Extractive Resources and Public Capital in Developing Countries: Does Public-Private Partnership matter?

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Abstract

This paper investigates the relationship between extractive resources and public capital in developing countries. We rely on the IMF public capital new database which distinguishes "full public provision" capital and Public-Private Partnership capital to assess the effect of extractive resources on public capital on a sample of 95 developing countries over the period 1996-2015 using instrumental variables method. The results show that extractive resource exerts a negative effect on full public provision public capital while its effect on public-private partnership capital is positive. These effects are robust regardless of the type of extractive resources considered. Nevertheless, the negative effect of mineral resources is lower compared to energy resources (gas, coal and oil). A focus on the African region shows that both the adverse effect of extractive resources on public capital and its positive effect on public-private partnership capital are stronger. These findings shed some light on the fact that rent-seeking behavior (political or economic) might motivate public investment spending in resource-rich countries. However, "tying the hands" between the private sector and the public sector in investment projects helps to scale-up public capital. The paper calls for a closer look at the scaling-up effect of natural resources on public investment in developing countries claimed in the literature specifically when institutions are weak.

Keywords: Extractive resources, Public capital, Public-Private Partnership
JEL Classifications: P48, Q32.

1 Introduction

The management of natural resources, in developing countries, has received much attention within and beyond academia over the last two decades. For instance, in October 2000, the World Bank joined a consortium[1] to support and finance the Chad-Cameroon Oil Pipeline Project subject to the conditions that "a large part of the oil revenue goes to a Future Generations Fund, health, education and other development projects".[2] However, over the years, the Chadian government has failed to comply with the requirements of the agreement, and in 2008 the World Bank left the consortium.[3]

Within academia, the issue surrounding natural resources management has received a growing interest both theoretically and empirically since the pioneer works by Auty (1994) and Sachs

[1]With ExxonMobil, Petronas Malaysia, and Chevron
[2]https://dietmartemps.com/travel-blog/the-white-elephant-the-trouble-with-foreign-aid-in-africa_384/
[3]Some observers said that Chad government use the oil revenue to buy arms (source:www.dietmartemps.com)

and Warner (1995). This growing and ongoing literature has identified three main mechanisms through which resource wealth can be a curse: the "Dutch disease", the crowding-out effect on human and physical capital and the deterioration of institution quality (Gylfason, 2002). It turns out that these mechanisms are linked to the way the revenues drawn from natural resources are managed. Government spending is one of the closest ways to scrutinize how the "resource curse" operates and how it can be avoided (Bhattacharyya and Collier, 2013).

The empirical studies on the effect of natural resources on public expenditures yield mixed results. On the one side, Cockx and Francken (2014, 2016) support a negative relationship between natural resources wealth and public spending on education and public health, leaving a broad consensus that natural resources are detrimental for government spending on human capital (health and education)[4]. On the other side, Bhattacharyya and Collier (2013) and Karimu et al. (2017) analyzed the effect of the natural resource on public investment. While Bhattacharyya and Collier (2013), on a global sample of 45 countries[5] over the period 1970-2005, found a negative effect of the natural resources on public capital, Karimu et al. (2017) on a sample of 39 Sub-Saharan African countries, claimed that natural resource increases public investment. Besides this discrepancy in the result, Bhattacharyya and Collier (2013) add that good economic and political institutions reduce the adverse effect of the natural resources rents on public capital" whereas Karimu et al. (2017) argue that "the aggregate effect of resource rent on public investment is larger for countries with relatively poor political institutions than countries with stronger institutions" in developing countries. Considering these two contradictory conclusions, a further investigation of the relationship between government investment behavior and natural resources wealth, particularly in developing countries, is required.

Several aspects remain uninvestigated in the current state of the literature on the relationship between natural resources and public investment. First, Karimu et al. (2017) found that the aggregate effect of natural resources is stronger in Sub-Saharan African countries with weaker political institutions. Why would governments in resource-rich countries with weaker institutions invest more than those with stronger institutions Sub-Saharan Africa? Two plausible views[6] might explain this result. The first view is that public investment is higher in resource-rich countries with weak institutions as a result of *ex ante* limited managerial capacity in terms of projects appraisal, selection, implementation, and evaluation in these countries. The volume of public investment is, therefore, higher owing to investment mismanagement in these countries compared to those with higher institutional quality which benefit from their relative effectiveness. Dabla-Norris et al. (2012) provide evidence that Public Investment Management Index (PIMI) is lower in oil-rich countries. The other view is that the high public investment might be resulting from rent-seeking behavior (whether it is political or economic rent). In resource-rich countries, when institutions are poor and hence the control on executives is weak, governments can deliberately choose to increase public investment but in inefficient projects with "negative social surplus" (Robinson and Torvik, 2005). In both cases, the scaling-up effect of public investment claimed in the recent literature on natural resources management in developing countries can be misleading. The increase of public investment might not lead to an effective increase in public capital stock and the volume of money invested can end up being wasted.

Second, the previous studies on public capital assume a full translation of public investment into an increase in public capital stock. However, Keefer and Knack (2007) hypothesize that rent-seeking behavior leads to an increase in public investment in countries with the low institutional quality and warn against the effort to estimate "the growth effects of productive public investment using only observed measures of public investment". Additionally, Gelb (1988) quoted

[4]For further discussion on some nuances see Stijns (2006)

[5]Including three Sub-Saharan African countries: Kenya, Senegal, and South Africa

[6]The authors explain that institutions being correlated with economic development, the marginal effect of an increase in resource rents have less impact on public investment in countries with other alternative sources of financing public investment than those who rely on natural resources. But such a story implies that the endogeneity of institutions is not fully addressed.

by Torvik (2009) documented that "about half of the windfall gains from the OPEC shocks in the 1970s were invested domestically". While any growth model would predict a strong economic growth following the increase in public investment, growth was not only weak, but it was negative in the OPEC countries (Torvik, 2009). Furthermore, Krueger (1974) identifies public investment as one of the major sources of rent-seeking. Investment efficiency is therefore crucial when investigating the effect of natural resources on public investment.

Third, Bhattacharyya and Collier (2013) and Karimu et al. (2017) aggregate natural resources rents although natural "resource curse" literature emphasizes that the type of resource matters. Bhattacharyya and Collier (2013) only distinguished point resource from forest and agricultural resources. However, heterogeneity might still exist when it comes to public capital because of the difference in terms of infrastructure required for resource exploitation. Unlike these previous studies (Bhattacharyya and Collier, 2013; Karimu et al., 2017), we focus on extractive resources[7] and a sample of developing countries. The interest of focusing on extractive resources and developing countries is twofold. Firstly, as extractive resources are nonrenewable (and therefore exhaustible) their management is more challenging in developing countries where the institutions are poor. A mismanagement of these resources fuels social injustice and can lead to internal conflicts (Besley and Persson, 2008; Collier et al., 2004; Dube and Vargas, 2013; Ross, 2004). Secondly, while the policy recommendation for resources management in developed countries is straight forward to establish Sovereign Wealth Funds (SWF); it is recently argued that developing countries should invest resource windfall domestically in order to scale-up their infrastructure gap and sustain their economic development (Van der Ploeg and Venables, 2011; Venables, 2016). A good understanding of the mechanisms that underpin government investment behavior in developing resource-rich countries is imperative to address those challenges.

Finally, extractive resources entail investment in public infrastructures such as railways, roads, and social infrastructures which implicate the private sector in the form of Public-Private Partnership (PPP)[8] investment. Public-private partnership limit rent-seeking behavior and politically motivated investment as compared to full public provision investment. Indeed, private sector participation improves the decision-making process by performing as accountability mechanisms (Takano, 2017). Moreover, PPPs scheme are deemed to bring more efficiency in terms of financing and management for public infrastructure delivery (Ke, 2014; Miraftab, 2004).

The paper bridges two ongoing literature on public investment in developing countries. The first strand of the literature examines public investment efficiency and its implication on economic growth without an interest in natural resources endowment (Barhoumi et al., 2018; Dabla-Norris et al., 2012; Gupta et al., 2014; Pritchett, 2000). The second strand, dedicated to natural resource management in developing countries, analyses the effect of natural resource wealth on public investment but pays little attention to its efficiency (Bhattacharyya and Hodler, 2014; Karimu et al., 2017). Since rent-seeking behavior can motivate public investment in developing countries, considering solely the volume of government spending can be misleading. Indeed, the increase in public investment expenditures does not necessarily lead to an increase in public capital, at least not in the same proportions. Our main contributions to the literature are the followings: (*i*) we distinguish the effect of extractive resources on public capital provided by full public provision and public-private-partnership public capital; (*ii*) our measure of public capital consider a partial translation of public investment into public capital which is more realistic, owing to public investment inefficiency; and (*iii*) we use more disaggregated extractive resources (specifically into oil, coal, natural gas mining) to capture their specificity. As infrastructure required for resource extraction differs according to the resource, it is plausible to expect the

[7]Extractive resources refer to nonrenewable natural resource extracted from the ground such as oil, gas, coal and minerals."

[8]PPP investments "cover spending on various infrastructure services, including energy, water, transport, and telecoms." It relies on data for total PPP projects commitments taken from the European Investment Bank for European countries and the World Bank Private Participation in Infrastructure database for low- and middle-income countries. (IMF, 2017)

government to have different attitudes toward public investment depending on the type of the resource at their disposal.

Using a sample of 95 developing countries over the period 1996-2015 and instrumental variables techniques, our results show two keys findings. On the one hand, extractive resource exerts a negative effect on full public provision capital in developing countries. The size of the effect is varies following the type of resources. The negative effect of mineral resources is lower compared to energy resources (gas, coal and oil). On the other hand, extractive resources are associated with an increase in public-private partnership capital.

The rest of the paper is organized as follow: the second section reviews the literature; the third one describes the data; the fourth section presents the identification strategy; the fifth section presents the results and the last section concludes.

2 Literature review

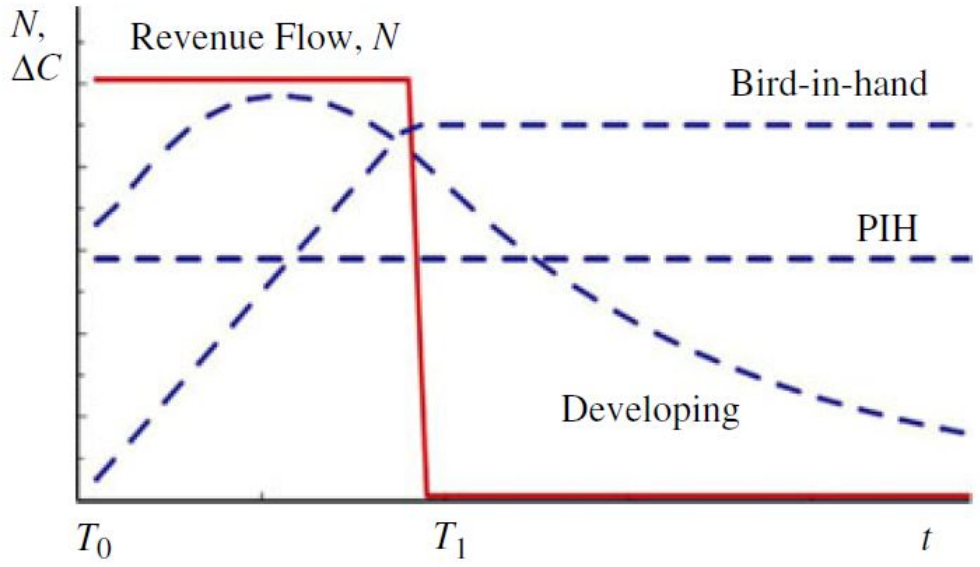
In this section, we present the theoretical background and the empirical studies related to natural resources and government spending.

2.1 The theoretical background

The conventional theories of natural resources management, based on the "Permanent Income Hypothesis" (PIH), recommends that resource rent should be saved in Sovereign Wealth Funds (SWF) to avoid instability inherent to extractive revenue volatility (Bems and de Carvalho Filho, 2011; Barnett and Ossowski, 2002). The policy implication is that after the discovery of a non-renewable resource, the increase in consumption should be equal to the expected annuity of the resource, the rest of the resource windfall being saved to ensure a continuous increase of consumption. A more conservative view of the PIH, the "bird-in-the-hand" approach, recommends that all the resource rents should be saved in sovereign wealth funds, and the consumption increase should be restricted to the interest generated by the rent (Van der Ploeg and Venables, 2011).

While the conservative approaches may limit countries' exposal to macroeconomic instability and ensure inter-generational equity, they have been criticized for overlooking current poverty and capital need in developing countries. A new strand of the literature contextualizes this recommendation. For developing countries facing financial constraints and capital scarcity, investing in domestic economy specifically in physical and human capital offers better pay-offs than saving in SWF (Van der Ploeg and Venables, 2011). Figure 1 shows the resource revenue flows N (in solid line) and the consumption path (in dashed line) for the three policy rules. The resource is extracted for period T_0 to T_1 and the resource is exhausted after T_1. In contrast to developed countries, where both the Permanent income hypothesis and Bird-in-hand hypothesis would be optimal, for developing countries Van der Ploeg and Venables (2011) show that because of capital scarcity and current poverty the optimal policy rule is to increase revenue spending for present generations so that they scale-up their infrastructure gap. This should be materialized in terms of public investment since the essential of the resource rent goes to the government as tax revenue.

However, it is worth noticing that this normative policy rule is what a welfare-maximizing benevolent and far-sighting government would follow as Van der Ploeg and Venables (2011) point out. The public choice theory has shown that governments maximize their own utility functions which often diverge from those of their people. In any case, some stylized facts show that "massive domestic investments have not given growth pay-off" in resource-abundant countries (Torvik, 2009). Gelb (1988) shows, in the cases of six oil-exporting countries (Algeria, Ecuador, Indonesia, Nigeria, Trinidad and Tobago, and Venezuela), that the effects of public investment undertaken between 1975 and 1978 on growth did survive after the windfall. The reason is that



Source: Van der Ploeg and Venables (2011)

Figure 1: Incremental Consumption and Revenue Flow

public investment expenditures fail to effectively increase in public capital networks—the engine of growth. The increase in public investment expenditures might be politically motivated but economically inefficient (Robinson and Torvik, 2005).

Robinson and Torvik (2005) propose a "white elephants" model of public investment based on probabilistic voting and show that economically inefficient investment projects are politically appealing. The inefficient projects have a large political benefit compared to efficient projects. Public investment is a source of rent-seeking activities specifically when institutions are weak. Rent-seeking governments tend to invest in more visible projects or projects that benefit their interest groups which increase their chance to be re-elected. Torvik (2009) argue that politically efficient spending hardly coincides with the economically efficient ones. A way to limit this pure rent-seeking behavior is to tie the link between the private sector and the public sector in public infrastructure provision.

Public-private partnerships are deemed to provide more efficiency in public policies (Ke, 2014; Miraftab, 2004). Besides bringing the expertise required to manage large scale public projects, the public-private partnership may influence project selection as private actors are profit-motivated. Moreover, in the case of resource-rich countries, the infrastructure might be crucial to the exploitation of the resource. Such conditions make public-private partnership investment less sensitive to political interest and henceforth more efficient. Peters (1998) argues that public-private partnership provides both instruments and institutions for public policies.

In the light of this literature, we hypothesize that extractive resources have different impact on public capital depending on whether the private sector is involved or not in the investment project.

2.2 The empirical literature

The resource curse literature identifies three main mechanisms through which the curse occurs (Gylfason, 2002): Dutch-disease through degradation of the competitiveness of domestic economy; a crowding-out effect on capital accumulation (human and physical); and deterioration in the quality of institutions. These different mechanisms are intrinsically linked to the ways natural resource revenue are managed. Thus, public spending is key to understanding the resource curse. According to Bhattacharyya and Hodler (2014), the link between natural resource

rents and public spending gives a direct view of the resource curse than the relationship between resource rent and growth or income. However, the literature on the relationship between natural resources and public spending provides mixed evidence.

Several works analyzed the relationship between natural resource rents and public spending using both its functional and economic classification. From the functional classification side, the literature is interested in the effect of resource rent on education and healthcare spending (Cockx and Francken, 2014, 2016). Cockx and Francken (2014) provide evidence, based on a sample of 140 countries over the period 1995-2009 that natural resource-rich countries tend to spend less on education. Similarly, Cockx and Francken (2016) showed that natural resource dependence exerts an adverse effect on healthcare expenditure. Their study is based on 118 countries over the period 1990-2008. Likewise, some studies showed that natural resource abundance is negatively correlated with human capital accumulation (Behbudi et al., 2010; Gylfason et al., 1999; Gylfason, 2002).

From the economic classification of public spending perspective, the literature investigates the effect of resource rent on public investment expenditure (or public capital) and current consumption expenditure (Berg et al., 2013; Bhattacharyya and Collier, 2013; Karimu et al., 2017; Philippot, 2008). Berg et al. (2013) develop a Dynamic Stochastic General Equilibrium (DSGE) model to assess the effect of the resource rent on public investment. Applying their model to Central African Economic and Monetary Community (CEMAC) region and Angola, they found that the sustainable investment approach can address the resource curse menace. Bhattacharyya and Collier (2013) analyze the effect of resource rent on the public capital over the period 1970-2005. Their results show that resource rents reduce significantly and substantially the stock of public capital. The quality of institutions contributes to mitigating this adverse effect on the public capital stock. Their study relies on a global sample of 45 countries (22 OECD countries and 26 advanced and developing economies among which three Sub-Saharan African countries). However, Karimu et al. (2017) analyze the impact of natural resource rent on public investment on a sample of thirty-nine (39) Sub-Saharan African countries. They found a positive effect of natural resource rents on public investment in Sub-Saharan Africa. The authors add that "the aggregate effect of natural resource rents is larger in countries with weak political institutions".

Our analysis fits into this aspect of the literature and is mostly related to Bhattacharyya and Collier (2013) and Karimu et al. (2017). We rely on the IMF's new public capital dataset which has two advantages. First, the data assume a partial transmission of public investment into public capital in the perpetual inventory equation. Assuming a full transmission of public investment into public capital is not a good way to measure public capital. In fact, an increase in public investment expenditure might be resulting from rent-seeking behavior (whether it is political or economic rent). In resource-rich countries, when institutions are poor and hence the control on executives weak, governments can deliberately choose to increase the public investment but in inefficient projects with "negative social surplus" (Robinson and Torvik, 2005). Also, developing countries are deemed to have limited managerial capacity in terms of project appraisal, selection, implementation, and evaluation. A surge in public investment expenditures resulting from resource windfalls might not be fully translated into public capital. Dabla-Norris et al. (2012) provide evidence that Public Investment Management Index (PIMI) is lower in oil-rich countries. In all cases, the scaling-up effect of public investment based on investment expenditures in developing countries can be misleading. The increase of public investment does not lead to an effective increase in public capital stock and the volume of money invested can end up being wasted. Second, the data distinguish full public provision's public capital and public-private partnership capital. Using this dataset allows analyzing the role of public-private partnership in the relationship between extractives resources and public capital. Indeed, extractive resources entail investment in public infrastructures such as railways, roads, and social infrastructures which implicate the private sector in the form of Public-Private Partnership (PPP) investment.

Public-private partnership limits rent-seeking behavior and politically motivated investment as compared to full public provision investment. Indeed, private sector participation improves the decision-making process by performing as accountability mechanisms (Takano, 2017). Moreover, PPP schemes are deemed to bring more efficiency in terms of financing and management for public infrastructure delivery (Ke, 2014; Miraftab, 2004). Moreover, we investigate the role of different types of institutional quality. Bhattacharyya and Collier (2013) consider democracy (polity 2 index) and the constraints on executive developed by Hall and Jones (1999) which capture mainly the political aspects of institutions. Precisely, we examine contractual institutions (Azomahou et al., 2018; Nunn, 2007) such as the rule of law and regulatory quality, political institutions such as voice and accountability and political stability & absence of violence, governance quality like corruption and government effectiveness; and their interactions with each type of extractive resources. By large, the literature on natural resources and public investment does not consider enough the type of resources, the role of the private sector and public investment efficiency although the recent literature on public investment and growth highlights the importance of the efficiency of the investment. This is important, specifically, in developing countries with weak institutions (Keefer and Knack, 2007; Torvik, 2009). For instance, Pritchett (2000) documented 31 projects financed by the World Bank at the cumulative cost of 915 million $US that achieved the median rate of return of zero in one Sub-Saharan African country between 1972 and 1991.[9]

3 Data and Descriptive Analyses

This section defines the variables used, describes the data and their sources. We discuss the measures of public capital, extractive resources, institutional and the other control variables. The sample covers 95 developing countries for which the data for our main variables are available over the period 1996-2015.

3.1 Measuring Public Capital

A large part of the empirical literature on public capital uses public investment expenditures because of the lack of data on public capital, specifically for developing countries despite several warnings (Dabla-Norris et al., 2012; Gupta et al., 2014; Kamps, 2006; Keefer and Knack, 2007; Pritchett, 2000). Besides the fact that not all public investment is fully translated into public capital, it is more the stock of public capital network than the additions to it that provide productive services (IMF, 2017); hence the interest of considering public capital stock per capita.

Kamps (2006) provides a first attempt to build public capital stock data based on "the perpetual inventory equation" (equation 1 below) for 22 OECD countries over the period 1960-2001.

$$K_{it} = K_{it-1} - \delta_{it} \times K_{it-1} + I_{it} \tag{1}$$

Where K_{it} is the country public capital stock at time t, I_{it} the current public investment and δ_{it} the depreciation rate.

Based on Kamps (2006)'s methodology, Arslanalp et al. (2010) estimate public capital stock on a sample of 48 countries including OECD and developing countries. Bhattacharyya and Hodler (2014) used this dataset. However, the dataset covers only 26 developing countries among which three Sub-Saharan African countries and the method implies a full transformation of public investment to public capital.

[9]The anecdotal cases include the World Bank financed Morogoro Shoe factory in Tanzania which cost $40 million and peak production was 4% of planned capacity (Pritchett, 2000); the Industrial Development Corporation of Zambia; Nigeria Tinapa project which cost $450 million; Yamoussoukro basilica (the world biggest religious edifice) and Senegal monument of "African renaissance" ($27 million).

In the present study, we use the new dataset of public capital developed by the IMF (IMF, 2017). This dataset covers 170 (developed and developing) countries. Apart from covering a large sample of developing countries, the dataset has the advantages for distinguishing "full public provision" investment from public-private partnership (PPP) investment and its "perpetual inventory equation" (equation 2 below)is more flexible than that of Kamps (2006) and Arslanalp et al. (2010) as public investment is not considered to be fully translated into public capital $[(1 - \delta_{it}/2)<1]$.

$$K_{it} = K_{it-1} - \delta_{it} \times K_{it-1} + (1 - \delta_{it}/2) \times I_{it} \tag{2}$$

Our measure of public capital relies on these data which do not assume a full transmission of public investment expenditure into public capital. Doing so, we are able to identify the effect of extractive resources on an effective change in public capital. The procedure remains the same for Public-Private Partnership capital data.

Figure 2 shows the evolution of the average full public provision public capital per capita and public-private partnership public capital per capita over the period 1996-20015. Both variables are evolving in two stages. Public-private partnership capital experienced a sharp increase before 2002 and a slow-down after this year. In return full public provision public capital per capita encountered a relatively slow growth before 2007 and an acceleration from 2006. Public-private partnership capital is low compared to full public provision public capital it grows at a higher rate. These trends might be explained by the 2007 financial crisis. The weakening of the momentum of investment in partnership with the private sector could be driven by the crisis of 2007-2008.

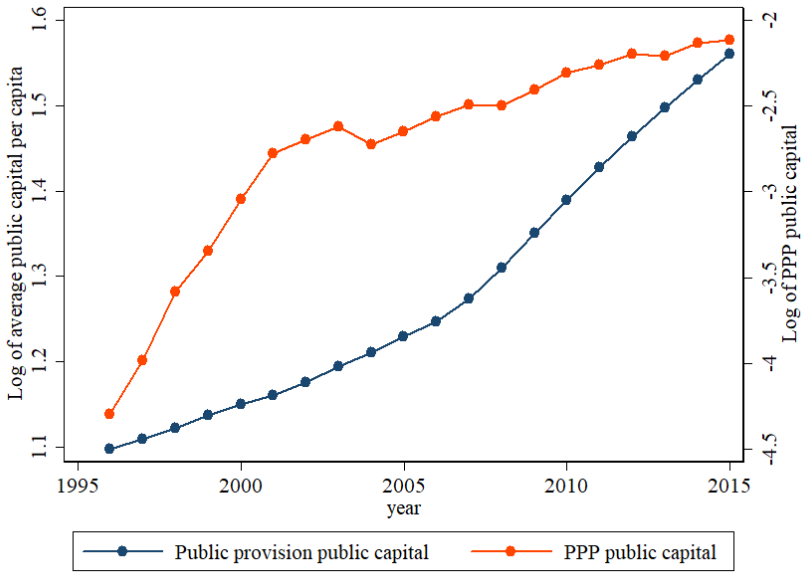


Figure 2: Evoltion of public capital per capita

3.2 Measuring extractive resource wealth

A plethora of measures have been used in the literature to assess natural resources wealth. Some of these measures turn out to capture resource dependence rather than measures of resource abundance. Resource dependence refers to the degree to which a country relies on resource revenues whereas resource abundance refers to a country's estimated finite endowment of subsoil wealth (Badeeb et al., 2017; Brunnschweiler, 2008). These measures include primary exports as share of total export (Sachs and Warner, 1995), primary exports per worker (Lederman and Maloney, 2003), resource exports as share of merchandise exports (Davis, 1995), ratio of resource

rents to GDP (Stijns, 2006) and subsoil resource wealth (Ding and Field, 2005; Brunnschweiler, 2008).[10] The resource export over total exports (or GDP) is the most widespread in the literature. As we can expect, a high share of natural resource in national income (or exports) for a given country can be less informative in terms of its resource wealthiness specifically in developing countries when the size of the economy is smaller and export less diversified. It can be the byproduct of previous economic policy choices and therefore endogenous.

In this paper, we measure extractive resource by the resource rents normalized by the population instead of the GDP (or the exports) to limit the influence of the economic conditions. Additionally, as in Bhattacharyya and Collier (2013), we use commodity price indices as instruments of resource rents to deal with the endogeneity. The resource rents data are from the World Development Indicators. Extractive resources prices data are determined on the international market and are therefore less likely to be correlated to countries' domestic economic conditions. Moreover, change in extractive resources revenue depends on the variation of resource prices. The resource price is hence a relevant instrument for extractive resource endowment. The data on resource prices are from the IMF commodity price index dataset.

Table 1 shows the correlation between resource rent per capita and resource prices. There is a positive and strongly significant (at 1% significance level) correlation between resource *per capita* and their prices.

Table 1: Correlation Matrix of resources and resource prices

	Oil rents	Mineral rent	Gas rents	Coal rents	Oil Price	Metal price	Gas Price	Coal Price
Oil rents	1							
Min. rent	-0.0283	1						
Gas rents	0.599***	-0.0206	1					
Coal rents	-0.0211	0.187***	-0.0106	1				
Oil Price	0.118***	0.184***	0.111***	0.147***	1			
Min. price	0.109***	0.190***	0.105***	0.150***	0.950***	1		
Gas Price	0.115***	0.156***	0.0977***	0.145***	0.920***	0.796***	1	
Coal Price	0.109***	0.170***	0.0926***	0.184***	0.893***	0.896***	0.839***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 3 displays the evolution of the average oil, natural gas, coal and mineral resources rent per capita. Three global trends are observed over the period 1996-2015: a stagnation before 2000; a sharp increase between 2000 and 2007 and slow-down and even decrease after 2007. Mineral resource rent experiences spectacular growth between 2002 and 2008 and has become the first source of rents since 2008. The increase in coal rent is relatively small.

3.3 Measuring Institutions

To investigate how institutions shape the relationship between extractive resources and public capital we consider a broader set of institutional quality. We are interested specifically on how the interaction between contractual institutions and specific extractive resource affect public capital accumulation. We measure contractual institutions using *rule of law* and *regulatory quality*. The additional set of institutional variables include control of corruption, government effectiveness (for economic institutions), political stability and voice and accountability (for political institutions). The data are gathered from the World Governance Indicators (Kaufmann et al., 2011).

[10] For further discussion on the measures of resource wealth see Badeeb et al. (2017), Brunnschweiler (2008) and Stijns (2006).

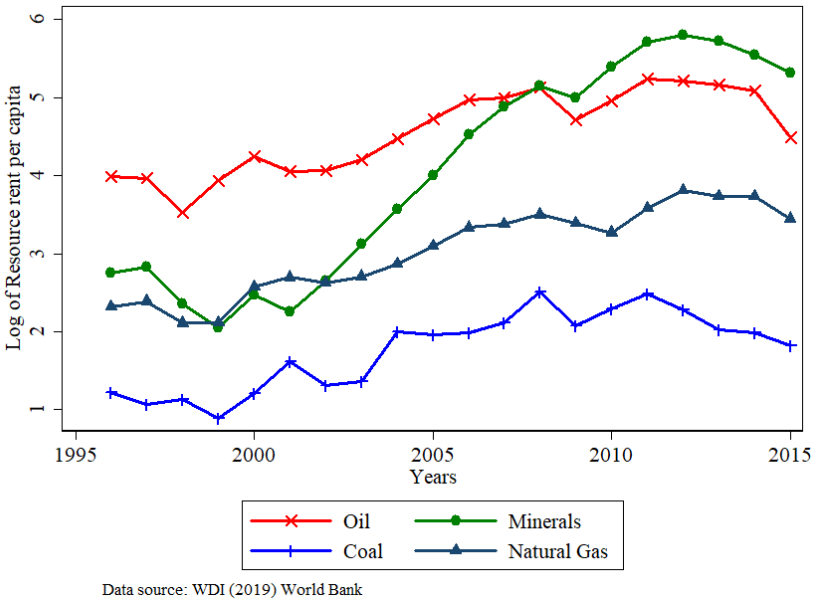


Figure 3: Evoltion of extractive resource rents per capita

3.4 Other control variables

The previous literature on the determinants of public investment (Berg et al., 2013; Bhattacharyya and Collier, 2013; De Haan et al., 1996; Karimu et al., 2017; Kotera and Okada, 2017; Shelton, 2007; Sturm, 2001) guide the choice of control variables included in the model. This literature considers, the GDP *per capita*, private investment, foreign aid, openness to trade and absorptive capacity as the main determinants of public investment (public capital).

The GDP *per capita* controls for level of development (Karimu et al., 2017; Sturm, 2001). The expected sign is positive. The higher the level of development of a country, the more it can afford to finance public capital effectively.

Foreign aid is resources for financing domestic economy. Donors often target aid to improvement of the economic environment and investment in health and education (Karimu et al., 2017). Also, aid can alleviate idiosyncratic shocks that affect the domestic economy (Sturm, 2001). We measure foreign aid by net ODA received *per capita*. Thus, we expect a positive relationship between foreign aid and public capital.

Openness to trade, not only, eases capital goods importation but also increases the demand for public investment specifically on infrastructure (Sturm, 2001). Indeed, to be competitive in the international market the domestic economy needs to invest in its infrastructure. Countries that are opened to trade are likely to increase their investment in public capital. The sum of export and import of goods and services as percent of GDP measure the openness to trade.

We also control for private capital. Theoretically, private investment can complement or substitute public capital. The net effect of private investment depends on the size of each effect. We expect a net positive effect of private investment on public capital because the private sector is still underdeveloped in developing countries and is likely to complement rather than crowd out to public capital (Shonchoy et al., 2010).

Public debt can contribute to financing public capital. However, high public debt increases debt burden and limit country capacity to finance public capital. We use public and publicly guaranteed external debt stock that we normalize by the size of the population.

Absorptive capacity matters for public investment spending management (Berg et al., 2013). We use tertiary school enrollment as a proxy of administrative capacity. Table A1 in Appendix presents detail information about the data sources as well as the definition of the variables.

4 Estimation strategy

4.1 Preliminary test

We conduct a panel unit root test on all our variables using Fisher-type tests. The Fisher-type tests combine the p-values from the panel-specific stationarity tests using the four methods proposed by (Choi, 2001). We use two lags in the ADF regressions and remove the cross-sectional means. We include the drift because of the nonzero mean of our variable but we do not include the trend. Removing the cross-sectional mean as suggested by Levin et al. (2002) mitigate the impact of cross-sectional dependence. All the four statistics strongly reject the null hypothesis that "all the panels contain unit root". Hence, we do not suspect our panel to be cointegrated. Choi (2001) shows that the inverse normal Z statistic offers the best trade-off between size and power and recommends it in applications. Thus, we report only the inverse normal Z statistics in table A3 in appendix.

4.2 Empirical Model

This section presents the empirical model, the estimation methods adopted to identify the relationship between extractive resources and public capital. As we are interested in the role of institutions in this relationship, we estimate the following equation 3:

$$K_{it} = \alpha_i + \phi_t + \gamma_1 ER_{it} + \gamma_2 Inst_{it} + \gamma_3 ER_{it} \times Inst_{it} + X'_{it}\Lambda + \epsilon_{it} \tag{3}$$

where our dependent variable K_{it} denotes public capital stock *per capita* for country i at year t. ER_{it} and $Inst_{it}$ denote respectively our variables of interest extractive resources and institutional quality. We add an interactive term ($ER_{it} \times Inst_{it}$) to estimate effect of extractive resources on public capital conditional to institutional quality. The idea is that the effect of extractive resources on public capital differs according to the quality of institutions. Indeed, the previous literature (Bhattacharyya and Collier, 2013; Karimu et al., 2017) suggests that the relationship between natural resources and public capital is conditional to institutional quality. X'_{it} is a set of our control variables and Λ the vector of associated parameters. α_i and ϕ_t are respectively country fixed and time fixed effects. $\gamma_{i,i=1,2,3}$ are our parameters of interest to be estimated.

Identifying the effect of extractive resources on public capital is challenging for a couple of reasons. First, considerable variability of extractive resource rents both across countries and over time might affect the results. To cope with this issue, we normalized public capital and extractive resource variables with the size of the population and the natural log. The estimated coefficients are elasticities. Second, endogeneity might be a serious concern in this relationship. A large share of extractive resources rents might reflect countries economic conditions rather than resource wealth. We resort to instrumental variables methods to deal with this problem. In particular, we use the prices of extractive resources and its first lag as instruments for resource rents. The variability in resource price determines that of resource rents for a given country. But we do not expect resource price to be influenced by country domestic conditions; at least countries' public capital. The rationale behind introducing the lag is that countries (or companies) anticipate resource price and can manage to sell when the prices increase with limited storage capacity (physical or financial). We rely on two Stage Least Square (2SLS) method to estimate equation 3. Nevertheless, as robustness, we use Limited information maximum likelihood method as well.

For equation 3 to be properly identified, the instruments should satisfy two conditions. First, extractive resources prices must be correlated with resource rents. Second, the variations in extractive resources prices affect public capital only through resource rents. In other words, the extractive resources prices must be uncorrelated with the error terms.

We test whether our instruments satisfy the first condition using Kleibergen and Paap (2006)'s LM statistic. It tests the correlation between the excluded instrument and the endogenous regressors. The null hypothesis is that "the minimal canonical correlation between

the endogenous variables and the instruments is statistically different from zero" (Bazzi and Clemens, 2013). For the model to be identified the null hypothesis might be rejected. Also, as weak instruments are biased towards OLS estimates, we report the F-statistic from the first stage to examine the strength of our instruments. The rule of thumb is that the F-statistic value should greater or equal to 10 (Stock and Yogo, 2005; Staiger and Stock, 1997).

Further, we report Hansen J statistics (Hansen and Singleton, 1982) to test whether our instruments satisfy the exogeneity restriction. The joint null hypothesis is that the instruments are uncorrelated with the error terms and that the excluded instruments are properly excluded from the second stage regression. A rejection of the null hypothesis means that the instruments might be invalid, but its non-rejection does not necessarily mean that the exclusion restriction is satisfied.

5 Baseline Results

In this section we present the results of the aggregated extractive resources on public capital (5.1); then we desaggregate into each type of extractive resources (5.2) before turning to Public-Private Partnership public capital (5.3) and a focus Africa region (5.4).

5.1 Results from Aggregated Extractive Resources

Tables 2A and 2B bellow present the results of the regressions for equation 3 using two-stage least squares (2SLS) method with resource prices and its lag as instruments for resource rents. The dependent variable is public capital per capita. The governance variable in table 2A are voice and accountability, political stability and government effectiveness while in table 2B we use regulatory quality, rule of law, and control of corruption as institutional variables.

Most of the control variables are significant and have the expected signs. Economic development increases public capital per capita. On average, 1% increase in GDP per capita significantly increases public capital per capita by about 0.55%. This result is in line with that of Bhattacharyya and Hodler (2014) for which high income eases public capital accumulation. Private capital creates a leverage effect on public capital. The effect is significant at 1% level in all the specifications in table 2A and table 2B. 1% increase in private capital per capita increases public capital by 0.4%. In fact, a dynamic private sector increases government incentive to invest in public capital for domestic economy competitiveness. Karimu et al. (2017) found the same result although the effect was not significant. Openness to trade increases public capital. This result is similar to Karimu et al. (2017). Surprisingly, the effect of aid is negative and insignificant. This might be related to the fact that aid is mostly targeted to social expenditures. Public debt is harmful to public capital accumulation in most of the regressions. However, the effect is insignificant since we interact extractive resources with governance variables (column 2, 4, and 6 in table 2A and column 8 and 10 in table 2B. Our control of administrative capacity, tertiary school enrollment, has a positive and significant effect on public capital accumulation. Countries that benefit from a high rate of university school enrollment are more likely to be able to hire competent civil servants and therefore have good capacity to handle projects selection, appraisal, monitoring and execution. Good administrative capacity helps to address absorptive capacity for efficient investment expenditures.

The effect of extractive resources on public capital is negative and significant at 1% level. The coefficients associated with the extractive resources are comprised between -0.035 (column 9 table 2) and -0.098 (column 6 table 2). On average, an increase of 1% in extractive resources leads to 0.06% decrease in public capital per capita.

We investigate the role of governance using World Governance Indicators six variables of governance which are voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption. Not only that these aspects of governance

affect positively public capital but also the effect tend to be sizable in the context of extractive resources.

Table 2A: Extractive Resources and Public Capital

	Dependent variable: Log of Public capital per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of GDP pc	0.605***	0.422***	0.552***	0.408***	0.546***	0.526***
	(0.108)	(0.111)	(0.110)	(0.116)	(0.115)	(0.117)
Log of Private Capital pc	0.344***	0.380***	0.348***	0.352***	0.357***	0.380***
	(0.0587)	(0.0610)	(0.0582)	(0.0571)	(0.0578)	(0.0576)
Openess to trade (Log)	0.124***	0.0728*	0.127***	0.0889**	0.122***	0.0892**
	(0.0391)	(0.0404)	(0.0385)	(0.0404)	(0.0385)	(0.0371)
Log Aid per capita	-0.00698	-0.0171	-0.00620	-0.0335***	-0.00656	-0.0226*
	(0.0148)	(0.0137)	(0.0144)	(0.0129)	(0.0147)	(0.0131)
Log of public Debt per capita	-0.0525***	-0.0183	-0.0449**	0.0114	-0.0548***	-0.0246
	(0.0195)	(0.0182)	(0.0195)	(0.0200)	(0.0191)	(0.0198)
Shool enrollement (tertiary)	0.135***	0.112***	0.134***	0.132***	0.140***	0.123***
	(0.0303)	(0.0316)	(0.0296)	(0.0299)	(0.0301)	(0.0304)
Log of Extractive Resources pc	**-0.0630*** **	**-0.0670*** **	**-0.0559*** **	**-0.0687*** **	**-0.0579*** **	**-0.0958*** **
	(0.0148)	**(0.0159)**	**(0.0147)**	**(0.0161)**	**(0.0149)**	**(0.0208)**
Voice and Accountability	**0.0459**	**0.417*** **				
	(0.0300)	**(0.0962)**				
lnextractxVA		**-0.0516*** **				
		(0.0124)				
Political Stability			**0.0445*** **	**0.411*** **		
			(0.0172)	**(0.0816)**		
lnextractxPS				**-0.0558*** **		
				(0.0120)		
Government Effectiveness					**0.108*** **	**0.651*** **
					(0.0367)	**(0.151)**
lnextractxGE						**-0.0798*** **
						(0.0221)
Observations	1120	1120	1120	1120	1120	1120
Number of countries	95	95	95	95	95	95
KP LM Statistic (P-value)	0.000	0.000	0.000	0.000	0.000	0.000
KP F Statistic	58.79	41.85	58.95	42.20	56.06	35.52
Hansen J-Statistic (P-value)	0.947	0.411	0.765	0.562	0.853	0.928

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 2B: Extractive Resources and Public Capital (continued)

	Dependent variable: Log of Public capital per capita					
	(7)	(8)	(9)	(10)	(11)	(12)
Log of GDP pc	0.543***	0.515***	0.371***	0.275**	0.599***	0.536***
	(0.107)	(0.113)	(0.109)	(0.115)	(0.111)	(0.114)
Log of Private Capital pc	0.358***	0.382***	0.402***	0.421***	0.341***	0.356***
	(0.0570)	(0.0588)	(0.0576)	(0.0602)	(0.0570)	(0.0573)
Openess to trade (Log)	0.107***	0.0834**	0.0914**	0.0504	0.128***	0.118***
	(0.0375)	(0.0369)	(0.0360)	(0.0410)	(0.0391)	(0.0385)
Log Aid per capita	-0.00726	-0.0140	-0.0189	-0.0244*	-0.00449	-0.00736
	(0.0141)	(0.0133)	(0.0136)	(0.0129)	(0.0150)	(0.0143)
Log of public Debt per capita	-0.0616***	-0.0264	-0.0339*	0.00234	-0.0519***	-0.0366*
	(0.0195)	(0.0205)	(0.0180)	(0.0181)	(0.0198)	(0.0193)
Shool enrollement (tertiary)	0.144***	0.109***	0.127***	0.116***	0.138***	0.130***
	(0.0296)	(0.0344)	(0.0286)	(0.0305)	(0.0304)	(0.0312)
Log of Extractive Resources pc	**-0.0587*** **	**-0.0808*** **	**-0.0352** **	**-0.0545*** **	**-0.0639*** **	**-0.0825*** **
	(0.0143)	**(0.0162)**	**(0.0139)**	**(0.0161)**	**(0.0146)**	**(0.0172)**
Regulatory Quality	**0.143*** **	**0.564*** **				
	(0.0363)	**(0.130)**				
lnextractxRQ		**-0.0661*** **				
		(0.0185)				
Rule of Law			**0.348*** **	**0.686*** **		
			(0.0386)	**(0.123)**		
lnextractxRL				**-0.0547*** **		
				(0.0167)		
Control of Corruption					**0.0317**	**0.310** **
					(0.0372)	**(0.122)**
lnextractxCC						**-0.0409** **
						(0.0178)
Observations	1120	1120	1120	1120	1120	1120
Number of countries	95	95	95	95	95	95
KP LM Statistic (P-value)	0.000	0.000	0.0449	0.000	0.000	0.000
KP F Statistic	61.12	39.90	59.61	40.06	58.51	40.38
Hansen J-Statistic (P-value)	0.978	0.845	0.946	0.663	0.917	0.805

Robust standard errors in parentheses *** p < 0.01, ** p<0.05, * p<0.1

5.2 Extractive Resources and Public Capital: Does the type of resource matter?

In table 3 we investigate the specificity of each type of resources. Most of the control variables remain significant. We consider the rule of law as our institutional variable. However, the results are similar with the other governance indicators. The results show that all the extractive resources exert an adverse effect on public capital per capita. But the size of the effect differs. Natural gas has the highest negative and significant effect on public capital whereas mining resources (metal and mineral) have a lower negative effect. These heterogeneities shed light on the importance of considering the type of resources. Regardless of the resources considered, extractive resources are negatively associated to public capital accumulation.

To sum up, extractive resources exert an adverse effect on public capital in developing countries regardless of the type of resource even though the size of the negative effect vary following the resource; the higher being natural gas while mining is less harmful to public capital. However, an important aspect of extractive resources we should keep in mind is that the exploitation of some of them required public infrastructures such as road, electricity supply and railway more than others. Their exploitation might entail the supply of these infrastructures. These often take place as a public-private partnership (PPP) investment.

Table 3: Extractive Resources and Public Capital: Does the type of resource matter?

	Dependent variable: Log of Public capital per capita							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of GDP pc	0.399***	0.411***	0.416***	0.427***	0.400***	0.403***	0.402***	0.472***
	(0.0618)	(0.0637)	(0.0573)	(0.0544)	(0.0644)	(0.0601)	(0.0581)	(0.0668)
Log of Private Capital pc	0.101**	0.0131	0.0657*	0.0584*	0.0815**	0.0903**	0.0697*	0.0548
	(0.0401)	(0.0560)	(0.0363)	(0.0336)	(0.0401)	(0.0362)	(0.0360)	(0.0371)
Openess to trade (Log)	-0.0242*	-0.0334**	-0.0224	-0.0245*	-0.0280**	-0.0296**	-0.0262**	-0.0171
	(0.0139)	(0.0138)	(0.0140)	(0.0129)	(0.0143)	(0.0146)	(0.0129)	(0.0155)
Log Aid per capita	-0.0170	0.0424**	-0.0281	-0.00241	-0.0606***	-0.0202	-0.00967	0.00565
	(0.0169)	(0.0212)	(0.0185)	(0.0175)	(0.0226)	(0.0247)	(0.0172)	(0.0179)
Log of public Debt per capita	0.385***	0.177	0.306***	0.242**	0.470***	0.453***	0.321***	0.141
	(0.121)	(0.129)	(0.107)	(0.104)	(0.129)	(0.125)	(0.0953)	(0.108)
Log of tertiary school enrollement	0.0860***	0.107***	0.113***	0.113***	0.134***	0.121***	0.0992***	0.101***
	(0.0304)	(0.0320)	(0.0283)	(0.0273)	(0.0312)	(0.0321)	(0.0275)	(0.0285)
RuleofLaw	0.293***	0.955***	0.377***	0.521***	0.323***	0.605***	0.363***	0.617***
	(0.0533)	(0.210)	(0.0366)	(0.0626)	(0.0489)	(0.137)	(0.0377)	(0.0948)
lnoilpc	**-0.0556****	**-0.0861****						
	(0.0261)	**(0.0338)**						
lnoilxRL		**-0.134*****						
		(0.0409)						
lnminpc			**-0.0166**	**-0.0355*****				
			(0.0101)	**(0.0115)**				
lnminxRL				**-0.0358*****				
				(0.0104)				
lngaspc					**-0.113*****	**-0.184*****		
					(0.0351)	**(0.0438)**		
lngasxRL						**-0.128****		
						(0.0506)		
lncoalpc							**-0.0414****	**-0.0876*****
							(0.0187)	**(0.0249)**
lncoalxRL								**-0.120*****
								(0.0358)
Observations	1126	1126	1127	1127	1124	1124	1124	1124
Number of countries	95	95	95	95	95	95	95	95
KP LM Statistic (P-value)	0.033	0.000	0.041	0.000	0.000	0.000	0.039	0.000
KP F Statistic	23.77	13.14	91.10	52.56	26.48	12.04	47.45	24.17
Hansen J-Statistic (P-value)	0.179	0.873	0.0866	0.0744	0.767	0.472	0.712	0.205

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.3 Does Public-Private Partnership mitigate "the curse on public capital"?

Table 4 reports the results of the regression of extractive resources on Public-Private Partnership capital. In the first column, we have all of the extractive resources (oil, mining coal and natural

gas) and in the following column, we disaggregate extractive resources into oil, mining, natural gas and coal respectively.

We can notice that extractive resources are positively related to PPP capital while its effects on public capital are negative. This result sheds some light on the capacity of the private sector to monitor public investment so that the government will reduce spending on wasteful projects.

An increase in extractive resources by 1% leads to an increase in PPP capital by 0.23% on average. The scope of the effect differs from the type of resource. Natural gas has the highest effect on PPP capital per capita followed by oil, natural gas and mining respectively.

Table 4: Extractive Resources and PPP Capital: is it a solution?

	Dependent variable: Log of Public-Private Partnership Capital				
	(1)	(2)	(3)	(4)	(5)
Log of GDP pc	1.013***	0.811*	1.197***	0.470	1.438***
	(0.376)	(0.450)	(0.391)	(0.500)	(0.383)
Log of Private Capital pc	0.288	0.523**	0.0548	0.269	0.0622
	(0.204)	(0.257)	(0.185)	(0.242)	(0.199)
Openess to trade (Log)	-0.0381	-0.0937	0.0830	-0.00284	0.0474
	(0.111)	(0.118)	(0.129)	(0.127)	(0.120)
Log Aid per capita	0.0862**	0.0879*	0.0907**	0.0948*	0.122***
	(0.0433)	(0.0481)	(0.0412)	(0.0507)	(0.0416)
Log of public Debt per capita	-0.0423	-0.0964	-0.0159	0.153*	-0.0948
	(0.0704)	(0.0713)	(0.0719)	(0.0910)	(0.0694)
Log of tertiary school enrollement	0.209*	0.444***	0.350***	0.267**	0.514***
	(0.122)	(0.104)	(0.117)	(0.114)	(0.106)
RuleofLaw	0.369**	0.469**	0.0831	0.459**	0.0535
	(0.172)	(0.210)	(0.158)	(0.198)	(0.167)
lnextractpc	**0.229*** **				
	(0.0601)				
log of oil rents per capita		**0.379*** **			
		(0.103)			
log of mineral rents per capita			**0.139*** **		
			(0.0464)		
log of natural gas rents per capita				**0.435*** **	
				(0.113)	
log of coal rents per capita					**0.150***
					(0.0801)
Observations	870	876	876	873	873
Number of countries	83	83	83	83	83
KP LM Statistic (P-value)	0.000	0.000	0.011	0.000	0.069
KP F Statistic	54.67	35.81	48.05	28.96	30.68
Hansen J-Statistic (P-value)	0.093	0.000	0.643	0.460	0.132

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

5.4 A regional focus: the case of Africa

In this section, we focus our analysis on Africa for at least two reasons. Firstly, because among developing regions, the case of Africa is more problematic. African extractive resources wealthiness contrast with its endemic poverty and its development level as compared to the other regions of the world. The continent accounts for about 30% of the world mineral reserves and; 8% and 7% for oil and natural gas proven reserves respectively (AfDB). Also, the extractive sector has a significant contribution to public finance in Africa.[11]. However, simulating the effect of

[11] An average minerals account for 70% of African total exports and about 28% of GDP. African Development Bank (AfDB) estimates that Africa's extractive resources will contribute over USD 30 billion per annum in

commodity boom on a typical African commodify exporter, Collier and Goderis (2007) find that "if global history repeats itself, after two decades output will be around 25 percent lower than it would have been without the booms." Moreover, Carmignani and Chowdhury (2010) study "the nexus between natural resources and growth in Sub-Saharan Africa (SSA) and find that **SSA is indeed special: resources dependence retards growth in SSA, but not elsewhere**". For to Collier (2010) natural resources constitute an opportunity and "the economic future of Africa will be determined by whether this opportunity is seized or missed".

Secondly, according to the World Bank[12], closing Sub-Saharan Africa infrastructure gap (both quantity and quality) could increase GDP *per capita* growth by 2.6% per year. Understanding how extractive resources can contribute to building good quality infrastructure for sustained economic growth is an important economic policy issue for Africa.

In table 5 we regress equation 3 on 40 African countries. The results are similar to those found with the all sample. Extractive resources exert an adverse effect on public capital. On average, the negative effect is even stronger in the case of African countries than in the global sample of developing countries. The control variables remain significant and have the expected signs. Openness to trade, private capital and GDP per capita have a positive effect on public capital in Africa. Unlike in the full sample regressions where the effect of aid is negative and non-significant, the effect of aid on public capital per capita in Africa is positive and strongly significant. However, the role of institutions is mixed. Political stability and rule of law have a positive effect on public capital while the effect of voice and accountability, regulatory quality and government effectiveness is non-significant. The effect of corruption is negative and significant which is counter-intuitive.

In table 6 we regress equation 3 on 30 African countries where we have data on public-private partnership capital data. Here again, the results are similar to those in table 4. Extractive resources exert a positive effect on public capital. On average, the positive effect of extractive resources on public-private partnership capital in Africa is higher than developing countries average.

Some of the control variables are no longer significant. Opposite to public capital, aid and private capital have a non-significant effect on public private partnership capital. This result is expected since aid is mostly given to governments rather than the private sector. Openness to trade has a negative and significant effect on public-private partnership capital per capita. The effect of public debt is negative but not significant in all the regressions. Here again, the effect of institutions depends on the type of institution. Voice and accountability and Political stability affect positively the public-private partnership capital per capita while the effect of rule of law, regulatory quality, government effectiveness and corruption is non-significant.

Summing up, we found that in the sample of African countries, extractive resources exert an adverse effect on public capital and positive effect on public-private partnership public capital. The negative effect on public capital is stronger in Africa than the sample of developing countries while the positive effect on public-private partnership is stronger in Africa than in the developing countries on average.

government revenue for the next 20 years

[12] https://www.africa.com/closing-africas-infrastructure-gap/

Table 5: African sample regressions: Public capital per capita

	Dependent variable: Log of Public capital per capita					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of Private Capital pc	0.380***	0.435***	0.396***	0.410***	0.470***	0.382***
	(0.112)	(0.110)	(0.108)	(0.108)	(0.112)	(0.101)
Openess to trade (Log)	0.418***	0.323***	0.396***	0.352***	0.257**	0.458***
	(0.146)	(0.120)	(0.134)	(0.124)	(0.115)	(0.132)
Log Aid per capita	0.0831**	0.0675*	0.0811**	0.0716**	0.0577*	0.0944***
	(0.0365)	(0.0345)	(0.0370)	(0.0339)	(0.0322)	(0.0356)
Log of public Debt per capita	-0.0581	-0.0341	-0.0550	-0.0484	-0.0112	-0.0922**
	(0.0356)	(0.0316)	(0.0338)	(0.0322)	(0.0305)	(0.0373)
Log of GDP pc	1.157***	0.950***	1.131***	1.038***	0.725***	1.372***
	(0.232)	(0.199)	(0.225)	(0.207)	(0.196)	(0.228)
Shool enrollement (tertiary)	0.0344	0.0371	0.0336	0.0318	0.0420	0.0355
	(0.0475)	(0.0444)	(0.0476)	(0.0452)	(0.0425)	(0.0488)
Log of Extractive Resources pc	**-0.102*** **	**-0.0773*** **	**-0.101*** **	**-0.0866*** **	**-0.0592** **	**-0.128*** **
	(0.0347)	**(0.0292)**	**(0.0349)**	**(0.0307)**	**(0.0286)**	**(0.0338)**
Voice and Accountability	-0.0846					
	(0.0795)					
Political Stability and Absence of violence		0.0645**				
		(0.0302)				
Government Effectiveness			-0.0384			
			(0.0658)			
Regulatory Quality				0.0578		
				(0.0720)		
Rule of Law					0.298***	
					(0.0785)	
Control of Corruption						-0.305***
						(0.0759)
Observations	419	419	419	419	419	419
Number of countries	40	40	40	40	40	40
KP LM Statistic (P-value)	0.008	0.024	0.012	0.012	0.148	0.000
KP F Statistic	9.239	12.09	8.225	10.49	10.69	10.90
Hansen J-Statistic (P-value)	0.218	0.210	0.263	0.256	0.563	0.301

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: African sample regressions: Public-private partnership capital

	Dependent variable: Log of Public-Private Partnership Capital					
	(1)	(2)	(3)	(4)	(5)	(6)
Log of Private Capital pc	0.197	0.274	0.168	0.158	0.211	0.165
	(0.464)	(0.456)	(0.391)	(0.415)	(0.438)	(0.450)
Openess to trade (Log)	-1.245**	-1.006**	-0.970*	-0.926**	-1.018**	-1.120**
	(0.524)	(0.460)	(0.496)	(0.444)	(0.466)	(0.509)
Log Aid per capita	-0.0442	-0.0382	-0.0161	0.00692	-0.0124	-0.0416
	(0.106)	(0.106)	(0.116)	(0.0946)	(0.0974)	(0.109)
Log of public Debt per capita	-0.192	-0.219*	-0.265**	-0.234**	-0.244*	-0.219
	(0.131)	(0.127)	(0.111)	(0.116)	(0.132)	(0.135)
Log of GDP pc	2.193**	2.433**	2.813***	3.053***	2.565**	2.418**
	(1.031)	(1.015)	(0.972)	(0.917)	(1.080)	(1.021)
lnschoolenroll	-0.548	-0.516	-0.504	-0.492	-0.512	-0.537
	(0.358)	(0.352)	(0.356)	(0.319)	(0.341)	(0.370)
Log of Extractive Resources pc	**0.566*** **	**0.532*** **	**0.484** **	**0.448*** **	**0.507*** **	**0.561*** **
	(0.173)	**(0.160)**	**(0.208)**	**(0.154)**	**(0.174)**	**(0.178)**
Voice and Accountability	0.835**					
	(0.425)					
Political Stability		0.351*				
		(0.184)				
Government Effectiveness			0.0230			
			(0.648)			
Regulatory Quality				-0.382		
				(0.424)		
Rule of Law					0.264	
					(0.538)	
Control of Corruption						0.706
						(0.459)
Observations	271	271	271	271	271	271
Number of countries	30	30	30	30	30	30
KP LM Statistic (P-value)	0.000	0.000	0.005	0.000	0.001	0.000
KP F Statistic	12.75	12.94	7.398	10.94	11.80	10.91
Hansen J-Statistic (P-value)	0.701	0.648	0.689	0.659	0.740	0.682

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6 Robustness Checks

To check the robustness of our results we performed several tests. First, we use the fuller version of Limited information maximum likelihood estimator instead of the 2SLS method which is deemed to perform better even with weak instruments (Murray, 2006). The results are reported in table A4 and table A5 in appendix. Second, our results still hold when we use five-years average data instead of yearly data because of cyclical concern, when we divide our sample into low income countries and middle income countries, and when we drop oil major producers to control for potential outliers.

7 Conclusion

Public investment in developing resource-rich countries is often associated with rent-seeking behavior. As a result, a massive increase in public investment expenditures yields limited economic outcomes while any growth model would predict the opposite (Torvik, 2009). This puzzle legitimizes the doubt around the ability of these investments to generate effective public capital accumulation in developing resource-rich countries. Little attention has been paid to this aspect of public investment in the literature on the relationship between natural resources and public investment despite several warnings in the literature (Barhoumi et al., 2018; Dabla-Norris et al., 2012; Gupta et al., 2014; Pritchett, 2000). While Karimu et al. (2017) consider public investment expenditures as their measure on public capital Bhattacharyya and Collier (2013) admit a full transmission of public investment into public capital in their perpetual inventory equation (equation 1). Consequently, these previous investigations yield contrasted conclusions. While Bhattacharyya and Collier (2013) found a negative effect of natural resources on public capital, Karimu et al. (2017) found that natural resources increase public investment in Sub-Saharan Africa and the effect is even higher when political institutions are weak. Moreover, while the implication of the private sector in public capital delivering become increasing, the private sector often is ignored.

In this paper, we examine the effect of extractive resources on public capital on a sample of 95 developing countries over the period 1996 to 2015. Using IMF's new dataset on public capital, we are able to distinguish full public provision public capital from Public-Private Partnership capital. Also its perpetual inventory equation (equation 2) is more flexible than that considered by Bhattacharyya and Collier (2013). Employing instrumental variables estimation techniques, our results show two keys findings. On the one hand, extractive resource exerts a negative effect on full public provision capital in developing countries which is in line with Bhattacharyya and Collier (2013). The size of the effect varies following the type of resources. The negative effect of mineral resources is lower compared to energy resources (gas, coal and oil). This is consistent with the infrastructure required for resource exploitation. Indeed, mining exploitation might require paved roads and railways, while oil can be exploited without these infrastructures. On average, 1% increase in extractive resources per capita leads to 0.06% decrease in public capital per capita. On the other hand, extractive resources are associated with an increase in public-private partnership capital. The effect is robust regardless of the type of resource.

These findings shed light on the fact that rent-seeking behavior (political or economic) might motivate public investment increase in resource-rich countries. "Tying the hands" between the private sector and the public sector in investment projects can scale-up public capital. The paper calls for a closer look at the scaling-up effect of natural resources on public investment in developing countries claimed in the literature specifically when institutions are weak.

Two policy recommendations emerged from these findings. Fist, beyond the classical recommendation on improving governance or counting on benevolent far-sighted government to address the resource curse on public capital in developing resource-rich countries, this paper shows that a partnership between the public and the private sector in the implementation of public investment projects can contribute to mitigating the curse. Developing resource-rich countries should implicate more the private sector in investing on public capital specifically in infrastructure. This has the advantage of addressing the 'curse on public capital' (Bhattacharyya and Collier, 2013) due to both the proverbial inefficiency of developing countries in implementing (large scale) public investment (Gupta et al., 2014; Dabla-Norris et al., 2012) and pure politically motivated investment (Robinson and Torvik, 2005). Second, the designing of public-private partnership is key to social welfare maximizing partnership. Developing countries should invest in civil servant capacity building on designing public-private partnership projects. In any case, public-private partnership is not the panacea. Its designing should matter. Henceforth, future research could implement case studies on some experiences of public-private partnership investment projects in resource-rich countries.

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List of countries

All sample

Albania; Algeria; Angola; Armenia; Azerbaijan; Bangladesh; Belarus; Belize; Benin; Bhutan; Bosnia and Herzegovina; Botswana; Brazil; Burkina Faso; Burundi; Cabo Verde; Cambodia; Cameroon; Central African Republic; Chad; China; Colombia; Comoros; Democratic Republic of Congo; Congo, Republic of; Costa Rica; Cote d'Ivoire; Dominican Republic; Ecuador; Egypt; El Salvador; Ethiopia; Fiji; Gabon; Gambia, The; Georgia; Ghana; Guatemala; Guinea; Guinea Bissau; Honduras; India; Indonesia; Iran; Jordan; Kazakhstan; Kenya; Kyrgyz Republic; Lao P.D.R.; Lebanon; Lesotho; Liberia; FYR Macedonia; Madagascar; Malawi; Maldives; Mali; Mauritania; Mauritius; Mexico; Moldova; Mongolia; Montenegro, Rep. Of; Morocco; Mozambique; Myanmar; Nepal; Nicaragua; Niger;Nigeria; Pakistan; Paraguay; Peru; Philippines; Rwanda; Senegal; Serbia; Sierra Leone; South Africa; Sri Lanka; Sudan; Tajikistan; Tanzania; Thailand; Togo; Tunisia; Turkey; Uganda; Ukraine; Uzbekistan; Venezuela; Vietnam; Yemen; Zambia; Zimbabwe.

African countries

Algeria; Angola; Benin; Botswana; Burkina Faso; Burundi; Cabo Verde; Cameroon; Central African Republic; Chad; Comoros; Democratic Republic of Congo; Congo, Republic of; Cote d'Ivoire; Egypt; Ethiopia; Gabon; Gambia; Ghana; Guinea; Guinea Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritania; Mauritius; Morocco; Mozambique; Niger; Nigeria; Rwanda; Senegal; Sierra Leone; South Africa; Sudan; Tanzania; Togo; Tunisia; Uganda; Zambia; Zimbabwe.

Table A1: Data sources and descriptions

Variables	**Definition**	**Sources**
Public capital per capita	Stock of public capital divided by the total population	IMF Investment and Capital Stock Dataset, 2017
Private capital	Stock of private capital divided by the total population	IMF Investment and Capital Stock Dataset, 2017
Extractive resource rents	oil rents, natural gas rents, coal rents (hard and soft) and mineral rents per capita	WDI (2018)
Public-Private Partnership capital	Stock of PPP capital divided by the total population	IMF Investment and Capital Stock Dataset, 2017
Extractive resource prices	Calculated price index of oil, natural gas, coal, mineral	IMF commodity prices database
GDP per capita	Annual percentage growth rate of GDP per capita based on constant 2005 US dollars	WDI (2018)
Population	Population is the midyear estimate of the total population based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	WDI (2018)
Openness to trade	Openness to trade is the sum of exports and imports of goods and services (in % of GDP)	WDI (2018)
Public debt	Public and publicly guaranteed external debt stock divided by the total population	WDI (2018)
Aid	Aid is the Net official development assistance (ODA) per capita. It consists of disbursements of loans made on concessional terms and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries.	WDI (2018)
Control of Corruption	"Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests".	WGI (2018)
Rule of Law	"Reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence".	WGI (2018)
Political Stability and Absence of Violence	"Measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism".	WGI (2018)
Voice and Accountability	"Reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media".	WGI (2018)
Government Effectiveness	"Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy".	WGI (2018)
Regulatory Quality	"Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development".	WGI (2018)

Table A2: Descriptive Statistics

VARIABLES	**N**	**mean**	**sd**	**min**	**max**
GDP_pc	2526	5468	8735	122.9	72671
Trade	2449	80.53	40.16	0.0269	531.7
Pubk_pc	2560	8.112	13.54	0.0253	139.8
Privk_pc	2560	11.75	16.68	0.235	183.7
PPPk_pc	2300	0.199	0.398	0	4.730
Oilpc	2534	52235	241431	0	3.068e+06
Minpc	2546	3975	17526	0	263394
Gaspc	2526	4779	32238	0	736050
Coalpc	2525	635.0	3391	0	95386
Extractpc	2515	62000	263031	0	3.319e+06
Debtpc	2120	1078	1463	0	12386
All Metals Index	2580	81.99	46.03	32.72	170.0
Crude Oil petroleum Price index	2580	119.7	65.29	31.28	222.5
Natural Gas Price Index	2580	148.2	60.49	57.45	271.0
Coal Price Index	2580	88.93	47.30	37.31	192.2
Tertiary School Enrollment	1599	24.27	20.27	0.194	95.43
Voice and Accountability	2578	-0.396	0.770	-2.233	1.343
Political Stability and Absence of Violence	2558	-0.365	0.876	-3.181	1.283
Government Effectiveness	2559	-0.383	0.668	-2.089	1.572
Regulatory Quality	2560	-0.335	0.695	-2.344	1.543
Rule of Law	2574	-0.448	0.690	-2.130	1.555
Control of Corruption	2574	-0.427	0.688	-1.773	1.725

Table A3: Stationary test

Variables	Inverse normal Z -statistics	P-value
Public capital per capita	-5.9574	0.0000
Private capital per capita	-10.2204	0.0000
Extractive resources per capita	-9.9377	0.0000
Oil rents per capita	-17.0043	0.0000
Mineral rents per capita	-13.1282	0.0000
Natural gas rents per capita	-16.2187	0.0000
Coal rents per capita	-12.7989	0.0000
GDP per capita	-9.3130	0.0000
Trade openess	-12.9090	0.0000
Aid per capita	-13.4609	0.0000
Public debt per capita	-11.1046	0.0000
School enrollement	-6.2344	0.0000
Voice and Accountability	-15.8136	0.0000
Political Stability and Absence of violence	-15.0509	0.0000
Government Effectiveness	-12.7190	0.0000
Regulatory Quality	-13.9433	0.0000
Rule of Law	-14.1645	0.0000
Control of Corruption	-14.7095	0.0000

Notes: N=95; T=20. Panel means and drift term included; time trend not included. Number of lags equals 2.

Table A4: Limited information maximum likelihood estimator 1

	Dependent variable: Log of Public capital per capita											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
lnextractpc	**-0.063*** **	**-0.071*** **	**-0.056*** **	**-0.069*** **	**-0.058*** **	**-0.096*** **	**-0.059*** **	**-0.081*** **	**-0.035** **	**-0.054*** **	**-0.064*** **	**-0.083*** **
	(0.015)	**(0.016)**	**(0.015)**	**(0.016)**	**(0.015)**	**(0.021)**	**(0.014)**	**(0.016)**	**(0.014)**	**(0.016)**	**(0.015)**	**(0.017)**
lnprivk_pc	0.344***	0.378***	0.348***	0.352***	0.357***	0.380***	0.358***	0.382***	0.402***	0.421***	0.341***	0.356***
	(0.059)	(0.061)	(0.058)	(0.057)	(0.058)	(0.058)	(0.057)	(0.059)	(0.058)	(0.060)	(0.057)	(0.057)
lntrade	0.124***	0.078*	0.127***	0.089**	0.122***	0.089**	0.107***	0.083**	0.091**	0.050	0.128***	0.118***
	(0.039)	(0.040)	(0.038)	(0.040)	(0.039)	(0.037)	(0.038)	(0.037)	(0.036)	(0.041)	(0.039)	(0.039)
lnaidpc	-0.007	-0.016	-0.006	-0.033***	-0.007	-0.023*	-0.007	-0.014	-0.019	-0.024*	-0.004	-0.007
	(0.015)	(0.014)	(0.014)	(0.013)	(0.015)	(0.013)	(0.014)	(0.013)	(0.014)	(0.013)	(0.015)	(0.014)
lndebtpc	-0.052***	-0.021	-0.045**	0.011	-0.055***	-0.025	-0.062***	-0.026	-0.034*	0.002	-0.052***	-0.037*
	(0.019)	(0.018)	(0.019)	(0.020)	(0.019)	(0.020)	(0.020)	(0.021)	(0.018)	(0.018)	(0.020)	(0.019)
lngdp_pc	0.605***	0.441***	0.552***	0.408***	0.546***	0.526***	0.543***	0.515***	0.371***	0.275**	0.599***	0.536***
	(0.108)	(0.111)	(0.110)	(0.117)	(0.115)	(0.117)	(0.107)	(0.113)	(0.109)	(0.115)	(0.111)	(0.114)
lnschoolenroll	0.135***	0.116***	0.134***	0.132***	0.140***	0.123***	0.144***	0.109***	0.127***	0.116***	0.138***	0.130***
	(0.030)	(0.032)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.034)	(0.029)	(0.031)	(0.030)	(0.031)
Voice and Accountability	0.046	0.408***										
	(0.030)	(0.096)										
lnextractxVA		-0.051***										
		(0.012)										
Political Stability			0.044***	0.411***								
			(0.017)	(0.082)								
lnextractxPS				-0.056***								
				(0.012)								
Government Effectiveness					0.108***	0.651***						
					(0.037)	(0.151)						
lnextractxGE						-0.080***						
						(0.022)						
Regulatory Quality							0.143***	0.564***				
							(0.036)	(0.130)				
lnextractxRQ								-0.066***				
								(0.018)				
Rule of Law									0.348***	0.686***		
									(0.039)	(0.123)		
lnextractxRL										-0.055***		
										(0.017)		
Control of Corruption											0.032	0.311**
											(0.037)	(0.123)
lnextractxCC												-0.041**
												(0.018)
Observations	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120	1,120
Number of Countries	95	95	95	95	95	95	95	95	95	95	95	95
KP LM Statistic (P-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.045	0.000	0.000	0.000
KP F Statistic	58.79	31.52	58.95	42.20	56.06	35.52	61.12	39.90	59.61	40.06	58.51	40.38
Hansen J-Statistic (P-value)	0.947	0.0625	0.765	0.562	0.853	0.928	0.978	0.845	0.946	0.663	0.917	0.805

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A5: Limited information maximum likelihood estimator 2

	Dependent variable: Log of Public-Private Partnership Capital				
	(1)	(2)	(3)	(4)	(5)
Log of Private Capital pc	0.291	0.601**	0.0548	0.0623	0.269
	(0.205)	(0.276)	(0.185)	(0.200)	(0.243)
Openess to trade (Log)	-0.0400	-0.127	0.0830	0.0447	-0.00331
	(0.111)	(0.122)	(0.129)	(0.120)	(0.127)
Log Aid per capita	0.0857**	0.0828	0.0907**	0.122***	0.0947*
	(0.0434)	(0.0508)	(0.0413)	(0.0418)	(0.0508)
Log of public Debt per capita	-0.0415	-0.0954	-0.0159	-0.0944	0.154*
	(0.0705)	(0.0727)	(0.0719)	(0.0695)	(0.0912)
Log of GDP pc	1.001***	0.631	1.197***	1.418***	0.464
	(0.379)	(0.495)	(0.391)	(0.388)	(0.502)
RuleofLaw	0.373**	0.540**	0.0832	0.0540	0.461**
	(0.172)	(0.226)	(0.158)	(0.168)	(0.198)
lnschoolenroll	0.205*	0.432***	0.350***	0.514***	0.266**
	(0.123)	(0.106)	(0.117)	(0.106)	(0.114)
lnextractpc	**0.232*** **				
	(0.0613)				
lnoilpc		**0.442*** **			
		(0.123)			
lnminpc			**0.139*** **		
			(0.0465)		
lncoalpc				**0.156***	
				(0.0830)	
lngaspc					**0.437*** **
					(0.113)
Observations	870	876	876	873	873
Number of countries	83	83	83	83	83
KP LM Statistic (P-value)	0.000	0.000	0.011	0.069	0.000
KP F Statistic	54.67	35.81	48.05	30.68	28.96
Hansen J-Statistic (P-value)	0.0940	0.0009	0.643	0.133	0.460

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1