CSAE Working Paper WPS/2011-14

Public Capital in Resource Rich Economies: Is there a Curse?[1]

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10 August, 2011

Abstract: As poor countries deplete their natural resources, for increased consumption to be sustainable some of the revenues should be invested in other public assets. Further, since such countries typically have acute shortages of public capital, the finance from resource depletion is an opportunity for needed public investment. Using a new global panel dataset on public capital and resource rents covering the period 1970 to 2005 we find that, contrary to these expectations, resource rents significantly and substantially *reduce* the public capital stock. This is more direct evidence for a policy-based 'resource curse' than the conventional, indirect evidence from the relationships between resource endowments, growth and income. The adverse effect on public capital is mitigated by good economic and political institutions and worsened by GDP volatility and ethnic fractionalization. Rents from depleting resources have more adverse effects than those that are sustainable. Our main results are robust to a variety of controls, and to instrumental variable estimation using commodity price and rainfall as instruments, Arellano-Bond GMM estimation, as well as across different samples and data frequencies.

JEL classification: E0, O1

Key words: Natural resources; public capital

[1] We gratefully acknowledge discussions with Sanjeev Gupta, Cathy Pattilo, Luis Serven, Ragnar Torvik, Rick van der Ploeg, David Vines. All remaining errors are our own.

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1 Introduction

Inadequate public capital is a defining feature of poor countries. Some types of public capital directly contribute to living conditions so that shortage impairs wellbeing; other types are complementary to private capital so that shortage curtails private investment. Poor countries governments are insufficiently creditworthy to finance the investment necessary to redress these shortages. However, for some of them the conjunction of high global commodity prices and natural resource discoveries can provide a major new source of finance. The governments of these countries possess legal entitlement to the rents generated by the depletion of natural assets. They have the opportunity to tax the rents and use the revenues to transform the public capital stock. Not only is such a use of resource rents a political opportunity, it is also economically prudent. Since the revenues from the depletion of natural assets are intrinsically unsustainable, a society that fails to devote a substantial part of them to the accumulation of other assets risks suffering declining consumption. Van der Ploeg and Venables (2011) formally analyze how a poor, growing economy should optimally use depleting resource rents and show that they should indeed in part be devoted to public capital accumulation.

It might therefore be expected that in the course of development, those countries well-endowed with natural resources would choose to accumulate larger stocks of public capital. In this paper we use a new dataset to test this proposition. We show that on the contrary, the possession of rents from natural resource depletion has typically significantly *reduced* public capital. This fills in an important missing link in the analysis of the 'resource curse'. [3] To date, the consequences of natural resource endowments have been analyzed through their effects on overarching economic outcomes such as the growth of output and the level of income, the results generally being ambiguous. However, natural resources can affect these outcomes through many channels which

[3] See van der Ploeg (2011) and Ross (2011) for surveys of this literature.

depend upon multiple decision takers. An advantage of focusing on public capital is that there is a single clear mechanism: resource rents directly generate revenue for governments and public capital is directly under government control. If, instead of using some of these revenues to increase the capital stock governments actually reduce it, this can reasonably be regarded as a policy error – a 'curse'. Despite such an error, natural resource endowments might nevertheless raise growth or incomes, for example by attracting foreign investment, so that these higher level outcomes would be misleading diagnostics of whether the political process was delivering flawed economic decisions.

We use a new global panel dataset on public capital and resource rents covering the period 1970 to 2005 and 45 developed and developing countries to test how resource rents are used. In addition to using aggregate measures of public capital, we are also able to test the relationship between resource rents and telephone networks, resource rents and rail networks, and resource rents and road networks. We find strong evidence of resource curse in public capital even after controlling for country fixed effects and time varying common shocks. Our instrumental variables estimates using international commodity price as an instrument also confirm the said relationship between natural resource rents and public capital. In particular, we find that a one standard deviation (2.69) increase in log resource rents per capita leads to approximately a one third of a standard deviation (25.09) decline in public capital stock in an average country. In other words, Brazil, approximately the mean resource rich country in our sample with rent as a share of GDP of 2 percent would experience a reduction in public capital stock to GDP ratio by 8 percentage points from a period average of 37 percent to 29 percent. We also find that precisely contrary to the dictates of prudent economic management, the depleting 'point source' resource rents reduce public capital rather than resource rents from potentially sustainable forestry and agriculture. This pattern remains unaltered when 'resource abundance' measures such as subsoil wealth, land wealth, and forest wealth are used. Our main results hold when we control for income and various additional covariates. It is also robust to various alternative samples. Consistent with these effects on the public capital stock being policy errors, using measures of institutions, GDP volatility, and ethnic fractionalization we find that good economic and political institutions limit the curse whereas GDP volatility and ethnic fractionalization magnifies it.

In the past, most studies of public capital were restricted to a sample of 22 OECD countries and cross-section data due to the paucity of data (Kamps, 2006). The novelty of our study is that we use a new global panel dataset on public capital developed by Arslanalp et al. (2010) which includes both OECD and developing countries. The usage of panel data allows us to tackle endogeneity issues, omitted variable bias relatively effectively and limit bias originating from sample selection. Furthermore, by merging the new global panel dataset on public capital with a global panel dataset on resource rents developed by Hamilton and Clemens (1999) we are able to empirically test the effect of resource rents on public capital in a global panel. This, to the best of our knowledge, is entirely new. Using measures of institutions, GDP volatility, and ethnic fractionalization we are also able to explore the channels through which resource rents may have an impact on public capital.

Our paper is related to a large literature on public investments and growth. This literature assesses whether public investments are productive and growth promoting. Some of the early empirical studies by the IMF produced no clear cut results (IMF, 2004; 2005). World Bank (2007) in contrast found positive growth effects of public spending on infrastructure, education and health. In a related paper Keefer and Knack (2007) deal with the political economy of public investments. Using a cross-section dataset of 89 countries they show that public investment as a share of GDP and as a share of total investment is higher in countries with bad institutions. They argue that weak institutions in general and weak property rights in particular enhance rent seeking incentives of politicians which lead to an increase in public investment. In a recent study, Arslanalp et al. (2010) comment that the mixed results noticed in this literature are due to the usage of the public investment rate as an explanatory variable as opposed to the rate of change in public capital. They observe that studies using the latter variable often come up with a positive result. They argue that the public investment and public capital variables can differ substantially for a country depending on the initial level of the public capital stock. Therefore, the empirical results could be substantially different for these two variables. Romp and de Haan (2007) presents a comprehensive review of this literature. None of the above studies however look at the relationship between resource rents and public capital.

Finally, our paper is related to the resource curse literature. Sachs and Warner (2001, 2005) note that resource rich countries on average grow much slower than resource poor countries. Subsequent studies have argued that natural resources may lower the economic performance because they strengthen powerful groups and foster rent-seeking activities (e.g., Lane and Tornell, 1996; Tornell and Lane, 1999; Collier, 2000; Torvik, 2002). Others have argued whether natural resources are a curse or a blessing depends on country-specific circumstances especially institutional quality (eg., Mehlum et al., 2006; Robinson et al., 2006; Collier and Goderis, 2007; Collier and Hoeffler, 2009; Bhattacharyya and Hodler, 2010a,b).

The remainder of the paper is structured as follows: Section 2 discusses measurement issues relating to public capital and resource rent. Section 3 presents the empirical evidence on the relationship between resource rent and public capital. Section 4 concludes.

2 Measuring Public Capital and Resource Rent

Most of the existing empirical studies on public investment and growth use the public investment rate as a measure of public investment as opposed to the rate of change in public capital. The limitation of using the former is that it is dependent on the initial level of the capital stock and could vary significantly from the latter for a particular country. This could bring in systematic measurement error and potentially bias the results.

In this study we use a new global panel dataset on public capital developed by Arslanalp et al. (2010) which includes both OECD and developing countries. The original dataset covers 48 developed and developing countries and the period 1960 to 2007. Here however we are able to use data for 45 countries and the period 1970 to 2005 because our resource rent dataset only covers as many countries and years. Arslanalp et al. (2010) follow the methodology used in Kamps (2006)[4] to build a capital stock series. Their series is based on the perpetual inventory equation $K_{it} = K_{it-1} - \delta_{it} * K_{it-1} + I_{it-1}$, where for each country *i*, K_t is the stock of public capital at time *t*, $I_{t-1}$is public investment spending at time *t-1*, and δ_{it} is country *i*'s time-varying rate of depreciation of the capital stock.[5] Using data for 48 countries on total investment and GDP from the Penn World Tables (PWT) version 6.2 and applying public and private investment shares from IMF World Economic Outlook (WEO) database to disaggregate total investment into public and private Arslanalp et al. (2010) create the panel dataset on public capital which is the largest available for developing countries.

Using the Arslanalp et al. (2010) public capital measure has the following advantages. First, the public capital measure allows us to effectively address endogeneity concerns. The public investment rate could be influenced by the business cycle. It could even turn negative due to a lack of revenues in an economy faced with an economic downturn. Often it is the first expenditure item to be cut down during a recession. In contrast, the public capital stock could be independent of business cycle fluctuations as it is measured at the beginning of the period. Second, the panel nature of the dataset allows us to effectively tackle omitted variable concerns by controlling for country

[4] Note that Kamps (2006) only construct public capital series for 22 OECD countries for the period 1960 to 2000.

[5] For the OECD countries they follow Kamps (2006) and use the US Bureau of Economic Analysis estimated depreciation rates as proxies. For middle-income non-OECD countries they use a time-varying profile with a flatter slope than the one used for the OECD countries. For low-income countries they hold the depreciation rate constant over time.

fixed effects and time varying common shocks. It also allows us to limit potential sample selection bias as we use a larger sample with both country and time variations. Third, it is also the largest available dataset for developing countries.

We notice in figure 1 that the 1970s experienced maximum public capital growth for all countries with the stock growth rate of 6.6 percent for middle income countries (MICs). In contrast, the 1990s witnessed an overall decline in public capital stock growth as more and more countries resorted to globalization and liberalization and perhaps moved away from public capital and towards accumulation of private capital. Public capital stock growth in low income countries (LICs) improved significantly during the first decade of the twenty first century. This is perhaps explained by the fact that low income countries experienced relatively steady growth during this decade while growth in the OECD member countries were badly affected by the global financial crisis.

Our main natural resource measure (RR_{it}) is the log of per capita rents from natural resources, which include energy, minerals and forestry.[6] This measure is based on the World Bank's adjusted net savings dataset and covers the period 1970 to 2005.[7] The rent from a particular commodity is defined as the difference between its world price and average extraction costs both expressed in current US dollars. The world price of a particular commodity is global and only varies over time. The extraction costs however are variable over time and across countries. We calculate total rents accruing from a variety of natural resources by following a three step procedure. First, we multiply the natural resource rent per unit of output of a particular commodity by the total volume extracted of that commodity. Second, we aggregate them across commodities for a country and a particular year. Third, we divide them by total population and average them for five year periods and take natural logs to smooth out any noise in the data. Averaged over the sample period,

[6] Note that we also distinguish between non-renewable and renewable resources by omitting forestry from the mix in table 4, column 2. We call this a measure of point source resources rent. This is also a measure of rents from non-renewable resources.

[7] Hamilton and Clemens (1999) provide a detailed description of this dataset.

Madagascar has the lowest per capita resource rent with an average value of RR_{it} of 4.95 international dollars, and the United Arab Emirates the highest with an average value of RR_{it} of 8.9 million international dollars. The summary statistics are reported in table 1.

We use this measure of natural resource for the following reasons. First, per capita resource rent is potentially a good proxy for resource dependence of a country. Unlike many of the other measures used in the literature, it is available for a panel of countries. Second, by construction it allows us to examine the impacts of varieties of natural resources namely oil, minerals, forestry and agriculture. Third, it is fairly wide in terms of country coverage. Therefore we are able to minimize the risk of sample selection bias. It also provides a long time dimension unmatched by other datasets of natural resource dependence. Fourth, it has been used by a number of recent studies (e.g., Ross, 2006; Collier and Hoeffler, 2009; Bhattacharyya and Hodler, 2010a,b). Fifth, it may help to bypass some endogeneity related concerns as resource rents predominantly depend on the stock of natural resources and exogenous world prices. But RR_{it} may still be endogenous as the stock of public capital may influence the cost of resource extraction. Therefore, we also use lagged RR_{it}, and we instrument for RR_{it} by using international prices of commodities. It is less likely that public capital stock at time t would influence resource rent in time t-5. International commodity price are driven by global demand for resources and hence are exogenous to a country.

We also use log GDP per capita and several other additional control variables. Detailed definitions and sources of all variables are available in Appendix A1. Table 1 reports descriptive statistics of the main variables used.

3. Testing for a Curse

3.1 Empirical Strategy

We start by plotting the change in public capital (ΔK_{it}^{G}) against the change in resource rent (ΔRR_{it}) in figure 2. We find that public investment is typically lower in resource rich countries as there is a significant negative pattern in the data when we draw a line through it. In order to explore whether the negative correlation reported in figure 2 would stand the test of more rigorous econometric models we follow the following empirical strategy. We use a panel dataset covering the period 1970 to 2005 and 45 countries.[8] Our main specification uses five year averages of our measures of public capital, natural resource rent, and GDP per capita. To estimate whether public capital suffers from a resource curse, we use the following model:

$$K_{it}^{G} = \alpha_i + \beta_t + \gamma_1 RR_{it} + \gamma_2 Y_{it} + X'_{it}\Lambda + \varepsilon_{it}, \qquad (1)$$

where K_{it}^{G} is the public capital stock in country i averaged over years $t-4$ to t, α_i is a country dummy variable which indicates the use of country fixed effects, β_t is a year dummy variable controlling for time varying common shocks, RR_{it} is the log of per capita natural resource rent in country i averaged over years $t-4$ to t, Y_{it} is log GDP per capita in country i averaged over years $t-4$ to t, and X'_{it} is a vector of other control variables. The country fixed effects control for time invariant country specific factors including initial endowments, legal origin, time invariant components of institutions, and social capital.

We are mainly interested in the effect of a change in RR_{it} on K_{it}^{G}. The point estimate of this effect is γ_1. Therefore we focus on the coefficients γ_1. We expect γ_1 to be negative and statistically significant. This would imply that indeed there is a public capital resource curse - resource rich countries have lower levels of capital stock. We also ask the question whether the curse holds in case of public investments. We estimate a dynamic model in table 2 to test the effect

[8] Due to data limitations, not all specifications cover exactly 45 countries and in most specifications, the panel is unbalanced. Appendix A2 presents a list of countries included in the sample. The size of the sample is mainly dependent on the size of the public capital dataset.

of natural resources on the change in public capital stocks (public investments).

There may be issues of endogeneity and omitted variable bias. The stock of public capital may influence the cost of resource extraction and hence natural resource rent. The stock of public capital could also influence the level of income. To address such concerns we use the following two strategies. First, we use lagged resource rent. It is less likely that the current public capital stock would influence lagged resource rent. Second, we use international commodity prices and rainfall as instruments for resource rent and log GDP per capita and estimate the model using the Fuller version of Limited Information Maximum Likelihood (LIML) instrumental variable (IV) method. The advantage of using Fuller LIML over standard IV estimator is that the former works better even when the instruments are weak. International commodity prices depend on global demand for commodities and hence are exogenous. They are also correlated with resource rent and may not have any effect on public capital stock through channels other than public capital. Therefore it is a valid instrument for resource rent. Rainfall is geography-based and hence exogenous to the model. It is also correlated with income and could serve as a good instrument. To address omitted variable concerns, we control for country fixed effects and time dummy variables. Country fixed effects control for country specific time invariant observables which may influence both public capital and resource rent. Time dummy variables control for shocks that are time varying and common to all countries. Furthermore, we also control for many additional covariates in table 6.

3.2 Is there a Curse?

Table 2 presents our main results on the public capital resource curse. In column 1 we look at the unconditional correlation between resource rents and public capital. We notice a statistically significant negative relationship. Similar to figure 2 this suggests that resource rents are associated with low levels of public capital stock. But this association may be driven by omitted factors (such as income, time invariant institutions, legal origin, culture, geography, time varying common shocks etc.) influencing both resource rents and public capital stock. To tackle this issue in column 2 we add log per capita income. We notice that the negative relationship survives, but the magnitude of the coefficient falls marginally. In column 3 we further control for country dummies and year dummies. The strong statistically significant negative relationship survives indicating a public capital resource curse. Figure 3 plots this partial effect. In column 4, we address concerns of endogeneity by using RR_{it-5} instead of RR_{it}. We continue to find support for the curse thesis. To convince ourselves even further that we have addressed endogeneity concerns adequately, we adopt the Fuller LIML IV estimation strategy in column 5. We use international commodity price and rainfall as instruments for resource rent and income respectively. We continue to find evidence of a curse in our 45 country panel dataset. Table 3 reports the first stage regressions where commodity price and rainfall are noticed to be highly significantly correlated with resource rent and GDP per capita. They are also not weak instruments as they satisfy the Stock-Yogo criteria (see column 5, table 2).

A further concern of endogeneity stems from the possibility of a mechanical effect between resource rent and our preferred public capital measure K_{it}^{G}. Our preferred public capital measure is normalized by GDP. Therefore it is possible that we are picking up a positive correlation between resource rent and GDP. If resource rich countries are prosperous with a higher GDP then our preferred public capital measure would be mechanically lower for resource rich countries. This would lead us to an erroneous conclusion of public capital resource curse. To eliminate the possibility of such mechanical effect, we use log public capital as our dependent variable in column 7. Note that log public capital is not normalized by GDP and is representative of the aggregate public capital stock in a country. We find that the negative effect of resource rent on public capital survives leading us to conclude that we are indeed picking up a public capital resource curse.

To put the estimates of our main specification (column 3) into perspective, let us focus on

Egypt and Kenya. Egypt is a resource rich country ($RR_{EGY2000} = 12.31$, i.e., a per capita resource rent of almost 222,000 international dollars) with moderate levels of public capital to GDP ($K^{G}_{EGY2000} = 44.4$, i.e., a public capital stock to GDP ratio of 44.4 percent) whereas Kenya is a resource poor country ($RR_{KEN2000} = 8.76$, i.e., a per capita resource rent of 6374 international dollars) with relatively high levels of public capital to GDP ($K^{G}_{KEN2000} = 70.2$, i.e., a public capital stock to GDP ratio of 70.2 percent). Given the difference in resource rents across the two countries of $RR_{EGY2000} - RR_{KEN2000} = 12.31 - 8.76 = 3.55$ our empirical model predicts that the difference in public capital stock would be $|\hat{\gamma}_1| \times [RR_{EGY2000} - RR_{KEN2000}] = 2.99 \times 3.55 = 10.61$ percentage points, which is approximately 41 percent of the actual difference of $K^{G}_{KEN2000} - K^{G}_{EGY2000} = 70.2 - 44.4 = 25.8$. In other words, the model explains approximately 41 percent of the variation in public capital stock between Egypt and Kenya. Overall a one sample standard deviation (2.69) increase in log resource rents per capita leads to approximately 8 percentage points (i.e., one third of a sample standard deviation of 25.09) decline in public capital stock in an average country. Table 11 reports additional calculations on the impact of natural resources on public capital in the average resource rich country in our sample.

Finally, in column 6 we test the impact of resource rent on public investment by estimating a dynamic model using the Arellano and Bond GMM estimation method. This estimation method uses lagged levels of the dependent variable and explanatory variables as instruments. We notice that the coefficient of interest remains significant suggesting public investment resource curse.

3.3 Point Source Resources, Public Capital and the Curse

Countries exporting point source natural resources (minerals, oil and gas) are doubly disadvantaged in terms of growth when compared with countries exporting relatively less appropriable natural resources such as agricultural produce (Isham et al., 2005). Politicians in point source resource dependent countries could easily appropriate resource revenues and breed corruption (Bhattacharyya and Hodler, 2010a). This would be harmful to growth. Furthermore, point source resource dependency could result into high inequality which could also harm growth.

In table 4 we explore whether an increase in rent from appropriable resources have a distinctly differential effect when compared to less appropriable ones. We follow Isham et al. (2005) and test our model using agriculture resources rent (FRR_{it}) and point source resources rent ($PSRR_{it}$) as explanatory variables in columns 1 and 2 respectively. We find evidence of the curse in case of point source natural resources but not in case of less appropriable agricultural and forestry resources. In other words, non-renewable point source resources reduce public capital rather than potentially sustainable forestry and agriculture. In column 3 we control for both resources separately and arrive at a qualitatively similar empirical result. This may be due to the differential impact that point source resources have on institutions (Isham et al., 2005). Furthermore, it may also be due to the permanent nature of price shocks in mineral and hydrocarbon resources as opposed to temporary shocks in case of agricultural produce. Permanent price shocks in point source resources may often lead to a permanent adverse terms of trade shocks disadvantaging public investments. To test that in column 4 we restimate the model in column 3 using annual data. We find that results are similar as when using five year averages. This similarity suggests that the absence of a curse in case of forestry resource rents is probably not driven by a more temporary nature of price shocks. To be certain that our main result is not driven by the durability of price shocks, in table 8 we further estimate our baseline specification (column 3, table 2) using the main aggregate resource measure (RR_{it}) with different data frequencies. We get similar results with annual data, three year averages, and decadal averages as with five year averages. This suggests that our curse result is not driven by the durability of the price shocks.

To explore the variable effects of different types of natural resources further, in columns 5 –

7 we look at the impact of 'resource abundance'. We use subsoil wealth, land wealth and forest wealth as measures of 'resource abundance'. These measures are available as a cross-section from the World Bank's Natural Capital dataset. The 'resource abundance' measures are likely to reflect resource stocks which is independent of economic flows and 'resource dependence'. We find evidence of curse in case of subsoil wealth (column 5) but not in case of land wealth (column 6) and forest wealth (column 7). The subsoil wealth result survives when all three variables are used in the same regression in column 8.

3.4 The Role of Institutions, Volatility and Ethnic Fractionalization

A large literature suggests that the resource curse is conditional on the quality of institutions (e.g., Mehlum et al., 2006; Robinson et al., 2006; Collier and Hoeffler, 2009; Bhattacharyya and Hodler, 2010a,b). Resource rich countires with good economic and political institutions are unlikely to suffer from the curse. The curse however holds for resource rich countries with weak institutions.

In column 1 of table 5 we test the impact of political institutions measured by the POLITY2 democracy index from the Polity IV dataset. We find that the negative impact of resource rent on public capital gets moderated by the quality of democratic institutions. In other words, even though the coefficient on RR_{it} is negative and strongly significant, the coefficient on the interaction term $RR_{it} \times D_{it-5}$ is positive and significant. In column 2, we use the Hall and Jones (1999) institutions index which is a combined measure of economic institutions. They define it as the social infrastructure index and it is the average of five categories (law and order, bureaucratic quality, corruption, risk of expropriation, and government repudiation of contracts). The index ranges between 0 and 7 with 0 signifying the worst institutional quality. Using this index we find that on average the effect of the curse is 1.1 percentage points less in a country with one extra point score on the index scale. Furthermore, our model predicts that the curse is only experienced by countries below the Hall and Jones institutional index score of 3.1. To put this in perspective, Mexico is just above this threshold, scoring an average of 3.3 over the period 1980-2005. In column 3 we use lagged executive constraints which is sometimes used as a measure of property rights institutions. Our result of a curse conditional on the quality of institutions remains unaltered.

A large literature starting from the seminal contribution by Ramey and Ramey (1995) suggest that volatility is bad for growth.[9] GDP volatility could give rise to volatile government revenue and as a result very volatile public investment. Therefore, GDP volatility could potentially magnify the curse. In column 4, we test empirically how GDP volatility may impact on the curse. We construct a GDP volatility series by following a two step procedure. First, we estimate an empirical growth model with investments and population growth as explanatory variables using dynamic panel data estimation technique (Arellano – Bond GMM). Second, we extract the residual from this regression and use the squared residual as our measure of volatility.[10] We find that a one sample standard deviation (25.18) increase in GDP volatility in an average country increases the curse by 3.5 percentage points.

The other closely related thesis of resource curse is the 'voracity effect'. Lane and Tornell (1996) and Tornell and Lane (1999) argue that in ethnically fractionalized countries powerful ethnic groups dynamically interact through a fiscal process. In the event of a resource windfall or a terms of trade shock the country could experience more than proportionate increase in fiscal redistribution in favour of the powerful group thereby damaging growth. Such a fiscal adjustment process in the event of a resource price shock in a resource rich economy could potentially damage public investments. In column 5, we test this thesis by using ethnic fractionalization as a control variable and $RR_{i2000} \times ETN_i$ as the interaction term. Note that ethnic fractionalization is time invariant and therefore we estimate a cross-section regression. We find that ethnic fractionalization does aggravate the curse which supports the 'voracity effect' thesis.

[9] See Blattman et al. (2007) for an account on the recent contributions on this topic.
[10] Note that we have also used a simple five year GDP variance as a measure of volatility and our results are similar.

3.5 Robustness

In table 6 we add additional covariates into our main specification to address the issue of omitted variables. In columns 1-3 we add foreign direct investments, a trade liberalization index, and trade shares, respectively as additional control variables. Trade liberalization and foreign investments help ease control over the import of vital capital goods which could be crucial for public investments. We find in column 3 that trade has a positive and significant impact on public capital. In columns 4-5 we control for schooling and income inequality measured by the Gini coefficient. Schooling should increase the demand for public goods and hence public capital. It could also have a positive impact on public capital from the supply side as a better educated population and bureaucracy would be better able to support high quality public investments. High inequality in contrast could increase redistributive pressure on the government jeopardizing public investments. In columns 6 and 7 we control for terms of trade and changes in the real effective exchange rate to capture Dutch Disease effects. Adverse terms of trade shocks in a resource dependent economy could stunt growth in all other non-resource tradable sectors through real exchange rate appreciation. Lastly, in column 8 we add the real interest rate. An alternative causal channel of a financial resource curse could work through high interest rates in resource rich economies. Resource rich economies are often flushed with excess liquidity from resource booms. This excess liquidity is typically deposited in the form of foreign exchange in banks by the resource companies or the government. Banks would sell foreign exchange in the open market which would result in a decline in money base. To counter that, central banks would undertake open market operation and buy government bonds which would lead to higher interest rates. This is often characterized as sterilized intervention. As a result of high interest rates (cost of borrowing) the stock of public capital could be lower in resource rich countries. If the curse is working exclusively through the interest rate channel, then adding the real interest rate into our specification would make the coefficients on RR_{it} statistically insignificant. However, as shown in column 8, these coefficients remain statistically highly significant. Our main results survive in all other instances.

Table 7 presents robustness results with alternative samples. Columns 1-5 checks whether our results are influenced by any particular continent. We take out Africa, Asia, Europe, the Americas, and Neo-Europe[11] one at a time from our base sample. In column 6 we test the influence of OECD countries by excluding them from the sample. In columns 7-9 we also omit influential observations using Cook's distance, DFITS, and Welsch distance formulas respectively. In column 9, we drop major oil producers (Canada, Egypt, Mexico, and Norway) from our sample. Our main results hold in all these alternative samples.

3.6 Varieties of Public Capital and the Curse

So far our measure of public capital has been derived from expenditure adjusted for depreciation. However, the expenditure on capital may misrepresent the actual accumulation of capital because of variations in the efficiency of the process of public investment. The IMF has recently developed a Public Investment Management Index which attempts to measure the quality of the public investment process, (Dabla-Norris et al., 2011). The index is composed of 17 indicators grouped into four stages of the public investment management cycle: (i) Project Appraisal; (ii) Project Selection; (iii) Project Implementation; and (iv) Project Evaluation. Each stage is scored between 0 and 4, with a higher score reflecting better public investment management performance. The aggregate index is a weighted average of these four stages with equal weights. Using this Index as a measure of the quality of the public investment process, we now investigate whether it is affected by resource rents (Table 9). In column 1 we use the composite index as the dependent variable. Unfortunately, because the Index is recent it is as yet merely a one-time snapshot and so we are not able to control for country fixed effects. However, controlling for per capita income, we find a

[11] Neo-Europe includes all Anglo-Saxon countries outside Europe: Australia, Canada, New Zealand, and the United States.

strong negative relationship between the quality of the investment process and resource rents. In columns 2-5, we use different components of the index (appraisal, selection, implementation, and evaluation) to test which component is most affected. We find that all stages of public investment management are negatively affected by resource rents. The coefficients are significantly negative in all cases except appraisal (column 2). These results suggest that the reduction in expenditure on public capital caused by resource rents may even be amplified by deterioration in the quality of the investment process.

To investigate the link to the actual capital stock further we turn to some evidence on a few components which are readily observable over time, namely telephone lines and networks of road and rail. Even though in many countries these assets are no longer publicly owned, until recently they were considered to be strategic and were owned by the government.

Controlling for country fixed effects and year dummies we find evidence that resource rents have significant, although modest effects (Table 10). In columns 1 and 2 we consider the telephone network: resource rich countries on average have significantly fewer telephone lines per hundred people. In columns 3 and 4 we look at the association between resource rents and rail and road networks. Resource rents are positively related to the rail network but negatively related to the road network. The former is perhaps best explained by the fact that resource extraction needs railways to transport ores to ports and so investment in extraction has historically often been combined with investment in railways. Road networks however are a different matter. Road networks are more closely related to the non-resource sector and perhaps suffer from the curse due to the neglect of the non-resource sector in general by the government in a resource rich country (Bhattacharyya and Hodler, 2010b).

While the evidence on telephone and road networks is qualitatively consistent with our overall results that resource rents reduce the public capital stock, the scale of the effect falls far short of what is implied by our other results. The contrast is brought out in Table 11 where we consider the counterfactual of the public capital stock in the average resource rich country were it not to have had any resource rents. Such a counterfactual is, of course, highly stylized, but for illustrative purposes we hold constant at the mean for our sample of resource rich countries all observed characteristics other than the resource rents themselves and our measures of public capital (See Appendix 2 for details of these variables). We find that in the absence of resource rents the average resource rich country would have had a 30 percentage point increase in the ratio of its public capital stock to GDP. The quality of its public investment process, as scored by the Public Investment Management Index, would have been 1.2 points (= 30 percent) higher. Turning to observable physical capital, it would have had marginally fewer railways, but three percent more roads and four percent more telephones.

However, what all these counterfactuals agree on is that the depletion of resource rents does not augment the public capital stock. This, rather than the absolute adverse effects, is the crux of the policy problem: natural capital has typically been plundered by the state rather than converted to more productive forms of capital.

4 Concluding Remarks

This paper studies the impact of resource rents on public capital in resource rich countries. Natural resource rents provide an opportunity for resource rich developing countries to acquire public capital crucial for economic development. Further, since the depletion of natural assets is unsustainable, societies should offset such depletion by the accumulation of other forms of capital, of which public capital is most directly under the control of government. While the overall net effects of natural resource endowments on economic growth and the level of income are *a priori* ambiguous, it is unambiguous that some of the revenues from resource depletion should be used for the accumulation of public capital. Hence, this constitutes a direct test of whether resource rents significantly contaminate the political process of taking public economic decisions. However, until recently such a test has not been feasible because of a lack of appropriate data, so that analysis of whether there is a 'resource curse' has depended upon inference from the higher-level outcomes.

We use a new global panel dataset on public capital and resource rents covering the period 1970 to 2005 and 45 developed and developing countries. We find strong evidence in favour of a curse. We also find that good economic and political institutions limit the curse whereas GDP volatility and ethnic fractionalization magnifies it. Furthermore, precisely contrary to optimal public policy, depleting 'point source' resource rents are more harmful to public capital than resource rents from the potentially sustainable sources of forestry and agriculture. Our main results hold when we control for income, country and time fixed effects, and various additional covariates. They are also robust to instrumental variable estimation using commodity price and rainfall as instruments for resource rents and income respectively, Arellano-Bond GMM estimation of a dynamic panel data model, as well as across different samples and data frequencies.

Our findings have important implications for managing resource revenues in developing countries. To date international policy advice for resource-rich low-income countries has tended to advocate the accumulation of foreign financial assets, for example through Sovereign Wealth Funds. There are obvious grounds for regarding this privileging of foreign assets over domestic investment as mistaken for low-income countries (Collier et al., 2010). Our new results suggest that the critical policy error is yet more fundamental: resource rents so warp incentives that politicians actually reduce public investment in their own economies. Hopefully, this manifestly sub-optimal policy choice may be more amenable to influence than the accumulation of foreign reserves, since the need for public investment is readily apparent to ordinary citizens.

Appendices

A.1. Data description

Public Capital to GDP (K_{it}^{G}): Public capital stock as a share of GDP. Source: Arslanalp et al. (2010).

Log Resource Rent per capita (RR_{it}): Log of per capita natural resource rents. Natural resources include energy, minerals, and forestry. Rents are defined as the price minus the average extraction costs. Source: World Bank Adjusted Net Savings Dataset.

Commodity Price Index (P_{it}): Hamilton and Clemens (1999) estimate international market price for crude oil, natural gas, coal, metals and minerals, and forest to compute rent for use in their calculation of adjusted net savings. We use their estimated international market price of these commodities which is a weighted average of the individual prices with production volume index as weights. Source: Hamilton and Clemens (1999).

Log Rainfall: Log of Annual Precipitation. This data is approved by the International Panel on Climate Change (IPCC). *Source:* Mitchell *et al.* (2003).

Log GDP per capita (Y_{it}): Log GDP per capita PPP (in current international dollars). Source: WDI Online.

Democracy lagged (D_{it-5}): Lagged average POLITY2 coding (5 year averages) from the Polity IV dataset. POLITY2 is defined as the difference between democracy and autocracy scores, rescaled so that it ranges from 0 to 1 with higher value implying better institutions. Source: Polity IV.

Hall and Jones Institutions Index lagged ($HJINS_{it-5}$): The index is a combined measure of economic institutions. It is the average of five categories (law and order, bureaucratic quality, corruption, risk of expropriation, and government repudiation of contracts). The index ranges between 0 and 7 with 0 signifying the worst institutional quality. Source: Hall and Jones (1999).

Executive Constraints: Measure of institutionalized constraints on the power of chief executives, ranging from 1 to 7 with higher values representing greater constraints. Source: Polity IV.

GDP volatility [Ω_{it}^{Y}]: We construct a GDP volatility series by following a two step procedure. First, we estimate an empirical growth model with investments and population growth as explanatory variables using dynamic panel data estimation technique (Arellano – Bond GMM). Second, we extract the residual from this regression and use the squared residual as our measure of volatility. Source: Authors' calculation using WDI online.

Trade Share: Total volume of trade as a share of GDP. Source: WDI Online.

Foreign Direct Investments: Net inflow of foreign direct investment as a share of GDP. Source: WDI Online.

Sachs and Warner Trade Liberalization Index: Fraction of years open between years $t-4$ and t. Source: Wacziarg and Welch (2003).

Schooling: Average schooling years of the aged over 25 in the total population, measured at five year intervals from 1970 to 2000. Source: Barro and Lee (2000).

Gini Coefficient: Income inequality measured by Gini Coefficient in percentage points as calculated by UNU-WIDER. Source: World Income Inequality Database version 2 (WIID2).

Terms of Trade: Net Barter Terms of Trade. Source: WDI Online.

Change in Real Effective Exchange Rate: Change in Real Effective Exchange Rate computed using Real Effective Exchange Rate Index. Source: WDI Online.

Real Interest Rate: Source: WDI Online.

Public Investment Management Index (PIMI): PIMI is composed of 17 indicators grouped into four stages of the public investment management cycle: (i) Project Appraisal; (ii) Project Selection; (iii) Project Implementation; and (iv) Project Evaluation. Each stage is scored between 0 and 4, with a higher score reflecting better public investment management performance. Source: Dabla-Norris et al. (2011) provides more detail on the construction of the index.

Telephone Lines: Log of the number of telephone lines. Source: WDI Online.

Telephone Lines per 100 People: Log of the number of telephone lines per 100 people. Source: WDI Online.

Total Rail Network in Kilometers: Log of total rail network in kilometers. Source: WDI Online.

Total Road Network in Kilometers: Log of total road network in kilometers. Source: WDI Online.

A.2 Sample

Period 1970 to 2005:[12]

OECD Countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Non-OECD Countries: Argentina, Bangladesh, Bolivia, Brazil, Colombia, Egypt, Guatemala, Honduras, India, Jordan, Kenya, Malaysia, Mexico, Morocco, Pakistan, Paraguay, Peru, Senegal, South Africa, Thailand, Tunisia, Turkey, Uruguay.

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[12] This sample corresponds to our preferred specification reported in column 3 of table 2.

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Figure 1: Public Capital Stock Growth in Low and Middle Income Countries

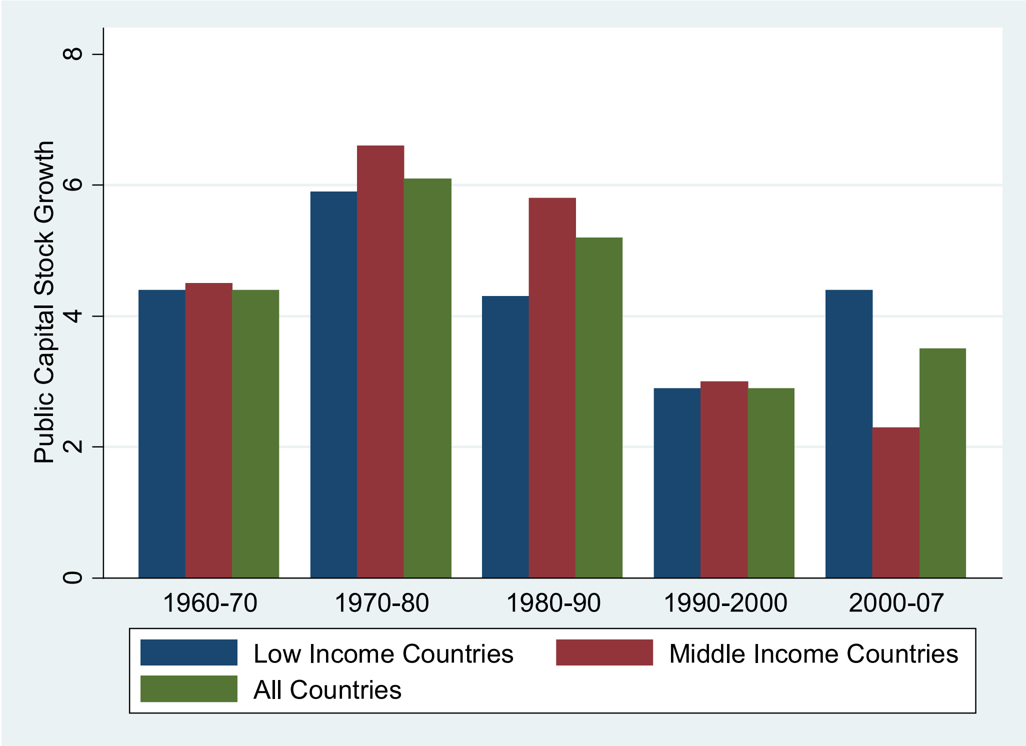


Figure 2: Public Capital in Resource Rich Economies

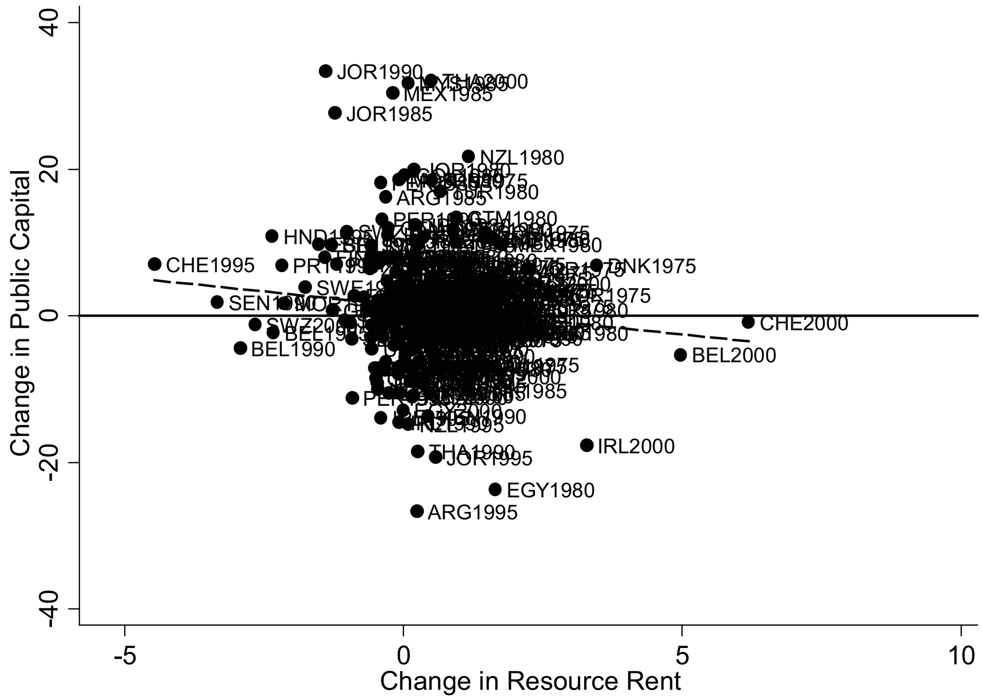
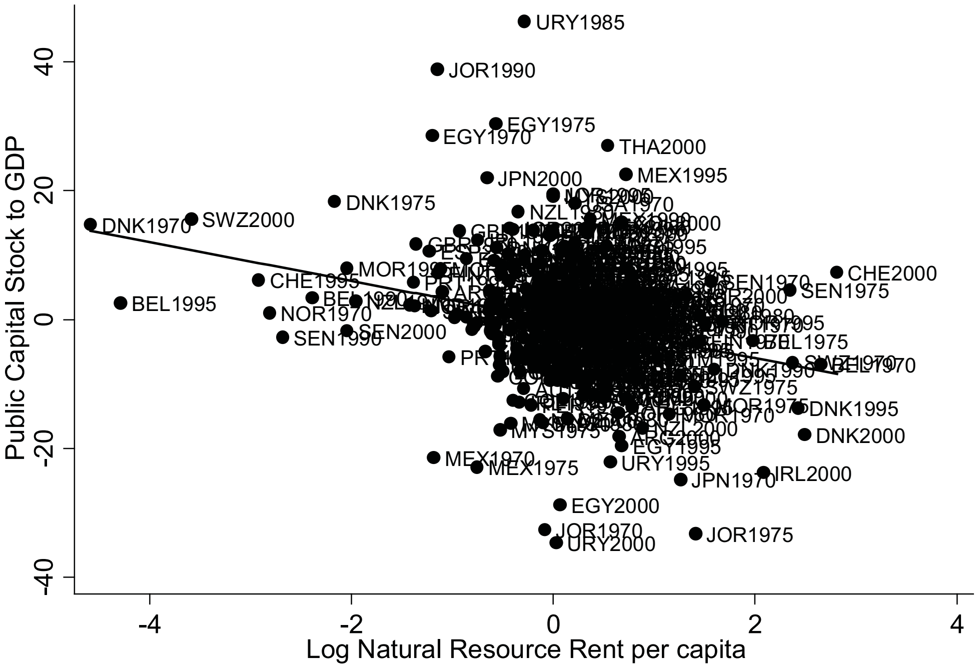


Figure 3: Public Capital and the Curse: Partial Effects



coef = -2.995043, (robust) se = 1.1065288, t = -2.71

Note: The added-variable (or partial) plot presented above is the diagrammatic representations of the coefficient estimate in regression reported in table 2 column 3. In particular, figure 3 plots the residual from a regression of RR_{it} on y_{it}, country dummies, and year dummies on the x-axis and the residual from a regression of K_{it}^{G} on y_{it}, country dummies, and year dummies on the y-axis.

Table 1. Summary Statistics

Variable	Number of obs.	Mean	Standard Deviation (overall)	Standard Deviation (between countries)	Standard Deviation (within countries)	Within and Between Standard Deviation Ratio (%)	Minimum	Maximum
Public Capital to GDP [K_{it}^{G}]	424	52.99	25.09	18.15	18.26	101	2.1	186.9
Log Resource Rent per capita [RR_{it}]	1171	10.12	2.69	1.22	0.25	21	-0.91	16.93
Democracy lagged [D_{it-5}]	1573	0.51	0.37	0.29	0.22	77	0	1
Log GDP per capita [Y_{it}]	1684	7.67	1.36	5.39	5.24	97	4.08	10.87
GDP volatility [Ω_{it}^{Y}]	1495	10.28	25.18	14.01	21.51	154	0	435.26

Table 2: Public Capital in Resource Rich Economies: Is there a Curse?

	Dependent Variable: Public Capital to GDP [K_{it}^{G}]						Log Public Capital
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS Estimates				LIML Fuller 1 IV Estimates	Arellano-Bond	OLS Estimates
Log Resource Rent per capita [RR_{it}]	-5.24*** (0.33)	-5.17*** (1.30)	-2.99*** (1.10)		-2.34** (1.04)	-1.91** (0.89)	-0.072** (0.037)
RR_{it-5}				-2.38** (1.21)			
Log GDP per capita [Y_{it}]		5.76*** (1.67)	-11.25 (10.55)	-16.51 (11.52)	-19.56 (32.87)	4.47*** (1.37)	0.59** (0.25)
Public Capital to GDP Lag [K_{it-5}^{G}]						0.99*** (0.02)	
F-stat on EI					31.3/13.9		
Partial R^2 EI					0.33/0.21		
Stock-Yogo					8.03/15.5		
Hansen test						0.81	
AR(1)Test						0.00	
AR(2)Test						0.52	
Controls:			Country Dummies, Year Dummies				
Instruments:					Commodity Price [P_{it}], Rainfall		
Countries	45	45	45	45	45	45	45
Observations	314	314	314	270	314	265	314
Adjusted R^2	0.79	0.82	0.97	0.97	--	--	0.97

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively against a two sided alternative. Figures in the parentheses are cluster standard errors, and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All regressions are carried out without an intercept. Sample years are every fifth year (averages) from 1970 to 2005. 'F-stat on EI', 'Partial R^2 EI' and 'Stock-Yogo' indicates F-statistic on excluded instruments, Partial R^2 on excluded instruments and Stock-Yogo critical values respectively. Fuller's modified LIML estimator with $\alpha = 1$ (correction parameter proposed by Hausman et al., 2005) is used in column (4). Reported Stock-Yogo critical values in column (4) are the 5 percent significance level critical values for weak instruments tests based on, respectively, 30 percent and 5 percent maximal Fuller relative bias. The null of weak instruments is rejected in the case that the F-statistic on the excluded instruments exceeds the Stock-Yogo critical value/s. Note that the Sargan/Hansen overidentification test for all instruments is not reported in column (4) as we have an exactly identified system. In column (5) Hansen test is the test of the H_0: the instruments as a group are exogenous. Hansen test p-value from two step Arellano & Bond estimations is reported which is robust to heteroskedasticity or autocorrelation. P-value of Arellano and Bond AR(1) & AR(2) tests in residuals are also reported. Note that to pass these tests, one has to reject the null of no AR(1) and fail to reject the null of no AR(2).

Table 3: Public Capital in Resource Rich Economies: First Stage Regressions

	Log Resource Rent per capita [RR_{it}]	**Log GDP per capita [Y_{it}]**
	OLS Estimates	
	(1)	(2)
Commodity Price [P_{it}]	20.78***	0.04
	(2.68)	(0.37)
Log Rainfall	-0.52	0.53***
	(0.50)	(0.08)
Controls:	Country Dummies, Year Dummies	
Countries	45	45
Observations	314	314
Adjusted R^2	0.90	0.98

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively against a two sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. Sample years are every fifth year from 1970 to 2005.

Table 4: Varieties of Natural Resources and Public Capital

	Public Capital to GDP [K_{it}^G]				**Public Capital to GDP in 2000 [K_{i2000}^G]**			
	(1)	(2)	(3)	(4) Annual Data	(5)	(6)	(7)	(8)
	OLS Estimates							
Log Forestry and Agriculture Resource Rent [FRR_{it}]	-0.29 (1.56)		-0.29 (1.03)	-0.28 (0.80)				
Log Point Source Resources Rent [$PSRR_{it}$]		-2.36** (0.97)	-3.53* (2.10)	-3.67** (1.74)				
Subsoil Wealth [SSW_{i2000}]					-9.81** (4.28)			-8.89** (3.99)
Land Wealth [LW_{i2000}]						5.29 (15.91)		7.69 (17.84)
Forest Wealth [FW_{i2000}]							-64.05 (73.23)	-69.14 (67.38)
Controls:	Log GDP per capita [Y_{it}], Country Dummies, Year Dummies				Log GDP per capita in 2000 [Y_{i2000}]			
Countries	21	45	21	21	48	48	48	48
Observations	111	306	103	401	48	48	48	48
Adjusted R^2	0.96	0.97	0.96	0.97	0.86	0.86	0.86	0.86

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively against a two sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All the regressions reported above are carried out without an intercept. Sample years are from 1970 to 2005. Point source resources include minerals (Bauxite, Copper, Lead, Nickel, Phosphate, Tin, Zinc, Gold, Silver, Iron Ore), hard coal and lignite, oil and natural gas.

Table 5: The Role of Institutions and Volatility for Public Capital in Resource Rich Countries

	Public Capital to GDP [K_{it}^G]				Public Capital to GDP in 2000 [K_{i2000}^G]
	(1)	(2)	(3)	(4)	(5)
	OLS Estimates				
Resource Rent [RR_{it}]	-8.26** (3.20)	-3.34* (1.87)	-9.05** (3.86)	-2.89*** (1.08)	
Democracy lagged [D_{it-5}]	-45.43 (28.80)				
$RR_{it} \times D_{it-5}$	5.69* (3.23)				
Hall and Jones Institutions Index lagged [$HJINS_{it-5}$]		-3.63* (1.79)			
$RR_{it} \times HJINS_{it-5}$		1.09*** (0.32)			
Executive Constraints lagged [$EXCONST_{it-5}$]			-7.15 (4.57)		
$RR_{it} \times EXCONST_{it-5}$			0.87* (0.51)		
GDP volatility [Ω_{it}^Y]				1.24 (0.93)	
$RR_{it} \times \Omega_{it}^Y$				-0.14* (0.08)	
Resource Rent in 2000 [RR_{i2000}]					-4.82* (2.86)
Ethnic Fractionalisation [ETN_i]					75.59** (31.88)
$RR_{i2000} \times ETN_i$					-14.03** (6.21)
Controls:	Log GDP per capita [Y_{it}], Country Dummies, Year Dummies				Log GDP per capita in 2000 [Y_{i2000}]
Countries	45	44	44	45	43
Observations	308	217	298	312	43
Adjusted R^2	0.86	0.97	0.87	0.97	0.13

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively against a two sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All the regressions reported above are carried out without an intercept. Sample years are every fifth year from 1970 to 2005.

Table 6: Public Capital in Resource Rich Economies: Robustness with Additional Covariates

	Dependent Variable: Public Capital to GDP [K_{it}^G]							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS Estimates							
Log Resource Rent per capita [RR_{it}]	-3.05** (1.27)	-3.12*** (1.02)	-3.00*** (1.11)	-2.74*** (0.80)	-3.06* (1.69)	-2.94*** (0.99)	-3.15* (1.81)	-3.17** (1.58)
Controls:	Log GDP per capita [Y_{it}], Country Dummies, Year Dummies							
Additional Controls:	Foreign direct investments	Sachs & Warner trade liberalization index	Trade share (+)*	Schooling (+)***	Gini coefficient	Terms of trade (-)*	Change in real effective exchange rate	Real interest rate (-)**
Countries	45	45	45	44	44	45	24	38
Observations	296	306	309	302	214	309	134	174
Adjusted R^2	0.97	0.97	0.97	0.98	0.97	0.97	0.98	0.94

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively against a two sided alternative. Figures in the parentheses are cluster standard errors, and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All the regressions reported above are carried out without an intercept. Sample years are every fifth year from 1970 to 2005.

Table 7: Public Capital in Resource Rich Economies: Robustness with Alternative Samples

	Dependent Variable: Public Capital to GDP [K_{it}^{G}]									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS Estimates									
Log Resource Rent per capita [RR_{it}]	-2.91** (1.19)	-2.82*** (0.95)	-3.72* (2.16)	-3.50*** (1.08)	-3.10*** (1.13)	-3.85* (2.31)	-2.58*** (0.85)	-2.65*** (0.86)	-2.74*** (0.89)	-3.26*** (1.07)
Controls:	Log GDP per capita [Y_{it}], Country Dummies, Year Dummies									
Omitted Observations:	Base sample without Africa	Base sample without Asia	Base sample without Europe	Base sample without the Americas	Base sample without Neo-Europe	Base sample without OECD	Obs. Omitted using Cook's Distance	Obs. Omitted using DFITS	Obs. Omitted using Welsch Distance	Base sample without Major Oil Producers
Countries	38	38	28	33	41	23	45	45	45	41
Observations	261	262	190	228	281	153	293	292	302	286
Adjusted R^2	0.98	0.94	0.97	0.97	0.97	0.97	0.98	0.98	0.98	0.98

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively against a two sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All the regressions reported above are carried out without an intercept. Sample years are every fifth year from 1970 to 2005. In column 5, Neo-Europe includes Australia, Canada, New Zealand, and the United States. In column 6, omit if $\left|Cooksd_i\right| > 4/n$; in column 7, omit if $\left|DFITS_i\right| > 2\sqrt{k/n}$; and in column 8, omit if $\left|Welschd_i\right| > 3\sqrt{k}$ formulas are used (see Belsley et al. 1980). Here n is the number of observation and k is the number of independent variables including the intercept. The influential observations according to the DFITS formula are EGY1970-1975, EGY2000, IRL2000, JPN1970, JPN2000, JOR1970-1975, JOR1995, MYS1970-1975, MYS2000, MEX1970-1975, MEX1995, CHE2000, THA2000, USA1970, URY1985, and URY1995-2000. The influential observations according to the Cook's Distance formula are all of the above except MYS1970. Influential observations according to the Welsch Distance formula are EGY1970-1975, EGY2000, JOR1970-1975, JOR1990, MEX1970-1975, MEX1995, THA2000, URY1985, and URY2000. In column 9, we drop major oil producers Canada, Egypt, Mexico, and Norway from the sample.

Table 8: Public Capital in Resource Rich Economies: Alternative Data Frequency

	Dependent Variable: Public Capital to GDP [K_{it}^{G}]		
	(1)	(2)	(3)
	OLS Estimates		
	Annual Data	**Three Year Averages**	**Decadal Average**
Log Resource Rent per capita [RR_{it}]	-2.45*** (0.87)	-2.51*** (0.88)	-2.79** (1.06)
Controls:	Log GDP per capita [Y_{it}], Country Dummies, Year Dummies		
Countries	45	45	45
Observations	1391	463	178
Adjusted R^2	0.97	0.98	0.98

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. Sample years are from 1970 to 2005.

Table 9: Resource Rent and Public Investment Management

	PIMI	**PIMI - Appraisal**	**PIMI - Selection**	**PIMI - Implementation**	**PIMI - Evaluation**
	(1)	(2)	(3)	(4)	(5)
	OLS Estimates				
Log Resource Rent per capita in 2000 [RR_{i2000}]	-0.12*** (0.044)	-0.05 (0.09)	-0.12** (0.054)	-0.16*** (0.056)	-0.14** (0.062)
Log GDP per capita in 2000 [Y_{i2000}]	0.38*** (0.053)	0.27** (0.12)	0.41*** (0.071)	0.45*** (0.071)	0.38*** (0.078)
Countries	57	57	57	57	57
Observations	57	57	57	57	57
Adjusted R^2	0.92	0.69	0.89	0.89	0.84

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively against a two sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All the regressions reported above are carried out with an intercept. PIMI implies Public Investment Management Index.

Table 10: Natural Resources and Varieties of Public Capital

	Telephone Lines	Telephone Lines per 100 People	Total Rail Network in Kilometers	Total Road Network in Kilometers
	(1)	(2)	(3)	(4)
	OLS Estimates			
Log Resource Rent per capita [RR_{it}]	-0.04** (0.02)	-0.04** (0.018)	0.02** (0.011)	-0.03** (0.013)
Log GDP per capita [Y_{it}]	0.52*** (0.12)	0.72*** (0.09)	-0.06 (0.08)	0.002 (0.05)
Controls:	Country Dummies, Year Dummies			
Countries	158	158	97	142
Observations	1101	1101	416	380
Adjusted R^2	0.97	0.98	0.98	0.99

Notes: ***, **, and * indicates significance level at 1%, 5%, and 10% respectively against a two sided alternative. Figures in the parentheses are cluster standard errors and they are robust to arbitrary heteroskedasticity and arbitrary intra-group correlation. All the regressions reported above are carried out without an intercept. Sample years are every fifth year from 1970 to 2005.

Table 11: Impact of Natural Resources on Public Capital in the Average Resource Rich Economy in our Sample

Panel A: Average Resource Rich Economy Characteristics	
1. Resource Rent per capita	US$ 24,469/-
2. Public Capital to GDP	52.99 percent
3. Public Investment Management Index (PIMI)	1.7
4. GDP per capita PPP	3429 international dollars
5. Telephone Lines (total)	6791719
6. Telephone Lines per 100 people	18.14
7. Rail Network (total)	15534.4 Kilometers
8. Road Network (total)	451113.2 Kilometers
Panel B: Counter Factual - Ceteris paribus what happens if resource rents per capita decline from US$ 24,469/- to US$ 0.00/- in the Average Resource Rich Economy?	
1. Impact on Public to GDP	30.2 percentage points higher (+)
2. Public Investment Management Index (PIMI)	30 percent higher (=1.2 points more) (+)
3. Impact on Rail Network	2 percent less (=311 Kilometers less) (-)
4. Impact on Road Network	3 percent higher (=13533 Kilometers more) (+)
5. Impact on Telephone Lines	4 percent higher (=Approximately 271669 more telephone lines) (+)
6. Impact on Telephone Lines per 100 people	4 percent higher (=Approximately 0.7 more telephone lines per 100 people) (+)

Notes: The average resource rich economy here is the mean of the sample of countries reported in Appendix A 2.