0.027)		(0.026)	(0.024)
Average population growth rate 1970-2003	-0.633***	-0.445**	Average population growth rate 1970-2003	-0.719***	-0.671***
	(0.212)	(0.215)		(0.192)	(0.226)
log per capita GDP 1970	-0.018***	-0.014***	log per capita GDP 1970	-0.015***	-0.014***
	(0.003)	(0.003)		(0.003)	(0.003)
Human capital 1970	0.002**	0.001	Human capital 1970	0.002**	0.001
	(0.001)	(0.001)		(0.001)	(0.001)
Volatility (σ_i)	**-0.806*** **	**-0.382***	**Volatility (σ_i)**	**-0.514*** **	**-0.294**†
	(0.305)	**(0.204)**		**(0.184)**	**(0.180)**
Initial point-source resources 70	-0.060	-0.072	Initial point-source resources 70	0.071**	0.035
	(0.055)	(0.058)		(0.031)	(0.029)
Financial development 1970	-0.023	-0.011	Initial diffuse resources 70	0.010	0.003
	(0.032)	(0.028)		(0.030)	(0.027)
Sachs Warner updated openness dummy 70	-0.015**	-0.008	Financial development 1970	-0.014**	-0.008
	(0.007)	(0.005)		(0.006)	(0.006)
Initial point-source resources * openness 70	-0.007	-0.001	*Current Account Restrictions (yes=1)*	0.005	0.004
	(0.006)	(0.005)		(0.003)	(0.003)
Initial point-source resources * Fin. Dev. 70	0.125	0.139	*Capital Account restrictions (yes=1)*	-0.008**	-0.006*
	(0.098)	(0.087)		(0.004)	(0.004)
Ethnic Polarization	0.355	0.334	Constant	0.156***	0.134***
	(0.251)	(0.249)		(0.028)	(0.027)
Constant	0.193***	0.143***	1st Lag Error (ε)	0.228***	0.225***
	(0.034)	(0.026)		(0.019)	(0.018)
1st Lag Error (ε)	0.220***	0.236***	2nd Lag Error (ε)	-0.009	
	(0.017)	(0.017)		(0.020)	
2nd Lag Error (ε)	-0.007	-0.025	**Variance equation**		
	(0.020)	(0.021)	Initial point based resources 70	5.656***	0.751*
				(0.341)	(0.385)
			Initial diffuse resources 70	1.929***	-0.869
Variance equation				(0.498)	(0.644)
Initial point based resources 70	-5.749***	-0.990***	Initial financial development 1970	-1.725***	-0.948***
	(1.540)	(0.297)		(0.140)	(0.173)
Initial diffuse resources 70	0.791*	-0.338	Distance to nearest navigable river or coast	0.001***	0.000***
	(0.425)	(0.590)		(0.000)	(0.000)
Initial financial development 1970	-1.128***	-0.832***	Ethnic Polarization		0.416***
	(0.111)	(0.114)			(0.124)
Sachs Warner updated openness dummy 70	-0.623***	-0.520***	*Multiple Exchange Practices (yes=1)*	-0.730***	-0.378***
	(0.053)	(0.061)		(0.060)	(0.065)
Distance to nearest navigable river or coast	0.001***	0.001***	*Current Account Restrictions (yes=1)*	0.449***	0.428***
	(0.000)	(0.000)		(0.070)	(0.069)
Ethnic Polarization	0.386***	0.128	*Capital Account restrictions (yes=1)*	-0.479***	-0.560***
	(0.080)	(0.086)		(0.130)	(0.110)
Point-source resources 70 * Eth. Pol.	9.572***		*Surrender of Export receipts (yes=1)*	0.359***	0.511***
	(2.051)			(0.116)	(0.105)
Point-source export share volatility 70-03		9.660***	*Cur. Acc. Restrictions * Point Resources 70*	4.642***	
		(0.487)		(0.939)	
Diffuse export share volatility 70-03		4.648*	*Cap. Acc. Restrictions * Point Resources 70*	-1.995***	
		(2.500)		(0.462)	
Government share volatility 70-03		10.430***	Point-source export share volatility 70-03		9.499***
		(1.200)			(0.536)
Constant	-6.393***	-6.820***	Diffuse export share volatility 70-03		13.171***
	(0.082)	(0.086)			(2.862)
			Government share volatility 70-03		6.670***
					(1.304)
			Constant	-6.557***	-7.327***
				(0.113)	(0.139)
Observations	2084	2084	Observations	2015	2015
Log likelihood	3749.5	3817.3	Log likelihood	3603.9	3679.6

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

† P-value = 0.102

Table 6: Panel-ARCH Estimates of Volatility and the Natural Resource Curse

Dependent Variable	yearly GDP growth 1970-2003				yearly GDP growth **1990-2003**	
(constant 2000 international dollars, PWT 6.2)	(12a)	(12b) Within	(13a)	(13b) Within	(14a)	(14b) Within
	independent variables are 5-yearly means		independent variables are 5-yearly initial values		independent variables are 5-yearly initial values	
Mean equation						
Investment share of GDP	0.103***	0.113***	0.099***	0.114***	0.070***	0.153***
	(0.016)	(0.023)	(0.016)	(0.022)	(0.021)	(0.047)
Population growth rate	-0.562***	-0.352**	-0.733***	-0.317*	-0.498**	-0.755**
	(0.124)	(0.167)	(0.124)	(0.189)	(0.211)	(0.318)
log per capita GDP	-0.014***	-0.017***	-0.019***	-0.038***	-0.012***	-0.108***
	(0.002)	(0.005)	(0.002)	(0.004)	(0.004)	(0.011)
Human capital	0.001**	-0.000	0.002***	0.001	0.002*	0.000
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.004)
Volatility (σ_{it})	**-0.779****	**-0.072**	**-1.162****	**-0.051**	**-1.294**	**0.235**
	(0.365)	**(0.365)**	**(0.494)**	**(0.389)**	**(0.877)**	**(0.575)**
Point-source resource share	0.057	-0.040	0.090	-0.039*	0.097	0.121
	(0.058)	(0.027)	(0.068)	(0.023)	(0.120)	(0.088)
Diffuse resource share	0.042	0.017	0.055*	-0.044	0.042	-0.027
	(0.028)	(0.040)	(0.030)	(0.032)	(0.059)	(0.058)
Financial development	-0.011**	-0.005	-0.012**	-0.004	-0.018**	0.001
	(0.005)	(0.009)	(0.006)	(0.009)	(0.009)	(0.010)
Sachs Warner updated openness dummy	-0.003	0.011*	-0.008	0.006	-0.016	0.004
	(0.006)	(0.006)	(0.007)	(0.005)	(0.011)	(0.006)
Point-source resources*Financial development.	0.031	-0.033	0.031	0.003	0.070	-0.040
	(0.080)	(0.049)	(0.081)	(0.041)	(0.115)	(0.105)
Constant	0.163***	0.010	0.223***	0.002	0.158***	-0.027
	(0.029)	(0.020)	(0.032)	(0.021)	(0.047)	(0.026)
1st Lag Error (ε)	0.227***	0.147***	0.238***	0.161***	0.260***	-0.185***
	(0.016)	(0.015)	(0.017)	(0.016)	(0.027)	(0.032)
2nd Lag Error (ε)	0.076***	0.017	0.055***	-0.001	0.034	0.012
	(0.017)	(0.018)	(0.019)	(0.020)	(0.031)	(0.024)
Variance equation						
Point-source resource share	4.005***	0.223	3.716***	-0.159	4.278***	-2.846***
	(0.185)	(0.213)	(0.169)	(0.176)	(0.229)	(0.979)
Diffuse resource share	2.642***	-2.301***	2.266***	-1.532**	3.071***	-3.278*
	(0.361)	(0.700)	(0.385)	(0.676)	(0.684)	(1.725)
Financial development	-0.862***	-1.519***	-0.895***	-1.485***	-0.876***	-1.271***
	(0.064)	(0.039)	(0.065)	(0.041)	(0.080)	(0.056)
Sachs Warner updated openness dummy	-0.647***	-0.347***	-0.611***	-0.250***	-0.609***	0.148
	(0.048)	(0.057)	(0.053)	(0.055)	(0.090)	(0.161)
Distance to nearest navigable river or coast	0.000***	-	0.000***	-	-0.000	
	(0.000)		(0.000)		(0.000)	
Constant	-6.258***	-5.701***	-6.235***	-5.763***	-6.246***	-6.075***
	(0.061)	(0.023)	(0.066)	(0.024)	(0.109)	(0.032)
Observations	2585	2715	2346	2476	1005	1075
Log likelihood	4712.3	4826.1	4357.4	4503.7	1991.0	2137.1

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 Mean equations contain year dummies. Variables in columns 2, 4 and 6 are demeaned by country. Distance to nearest navigable river or coast is an observed fixed effect.

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							
Average investment share of GDP 1970-2003	0.063 **	17.26%	24.45%	14.96%	-9.50%		0.59%
Average population growth rate 1970-2003	-0.634 ***	1.72%	1.86%	2.75%	0.89%		0.56%
Initial log per capita GDP 1970	-0.018 ***	8.362	7.747	7.129	-0.619		-1.12%
Initial human capital 1970	0.002 ***	4.140	4.049	1.476	-2.574		0.58%
Volatility (σ_i)	-1.247 ***	4.04%	3.43%	6.02%	2.59%		3.23%
Initial point-source resources 1970	0.063 **	4.35%	4.32%	13.13%	8.80%		-0.55%
Initial financial development 1970	-0.023 ***	29.07%	26.89%	14.43%	-12.47%		-0.29%
Variance equation							
Initial point-source resources 1970	1.581 ***	4.35%	4.32%	13.13%	8.80%	-0.40%	0.50%
Initial diffuse resources 1970	0.765 **	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	-0.689 ***	0.374	0.746	0	-0.746	-1.37%	1.70%
Distance to nearest navigable river or coast	0.001 ***	277.763	90.902	552.571	461.669	-0.87%	1.09%
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							
Average investment share of GDP 1970-2003	0.063 **	17.26%	24.45%	12.13%	-12.32%		0.77%
Average population growth rate 1970-2003	-0.634 ***	1.72%	1.86%	2.57%	0.71%		0.45%
Initial log per capita GDP 1970	-0.018 ***	8.362	7.747	6.744	-1.004		-1.82%
Initial human capital 1970	0.002 ***	4.140	4.049	0.874	-3.176		0.72%
Volatility (σ_i)	-1.247 ***	4.04%	3.43%	6.88%	3.45%		4.30%
Initial point-source resources 1970	0.063 **	4.35%	4.32%	10.97%	6.65%		-0.42%
Initial financial development 1970	-0.023 ***	29.07%	26.89%	12.05%	-14.84%		-0.34%
Variance equation							
Initial point-source resources 1970	1.581 ***	4.35%	4.32%	10.97%	6.65%	-0.35%	0.44%
Initial diffuse resources 1970	0.765 **	7.27%	11.08%	7.99%	-3.09%	0.08%	-0.10%
Initial financial development 1970	-1.290 ***	29.07%	26.89%	12.05%	-14.84%	-0.63%	0.78%
Sachs Warner updated openness dummy 70	-0.689 ***	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	-1.79%	2.24%
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: Volatile Countries Have Lower Annual Growth in GDP per Capita

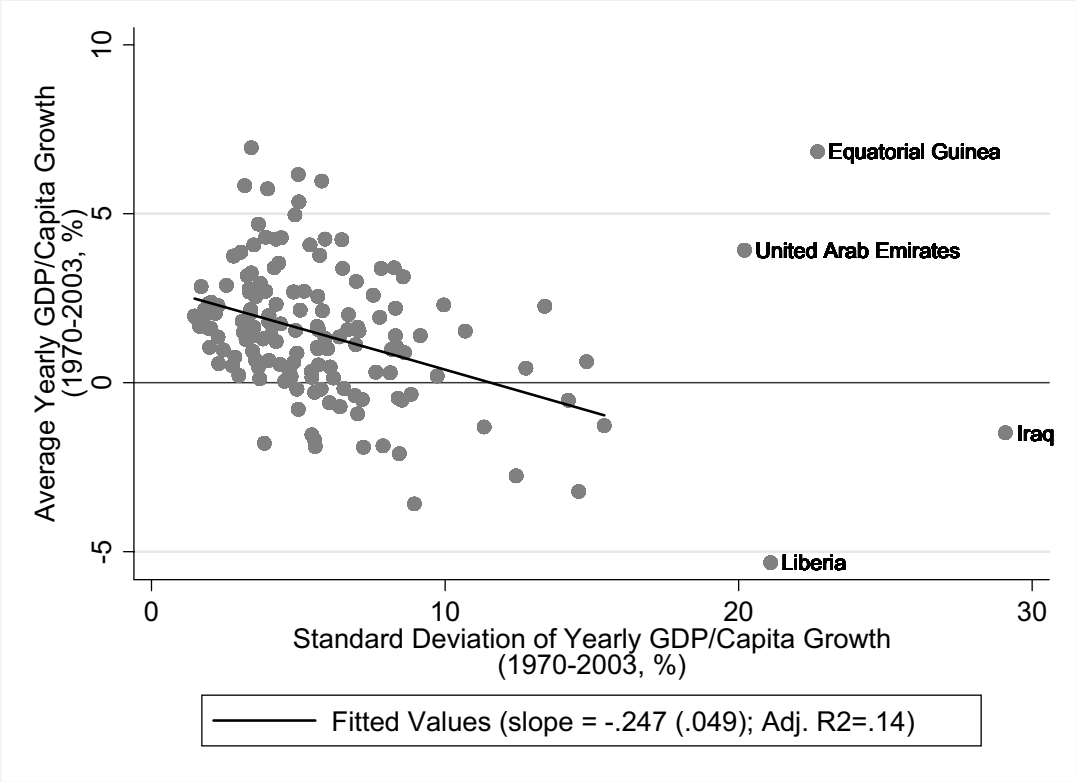


Figure 2: Resource-Rich Economies Are More Volatile

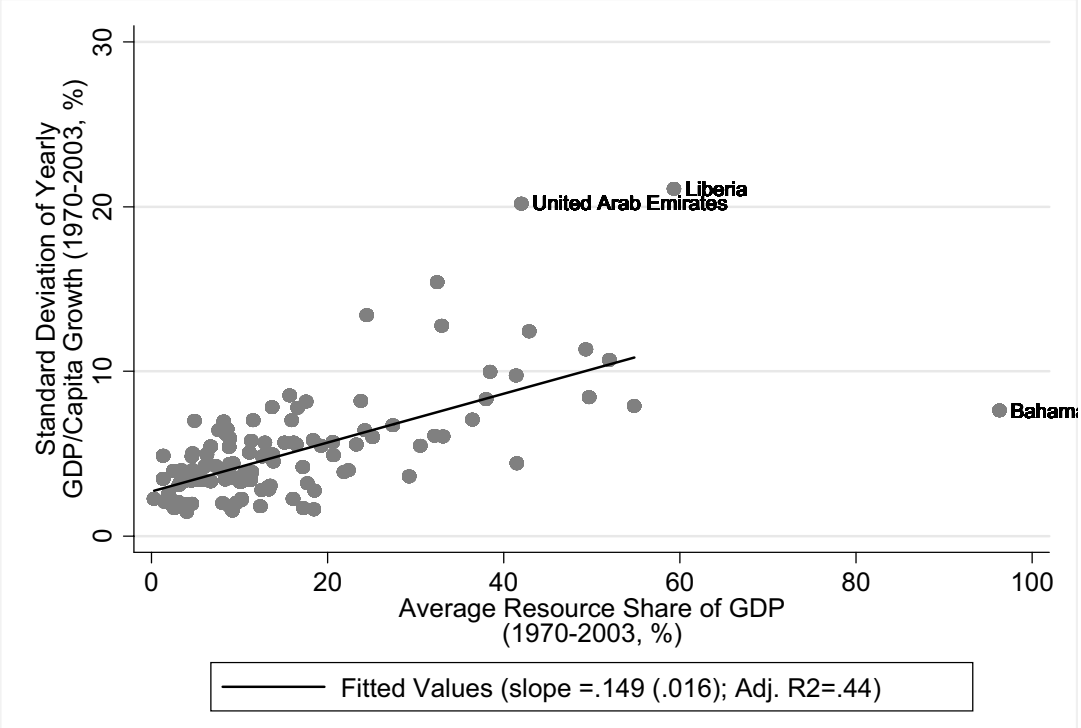


Figure 3: Cumulative density function of volatility of commodity prices

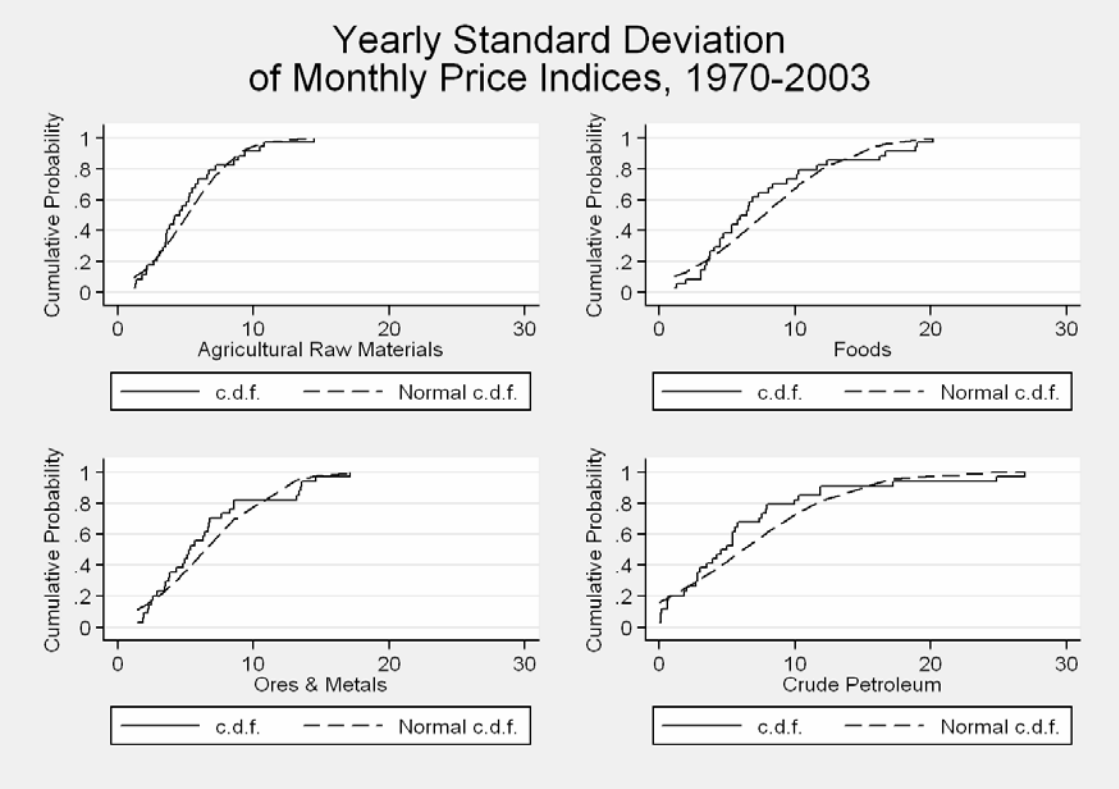


Figure 4: Declining Natural Resource Dependence in the Global Economy

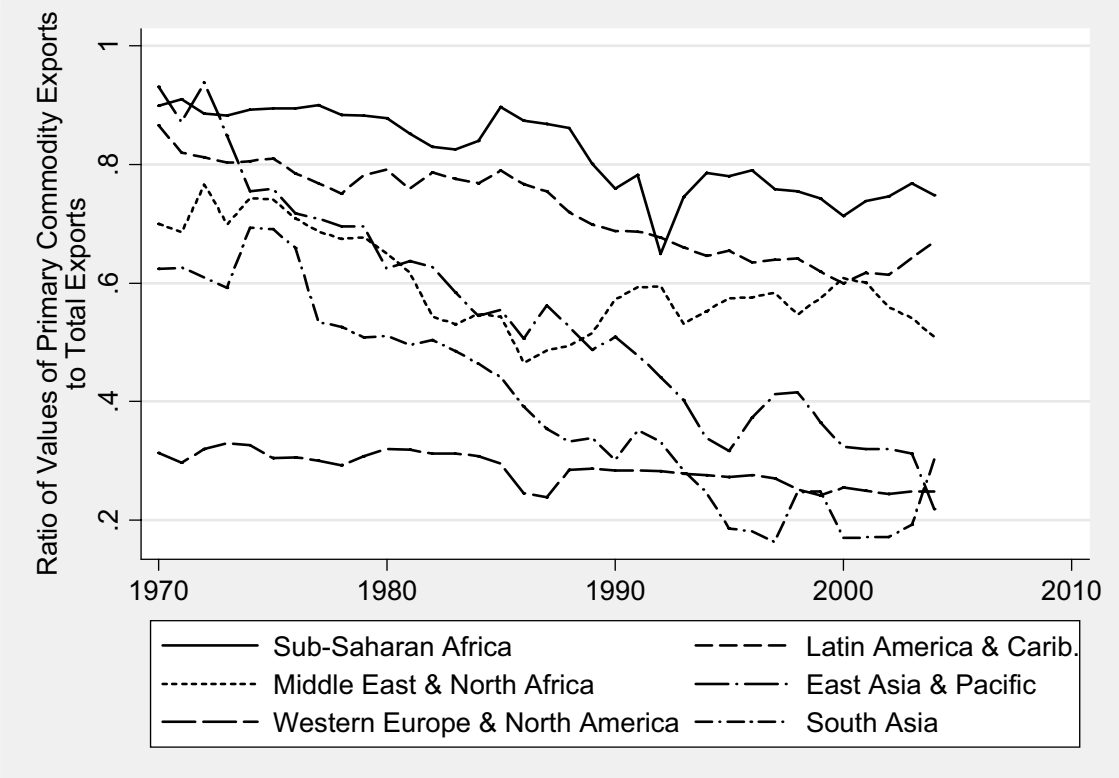
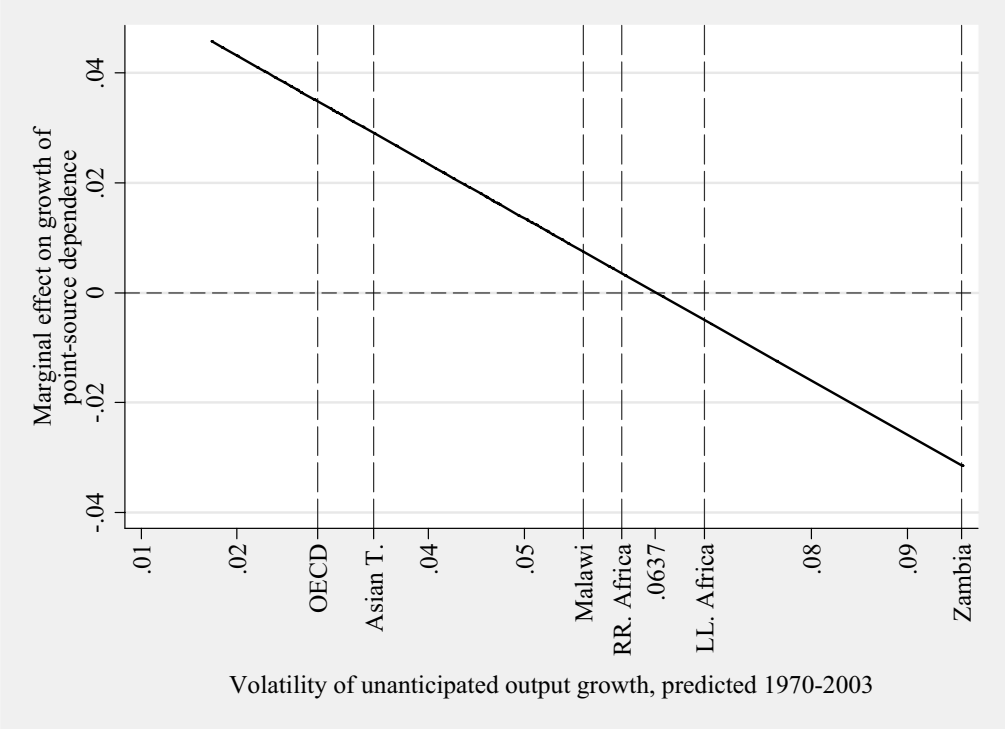
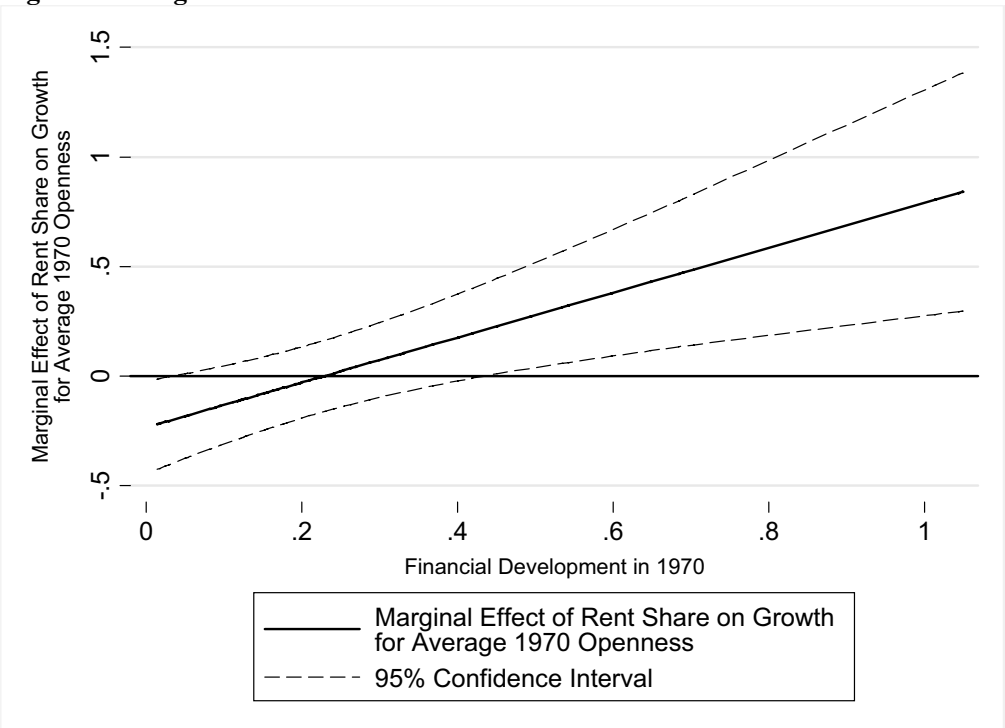


Figure 5: Marginal Effect of Point-Source Resource Dependence on Growth



Note: RR. Africa = resource-rich Africa; LL. Africa = Landlocked Africa; Asian T. = Asian Tigers, corresponding to Table 7. Based on regression 6a of Table 3.

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



Note: Based on regression 8 of Table 3.