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JEL Codes: C33; O13; O15 ; O41

Keywords: Resource-dependence; non-traded capital goods; absorption capacity



Absorption capacity and Natural Resource Curse*

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Abstract

This paper investigates the impact of absorption capacity (i.e. the level of non-traded capital goods such as infrastructure and human capital) on the intensity of the natural resource curse. Using panel data for 105 countries over the period 1975-2014, I construct two indexes to proxy absorption capacity among countries. A growth regression model, estimated by *IV – 2SLS* technique, shows that the natural resource curse is more intensive in countries with more absorption capacity constraints. Furthermore, based on the idea that some sorts of capital goods (e.g. infrastructure and human capital) can not be redeployed in major countries and they must be produced domestically (i.e. absorption capacity constraints), I put forward a simple two-sector framework, in line with Van der Ploeg and Venables (2013), to clarify the empirical finding.

Keywords: Resource-dependence; non-traded capital goods; absorption capacity

JEL Classification: C33; O13; O15 ; O41.

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1 Introduction

Is a natural resource a blessing or curse? This question has been attracting more attention of researchers in the literature of development economics. Conventional wisdom suggests a positive effect on economic growth from a natural resource abundance¹ (Brunnschweiler and Bulte, 2008; Alexeev and Conrad, 2009; Cavalcanti et al., 2011; Esfahani et al., 2013), but a large stand of empirical researches supports that resource dependence² countries have usually failed to benefit from their natural wealth and so to grow more rapidly than others, labeled the natural resource curse (e.g. Sachs and Warner (1995); Gylfason et al. (1999); Auty et al. (2001)).

The first enduring explanations for the resource curse follows political-economic perspectives. Several studies demonstrate that a natural resource rent decelerates the growth of countries with bad institutions and accelerates the growth of countries with good institutions (e.g. Mehlum et al. (2006); Arezki and Van der Ploeg (2011), among others). Related cross-country evidence strongly suggests that natural resources hit the rate of growth in an economy by weakening the institutions inside the economy (Sala-i Martin and Subramanian, 2013). The literature also contains studies seeking to reveal the relationship between resource rents and political regime. The combination of a democracy and the natural resource rent seems to retard growth in developing countries (Collier and Hoeffler, 2005) and the resource curse occurs in presidential, not parliamentary democracies (Andersen and Aslaksen, 2008). Further, the argument can also be related to the notion of "petro populism", clarified by Matsen et al. (2016). Using a rent-seeking approach, they suggest that better visibility and more information of voter may increase over-extraction and consequently economic performance is likely to be affected adversely.

The second main stream of the resource curse's explanations argue that a natural resource boom, through an appreciation in the real exchange rate, decreases the competitiveness of the traded sector, the so-called the Dutch disease hypothesis (Corden and Neary, 1982). Two features of the Dutch disease literature that have been studied in isolation from each other are described by the productivity growth with Learning by Doing (LBD) approach (Sachs and Warner, 1995; Torvik, 2001) and capital accumulation with absorptive capacity constraints (Van der Ploeg and Venables, 2013). Further, the adverse effect of the resource dependence on economic growth, the essence of the core hypothesis, has been empirically supported by scholars (e.g. Sachs and Warner (1995); Gylfason et al. (1999); Ismail (2010)).

Other possible explanation that has absorbed more attention in recent years is the destructive effect of volatility in commodity price on economic performance. Van der Ploeg and Poelhekke (2009), using cross-country evidence for 62 countries, found that the adverse effect of resources on growth is mainly driven by the volatility of commodity prices, especially for point-based resources (oil, diamonds), such that the indirect negative effect of resources on growth resulting from volatility erodes any direct positive effect of resources on growth. Furthermore, a strand of

¹ Resource abundance refers to per capita value of the stock of natural resource wealth.

² Resource dependence refers to the value of resource as a share of GDP or total national wealth.

the literature indicates that volatility in resource price through instability in government revenue may lead to boom and bust in public spending and thus undermines economic performance (Hausmann and Rigobon, 2003; El-Anshasy et al., 2017). In the same vein, Aghion et al. (2009) suggests that the adverse effect of volatility on economic growth is more intense in countries with less developed financial system.

Even though these hypotheses are well understood, the effect of absorption capacity constraints on the intensity of the natural resource curse seems to have received less attention among scholars. In the present paper, the notion of the absorptive capacity constraints, used frequently in the context of international aid, refers to a shortage in non-traded (public) capital goods such as human capital and infrastructure. It suggests that the marginal rate of return to aid (natural resource rents in this paper) reduces when the rising amount of aid is associated with lack of enough non-traded capital (Bourguignon and Sundberg, 2006). Since a shortage in non-traded capital goods and so facing with absorption capacity constraints leads to increasing the unit cost of an additional non-traded capital good and thus to decrease the incremental returns to aid (or resource rents). Although the literature well clarifies the positive effect of expansion in the non-traded (public) capital on economic growth (Barro, 2001; De la Fuente and Doménech, 2006; López, 2003; Sridhar and Sridhar, 2007), it is worth seeking the effect of resource wealth on the economic performance of a country facing with absorption capacity constraints. Therefore, the objective of this paper is to move in this direction by representing a response to the question of how the absorption capacity constraints due to a shortage in the non-traded capital induce the intensity of the natural resource curse.

In this vein, a number of papers investigate how human capital, as one of the main components of the absorption capacity, can influence the nexus between a resource boom and economic growth. A simple model, proposed by Gylfason and Zoega (2002), argues that investment in education increases the return to work through a higher productivity level and thereby moderates the natural resource curse. Kurtz and Brooks (2011) also find that the resource curse (or blessing) is strongly conditioned by the level of the domestic human capital. A piece of empirical evidence for major petroleum exporter countries consolidates this argument and suggests that the resource curse might arise since natural resource-rich countries neglect to invest in education (Behbudi et al., 2010). In addition, empirical findings for supporting a two-sector growth model, proposed by Bravo-Ortega and De Gregorio (2005), show that natural resources may lead to decelerating growth in countries with very low levels of human capital, while the adverse effects of natural resources may offset in countries with a high level of human capital. Furthermore, in a comparative analysis of Scandinavian countries versus Latin American countries, they suggest that human capital investment, fed by natural resource rents, could play a crucial role in the difference of their economic performance.

Despite the literature seeking to understand the relationship between resource dependence and public capital investment (Bhattacharyya and Collier, 2013; Cockx and Francken, 2014), a computable general equilibrium model calibrated for Chad shows that investment in the public

capital (particularly in road and irrigation infrastructure), financed by oil revenue, improves growth and household welfare (Levy, 2007). Further, using panel data for resource-rich sub-Saharan African countries over the period 1990-2013, Karimu et al. (2017) find that resource revenues increase the public capital investment which, in turn, accelerates the growth rate proportional to the level of resource rents.

The seminal theory linking the natural resource curse and absorption capacity constraints has been put forward by the models in Van der Ploeg (2011); Van der Ploeg and Venables (2013). These models challenge the common belief that falling the competitiveness of the traded sector relative to the non-traded sector is the determinant driving force in shrinkage of the traded sector and expansion of the non-traded sector (e.g. Sachs and Warner (1995); Torvik (2001))³. Those argue if existing capital goods lead to an additional absorption capacity so that there are not any supply bottlenecks, the expanded demand for non-traded goods, a consequence of a natural resource boom, is instantaneously adjusted. Consequently, there will not be upward pressure on the relative price of non-traded goods. But in reality, some sorts of capital goods (such as infrastructure and human capital) can not be bought or sold in world markets and they must be domestically produced, which in turn needs produced "home-grown" capital goods to function (e.g. roads need to extend roads, teachers to educate more teachers). This argument intuitively states one of the essential problems of developing economies. When there is no excess capacity in the economy, the relative price sharply appreciates in the short run as a natural resource rises. But the gradual expansion of capital goods scales up the domestic spending overtime to absorb the effects of the natural resource boom.

Motivated by the literature, I present an empirical study to investigate the effect of the absorption capacity (i.e. non-traded capital goods) on the natural resource curse. In this respect, I construct two indexes to proxy cross-country non-traded capital goods and so to align the economies in terms of the absorption capacity. Using panel data for 105 countries over the period 1975-2014, I find that the natural resource curse is more intensive in countries with smaller non-traded capital indexes (more absorption capacity constraints). Furthermore, following Van der Ploeg and Venables (2013), I develop a model to describe the economic performance of a resource-dependent country with restriction in the absorption capacity and to clarify the main empirical finding.

The remainder of this paper is structured as follows. Section 2 describes a framework and discusses the role of capacity constraints in the response of an economy to a resource boom. Section 3 presents some stylized facts on the natural resource curse and the absorption capacity. Section 4 undertakes an empirical study to investigate the objective. Section 5 develops a dynamic model to clarify the long-term mechanism of an economy constrained by the absorptive capacity. Section 6 concludes.

³ The theories based on Learning by Doing (LBD) approach (Sachs and Warner, 1995; Torvik, 2001) seems to be feasible only in the short run. Since for a longer period one must allow both labor and capital move across sectors.

2 Implication of Absorption capacity

In this paper, the notion of absorptive capacity constraints refers to a shortage in the non-traded capital such as the public human capital and the infrastructure. A useful starting point to study the role of absorptive capacity constraints on the economic performance of a resource-dependent economy is to revisit the Dutch disease theory. Following Nkusu (2004a), I rebuild a small open economy model in a Salter-Swan framework. The core assumptions are as follows: 1) There are two sectors: the traded and non-traded sectors ⁴, 2) There are no asset and capital accumulation and the labor force (i.e. the Human capital ⁵) is only production factor, 3) The labor force is normalized to unity to expel the population growth, 4) The labor force is fully employed by sectors and they can move freely across sectors, 5) There are decreasing returns to labor in each sector, 6) Agents have an identical taste and there is perfectly elastic demand for traded goods, 7) The windfall income (resource boom) is a constant exogenous gift over time.

Figure 1 illustrates the response of an economy to a natural resource boom. Markets for the traded and non-traded sectors represent, respectively, in the upper-left and -right quadrants with the price on the vertical axis and production & demand on the horizontal axis. The upward-sloping lines of ST and SNT show the supply-side of the traded and non-traded sectors, respectively. The downward-sloping line of DNT illustrates the demand-side of the non-traded sector. While, the demand for the traded sector, DT , is represented by a horizontal line. This stands for two reasons: first, a perfectly elastic demand for traded goods and second, the small open economy hypothesis. Production possibility frontier, PPF , shows in the lower-right quadrant. It represents all possible combinations of traded and non-traded goods that can be produced by employing the labor force (i.e. human capital). Also, the budget constraint (income line) and indifference curve are indexed by Y and ID , respectively.

Assume there is initially a trade balance and the price of both goods is equal. The economy produces and consumes at point B on the PPF and ID , corresponding to point C for the traded market and point M for the non-traded market. The literature on the Dutch disease highlights three different effects. The first one is the spending effect. Resource boom brings about an expansion in the total income of the economy and so increases the demand for both traded and non-traded goods. Whereas the price of traded goods is determined exogenously by the international market and so the demand is perfectly elastic, the relative price of non-traded to traded goods must appreciate in order to confront the expanded demand for non-traded goods. This is graphically represented by shifting DNT to up and left (a move from point M to M').

The second one is called the resource transfer effect. A relative price appreciation increases the real wage of the labor force working in the non-trade sector, with respect to those working in the traded sector. It makes a signal for the labor force to shift away from the traded sector and into the non-traded sector. Consequently, the traded sector shrinks and the non-traded sector

⁴ In the standard Dutch disease model proposed by Corden and Neary (1982), there are three sectors: the booming and lagging sectors producing traded goods and the non-traded sector producing services goods.

⁵ As an alternative, we can assume the infrastructure capital good as the only factor of the production function.

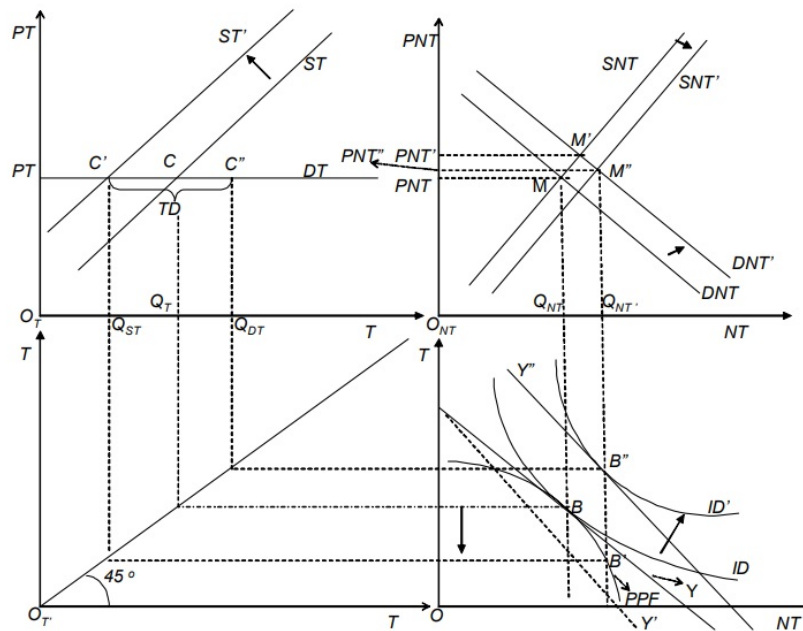


Figure 1: Analytical framework of the Dutch Disease Model, source: Nkusu (2004a).

expands (i.e. the Dutch disease). This effect is graphically shown by a downward shift in SNT and an upward shift in ST . Those shifts are consistent with moving from point B to B' on PPF . It is because that the slope of PPF , called the marginal rate of transformation (MRT), is also the opportunity cost of producing non-traded goods in terms of traded goods and so equals the relative price of non-traded to traded goods. Therefore, relative price appreciation makes the slope be steeper in B' than in B .

The third highlighted effect in the literature is the expenditure effect. Two substitution and direct resource boom effects are coupled to move the income line Y in the lower-right quadrant. Turning clockwise of the income line, on the one hand, reflects the substitution of the traded with non-traded goods, resulting from the relative price appreciation (i.e. line Y'). On the other hand, the direct effect of the resource boom pushes up the income line, displayed by Y'' . Therefore, the economy now produces at point B' and consumes at point B'' . Whereas the former point is consistent with a lower level of the produced traded goods Q_{ST} and higher level of the produced non-traded goods $Q_{NT'}$, the latter point is associated with a higher level of consumption for both traded Q_{DT} and non-traded $Q_{NT'}$ goods. As illustrated in Figure 1, the expanded demand for traded goods will be substituted by more imported goods, paraphrased as the trade deficit TD .

The presented analytical framework concentrates on a prospect of the core Dutch disease under the given assumptions. The first questionable assumption is that the economy produces on its PPF . This assumption doesn't seem to be realistic (Nkusu, 2004a). The main reason why many developing countries don't efficiently operate on its PPF comes back to observing a large amount of unused available productive resources such as high unemployment and unused lands (Verbeke, 2007). To support this assumption, Nkusu (2004b) presented the case of Uganda where available unused lands allowed the economy to increase the production of food crops

without a decrease in cash crop products. Nevertheless, Brownbridge and Tumusiime-Mutebile (2007) found less evidence of this resenting and they conclude that Uganda's economy has reached its *PPF* after two decades. Contrary to those, the present paper is going to highlight the case in which employing the unused production factors is theoretically costless. In particular, without decreasing the production of one good to increase the production of another good, an economy can costlessly and immediately respond to externalities when its absorption capacity is not fully used. Therefore, the assumption that the economy must produce in its *PPF* doesn't seem to be problematic in the developing economies. Since those can not costlessly reach to their potential *PPF* as regards suffering structural labor and capital market constraints as well as limited infrastructure and human capital resources. Therefore, we can conclude that the actual *PPF* of the developing countries is matched on their potential *PPF*.

The other side of the coin turns to the developed economies. One of the notable features of these economies and some natural resource-rich economies is to have the spare economic capacity to absorb the windfall income. This argument rests on the fact that having reserved capacity for infrastructure and human capital or providing them from the international market let the economy respond immediately and almost costlessly to resource boom effects. Therefore, it is more realistic to take into account a production beneath the curve *PPF* in developed countries with a higher level of capacity (i.e. infrastructure and human capital).

The conclusion of this argument is that the structural economic problems in developing countries are more likely to enforce the economy to scarify one good to produce another good. While the spare absorption capacity in the developed economies allows them to increase the production of both goods simultaneously. Briefly, whereas the developing economies produce on the *PPF* curve, the developed economies operate beneath the *PPF* curve.

A modification framework of the core Dutch disease for economies having spare capital goods (infrastructure and human capital) is shown in Figure 2. In contrast with the previous analysis presented in Figure 1, the economy produces and consumes initially at point *B* which lies within *PPF* (see. Figure 2). At point *C*, the demand and supply of the traded goods are equal and the demand and supply curves for the non-traded sector meet each other at point *M*. When the economy receives the windfall income, the demand for both goods increases. The expanded demand for the non-traded goods is reflected by an upward-shift of the demand line to *DNT'* which, in turn, appreciates the price of non-traded goods. While the demand line of the traded sector *DT* doesn't move and its price remains unchanged, in following the small open economy hypothesis. In response to the expanded demand, the economy moves its production from point *B* to a point on the curve *EB'F*⁶. Assume the economy shifts to point *B'*, corresponding to new market-clearing for the traded and non-traded sectors at point *C'* and *M''*, respectively. In following this movement, the supply in the non-traded sectors expands from *SNT* to *SNT'*. While, in contrast with the previous analysis which is consistent with a developing country's situation, the supply of the traded sector expands and *ST* shifts down to the right to *ST'*. This

⁶ At point *E* and *F*, the economy expands just the production of the traded and non-traded goods, respectively.

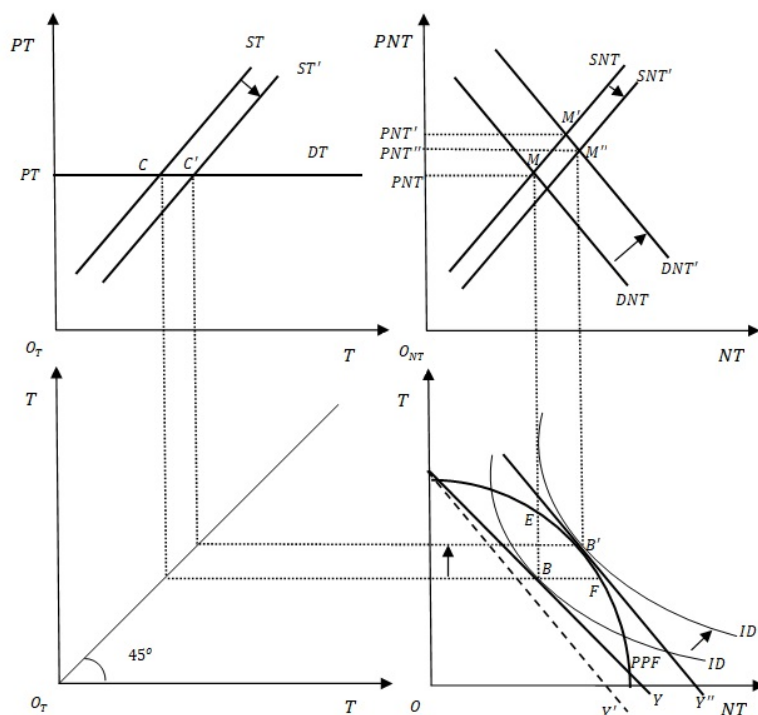


Figure 2: Modified analytical framework of the Dutch Disease Model: source: Author.

argument states that in countries with the spare absorptive capacity none of the production sectors shrinks. Therefore, the framework shows that the resource curse arises only in countries with a limited absorptive capacity.

3 Stylized Facts

The main objective of this section is to assess cross-country correlations between the dependence on the resource rent and the economic growth, on the one hand, and also between the dependence on the resource rent and the capital proxies, on the other hand. Figure 3 portrays the correlation between average of economic growth, Human capital index, Electric consumption and fixed telephone with respect to average total natural resource rents (% of GDP) as a proxy for the dependence on the resource rent (Statistical estimations are presented in Appendix A)⁷. It shows a negative and significant correlation between the resource rent (% GDP) and per capita GDP growth rate. In line with the seminal paper applying a cross-country study to find the resource curse evidence (e.g. Sachs and Warner (1995)), this latter correlation suggests that resource-dependence countries grow slower than resource-poor countries at the long term. In addition, looking at the correlation between resource rent (% GDP) and three proxies identifying the absorption capacity: (1) Human capital index, (2) Electric power consumption (MWh per

⁷ Description of data is presented in the section 3. Variables are approximated on average over period 1985-2014 and only countries where their time-series dataset are available on this period are covered in the cross-country study (see. Appendix B).

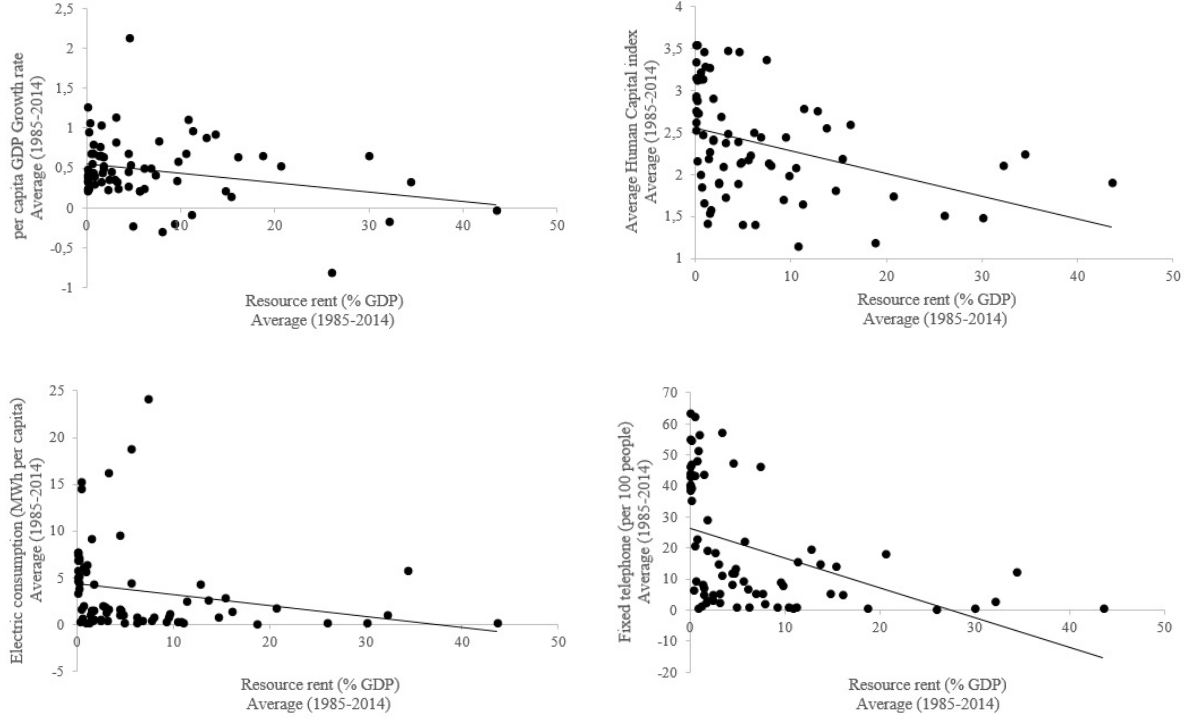


Figure 3: Cross-country correlation between resource rent, Growth and the absorption capacity proxies. Source: author, based on data from the World Development Indicator (*WDI*) and the Penn World Table (*PWT* 9.0).

capita) and (3) Fixed telephone subscriptions (per 100 people), we can see that resource-rich countries always exhibit lower level of capacity. Briefly, the initial analysis reveals that smaller non-traded capital (absorption capacity) might result in the natural resource curse. This argument motivates us to investigate the impact of absorption capacity constraints (i.e. shortage in the non-traded capital goods) on the intensity of the resource curse.

4 Empirical approach

4.1 Methodology and Data

This section describes the econometric methodology to peruse the objective of the paper. In this respect, I extend the traditional economic growth regression (see. Barro (2004)) by the inclusion of a natural resource proxy, an absorption capacity proxy and an interaction term between these two variables of interest. The regression is used to test whether a larger absorption capacity index hinders the adverse effect of a natural resource-dependence on economic growth.

I utilize a panel data approach to estimate the main contribution of the empirical model. An unbalanced panel sample comprises 105 countries and covers the available data observed from 1975 to 2014. The list of countries included in the sample database presents in Appendix B. The specification model can be expressed as follow:

$$GY_{i,t} = \beta_0 + \beta_1 \ln Y_{i,t-1} + \beta_2 WI_{i,t-1} + \beta_3 NK_{i,t-1} + \beta_4 (WI_{i,t-1} * NK_{i,t-1}) + Z'_{i,t} \beta_5 + \mu_i + \varepsilon_{i,t}. \quad (1)$$

This model allows to evaluate the overall impact of a resource-dependence proxy on economic growth and also to clarify the role the absorption capacity in economic performance ⁸. In my benchmark, the subscripts $i = 1, \dots, N$ and $t = 1, \dots, T$ index, respectively, the countries and periods in the panel. GY is GDP per capita growth rate⁹ and LnY , the natural logarithm of per capita GDP, is included to estimate the hypothesis of the convergence result in the balance growth model. WI stands for the resource-dependence index and NK is a proxy for the absorption capacity in economy (e.g. human capital and/or infrastructure). Z' is the vectors of control variables that are expected to affect economic growth. Further, μ_i is a country fixed effect and $\varepsilon_{i,t}$ denotes the disturbance term.

Table 1 reports summary statistics for 5-year average value of data variables ¹⁰. The data for GDP per capita (Constant 2011 US dollars) is collected from the *Penn World Table (PWT 9.0)* and total natural resources rents (% of GDP), a proxy for resource dependence, is sourced from the *World Development Indicator (WDI)*. Given my interested in determining the possible effect of absorption capacity (non-traded capital goods) on the resource curse, I first collect data for Human Capital Index ¹¹, Electricity index ¹² and Telephone index ¹³ and then I construct two indexes to proxy cross-country capital goods and so to capture the absorption capacity.

The first one, called Infrastructure index, is defined by the average of normalized Electricity

Table 1: Summary Statistics

	Obs.	Mean	Std Dev.	Min	Max
Ln (per capita GDP)	699	9,03	1,15	5,80	11,35
Resource dependence index	699	7,04	9,61	0,01	51,09
Population growth	699	1,54	1,19	-1,50	7,13
Investment ratio	699	23,42	6,69	3,96	54,42
Human Capital index	699	2,28	0,69	1,06	3,72
Openness index	699	69,54	33,86	9,50	205,54
Terms of Trade	697	1,02	0,30	0,14	4,69
Real effective exchange rate (Ln)	690	4,68	0,40	3,51	9,56
Institution index	699	0,05	1,02	-2,07	1,99
Electricity index	699	2,98	4,19	0,01	24,67
Telephone index	699	16,72	18,39	0,02	73,33

⁸ The aim of this empirical procedure is not to systematically analyze both direct effect of resource rent on outcome and indirect effect, through a change in capacity index. A moderated mediation model proposed by Muller et al. (2005) might be used to deal this issue.

⁹ GY_t denotes growth rate of GDP per capita and it is calculated as following: $GY_t = \left[\frac{Ln(Y_t)}{Ln(Y_{t-1})} \right]$.

¹⁰ 5-year periods are: 1975-79, 1980-84, 1985-89, 1990-94, 1995-99, 2000-04, 2005-09, 2010-14.

¹¹ This index is constructed by *Penn World Table* based on Barro and Lee (2013) database for the average years of schooling and an estimated rate of return for primary, secondary, and tertiary education introduced by Caselli (2005).

¹² It represents electric power consumption (MWh per capita) estimated by *WDI* database.

¹³ Fixed telephone subscriptions (per 100 people) is defined as telephone index and data are collected from *WDI* database.

index and normalized Telephone index ¹⁴, while the second one, called Absorption index, is the average of normalized Human Capital Index and normalized Infrastructure index ¹⁵,

$$\text{Infrastructure index} = (\text{normalized Electricity index} + \text{normalized Telephone index})/2 \quad (2a)$$

$$\text{Absorption index} = (\text{normalized Human Capital index} + \text{normalized Infrastructure index})/2 \quad (2b)$$

Figure 4 represents the normalized Infrastructure and Absorption indexes with respect to income level. The plots reveal two patterns of absorption capacity constraints. First, in poor countries (GDP per capita (Ln) less than 8), Absorption index is larger than Infrastructure index. It may imply that in poor countries low level of infrastructure is the main determinant of absorption capacity constraints. Second, when GDP per capita (Ln) reaches around 10, both indexes rise sharply. Dropping the constraints corresponding to rising capital goods may suggest that the effects of a natural resource rent is adjusted faster in developed than developing countries.

I Also include a number of control variables, namely Population Growth, Investment ratio (i.e.

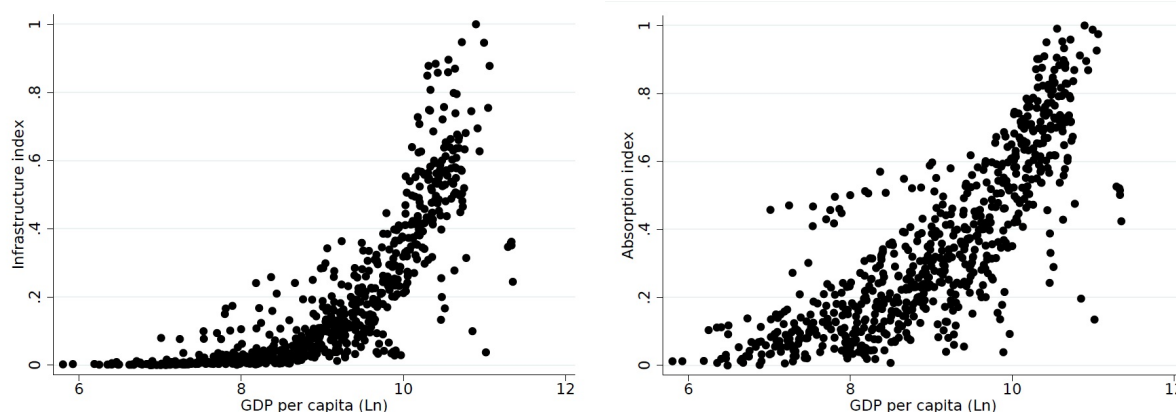


Figure 4: Infrastructure and Absorption indexes with respect to *GDP* per capita

Gross capital formation (of % GDP)), Openness index (i.e. Trade (of % GDP)) ¹⁶, Terms of trade ¹⁷, and real effective exchange rate ¹⁸. Further, Rule of Law indicator ¹⁹ is considered as a proxy for quality of institution (Institution index).

Two econometric problems may arise in estimation of Equation 1: 1) inclusion of the lagged per

¹⁴ Because of the lack of data for variables having long-term series and covering many countries such as the stock of buildings, rail lines, internet accessibility, the Infrastructure index restricts to these two variables.

¹⁵ Normalized X is computed as $\frac{X_{i,t} - X_{min}}{X_{max} - X_{min}}$, where X_{max} and X_{min} are, respectively, maximum and minimum values of the sample dataset.

¹⁶ Data of these three variables are collected from *WDI*.

¹⁷ The net barter terms of trade index (2005=1) are calculated as the percentage ratio of the export unit value indexes to the import unit value indexes. The average value for the 5-year periods is derived from *WDI* database.

¹⁸ The index estimated by *Bruegel* is calculated as $REER = \frac{NEER \cdot CPI^{domestic}}{CPI^{foreign}}$, where *NEER*, the nominal effective exchange rate, is a measure of the value of a currency against a weighted average of several foreign currencies and *CPI* denotes the consumer price index (see. *Darvas (2012)*).

¹⁹ The original indicator proposed by *World Bank's Governance Indicators Project* is in the range of approximately -2.5 (weak) to $+2.5$ (strong). The data are available over period 1996-2014. For preceding periods, I assume that the indicators are equal the earliest value.

capita GDP in regression which rises autocorrelation problem and 2) a simultaneous causality between proxies for the absorption capacity and per capita GDP, leading to the endogeneity problem. The latter problem rests on twofold. The hypothesis of non-correlation between the explanatory variables and error is relaxed if proxies observed at time t is correlated with per capita GDP and so with the error term in the same period. Therefore, I apply the lagged value of absorption capacity proxies, instead of their current value, in the regression model (see. Equations 1) to prevent this problem. But Figure 4 shows a strong correlation in each period between these two explanatory variables of interest so that dropping absorption constraints are associated with rising income level. In other words, per capita GDP could reflect as much the absorptive capacity constraint identified by two non-traded capital indexes. The standard way to deal with this type of bias is to apply the instrumental variables regression. Hence, I use *IV – 2SLS* technique to cope these problems.

Instrumental-variables approach stands on the assumption that the excluded instruments affect the dependent variable through their correlations with the endogenous variables. The *Hansen* test of over-identifying restrictions²⁰ can be used to check this assumption. The null hypothesis is that the instruments, as a group, are distributed independently of the error process. In other words, the excluded instruments are uncorrelated with the error term and thus they are correctly excluded from the regression equation. Nevertheless, the *Hansen* test which only checks the joint validity of full instruments doesn't specify whether the instruments are correlated with the endogenous variables. The Underidentification test (*Kleibergen – Paap* rk LM statistic) addresses this question. The null hypothesis is that the regression equation is underidentified. Although a rejection of the null indicates that the model is identified, the weak identification test need to be considered as well to check whether the correlation between instruments and endogenous variables is weak or strong. Stock and Yogo (2002) propose a test to check weak identification by using *Kleibergen – Paap* rk Wald F statistic²¹. Their null hypothesis is that the estimator is weakly identified. Hence, when the value of *Kleibergen – Paap* rk Wald F statistic is larger than the tabulated critical value, estimated by Stock and Yogo (2002), the null hypothesis is rejected.

First-lagged of GDP per capita (Ln) and proxies for capital goods are endogenous variables. Hence, I apply second-lagged of resource-dependence index and GDP per capita (Ln) as instruments for endogenous variables to avoid the econometric problems. Further, first-lagged of Telephone index will be an instrument for endogenous variables when Infrastructure index is included²², while first-lagged of Infrastructure index and Human capital index will be instruments when Absorption index is included²³.

²⁰ *Hansen* test is adequate when the estimation considers an *heterocedastic* weight matrix.

²¹ Kleibergen and Paap (2006)

²² First-lagged of GDP per capita and Infrastructure index are functions of second-lagged of resource-dependence index and GDP per capita (Ln) as well as first-lagged of Telephone index. Note that I exclude the Electricity index as an instrument. Since the null hypothesis of the joint validity test (*Hansen* test) is rejected.

²³ First-lagged of GDP per capita and Absorption index are functions of second-lagged of resource-dependence index and GDP per capita (Ln) as well as first-lagged of Infrastructure index and Human capital index.

4.2 Estimation Results

In this sub-section I discuss the results of my empirical analysis²⁴. The baseline model estimates the average empirical association for pooling data of the countries included in the dataset. The presence of unobservable heterogeneity across countries that may undermine the reliability of the empirical results is evaluated by the *Hausman* test²⁵. Moreover, the estimations include *heteroskedasticity – robust* standard errors²⁶ and a separate intercept for each time period²⁷.

Table 2 summarizes the results of the regression model (Equations 1). *OLS* estimator for the baseline specification models are respectively reported in columns (1) and (4). Although these results may not be informative, they may still be interesting as a benchmark. Columns (2) and (5) represent the results of the baseline specification models for cases in which Infrastructure index and Absorption index are respectively included. I first evaluate the estimation results for control variables and then discuss the core independent variables. The main findings of columns are as follows. First, the income level (GDP per capita in Ln) has a significantly negative coefficient. It seems to confirm the hypothesis that low-income countries tend to grow faster than high-income countries, holding fixed other explanatory variables. Second, following *Solow* model (Solow, 1956) and empirical studies (e.g. Mankiw et al. (1992); Knight et al. (1993)), there is a negative impact on the economic growth from population growth. Third, investment ratio as well as human capital index (at column 2) enter with significantly positive signs. Consistently with the recent empirical studies (Benhabib and Spiegel, 1994; Gylfason et al., 1999; Bravo-Ortega and De Gregorio, 2005; Bond et al., 2010), these findings accentuate the role of human capital in acceleration of the GDP per capita growth rate. Forth, the estimated coefficient on openness index implies that countries with higher trade shares expand faster than other countries, as in Yanikkaya (2003). Finally, the correlation between institution index and economic growth is positive and suggests that improvement of quality of institution accelerates the economic growth. Nevertheless, the estimation results are insignificant. This may reflect that the mixture of cross-country heterogeneity has weakened the robustness of correlation.

The coefficient on the resource-dependence enters with a negative sign and is significant at 1%. It stresses that economic growth, on average, reduces by about 0.7% per year as one-standard-deviation increases in the resource-dependence. The result is consistent with the recent empirical studies (e.g. Sachs and Warner (1995); Gylfason and Zoega (2002)) and the theory of the Dutch disease (e.g. Torvik (2001); Van der Ploeg and Venables (2013)). Further, the coefficients on Infrastructure index (at column 2) and Absorption index (at column 5) are significantly positive. These strong findings suggest that infrastructure and human capital development lead to a faster economic expansion. In other words, falling absorption constraints are associated with rising

²⁴ All estimations and statistical tests reported in the following are carried out using STATA 15.1 software. The regressions are estimated by *xivreg2* command, implemented by Schaffer (2015).

²⁵ The *Hausman* test checking that the preferred model is random effects is rejected with a *p – value* of 0.000 for both baseline regression models.

²⁶ A test that the variance of error term is constant (*homoskedasticity*) is rejected with a *p – value* of 0.000 for both baseline regression models.

²⁷ A test that these time dummy variables are jointly equal to zero is rejected with a *p – value* of 0.006 for both baseline regression models.

Table 2: Estimation results

Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV-2SLS	IV-2SLS	OLS	IV-2SLS	IV-2SLS
	Full Sample	Full Sample	Full Sample	Full Sample	Full Sample	Full Sample
Resource dependence (lagged)	0,00133** (0,00059)	-0,00729*** (0,00168)	-0,00888*** (0,00193)	0,00133** (0,00060)	-0,00720*** (0,00168)	-0,0112*** (0,00219)
Infrastructure index (lagged)	-0,00601 (0,0421)	0,482*** (0,113)	0,443*** (0,112)			
Absorption index (lagged)				0,0987** (0,0385)	0,793*** (0,167)	0,688*** (0,164)
Infrastructure * Resource (lagged)			0,0150** (0,00630)			
Absorption * Resource (lagged)						0,0157*** (0,00522)
Ln (per capita GDP) (lagged)	-0,0714*** (0,00689)	-0,385*** (0,0435)	-0,382*** (0,0419)	-0,0722*** (0,00688)	-0,379*** (0,0436)	-0,365*** (0,0419)
Population growth	-0,0398*** (0,00608)	-0,0266** (0,0117)	-0,0229** (0,0117)	-0,0434*** (0,00568)	-0,0258** (0,0115)	-0,0232** (0,0111)
Investment ratio	0,00913*** (0,00070)	0,0144*** (0,00141)	0,0143*** (0,00139)	0,00926*** (0,00070)	0,0143*** (0,00141)	0,0140*** (0,00135)
Openness index (lagged)	0,00039*** (0,00014)	0,00172*** (0,00038)	0,00177*** (0,00039)	0,00043*** (0,00014)	0,00171*** (0,00038)	0,00175*** (0,00040)
Institution index	0,0232*** (0,00815)	0,0171 (0,0324)	0,0217 (0,0318)	0,0197** (0,00788)	0,0178 (0,0324)	0,0239 (0,0315)
Human Capital index (lagged)	0,103*** (0,0366)	0,432*** (0,146)	0,381*** (0,143)			
Country fixed effects	NO	YES	YES	NO	YES	YES
Time dummies	NO	YES	YES	NO	YES	YES
Observations	594	489	489	594	489	489
Number of Countries	105	105	105	105	105	105
R-squared	0,408	0,529	0,538	0,405	0,531	0,548
Hansen OID test (p-value)		0,136	0,203		0,307	0,307
K-P UID test (p-value)		0,000	0,000		0,000	0,000
K-P Weak ID, F statistic		122,14	126,58		130,44	131,67

Note: The dependent variable is per capita GDP growth rate. Infrastructure index (first lagged), Absorption index (first lagged) and per capita GDP (first lagged) are endogenous variables. They are instrumented by the windfall income (second lagged), per capita GDP (second lagged) and Telephone index (first lagged) in Column (2) and (3) and They are instrumented by the windfall income (second lagged), per capita GDP (second lagged), Human capital index (first lagged) and infrastructure index (first lagged) in Column (5) and (6). Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels.

The null hypothesis of *Hansen* test is that the instruments, as a group, are uncorrelated with the error term. The null hypothesis of Underidentification test (K-P UID test) is that the regression equation is underidentified. The null hypothesis of weak identification test (K-P Weak ID) is that the estimator is weakly identified (Point: 5% maximal IV relative bias is 13.91).

economic growth rate.

The next interesting question which we can suggest is whether the adverse effect of the resource-dependence on economic growth is stronger in countries with a lower level of capital goods (infrastructure and human capital) and larger absorption capacity constraints? To address this question, I include an interaction term between the resource-dependence index and proxies for the absorption capacity. The results for Infrastructure index and Absorption index are respectively reported at columns (3) and (6) of Table 2. In both regression models, the coefficients on the resource-dependence and the interaction term are significant and enter with a negative and positive signs, respectively. The estimations state that the natural resource curse attenuates as the absorption capacity expands. Now given the significance of the coefficient on the interaction term I investigate whether it would be feasible to change the sign of the effect of resource-dependence on economic growth. This refers to a derivative of the estimation model (i.e. Equations 1) with respect to the resource-dependence,

$$\frac{dGY_{i,t}}{dWI_{i,t-1}} = \beta_2 + (\beta_4 * NK_{i,t-1}). \quad (3)$$

Accordingly, the natural resource curse, on average, is vanished at an Infrastructure index larger than 0.6 and at an Absorption index larger than 0.7. Figure 5 represents the relationship between the natural resource curse and the constructed proxies. The horizontal axis shows the absorption capacity indexes (i.e. NK in Equations 3) and the vertical axis represents the impact on economic growth from the resource-dependence index (coefficient on resource dependence) (i.e. $\frac{dGY}{dWI}$ in Equations 3). The estimated results, reported in columns 4 and 6 of Table 2, are drawn by continues lines and dotted lines plot the 95% confidence interval. Furthermore, the circles show the average effect of the resource-dependence on economic growth with respect to the average of capital index for each country ²⁸.

A comparative study between two African countries- Ghana (*GHA*) and Cameroon (*CMR*)- can offer an example of how difference in the absorption capacity can influence the natural resource curse. A closer look at time series data shows that the average value of the resource-dependence index and per capita GDP (Ln) over 1975-2014 are approximately equal between two countries (see. Table 3). Nevertheless, average of Human capital index in Ghana is 1.2 times larger than that in Cameroon. Further, Electricity index and Telephone index are, respectively, 60 % and 17 % larger in Ghana. Briefly, absorption capacity constraints are less intensive in Ghana than in Cameroon. The estimation results represent that the adverse effect of a natural resource rent on economic growth is approximately 25 % less in Ghana, with respect to that in Cameroon (see. Figure 5).

²⁸ Those are estimated by $\frac{dGY_i}{dWI_i} = \beta_2 + (\beta_{4,i} * NK_i)$, where β_2 is the coefficient on the resource-dependence for full sample and $\beta_{4,i}$ is the coefficient on the interaction term for country i . Further NK_i is average of capacity index for country i over its periods.

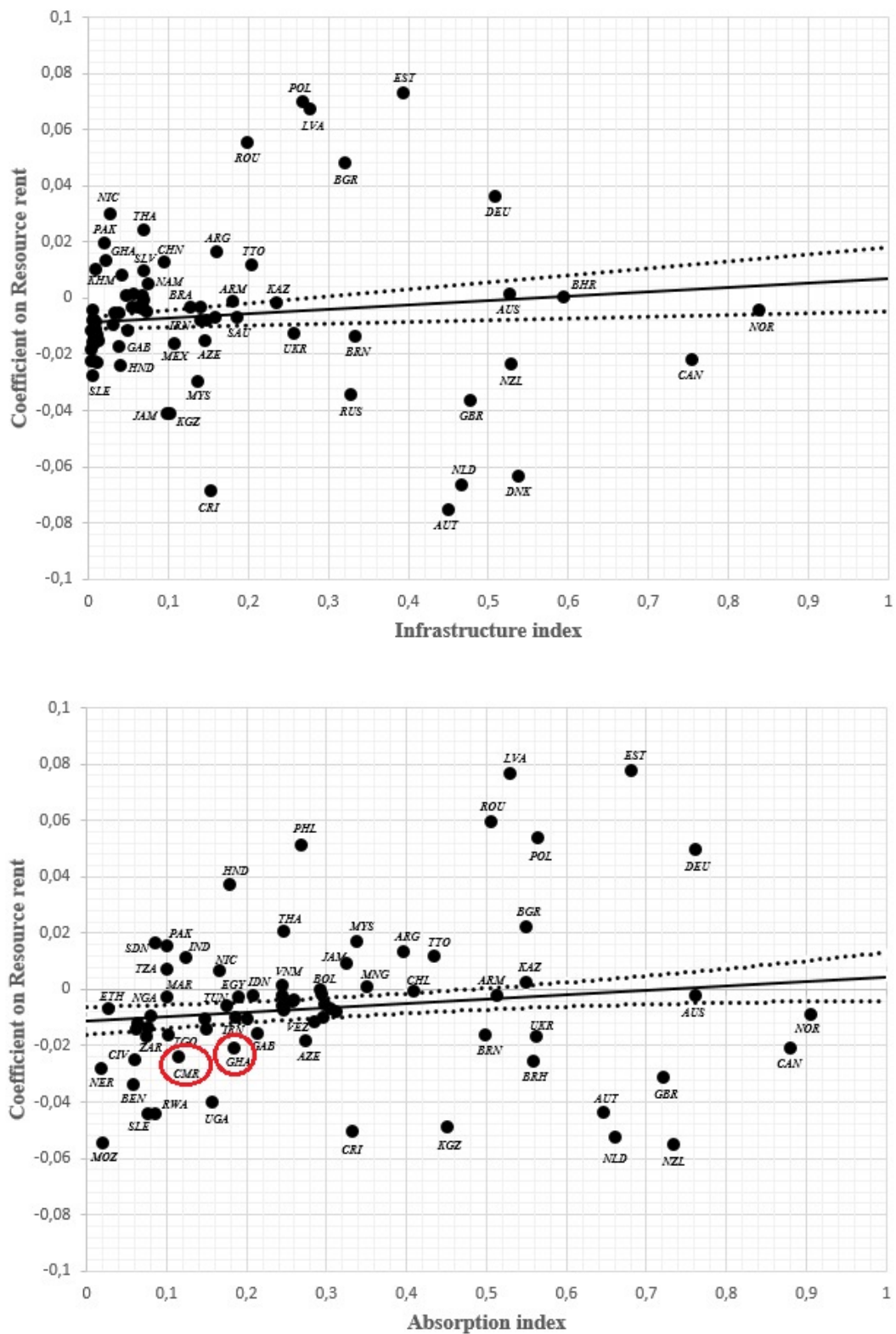


Figure 5: Average estimation result for coefficients on resource rent (the impact on economic growth from the resource-dependence index). Continues line: estimation results of Table 2 (columns 4 and 6) and dot line: 95% confidence interval. The circles: average effect of the resource-dependence rent on economic growth for each country. Only countries with an estimated coefficient larger than -0.1 and smaller than 0.1 are represented.

Table 3: Comparative study between *Ghana* to *Cameroon*

Period	Resource dependence	per capita GDP (Ln)	Human capital index	Electricity index	Telephone index
1975-84	0,81	0,95	1,16	1,88	1,62
1985-94	0,68	0,94	1,23	1,51	0,86
1995-04	1,28	0,98	1,22	1,83	1,7
2005-14	1,44	1	1,22	1,17	0,52
Average	1,05	0,97	1,21	1,6	1,17

Note: relative value of variables (*Ghana* to *Cameroon*).

4.3 Robustness Tests

Table 4 represents a robustness analysis to check the results of the baseline model in terms of heterogeneity across countries, another proxy to identify the absorption capacity, and another estimation approach. Columns (1) and (2), respectively, show the results of restricted samples for developing and developed countries, introduced by the International Monetary Fund's World Economic Outlook Database. Regarding these results, the hypothesis of a positive impact on economic growth from the Absorption index is only valid in developing countries. It might be because of having a little number of observations in the sample of developed countries. In addition, the natural resource curse remains for a longer interval level of the absorption index (equal to 0.9) in the developing countries' sample than in the full sample (i.e. 0.7). It seems to confirm the more intensive resource curse in developing countries than in developed countries.

Many countries, included in the baseline sample, have small shares of the total natural resources to GDP. Further, the different quality of institutions might affect the correlation between the variables of interest. Hence, one seems to be worth studying the effect of the absorption capacity constraints on the resource curse for a sample of non-resource-poor countries, the resource-dependence index larger than 2%, and for a sample of poor-institution countries, the institution index less than one. Columns (3) and (4), reporting respectively the estimation results for non-resource-poor countries and poor-institution countries, suggest that there is a significant and positive impact on economic growth from the Absorption index, the same as the baseline results. The coefficient on the Absorption index is larger in non-resource-poor and poor institution countries' samples than the full sample. More precisely, the marginal productivity of one more unit of the absorption capacity is stronger in these two groups of countries. Further, the negative coefficient on the resource-dependence and the positive coefficient on the interaction term between variables of interest are less intensive in the restricted samples than in the full sample. These suggest that the natural resource curse remains for a longer interval of the absorption capacity's proxy when I estimate the regression model for the restricted samples (less than 0.85) than what is estimated for the full sample (less than 0.7). The latter result may state that capacity constraints which are more intense in a sample of non-resource-poor countries or low-quality-institution countries lengthen the persistence of the resource curse.

In addition, in column (5), representing the estimation results of the regression model for a sample of Non-European countries, the currency union's effects are controlled. It shows when

Table 4: Estimation results for robustness check

Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV-2SLS Developing	IV-2SLS Developed	IV-2SLS Non-Reso Poor	IV-2SLS Poor Institution	IV-2SLS Non-European	IV-GMM Full Sample	IV-2SLS Full Sample	IV-2SLS 10-year period
Resource dependence (lagged)	-0.0105*** (0.00237)	-0.00143 (0.0232)	-0.0104*** (0.00245)	-0.0111*** (0.00231)	-0.0104*** (0.00228)	-0.0103*** (0.00210)	-0.0112*** (0.00220)	-0.0112*** (0.00268)
Absorption index (lagged)	0.773*** (0.279)	0.157 (0.221)	1.001*** (0.337)	0.723*** (0.232)	0.741*** (0.200)	0.610*** (0.156)	0.697*** (0.166)	0.503*** (0.187)
Absorption * Resource (lagged)	0.0116** (0.00647)	-0.000550 (0.0246)	0.0121* (0.00682)	0.0132** (0.00629)	0.0104* (0.00562)	0.0141*** (0.00511)	0.0157*** (0.00523)	0.0235*** (0.00612)
Ln (per capita GDP) (lagged)	-0.350*** (0.0435)	-0.348*** (0.0738)	-0.326*** (0.0499)	-0.357*** (0.0453)	-0.357*** (0.0419)	-0.365*** (0.0419)	-0.368*** (0.0421)	-0.287*** (0.0611)
Population growth	-0.0186 (0.0164)	-0.00387 (0.0175)	-0.0248 (0.0164)	-0.0212 (0.0153)	-0.0203 (0.0147)	-0.0246** (0.0111)	-0.0231** (0.0111)	-0.0272 (0.0182)
Investment ratio	0.0130*** (0.00160)	0.00987*** (0.00199)	0.0129*** (0.00200)	0.0133*** (0.00157)	0.0127*** (0.00156)	0.0135*** (0.00131)	0.0140*** (0.00136)	0.0131*** (0.00176)
Openness index (lagged)	0.00176*** (0.000447)	0.00110 (0.000681)	0.00169*** (0.000647)	0.00177*** (0.000439)	0.00179*** (0.000419)	0.00175*** (0.000397)	0.00176*** (0.000400)	0.000750 (0.000528)
Institution index	0.0317 (0.0335)	0.118*** (0.0384)	0.0454 (0.0446)	0.0402 (0.0328)	0.0249 (0.0339)	0.0282 (0.0313)	0.0240 (0.0315)	0.0223 (0.0431)
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES
Observations	359	130	240	372	378	489	489	223
Number of Countries	82	23	56	84	81	105	105	78
R-squared	0.564	0.782	0.516	0.565	0.543	0.547	0.547	0.540
Hansen OID test (p-value)	0.302	0.313	0.105	0.307	0.303	0.307	0.158	0.203
K-P UID test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
K-P Weak ID, F statistic	108.91	44.86	78.88	102.11	121.72	131.67	188.56	29.76

Note: The dependent variable is per capita GDP growth rate. Absorption index (first lagged) and per capita GDP (first lagged) are endogenous variables. They are instrumented by the windfall income (second lagged), per capita GDP (second lagged), Human capital index (first lagged) and infrastructure index (first lagged) in Columns (1)-(6). While, in column (7) per capita GDP (first lagged) is only endogenous variable and it is instrumented by the windfall income (second lagged) and per capita GDP (second lagged). Further, in column (8) independent variables of interest are in current period and Absorption index (current) and per capita GDP (first lagged) are instrumented by the windfall income (first lagged), per capita GDP (second lagged), Human capital index (current) and infrastructure index (current). Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels.

The null hypothesis of *Hansen* test is that the instruments, as a group, are uncorrelated with the error term. The null hypothesis of Underidentification test (K-P UID test) is that the regression equation is underidentified. The null hypothesis of weak identification test (K-P Weak ID) is that the estimator is weakly identified.

the observations for European countries are excluded, the resource curse remains in the rest of countries with each level of capacity constraint. However, less constraint tends still to moderate the resource curse.

I also estimate the regression model using *IV – GMM* to check the accuracy of the results. *IV – GMM* estimator is more comprehensive and efficient than the conventional *IV – 2SLS* estimator in the presence of arbitrary heteroskedasticity (see. Baum et al. (2003)). The results reported in columns (6) suggest that the coefficients on the absorption proxy and the interaction term are yet significant but their values are smaller than the values estimated by *IV – 2SLS*. In general, this may reflect that the difference in estimator doesn't qualitatively bias the intensity of the natural resource curse to a change in the capital index.

The next question that may arise is whether the results depend on the specified instruments for the endogenous variables. To analyze the question, I first assume that Absorption index is exogenous and the first-lagged GDP per capita (L_n) is the only endogenous variable. I then instrument the remained endogenous variable by the second-lagged of resource-dependence index and GDP per capita (L_n). Column (7) reports the results estimated by *IV – 2SLS* technique. It shows that the finding is independent of applying a specified regression model or taking into account the Absorption index as an endogenous variable²⁹.

I finally consider an alternative model specification that may yield some insight into the finding that the mean years of variables is not a robust and relevant regressor in the growth model. I consider a panel dataset that has been constructed over 10-year average value of variables, instead of 5-year as in the primary sample. The reason for this is twofold. First, measurement error has a potentially weaker impact on the regression estimates as the time interval over which the data are averaged increases. So taking into account a 10-year average dataset may unearth some signs of variable relevance that may be masked by measurement error in the 5-year panel setting. Second, consideration of a 10-year averaged panel let me investigate the more long-term effect of the absorption capacity on economic growth. In column (8), I present the results of the panel including the data for 78 countries. It clearly shows that there is no difference in statistical relevance averaging the data over 10-year and 5-year intervals. In addition, the natural resource curse seems to remain for a shorter interval level of the absorption index (equal to 0.48) for the 10-years average dataset than the primary sample dataset (i.e. 0.7). The latter point may implicitly suggest that expansion of the absorption capacity over time can neutralize the adverse effect of a resource boom.

Furthermore, it can be empirically more efficient to check the accuracy and sensitivity of the main finding using a different specification model and an estimation method. Hence, following Sridhar and Sridhar (2007), I use *IV – 3SLS* to estimate a system of equations that endogenizes the absorption capacity index through being dependent on GDP per capita. Table 5 report the estimation results. Columns (1) shows the results of the baseline model. The presence of unobservable heterogeneity across countries is rejected using a *Breusch – Pagan Lagrange multiplier*

²⁹ Note that we will find a similar qualitative conclusion, even if we apply a deeper lagged-level for instruments.

Table 5: Estimation results for robustness check: 3SLS

Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)
Dependent: Growth						
Resource dependence (lagged)	-0.00211** (0.00101)	-0.00452*** (0.00138)	-0.00235** (0.000977)	-0.00427*** (0.00133)	-0.00215** (0.00101)	-0.00444*** (0.00138)
Absorption index (lagged)	0.379*** (0.118)	0.324*** (0.120)	0.351*** (0.114)	0.308*** (0.116)	0.371*** (0.118)	0.321*** (0.120)
Absorption * Resource (lagged)		0.00980** (0.00382)		0.00789** (0.00369)		0.00931** (0.00381)
Ln (per capita GDP) (lagged)	-0.239*** (0.0186)	-0.235*** (0.0186)	-0.250*** (0.0184)	-0.246*** (0.0184)	-0.240*** (0.0186)	-0.236*** (0.0186)
Population growth	-0.0383*** (0.00794)	-0.0352*** (0.00800)	-0.0415*** (0.00778)	-0.0391*** (0.00784)	-0.0376*** (0.00792)	-0.0347*** (0.00798)
Investment ratio	0.0115*** (0.000790)	0.0114*** (0.000787)	0.0113*** (0.000773)	0.0112*** (0.000771)	0.0114*** (0.000788)	0.0113*** (0.000785)
Openness index (lagged)	0.00102*** (0.000276)	0.00108*** (0.000275)	0.00158*** (0.000267)	0.00159*** (0.000267)	0.00111*** (0.000275)	0.00116*** (0.000275)
Institution index	0.0210 (0.0209)	0.0233 (0.0208)	-0.00411 (0.0209)	-0.00201 (0.0209)	0.0233 (0.0208)	0.0251 (0.0207)
Constant	1.753*** (0.156)	1.737*** (0.155)	1.808*** (0.153)	1.790*** (0.153)	1.766*** (0.156)	1.749*** (0.155)
R-squared	0,720	0,722	0,729	0,731	0,720	0,722
Dependent: Absorption index						
Ln (per capita GDP)	0.0744*** (0.00636)	0.0747*** (0.00636)	0.0777*** (0.00656)	0.0780*** (0.00656)	0.0744*** (0.00636)	0.0746*** (0.00636)
Constant	-0.237*** (0.0591)	-0.239*** (0.0591)	-0.266*** (0.0609)	-0.269*** (0.0609)	-0.236*** (0.0591)	-0.238*** (0.0591)
R-squared	0,988	0,988	0,988	0,988	0,988	0,988
Dependent: Openness index						
Ln (per capita GDP)			15.48*** (2.734)	15.19*** (2.735)		
Resource dependence			0.650*** (0.151)	0.648*** (0.151)		
Ln (Real exchange rate)			-6.642*** (1.678)	-6.552*** (1.680)		
Terms of Trade			-5.612** (2.320)	-5.839** (2.324)		
Constant			-32.19 (25.61)	-29.76 (25.62)		
R-squared			0.897	0.898		
Dependent: Resource dependence						
Resource dependence (lagged)					0.402*** (0.0360)	0.402*** (0.0360)
Ln (per capita GDP)(lagged)					-3.917*** (0.592)	-3.914*** (0.592)
Openness index					0.0430*** (0.00974)	0.0427*** (0.00974)
Constant					31.99*** (5.422)	31.99*** (5.422)
R-squared					0.923	0.923
Country fixed effects	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
Observations	594	594	586	586	594	594
Number of Countries	105	105	105	105	105	105

test³⁰. It would mean that random-effects estimators could be appropriate and so the pooled estimators, which ignore heterogeneity across individuals, could be applied. However, given the fact that country heterogeneity may undermine the reliability of the empirical results, the system of equations include fixed-effects estimators³¹. The coefficients on the resource-dependence and the absorption index are significantly negative and positive, the same as the results estimated by *IV – 2SLS*. Further, the value of the coefficient on the resource-dependence is larger while that on the absorption index is smaller than those estimated by base technique. These indicate that raising the resource curse and the positive impact of dropping capacity constraints on economic growth are less intensive when *IV – 3SLS* is used than when *IV – 2SLS* was applied.

Column (2) presents the results of studying the intensity of the resource curse to an increase in the capacity index. This states that the natural resource curse is vanished at Absorption index larger than 0.46. It is smaller than the critical value of index found by the base method. A comparison of the results estimated by this method and the base one demonstrates that the findings are quantitatively different while qualitatively similar.

The Openness index and the resource-dependence index are more likely to be correlated with the per capita GDP. Since they are defined as a percent of GDP and also trade includes natural resource exports. Therefore, these two indexes seem to be endogenous rather than exogenous. Hence, I extend the base system of equations by adding one more equation for each of these indexes. Columns (3) and (4) represent the results for an extended system of equations in which the openness index is endogenized, while columns (5) and (6) report the results for an extended system of equations in which the resource-dependence index is endogenized. Although the values of coefficients are various, the analyzed results support the hypothesis that dropping the capacity constraints decreases the intensity of the resource curse.

Further robustness test is a sensitivity analysis of coefficients of interest to a change in the composition of the samples. Following Mihasonirina and Kangni (2011), the baseline regression models (columns 3 and 6 of Table 2) are run for randomly 98% of the observations (without replacement). This process, repeated 250 times, gives us the mean and standard deviation of coefficients of interest. The same procedure is also used to run the baseline models on selected randomly 95%, 80% and 65% of observations. Table 6 represents the analysis. It shows when the baseline models are run on different sample sizes, the mean values of the coefficient remain close to full sample coefficient values, while their normal distributions have heavier tails. This may suggest that the coefficients become less significant as the sub-sample size shrinks.

I also conduct a recursive estimation to test the stability and accuracy of the coefficients on the absorption capacity in terms of cross-country heterogeneity. Firstly, the observations are ranked in increasing order of proxies (Infrastructure index and Absorption index). Then the regression model is run for a sample with lowest order of both indexes, less than 0.2. In the next step, the subsequent observations with larger index are added and the regression model is rerun. This procedure is replicated as long as the full sample is covered. The results show at

³⁰ A test for the baseline specification of economic growth has a *p – value* of 0.000.

³¹ The *Hausman* test checking that the preferred model is random effects is rejected with a *p – value* of 0.000 for the economic growth regression.

Table 6: Robustness test for the sensitivity of coefficients of interest

Regression for Infrastructure index					
Explanatory variable		98%	95%	80%	65%
Infrastructure index (lagged)	Coefficient	0.44758	0.44916	0.47700	0.45663
	Standard Deviation	0.04190	0.06294	0.17348	0.37443
Resource dependence (lagged)	Coefficient	-0.00894	-0.00885	-0.00873	-0.00728
	Standard Deviation	0.00078	0.00128	0.00318	0.00573
Interaction term (lagged)	Coefficient	0.01504	0.01491	0.01284	0.01187
	Standard Deviation	0.00240	0.00416	0.01315	0.02946
Regression for Absorption index					
Explanatory variable		98%	95%	80%	65%
Absorption index (lagged)	Coefficient	0.69155	0.68209	0.74709	0.79640
	Standard Deviation	0.05668	0.10473	0.25519	0.57478
Resource dependence (lagged)	Coefficient	-0.01117	-0.01097	-0.01083	-0.00925
	Standard Deviation	0.00073	0.00146	0.00318	0.00691
Interaction term (lagged)	Coefficient	0.01557	0.01535	0.013862	0.00950
	Standard Deviation	0.00185	0.00365	0.00887	0.01800

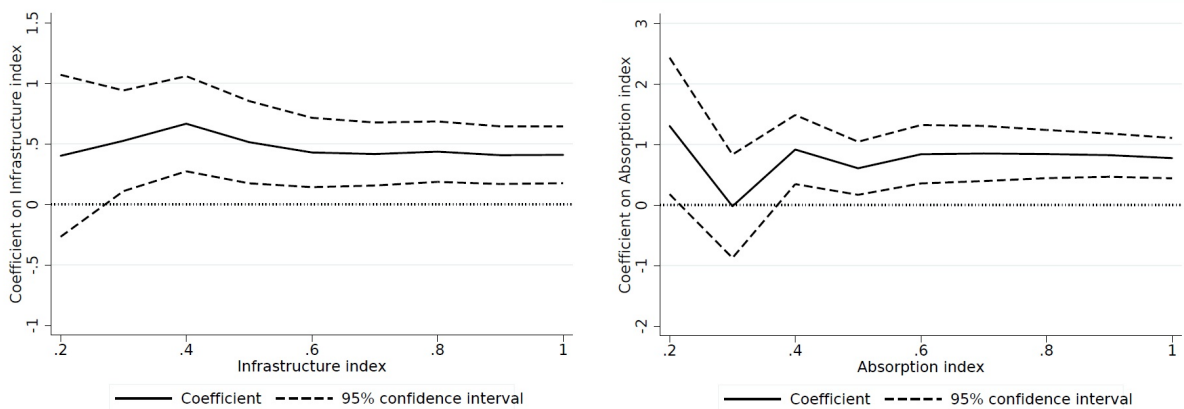


Figure 6: Recursive estimation on the coefficients of interest.

Figure 6. The coefficients on both Infrastructure index and Absorption index remain positive and significant. These demonstrate that the positive correlations between variables of interest are stable across country. Further, the marginal impact of infrastructure index on economic growth is approximately constant across the sample, while the marginal impact of Absorption index on economic growth is heterogeneous. The latter point may imply that a lack of human capital intensive sectors in countries with high absorption constraints prevents to absorb the effects of expansion in the capacity.

5 The Model

The presented analytical framework in section 2 highlights the short-term prospects of the resource curse. While non-traded capital goods (i.e. infrastructure and human capital) goes a long way to enhance economic performance. In the long-term, the economy extends its production possibility frontier (*PPF*) outward so that the natural resource curse is more likely to vanish. To address this issue and also to clarify the empirical findings, I develop the framework in following the model proposed by Van der Ploeg and Venables (2013). The model describes the dynamic mechanism of the resource curse in a developing economy constrained by the absorption capacity.

I consider a two-sector small open economy producing Traded (C_T), such as manufacturing goods, and non-Traded (C_{NT}) goods, such as services, public education and infrastructure. Price of traded goods is normalized to unity. Thereby, price of non-traded goods, denoted by P , is identified as the real exchange rate. The production technology in each sector is a homogeneous function. Assume that the non-traded sector (X_{NT}) employs labor (L_{NT}) and final capital goods (S), while the traded sector (X_T) produces goods by means of labor (L_T).

$$X_{NT} = S^\alpha (L_{NT})^{1-\alpha}, \quad (4a)$$

$$X_T = L_T. \quad (4b)$$

The labor force, inelastically supplied by households and moving freely across sectors, is normalized to unity to expel the population growth effect,

$$L_T + L_{NT} = L = 1. \quad (5)$$

Final capital goods (S) are normally made of the traded (such as equipment) and non-traded capital goods (such as the human capital and the infrastructure). Hence, the unit cost function for producing final capital goods can be denoted by $q(P) = P^\gamma$ in which $0 \leq \gamma \leq 1$ is a share of the non-traded capital goods used to produce one more unit of final capital goods³². As mentioned, some sorts of the capital goods (e.g. infrastructure, human capital) cannot normally

³² Bems and de Carvalho Filho (2011) found that the share of non-traded capital goods in total capital is stable across countries and over time and is in the range 0.54-0.62.

be traded in the international capital market. Hence, the case $\gamma = 0$, meaning that the required capital goods are totally imported, doesn't seem to be a feasible assumption³³. While the case $\gamma = 1$, implying that capital goods are produced fully domestic and the resource income can not be used to import them, highlights absorption capacity constraints best. Therefore, Equation 4a show that an expansion in the non-traded sector (e.g. the telecommunication service) requires non-traded final capital goods (e.g. skilled workers and infrastructures). To keep the model as simple as possible, I take in to account the case $\gamma = 1$ giving $q = P$.

This kind of formulation (Equation 4) captures in a simple way the feature of an economy where the non-traded sector is constrained by non-traded final capital goods (i.e. absorptive capacity constraint). In response to expanded demand for education and health service (non-traded goods), the economy must educate new teachers and doctors and construct new schools and hospitals (i.e. non-traded capital goods) which, in turn, requires teachers, doctors, and skilled workers to function. More generally, skilled workers as non-traded capital goods are intensively used in infrastructure and education sectors (the non-traded sector) to produce new skilled workers (Van der Ploeg and Venables, 2013). The argument rests on the key point that non-traded capital goods must domestically be produced. Hence, Equation 4 can represent an economy where most skilled workers (non-traded capital goods) are employed by the non-traded sectors such as the real estate (managers), the research sector (teachers and researchers), the health system (doctors and nurses) and the infrastructure sector (engineers).

Profit maximization yields labor employment in the non-traded sector,

$$L_{NT} = S[(1 - \alpha)P]^{1/\alpha}. \quad (6)$$

Labor market (Equation 5) gives labor employment in the traded sector,

$$L_T = 1 - S[(1 - \alpha)P]^{1/\alpha}. \quad (7)$$

Regarding Equation 6 and 7, output in the non-traded and traded sectors are given by:

$$X_{NT} = S[(1 - \alpha)P]^{\frac{1-\alpha}{\alpha}} \quad (8a)$$

$$X_T = 1 - S[(1 - \alpha)P]^{1/\alpha}. \quad (8b)$$

Therefore, $X = X_T + PX_{NT}$ is defined as the (non-windfall) gross national product. Moreover, $r = \frac{\partial X(P,S)}{\partial S} = \alpha(1 - \alpha)^{\frac{1-\alpha}{\alpha}} P^{\frac{1}{\alpha}}$ denotes the return on final capital goods and $w = 1$ is the real wage.

Following Van der Ploeg and Venables (2013), the windfall income ($NR(0)$) is supposed to be an exogenous flow, resulting from a discovery at initial time (t_0). The resource income can be spent to buy financial assets (B^F) or to finance capital goods over time. For simplicity, assume

³³ Note that some natural resource-rich countries, such as Persian Gulf States, can make almost all capital goods using the traded capital goods. They can provide the required human capital and infrastructure through employing, respectively, the foreign skilled and construction workers (Van der Ploeg and Venables, 2013).

Ricardian debt is neutrality held, implying that distribution of the natural resource wealth has no effect on the consumption of the economy. To capture this implication, define a foreign wealth (B) as a sum of the remaining natural resource wealth and financial asset (i.e. $B \equiv R + B^F$)³⁴. Thus the accumulated foreign wealth (B)³⁵ earns a return equal to an exogenously given world interest rate (r^*). I ignore the capital stock depreciation, then total investment (I) will be equal to capital accumulation (i.e. $I = \dot{S}$). Finally, the budget constraint of the economy is given by the following equation.

$$\begin{aligned} \dot{B} + PI &= r^*B + X_T(P, S) + PX_{NT}(P, S) - C_T - PC_{NT}, \\ S(0) &= S_0, \quad B(0) = B_0 = R(0) + B_0^F, \quad \lim_{t \rightarrow \infty} e^{-r^*t} B(t) = 0 \end{aligned} \quad (9)$$

Where a dot represents the time derivative (i.e. $\dot{B} \equiv \frac{dB(t)}{dt}$). Equation 9 displays the initial and transversality conditions³⁶. It says that total income, gained from abroad and domestic production, can be saved for investment if it exceeds the aggregate consumption.

On the demand side, I make the assumption that households have identical tastes. Hence the composition of the demand plays no rule in the economy's response to a natural resource boom. A representative household maximizes a log-linear utility function aggregated in his consumption of traded and non-traded goods subject to his budget constraint ($C_T + PC_{NT} = C$). The utility function is given by:

$$U(C_{NT}, C_T) = [\theta \log C_{NT} + (1 - \theta) \log C_T]. \quad (10)$$

θ is the consumption share of non-traded goods and C is the total consumption (expenditure). Households allocate their total income on traded and non-traded goods according to:

$$C_T = (1 - \theta)C \quad PC_{NT} = \theta C. \quad (11)$$

5.1 Consumer problem

Let me assume a benevolent social planner (e.g. Government) maximizes the utility function (Equation 10) subject to the budget constraint (Equation 9) and the capital accumulation (i.e. and $I = \dot{S}$),

$$\text{Max}_{\{C_N, C_T, I\}} \int_0^{\infty} U(C_N, C_T) e^{-\rho t} dt. \quad (12)$$

³⁴ The present value of the natural resource wealth is: $R(t) = \int_t^{\infty} NR(v) e^{-r^*(v-t)} dv$, so $\dot{B}^F = \dot{B} - \dot{R} = \dot{B} - r^*R + NR$.

³⁵ Precisely, assume the windfall income starts at time zero, so the initial foreign wealth is equal to the initial financial asset ($B_0 = B_0^F$). Furthermore, since the discovered natural resource is used to buy the costless financial assets, I can write

$$R(0) = R(t) + \Delta B^F = R(t) + B^F(t) - B_0^F = R(t) + B(t) - R(t) - B_0^F = B(t) - B_0^F \Rightarrow R(0) = \Delta B$$

³⁶ The no-Ponzi condition guarantees that the foreign assets (B^F) can not grow at a rate faster than the world interest rate.

ρ denotes the rate of discount or the agent's rate of time preference. The current value Hamiltonian for this optimization problem is:

$$H = [\theta \log C_N + (1 - \theta) \log C_T] + \mu [I - \dot{S}] + \lambda [r^* B + X_T(P, S) + P X_N(P, S) - C_T - P C_N - P I - \dot{B}], \quad (13)$$

where μ and λ are co-state variables. μ is the shadow value of the final capital goods and λ is defined as the social (shadow) value (marginal utility) of wealth in the form of foreign wealth (B). It is straightforward to show the optimality conditions with respect to control variables of C_T, C_{NT} and I :

$$\frac{1 - \theta}{C_T} = \lambda \quad (14a)$$

$$\frac{\theta}{C_{NT}} = P \lambda \quad (14b)$$

$$\frac{\mu}{\lambda} = P. \quad (14c)$$

The first pair optimal conditions are intertemporal envelop conditions and link the marginal utility of consumption to the social value of wealth. Equation 14c indicates when the social value of wealth is used as *numeraire*, the relative shadow value equals the unit cost to produce one more unit of the final capital good. In addition, the optimality conditions with respect to state variable of B lead to the familiar Keynes-Ramsey rule:

$$\frac{\dot{\lambda}}{\lambda} = \rho - r^* \quad (15)$$

This implies that marginal utility growth rate is equal to a fixed rate of return. Under a perfect international financial market, the rate of discount and the world interest rate can be assumed to be equal ($\rho = r^*$), meaning that the social value of wealth is constant over time ($\lambda = \bar{\lambda}$). This standard assumption in the small open economy's literature satisfies the existence of a nonzero finite steady-state equilibrium in a dynamic model. It allows to evaluate the response of the dynamic system to a change in the level of λ rather than a natural resource boom (see. Appendix C). Given Equation 14c and 15, the optimality condition with respect to state variable of S gives the arbitrage condition for the real exchange rate (or cost):

$$\frac{r}{P} = r^* - \frac{\dot{P}}{P}. \quad (16)$$

This condition represents an equality between the return on final capital goods (i.e. $r(P) = \frac{\partial X(P, S)}{\partial S}$) per unit cost of the installed capital (i.e. $q = p$) and its cost, the world rental charge

minus the inflation rate (cost rate). In addition, the market-clearing condition is as follows ³⁷:

$$X_{NT}(P, S) = C_{NT}(P, \lambda) + \dot{S} \quad (17)$$

This intuitively indicates that additional resource spending cannot immediately be absorbed by the economy since the final capital goods must domestically be produced. Equation 17 clearly represents the implication of absorptive capacity constraints ³⁸ and also highlights the importance of the gradual expansion of non-traded final capital goods, as one of the significant reasons for the supply bottleneck. A permanent decline in the social value of wealth, the consequence of a natural resource discovery at time zero (see. Appendix C), induces the aggregate demand for non-traded goods to increase and subsequently the growth rate of capital goods to decrease. Therefore, this equation may demonstrate why resource-dependent economies encounter a reduction in capital accumulation growth. In other words, the resource-dependent economies neglect to invest in non-traded capital goods (such as education and infrastructure) since they see no immediate need for it (Gylfason and Zoega, 2002).

The dynamic system is eventuated as follows:

$$\dot{S} = S[(1 - \alpha)P]^{\frac{1-\alpha}{\alpha}} - \frac{\theta}{\lambda P} \quad (18a)$$

$$\dot{P} = Pr^* - \alpha(1 - \alpha)^{\frac{1-\alpha}{\alpha}} P^{\frac{1}{\alpha}} \quad (18b)$$

5.2 Economic response to the windfall income

When the resource rent is permanently increased, the dynamic model is thrown out of the initial steady-state equilibrium. Let me draw the linear approximation of isoclines (i.e. phase diagram) to analyze the response of the non-linear dynamic system to an externality. In fact, the slope as well as how to shift the isoclines can be determined by the implicit function theorem. More precisely, I need to compute the partial derivatives of P with respect to S along isoclines of the capital growth (i.e. $\dot{S} = 0$) and the real exchange rate (i.e. $\dot{P} = 0$), respectively.

$$\left[\frac{\partial P}{\partial S} \right]_{\dot{S}=0} = - \frac{\frac{\partial \dot{S}}{\partial S} > 0}{\frac{\partial \dot{S}}{\partial P} > 0} < 0 \quad ; \quad \left[\frac{\partial P}{\partial S} \right]_{\dot{P}=0} = - \frac{\frac{\partial \dot{P}}{\partial S} = 0}{\frac{\partial \dot{P}}{\partial P} < 0} = 0 \quad (19)$$

It is easy to see a negatively sloped isocline for capital growth ($\dot{S} = 0$) and a horizontal isocline for the inflation locus ($\dot{P} = 0$) (see. Figure 7). The real exchange rate appreciation around the stationary shifts the isocline of S up to the right. Since more final capital goods are produced than

³⁷ Market-clearing condition is determined by derivative of the current value Hamiltonian with respect to the real exchange rate (i.e. $\frac{\partial H}{\partial P} = 0$).

³⁸ For a general case (i.e. $0 < \gamma < 1$ and $q(P) = P^\gamma$), Equation 17 yields: $X_{NT}(P, S) = C_{NT}(P, \lambda) + q_P(P)\dot{S}$, where $q_P(P) \equiv \frac{dq(P)}{dP}$ is the marginal cost of final capital good. Precisely, this formulation says when final capital goods only require traded capital goods to be produced ($\gamma = 0$), the unit cost function equals unity ($q = 1$) and so the marginal cost becomes zero ($q_P = 0$). Therefore, the economy will swallow the natural resource rent and is instantaneously adjusted to a new long-run structure good (i.e. $X_{NT}(P, S) = C_{NT}(P, \lambda)$).

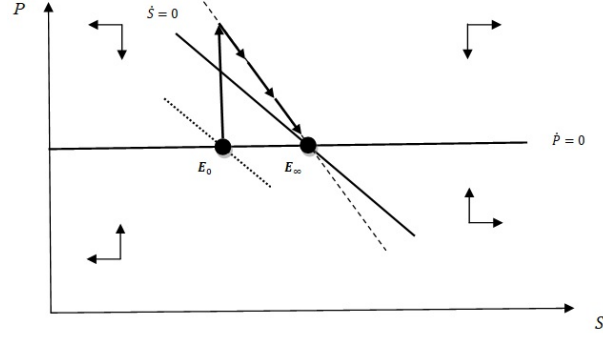


Figure 7: Phase Diagram and Dynamic effects of the windfall income

consumed when the economy is above S locus. Further, rising the real exchange rate increases the return on the capital and so investment. Thereby, falling the real exchange rate above the inflation locus ($\dot{P} = 0$) is consistent to keep stationary in its place.

The saddle path will be steeper than S locus to induces the capital accumulation (i.e. $\dot{S} > 0$) (for proof see Appendix D). The isoclines cross each other at the initial steady-state equilibrium, shown by E_0 in Figure 7, as long as the windfall income doesn't influence the economy. For a given P , a permanent natural resource boom, through a decline in the social value of wealth (λ), increases the demand for non-traded goods and so reduces investment. Therefore, the $\dot{S} = 0$ locus shifts up to the right to re-establish the steady-state equilibrium. The real exchange rate follows the boldly directed line (see. Figure 7). It jumps up to saddle path along which a portion of non-traded goods is invested. This temporary appreciation moderates over time as long as the capital stock gradually increases.

To clarify the resource curse, I further do an experimental study. A log-linearized solution of dynamic system has been described in Appendix D. The time path of S and P are given by:

$$S(t) = S_0 + \Delta S [1 - \exp(-t\sigma)] \quad (20a)$$

$$P(t) = \bar{P} + \left[\frac{(2-\alpha) \frac{r^*}{\alpha}}{Q_p} \right] \Delta S \exp(-t\sigma) \quad (20b)$$

and for the foreign wealth (B),

$$B(t) = B_0 - \left(\Delta B + \left[\frac{(2-\alpha) \frac{r^*}{\alpha}}{Q_p} \right] \Delta S \exp(-t\sigma) \right) \quad (21)$$

where $\sigma = \frac{1-\alpha}{\alpha} r^* > 0$ is the adjustment speed. \bar{P} is the steady-state real exchange rate and S_0 and B_0 denote initial capital stock and foreign wealth, respectively. ΔS is the gap between steady-state and initial capital stock while ΔB is the gap between steady-state and initial foreign wealth ($\Delta B = R(0)$). $Q_p > 0$ represents the slope of the supply of non-traded goods available for use in investment (Van der Ploeg and Venables, 2013), $Q = X_{NT}(S, P) - C_{NT}(P, \lambda)$. The capital intensity α is crucial for the dynamics adjustment path. The lower the capital intensity, the faster

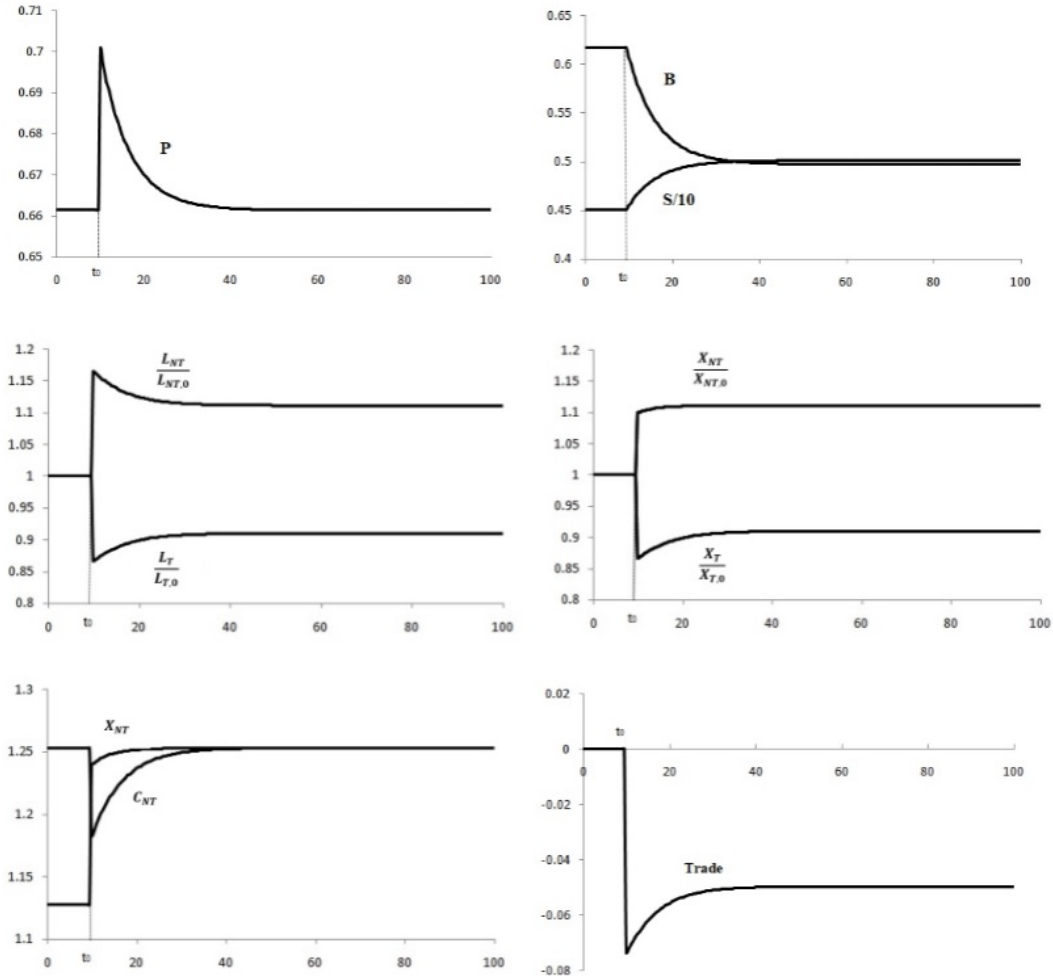


Figure 8: The dynamic adjustment path. Note: the dynamic path for S is divided by 10, denoted by $S/10$.

the adjustment speed.

Figure 8 shows the dynamics adjustment paths. The horizontal axis can be interpreted as months. The real exchange rate (P), capital accumulation (S) and foreign wealth (B) represent in the upper-left and -right sixths, while the sectoral labor shares and the sectoral outputs with respect to their initial values are illustrated in the middle parts. Supply and demand for non-traded goods are shown in lower-left sixth and the trade balance is represented in lower-right sixth. The simulation results in Figure 8 set the world interest rate at 10% and the consumption share of non-traded goods at 0.6. The capital intensity equals 0.4 and the social value of wealth is assumed to be equal to 0.724, giving the balance trade (i.e. $X_T - C_T = 0$). The reported experiment is a windfall with a negative jump in the social value of wealth of 10% (i.e. $\frac{\Delta \lambda}{\lambda} = -0.1$, referring to a initial capital goods' value of 3.47 times of the initial gross national product).

Regarding the absorptive capacity constraints, there is a supply bottleneck in the non-traded sector. Therefore, in response to a permanent windfall income, the real exchange rate appreciates to confront the expanded demand for non-traded goods. While the demand for traded goods is constant (see. Equation 14a and 14b). An appreciation in the real exchange rate rises the relative real wage in terms of non-traded sector's employments and so sends a signal for the labor to shift

away from the traded sector and into the non-traded sector. As a result, the traded sector shrinks and the non-traded sector expands. So that the de-industrialization is accompanied by the trade deficit (i.e. $C_T > X_T$). Further, rising the return on capital goods per unit cost ($\frac{r(P)}{P} = \frac{\partial X(P,S)}{\partial S}$) induces investment on the production of non-traded goods (i.e. $X_{NT} > C_{NT} \Rightarrow \dot{S} > 0$). The foreign wealth (B) gradually reduces to finance the capital goods (S)³⁹. More profit of production process in the non-traded sector than before⁴⁰ tends to reverse the temporary appreciation of the real exchange rate over time (X_{NT} converges to C_{NT}). In addition, a gradual real exchange rate depreciation decreases the relative real wage in terms of the non-traded sector's employment. This, in turn, leads to a countervailing movement of labor from the non-traded to the traded sector so that a portion of reduced labor share in the traded sector is recovered. Finally, the natural resource curse (i.e. de-industrialization) and the trade balance are gradually moderated as long as the gap between the supply and the demand of the non-traded goods vanishes.

Now regarding the main empirical finding, it is worth discussing the effect of initial capital

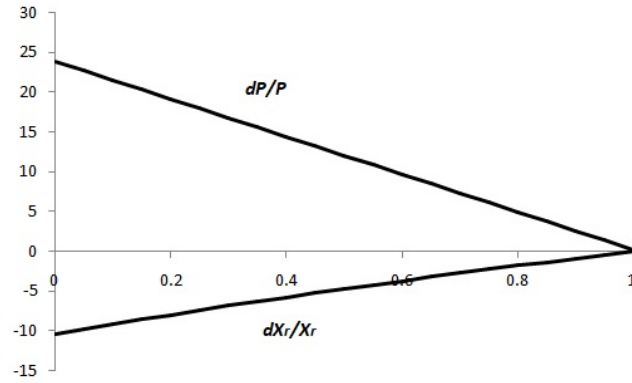


Figure 9: The effect of the absorption capacity on the intensity of the resource curse. The horizontal line is the normalized initial final capital stock (S_0); the original range $3 \leq S_0 \leq 5$.

goods (i.e. the absorption capacity) on the intensity of the resource curse. In this respect, the real output is defined as: $X_r = X_T + \bar{P}X_{NT}$ ⁴¹ and the experimental responses of the gap in the real exchange rate ($\frac{dP}{P} = \frac{P-\bar{P}}{\bar{P}}$) and the gap in the real output ($\frac{dX_r}{X_r} = \frac{X_r - X_r^*}{X_r^*}$) to 10% decreases in the social value of wealth (i.e. $\frac{\Delta\lambda}{\lambda} = -0.1$) are calculated for a range of initial capital goods. Figure 9 displays the gaps with respect to normalized initial capital goods⁴². This represents that larger capacity, smaller appreciation in the real exchange rate and less adverse effect of a resource boom on the real output. More precisely, 1% increases in initial capital goods is approximately associated with falling 25% in the real exchange rate appreciation and improving 10% in contraction of the real output. Given the model, the real exchange rate appreciation

³⁹ A change in the financial asset, B_F , depends on the time path of the remaining windfall income, R . For example, assume new discoveries remain the resource wealth at constant level (i.e. $R = cte \Rightarrow \dot{R} = 0$). Therefore, the financial asset follows the foreign wealth (i.e. $\dot{B} = \dot{B}_F$). As B falls to finance S so current account deficit arises and foreign debt is eventuated $\dot{B}_F < 0$.

⁴⁰ Note that $\frac{\partial \frac{r(P)}{P}}{\partial P} = \frac{1-\alpha}{\alpha} \frac{r}{P^2} > 0$.

⁴¹ An alternative is the gross national product in the nominal term (X) adjusted by the aggregate price index (P^θ) (i.e. $X_r = \frac{X}{P^\theta}$).

⁴² The maximum experimental value of initial capital goods is equal to its steady-state value.

will be smaller in higher levels of initial capital goods (see. Equation 20b)(see Appendix E for empirical evidence). It, in turn, can be translated to a cheaper production process (or more profit) and to less labor movement across sectors. Therefore, larger capital goods (absorption capacity) makes the natural resource curse smaller.

5.3 Imperfect financial market and changing the demand composition

In the preceding subsection, I analyzed the impact of a resource boom on economic performance of a country facing with absorption capacity constraints. The analysis was based on the assumptions such as the perfect financial market and unchanged consumption shares on goods. But these assumptions don't seem to be in keeping with the development process, specifically in developing countries. For example, along with the development, improving the quality of the financial system might relax the constraints on the supply of finance for domestic production or increasing income might change the composition of the demand. Hence, it is worth combining the presented model with a financial market imperfection and changing the demand composition over time.

I don't model these two issues endogenously. I merely suppose that they change over time along with the development (i.e. expansion of the final capital (S)). Hence, I, on the one hand, assume that the domestic production sector faces interest rate $r^* + \hat{r}(I_d)$, where r^* is the interest rate prevailing internationally and $\hat{r}(I_d)$ is an interest premium, reducing along with the development (i.e. $\frac{d\hat{r}(I_d)}{dI_d} < 0$)⁴³. On the other hand, I suppose that the consumption share of non-traded goods increases along with the development path (i.e. $\frac{d\theta(I_d)}{dI_d} > 0$). The modified dynamic system to capture these extensions is given as follow:

$$\dot{S} = S[(1 - \alpha)P]^{\frac{1-\alpha}{\alpha}} - \frac{\theta(I_d)}{\lambda P} \quad (22a)$$

$$\dot{P} = P[r^* + \hat{r}(I_d)] - \alpha(1 - \alpha)^{\frac{1-\alpha}{\alpha}} P^{\frac{1}{\alpha}} \quad (22b)$$

Figure 10 represents the dynamic effect of the extended model. The isoclines cross each other initially at E_0 . If the interest premium and the demand composition don't change along with the development, the $\dot{S} = 0$ locus and the $\dot{P} = 0$ locus intersect each other at E_∞ , described in section 5.2. But if the assumptions are relaxed there are two more effects at work. The first effect comes from changing the demand composition along with the development process. The demand for non-traded goods expands more than before and so the $\dot{S} = 0$ locus shifts up to the right more. It suggests that a larger value of capital goods has to be produced over time to respond to more expansion of the demand for non-traded goods. Whereas, the second effect originates from reducing the interest premium along with the development process. The $\dot{P} = 0$ locus now shifts down. The intuition is that producing capital goods become cheaper once its cost to finance is reduced. Graphically, The initial jump in the real exchange rate P converges to a lower level.

⁴³ Van der Ploeg and Venables (2013) supposed that the windfall income has the effect of reducing the interest premium \hat{r} along the development path.

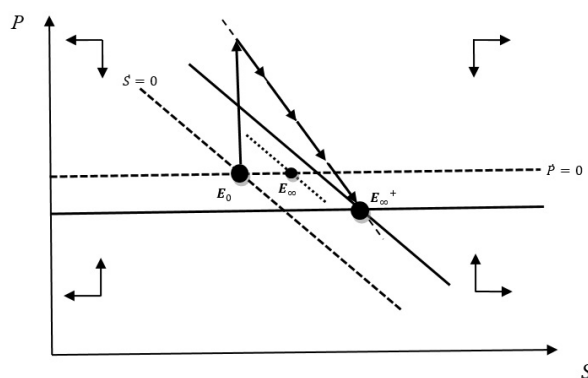


Figure 10: Phase Diagram of the extended model

Finally, the isoclines meet each other at E_∞^+ , so that the quantity of the capital is larger at E_∞^+ than at E_∞ , while its cost, P , is cheaper.

I further discuss the gap in the real exchange rate and in the real output once the two above constraints are ignored. Hence, I assume the consumption share of non-traded goods increases (from 0.6 to 0.7) and the interest premium decreases 1%, corresponding to a decrease of $r^* + \hat{r}(I_d)$ from 0.1 to 0.09. The experimental results represent that reducing the interest premium causes the gap in the real exchange rate to become larger to the extent of 0.75%. While increasing the consumption share on non-traded goods causes the gap in the real output to become more negative to the extent of 13%. As a conclusion, the adverse effect of a resource boom on the real output is more intensive for a case in which, along with the development, the imperfect financial market moderates and the demand for non-traded goods expands than for a case in which the financial market is fully perfect and the composition of the demand is unchanged.

6 Conclusion

This paper investigates how capital goods (i.e. absorption capacity) play a role in the intensity of the natural resource curse (the adverse effect of a resource boom on economic performance). The stylized facts represent that the natural resource curse is accompanied by a lower level of human capital and infrastructure proxies. Further, some sorts of capital goods (such as infrastructure and human capital) can not be imported or exported and they must be domestically produced, which in turn needs domestically produced "home-grown" capital goods to function (e.g. roads need to extend roads, teachers to educate more teachers) (i.e. absorption capacity constraint). Therefore, the main contribution of this paper is to testify and clarify the following hypothesis: the natural resource curse is more intensive in countries with more absorption capacity constraints (or a lower level of capital goods).

In this respect, I present an empirical study. I firstly collect data for 105 countries over the period 1975-2014. Then, two indexes are constructed to identify cross-country absorption capacity (capital goods): 1) Infrastructure index, the average of normalized Electricity index and normalized Telephone index, and 2) Absorption index, the average of normalized Human Capital

Index and normalized Infrastructure index. Using the *IV – 2SLS* technique, clear evidence in supporting the proposed hypothesis is founded.

Motivated by Van der Ploeg and Venables (2013), I develop a simple two-sector framework in which non-traded capital goods are only employed by the non-traded sector. This structure captures in a simple way the features of an economy in which the non-traded sector is constrained by absorption constraints. In the short-term, a permanent resource boom leads to a temporary appreciation in the real exchange rate and thereby arising the natural resource curse (de-industrialization). While in the long-term, a gradual expansion of capital goods reverses the temporary appreciation in the real exchange rate and so the natural resource curse moderates as long as the gap between supply and demand sides of the non-traded sector vanishes. The model also clarifies that less absorption capacity (or lower level of capital goods) increases the intensity of the natural resource curse. Moreover, the intensity becomes stronger if the development reduces the cost to finance the production of capital goods and increases the consumption share for non-traded goods.

Appendix A Statistical cross-country estimation

OLS results for the cross-country studies are reported in Table 7.

Table 7: Cross-country estimation results

Explanatory variable	(1) GDP Growth per capita	(2) Human Capital index	(3) Fixed Telephone subscriptions	(4) Electric Power consumption
Resource rent (% GDP)	-0.0117** (0.00514)	-0.0269*** (0.00770)	-0.960*** (0.233)	-115.9* (61.05)
Constant	0.551*** (0.0567)	2.545*** (0.0848)	26.27*** (2.568)	4,317*** (672.6)
Number of Countries	73	73	73	73
R-squared	0.068	0.147	0.193	0.048

Appendix B Countries included in the sample database

Table 8: List of Countries

	Period	No. Period		Period	No. Period
Albania	1990-2014	5	Japan	1975-2014	8
Algeria	1975-2014	8	Kazakhstan	1995-2014	4
Angola	1995-2014	4	Korea south	1975-2014	8
Argentina	1975-2014	8	Kyrgyzstan	1995-2014	4
Armenia	1995-2014	4	Latvia	1995-2014	4
Australia	1975-2014	8	Malaysia	1975-2014	8
Austria	1975-2014	8	Mexico	1975-2014	8
Azerbaijan	1995-2014	4	Moldova	1995-2014	4
Bahrain	1985-2014	6	Mongolia	1985-2014	6
Bangladesh	1975-2014	8	Morocco	1975-2014	8
Belgium	1975-2014	8	Mozambique	1985-2014	6
Benin	1975-2014	8	Namibia	1990-2014	5
Bolivia	1980-2014	7	Nepal	1975-2014	8
Botswana	1975-2014	8	Netherlands	1975-2014	8
Brazil	1975-2014	8	New Zealand	1980-2014	7
Brunei	1990-2014	5	Nicaragua	1975-2014	8
Bulgaria	1985-2014	6	Niger	1995-2014	4
Cambodia	1995-2014	4	Nigeria	1980-2014	7
Cameron	1975-2014	8	Norway	1975-2014	8
Canada	1975-2014	8	Pakistan	1975-2014	8
Chad	1995-2014	4	Paraguay	1990-2014	5
Chile	1975-2014	8	Peru	1975-2014	8
China	1975-2014	8	Philippine	1975-2014	8
Colombia	1975-2014	8	Poland	1995-2014	4
Congo, Dem. Rep.	1975-2014	8	Portugal	1975-2014	8
Congo, Rep.	1975-2014	8	Romania	1995-2014	4
Costa Rica	1975-2014	8	Russia	1995-2014	4
Cote d'Ivoire	1975-2014	8	Rwanda	1995-2014	4
Croatia	1995-2014	4	Saudi Arabia	1975-2014	8
Cyprus	1980-2014	7	Sierra Leone	1995-2014	4
Czech	1995-2014	4	South Africa	1975-2014	8
Denmark	1975-2014	8	Spain	1975-2014	8
Dominican Rep.	1980-2014	7	Sri Lanka	1975-2014	8
Ecuador	1975-2014	8	Sudan	1995-2014	4
Egypt	1975-2014	8	Swaziland	1995-2014	4
El Salvador	1975-2014	8	Switzerland	1985-2014	6
Eritrea	1995-2014	4	Sweden	1975-2014	8
Estonia	1995-2014	4	Tajikistan	1995-2014	4
Ethiopia	1985-2014	6	Tanzania	1995-2014	4
Finland	1975-2014	8	Thailand	1975-2014	8
France	1975-2014	8	Togo	1975-2014	8
Gabon	1980-2014	7	Trinidad and Tobago	1975-2014	8
Germany	1975-2014	8	Turkey	1975-2014	8
Ghana	1975-2014	8	Tunisia	1975-2014	8
Greece	1975-2014	8	Ukraine	1995-2014	4
Honduras	1975-2014	8	Uganda	1995-2014	4
Hungary	1995-2014	4	United Kingdom	1975-2014	8
India	1975-2014	8	Uruguay	1975-2014	8
Indonesia	1975-2014	8	Venezuela	1975-2014	8
Iran	1975-2014	8	Vietnam	1990-2014	5
Ireland	1975-2014	8	Yemen	1995-2014	4
Italy	1975-2014	8	Zimbabwe	1975-2014	8
Jamaica	1975-2014	8			

Appendix C Windfall income and social value of wealth

The size of the social value of wealth (λ) stimulated by a natural resource discovery (R_0) is determined using the economy's present value budget constraint and given $\rho = r^*$:

$$\int_0^{\infty} [C + PI] \exp(-r^*t) dt = B_0^F + R_0 + \int_0^{\infty} X(P, S) \exp(-r^*t) dt.$$

Where B_0^F is the initial value of the foreign asset and $B_0 = B_0^F + R_0$ represents the initial foreign wealth. By replacing $C = \frac{1}{\lambda}$ in the last equation, a sudden falling in the size of the social value of wealth, caused by a permanent jump in the natural resource discovery, can apparently be derived from the following relation:

$$\lambda = \left[\frac{\int_0^{\infty} \exp(-r^*t) dt}{B_0^F + R_0 + \int_0^{\infty} [X(P, S) - PI] \exp(-r^*t) dt} \right].$$

Appendix D Solution of dynamic system

Log-linearization of the dynamic system (Equation 18) gives $\dot{\tilde{y}} \approx A\tilde{y}$ where

$$\tilde{y} = \begin{bmatrix} S - S^* \\ P - \bar{P} \end{bmatrix} \quad \text{and} \quad A = \begin{bmatrix} \frac{\partial \dot{S}}{\partial P} & \frac{\partial \dot{S}}{\partial S} \\ \frac{\partial \dot{P}}{\partial S} & \frac{\partial \dot{P}}{\partial P} \end{bmatrix} = \begin{bmatrix} \frac{r^*}{\alpha} & Q_p \\ 0 & -\left(\frac{1-\alpha}{\alpha}\right) r^* \end{bmatrix}$$

Also, $S^* = \frac{\theta(1-\alpha)}{\lambda(r^*/\alpha)^{\frac{1}{1-\alpha}}}$ is the steady-state solution of capital stock, while $\bar{P} = \frac{(r^*/\alpha)^{\frac{\alpha}{1-\alpha}}}{1-\alpha}$ in the initial price level. Further, $Q_p = \frac{\theta}{\alpha\lambda\bar{P}^2} = \frac{C_N(\bar{P}, \lambda)}{\alpha\bar{P}}$ denotes the slope of the supply of non-traded goods available for use in investment.

Given the number of negative eigenvalues is equal to the number of pre-determined state variables (i.e. S), there is a unique optimal trajectory (saddle-path stable) and the negative eigenvalue is speed of convergence (calculation of $\det(A - \sigma I) = 0$ gives eigenvalues, $\sigma_1 = -\left(\frac{1-\alpha}{\alpha}\right) r^*$ and $\sigma_2 = \frac{r^*}{\alpha}$).

Routine calculation for a linearized dynamic system indicates that the solution for an unanticipated resource boom at time zero equals:

$$\begin{aligned} S(t) &= S_0 + \Delta S [1 - \exp(-t\sigma)] \\ P(t) &= \bar{P} + \left[\frac{(2-\alpha)r^*}{Q_p} \right] \Delta S \exp(-t\sigma). \end{aligned}$$

Given $\Delta P = 0$ and $X_{NT}(P, S) = C_{NT}(P, \lambda)$ at steady-state, $\Delta S \equiv S^* - S_0 = -S^* \frac{\Delta\lambda}{\lambda}$ and so $S_0 = S^* \left[1 + \frac{\Delta\lambda}{\lambda} \right]$.

Furthermore, the foreign wealth equation is determined independently. Since its eigenvalue is positive r^* . The steady-state value equals $-\frac{Trade^*}{r^*}$, where $Trade^* = X_T^* - C_T^*$.

Now it is useful to prove the slope of the saddle-path is negative and it is steeper than locus $\dot{S} = 0$.

We know that $P'(S) = \frac{\partial P}{\partial S} = \frac{dP/dt}{dS/dt} = \frac{\dot{P}}{\dot{S}} = \frac{S[(1-\alpha)P]^{\frac{1-\alpha}{\alpha}} - \frac{\theta}{\lambda\bar{P}}}{Pr^* - \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} P^{\frac{1}{\alpha}}}$. Consider slope of saddle-path at

steady-state

$$P'(S^*) = \lim_{S \rightarrow S^*} P'(S^*) = \lim_{S \rightarrow S^*} \frac{S[(1-\alpha)P]^{\frac{1-\alpha}{\alpha}} - \frac{\theta}{\lambda P}}{Pr^* - \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} P^{\frac{1}{\alpha}}} = -\frac{(\frac{1-\alpha}{\alpha})r^*}{\frac{r^*}{\alpha} + Q_p}$$

where the last equality follows L'Hopital rule. Given $\left[\frac{\partial P}{\partial S}\right]_{\dot{S}=0} = -\frac{r^*}{Q_p}$, we can conclude

$$\frac{\left[\frac{\partial P}{\partial S}\right]_{sd}}{\left[\frac{\partial P}{\partial S}\right]_{\dot{S}=0}} < 1.$$

Appendix E The real exchange rate and the capacity constraint

The proposed model demonstrates that an appreciation in the real exchange rate, with respect to its steady-state level, is more intensive in countries with more absorption capacity constraints. The latter point seems to be worth supporting empirically. But to keep the main contribution of the paper that highlights the intensity of the resource curse in terms of the non-traded capital level, this question is argued in the appendix.

The regression equation is given as follow:

$$\Delta REER_{i,t} = \beta_0 + \beta_1 REER_{i,t-1} + \beta_2 WI_{i,t-1} + \beta_3 NK_{i,t-1} + \beta_4 (WI_{i,t-1} * NK_{i,t-1}) + Z'_{i,t} \beta_5 + \mu_i + \varepsilon_{i,t}.$$

The dependent variable of the regression model is the change in the real effective exchange rate (i.e. $\Delta REER_{i,t} = REER_{i,t} - REER_{i,t-1}$) and the explanatory variables of interest are the resource-dependence index WI and the proxies for the absorption capacity constraints NK . Z' denoting the vectors of control variables includes the level of GDP per capita, Excess Money growth⁴⁴, Government spending⁴⁵, Terms of trade, Openness index and Foreign direct investment⁴⁶. Further, μ_i and $\varepsilon_{i,t}$ are, respectively, a country fixed effect and the disturbance term. Both dependent and independent variables are log-transformed. The normalized proxies of capacity constraints are multiplied by 100 to prevent their Ln form from being made negative.

The presence of unobservable heterogeneity across countries is evaluated by the *Hausman* test⁴⁷. Further, *heteroskedasticity – robust* standard errors⁴⁸ and a separate intercept for each time period⁴⁹ are included in the estimations. The estimated results are reported in Table 9. As

⁴⁴ The difference between the growth rate of the Broad money ($M2$) and Economic growth is defined as Excess Money growth. The average growth rate of $M2$ for each period is calculated as $GM_t = Ln\left(\frac{M2_t}{M2_{t-1}}\right)$. The data source is *WDI*.

⁴⁵ It refers to general government final consumption expenditure divided by GDP . The data is an average value for the 5-year period, sourced from *WDI*.

⁴⁶ It is defined as the net inflows of investment divided by GDP . The average value for the 5-year periods is collected from *WDI*.

⁴⁷ The *Hausman* test checking that the preferred model is random effects is rejected with a p – value of 0.000 for both baseline regression models.

⁴⁸ A test that the variance of error term is constant (*homoskedasticity*) is rejected with a p – value of 0.000 for both baseline regression models.

⁴⁹ A test that these time dummy variables are jointly equal to zero is rejected with a p – value of about 0.015 for both baseline regression models.

Table 9: Estimation results for the real exchange rate

Explanatory variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	IV-2SLS	IV-2SLS	OLS	IV-2SLS	IV-2SLS	IV-2SLS
	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>Bruegel</i>	<i>IMF</i>
Resource dependence (lagged)	0.0120* (0.00689)	0.0313 (0.0251)	0.0608** (0.0270)	0.0117* (0.00681)	0.0330 (0.0244)	0.0889** (0.0364)	0.0498** (0.0213)
Infrastructure index (lagged)	-0.0208 (0.0161)	-0.00254 (0.0480)	0.0245 (0.0475)				
Absorption index (lagged)				-0.0349* (0.0199)	-0.0495 (0.0666)	0.0130 (0.0731)	-0.264*** (0.0885)
Infrastructure * Resource (lagged)			-0.0170*** (0.00606)				
Absorption * Resource (lagged)						-0.0277*** (0.00989)	-0.0118* (0.00612)
Real effective exchange rate (lagged)	-0.393*** (0.0273)	-0.575*** (0.113)	-0.577*** (0.111)	-0.394*** (0.0271)	-0.581*** (0.115)	-0.581*** (0.109)	-0.822*** (0.0639)
Ln (per capita GDP)	0.0179 (0.0246)	0.285*** (0.102)	0.250*** (0.0969)	0.0138 (0.0186)	0.290*** (0.0732)	0.245*** (0.0707)	0.233*** (0.0676)
Money growth (lagged)	0.133*** (0.0335)	0.119** (0.0560)	0.120** (0.0554)	0.134*** (0.0333)	0.120** (0.0551)	0.118** (0.0541)	0.00739 (0.0414)
Government spending	0.124*** (0.0346)	0.475** (0.200)	0.464** (0.200)	0.107*** (0.0343)	0.469** (0.205)	0.460** (0.200)	0.206* (0.107)
Terms of trade	0.191*** (0.0448)	0.217** (0.100)	0.219** (0.0998)	0.190*** (0.0445)	0.214** (0.103)	0.220** (0.102)	0.00846 (0.0574)
Openness index	-0.0614** (0.0254)	-0.450*** (0.127)	-0.429*** (0.125)	-0.0570** (0.0254)	-0.453*** (0.130)	-0.400*** (0.131)	-0.289*** (0.0710)
Foreign direct investment (lagged)	0.0129 (0.00874)	0.0182 (0.0133)	0.0152 (0.0131)	0.0132 (0.00870)	0.0165 (0.0120)	0.0108 (0.0124)	-0.0167 (0.0138)
Country fixed effects	NO	YES	YES	NO	YES	YES	YES
Time dummies	NO	YES	YES	NO	YES	YES	YES
Observations	531	531	530	532	530	530	315
Number of Countries	101	101	101	101	101	101	64
R-squared	0.357	0.480	0.486	0.358	0.481	0.495	0.759
Hansen OID test (p-value)	-	0.173	0.184	-	0.286	0.307	0.088
K-P UID test (p-value)	-	0.000	0.000	-	0.000	0.000	0.000
K-P Weak ID, F statistic	-	55.14	51.12	-	165.83	164.21	88.05

Note: The dependent variable is the change in the real effective exchange rate. In Columns (2) and (3), Infrastructure index (first lagged) and per capita GDP are endogenous variables. They are instrumented by the windfall income (first and second lagged), per capita GDP (first and second lagged) and Telephone index (first lagged). While in Columns (5) and (6), Absorption index (first lagged) and per capita GDP are endogenous variables. They are instrumented by the windfall income (first and second lagged), per capita GDP (first and second lagged), Human capital index (first lagged) and infrastructure index (first lagged). Robust standard errors are reported in parentheses. ***, ** and * denote significance at 1, 5 and 10 percent levels.

The null hypothesis of *Hansen* test is that the instruments, as a group, are uncorrelated with the error term. The null hypothesis of Underidentification test (K-P UID test) is that the regression equation is underidentified. The null hypothesis of weak identification test (K-P Weak ID) is that the estimator is weakly identified (Point: 5% maximal IV relative bias is 13.97).

benchmarks, columns (1) and (4) represent *OLS* estimations of the baseline regression models. While, the core estimations are reported in columns (2) and (5). Although the coefficients on the resource-dependence index in both specification models in terms of capacity constraints proxy are insignificant, they enter with positive signs. The latter point seems to qualitatively support the appreciation of the real exchange rate due to an increase in the resource dependency and the insignificant results might be because of an interaction between the variables of interest.

To address this problem, I include an interaction term between the resource-dependence index and proxies identifying the non-traded capital stock. In line with the literature (e.g. Cashin et al. (2004)), the estimated results reported in columns (3) and (6) represent a positive and significant correlation between the resource-dependence index and the real effective exchange rate. Further, The coefficients on the interaction terms enter with negative signs and are significant at 1%. These results are consistent with the model's prediction and suggest that the real exchange rate appreciation attenuates as the proxies reflecting non-traded capital goods become larger. Furthermore, these represent that the appreciation vanishes at an absorption index larger than 0.25 (Point: the variables are in *Ln* form.).

The consistency of the results is examined in terms of the real exchange rate database source. The regression model is run for a database of the real effective exchange rate estimated by *IMF*⁵⁰ to capture a robustness check. Column (7) shows the results. It demonstrates that reducing the real exchange rate appreciation along the expansion of the absorption capacity doesn't depend on measurement approaches to estimate the real exchange rate. However, the significance of the coefficient on the interaction term is weaker when *IMF* database is applied (i.e. significant in %10). The latter is more likely to be because of a smaller number of countries' data included in *IMF* database than *Bruegel* database. Further, the real exchange rate appreciation remains for a much longer interval level of the absorption index (equal to 0.68) in *IMF* sample than in *Bruegel* sample (equal to 0.25).

⁵⁰ The main difference between *Bruegel* and *IMF* databases is in the calculation of the geometrically weighted average of *CPI* indices of trading partners.

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