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Effect of external debt on the level of infrastructure in Africa

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Abstract

The main objective of this paper is to analyse the effect of external debt on infrastructure development in Africa over the 2003-2018 periods. It employs a fixed-effects Driscoll and Kraay's estimator and the Lewbel's estimator after second-generation unit roots test. The estimations establish that the effect of external debt on the level of infrastructure in Africa is negative, but for a sustainable level of debt around 99%, the positive impact of the debt on infrastructure is observed. Similar results were obtained when Transport index, electricity index and water and sanitation index are used as the dependent variable, while the effect of external debt is positive when mobile cellular per habitant and ICT index are used as the dependent variables. These results imply that public policies for improving infrastructure investment and assuring sustainable debt should be promoted.

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Effects of external debt on the level of infrastructure in Africa

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Abstract

The aim of the paper is to analyse the effect of external debt on the level of infrastructure in Africa.The main contribution of the paper is the determination of the threshold beyond which external debt affect the level of infrastructure differently. The methodology focuses on the Generalized Method of Moments. The sample includes 37 countries within the period 2009-2017. The results show a positive effect of external debt on the level of infrastructure with bearable threshold which account for 36.71 % of GDP. Recommendations lie on the respect of a sustainable debt levels to no longer sink into a phase of unsustainability. There is also a need for diversification of economies to reduce their high dependent on oil revenues, given the fall in the price of oil on the international market.

Submitted: August 23, 2019.

1. Introduction

The discussion on debt efficiency is still up-to-date (Hakimi et al. 2019, Omodero 2019, Agyapong 2020). Indeed, two main contradictory strands of debate exist in the literature: the Classicals and the Keynesians. For the Keynesians, promoters of interventionism, indebtedness does not cause any burden, either for future generations or for present generations because of the investments it creates (Buchanan and Wagner 1978, Otaki 2015). However, the Classicals see indebtedness as a burden likely to compromise the accumulation of capital, present and future consumption (O'Brien 2004). They liken debt to a future tax and attribute a negative connotation to the State intervention (Yapo 2002; Njamen et al. 2020). From this theoretical debate stems the problem of the aptitude of external debt to finance infrastructure.

This theoretical puzzle is also observable in the empirical studies. For instance, Krugman (1988) asserts that debt servicing obligations cause distortions in an economy and as a result, discourages economic growth and investments. Eaton (1993) on his part argues that external debt is complementary to domestic savings and investment, hence a growth stimulus. An early African study by Chipumbu (1993) argues that it is necessary for African countries to complete the projects of which money was loaned for in order to develop the economic base from which the loans can be repaid. Recently, influential papers such as Reinhart and Rogoff (2010) and Reinhart et al. (2012) argue that there is a threshold effect between external debt and economic activities. Despite this theoretical and empirical controversy, several studies have established that public investment in infrastructure has a positive impact on the level of production and development (Aschauer 1989, Agénor 2010, Chukwuemeka et al. 2018); this in a context of good governance (Prabir 2012). Adequacy in infrastructure helps determine one country's success and another's failure in diversifying production, expanding trade, coping with population growth and reducing poverty (Bond 2016). The better-quality infrastructures increase regional integration, speeds urbanisation and positively affects economic growth (Calderon and Serven 2004, Estache et al. 2012).

In recent years, Africa has improved its infrastructure endowment. Based on the Africa Infrastructure Development Index (AIDI), on one hand, low-income states record fast results, while fragile states continue to sink. Progress is mainly in the areas of Information and Communication Technologies (ICT) and, to a lesser extent, access to Water and Sanitation (WSS). On the other hand, electricity production has stagnated and transportation development remained negligible, but commendable (Tumbare 2015, Laborda and Sotelsek 2019). At this level, infrastructural success of Kenya, Ghana and Senegal, mainly due to the best results obtained in the ICT sector are highlighted. There are also countries that are still lagging in terms of infrastructure development (these include Madagascar, Niger, Chad) but whose progress is already being felt (IMF 2014).

The implementation of these infrastructures requires huge investments (IMF 2014). However, given the budget and structural challenges faced by some African countries, the majority are referred to the external debt to support investment projects (Kapindula and Kaliba 2019). In the African context, most of these investment projects are mostly infrastructural development across the continent. In fact, in 2009, the World Bank issued a report on African infrastructure, in which it was estimated that about 125 billion US dollars will be needed per year to meet the infrastructural need of Sub-Saharan Africa alone (Briceno-Garmendia et al. 2009). But in 2014, total funding for infrastructure on the continent was estimated to have reached only 74.5 billion US dollars (Bond 2016).

Faced to this dynamism in infrastructural levels and financing sources, external debt is assuming considerable proportions in Africa. The level of indebtedness of the zone, as a percentage of Gross Domestic Product (GDP), after reaching the Heavily Indebted Poor

Countries (HIPC) Initiative, had decreased over the years, registering respectively as a percentage of GDP 51.19% in 2003, 24.03% in 2006 and 21.29% in 2008. Following the fall in oil prices on the international market and the financial crisis of 2008, the external debt of the zone is on the rise. Indeed, the total external debt stock of the zone stood at 25.16% in 2009, 32.89% in 2016 and 36.22% in 2018. At the same time, there is a gradual increase in the infrastructure development index scores in Africa from 17.13 units in 2009 to 23.26 units in 2013, then 27.12 units in 2016 and 28.44 units in 2017 (AfDB 2018, WDI 2018).

This study is relevant for at least three reasons. Firstly, most studies on the effect of debts on economic development in the literature are interested in a linear relationship. We consider a non-linear form that highlights the existence of a threshold beyond which any increase in external debt would degrade the level of infrastructure. Secondly, to the best of our knowledge, this paper provides the first empirical study that analyses the effect of external debt on the level of infrastructure in Africa using the AIDI. In fact, most studies on Africa and other Developing countries captures infrastructure level using a single-infrastructure sector for their analysis; for example, mobile cellular subscriptions (see Calderon 2009, Mathur 2009, Avom et al. 2020). The other works uses composite index mostly constructed through the PCA methodology (see Calderon 2009). The present study takes into consideration the AIDI and its composite components to capture the level of infrastructure. Thirdly, this study considers governance as an important determinant of infrastructural level. Based on Prabir (2012), we assess the respective impact of governance indicators of Kaufmann et al. (2011) on the level of infrastructure in Africa. Thus, the objective of this paper is to analyse the effect of external debt on the level infrastructure in Africa.

The rest of the paper is ordered as follows. Section 2 outlines the methodology. Section 3 provides the empirical results and discussions. And section 4 concludes the paper and discusses implications.

2. Methodology

In this section we examine the econometric specification, data and study area and lastly the estimation method used.

2.1. Econometric Specification

In reference to the studies of Pattillo et al. (2002), Benedict et al. (2003) and Ali and Sadraoui (2013), a nonlinear and quadratic specification is used to analyse the effect of external debt on infrastructure development. It is materialised by the following equation.

$$\mathrm{AIDI_{it}} = \mathrm{a_0} + \mathrm{a_1 AIDI_{it-1}} + \mathrm{a_2 Dext_{it}} + \mathrm{a_3 Dext^2_{it}} + \mathrm{a_4 InflationCP_{it}} + \mathrm{a_5 TnaturalRess_{it}} + \mathrm{a_6 Trade_{it}} + \mathrm{a_7 Tpop_{it}} + \mathrm{a_8 Apd_{it}} + \mathrm{a_9 GDPk_{it}} + \mathrm{a_{10} Gov_{it}} + \mathrm{E_{it}} \quad (1)$$

Where *AIDI* is a measure of the Africa Infrastructure Development Index; *Dext* is external debt stock as a percentage of GDP; $Dext^2$ is external debt stock squared, *InflationCP* is consumer's price inflation; *TnaturalRess* is total natural resources rents as a percentage of GDP; *Trade* is as measure of trade openness, it is the sum of imports and exports to GDP; *Tpop* is a logarithm of total population; *Apd* is an indicator of official development assistance as a percentage of GDP; *GDPk* is a logarithm of GDP per capita; *Gov* presents governance indicators. With *"i"* the individual effect, "*t*" the time effect and E_{it}, the error term. The details on each variable are presented in the appendix (table VI).

In the regressions, each of governance indexes of Kaufmann et al. (2011) are introduced one after another in our model to capture their individual effects on infrastructure development (Prabir 2012). Talking of these component indexes, Control of Corruption (*Corruption*) captures the impact of bad governance on economic interactions. It complements rule of law and regulatory quality putting in place the degree of lawless transactions in public-private transactions. Government Effectiveness (*Goveff*) represents the ability of the government to formulate and implement good policies. It is equally the extent to which the general public is satisfied with public services and infrastructure. Political Stability (*Polstability*) reflects the extent to which the government is being destabilised or overthrown by excessive violence against people and property and unconstitutional interferences. It is the instability aspect that this index captures. Regulatory quality (*RegQuality*) reflects the transaction costs that result from policy intrusion of the state in private trade or in inhibiting the market mechanisms. Rule of Law (*Rulelaw*) represents the measure of the quality of the legal system and contract enforcements; Voice and Accountability (*VoiceAcc*) denotes the extent to which citizens participate in selecting their leaders and hold them accountable for actions taken.

Following Agénor (2010), the level of infrastructure lagged by one period ($AIDI_{it-1}$) is expected to positively influence infrastructure development. This variable is used as instrument variable to correct for potential endogeneity (Vinayagathasan 2013).

2.2. Data and Study Area

The sample consists of the 40 African countries: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo verde, Cameroon, Chad, Rep. Congo, Dem. Rep. Congo, Ivory Coast, Egypt, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia.

The data covers the 2003-2018 periods and comes from the World Development Indicators (WDI 2019), African Development Bank Group (AfDB 2018) and the Worldwide Governance Indicators (WGI 2019). The choice of study period and number of countries depends exclusively on the availability of data, mainly with regard to AIDI. Estimates are made using Stata software.

2.3. Estimation Methods

Two estimation methods are applied in order to ensure valid statistical inference and robust standard errors in the panel with cross-sectional dependence: The Fixed effects Driscoll and Kraay's estimator and the Lewbel's estimator (Using Heteroskedasticity to Identify and Estimate Mismeasured and Endogenous Regressor Models) in case of under-identified regression.

Firstly, concerning Driscoll and Kraay's estimator, it gives the ability to control for all time-invariant differences between the individuals in the study, thereby eliminating potential large sources of bias. The error structure is assumed to be heteroscedastic, autocorrelated up to some lag; and standard errors are well calibrated when cross-sectional dependence is present (Hoechle 2007). This method can be applied on both balanced and unbalanced panels and it is capable to handle missing values. Because this technique of estimating standard errors does not place any restrictions on the limiting behaviour of the number of panels, the size of the cross-sectional dimension in finite samples does not constitute a constraint on feasibility - even if the individuals of panel is much larger than time dimension. Nevertheless, one should be somewhat cautious with applying this estimator to panels which contain a large cross-section but only a very short time dimension (Driscoll and Kraay 1998).

Secondly, to take into account the results of system GMM estimation in which equation 1 is under-identified, the method proposed by Lewbel (2012) can be applied. It is used to identify structural parameters in under-identified regression models. To do this, external instruments can be constructed from the residuals of the auxiliary equations. The validity of the instruments obtained is based on the Hansen (1982) over-identification test. This method produces three evaluation programs: *(i)* traditional estimation using instrumental variables, *(ii)* single estimation using the instruments produced, and *(iii)* estimation using the instruments produced and excluded. In order to apply the procedure proposed by Lewbel, the following two necessary and sufficient conditions are assumed: the heteroskedasticity of the residuals and the correlation of the squared residuals with the dependent variable (Lewbel 2012, Behrens et al. 2015). Again, the number of individual dimension should be greater than the time dimension. This results in convergent and efficient coefficients (Roodman 2009). The results are presented in the following section.

3. Empirical results

In this sub-section, we present the baseline results, results using Lewbel's estimator and the robustness checks.

3.1. Baseline Results

In this sub-section, the results prior to the estimation of the effects of external debt on infrastructure components are presented. Due to economic and financial globalisation materialised by financial integration in Africa, as well as common shocks that affect African countries, we have to account for cross-sectional dependence when implementing the estimations (Carrera et al. 2020). This test is very important because it allows to choose between the first generation and second-generation panel unit root test. Indeed, in the presence of cross-sectional dependence, the first generation panel unit root test can lead to a biased result.

To avoid any bias related to the omission of potential inter-country dependence, we implement the test of weak cross-sectional dependence (WCsD) developed by Pesaran (2015) on each variable included in equation 1. The results are presented in table I.

Table I: Testing weak cross-sectional dependence

Variable	Test name	Test statistics	P-value
AIDI	Pesaran WCsD test	61.023	0.000
Dext	Pesaran WCsD test	18.088	0.000
$Dext^2$	Pesaran WCsD test	46.76	0.000
InflationCP	Pesaran WCsD test	17.055	0.000
TnaturalRess	Pesaran WCsD test	14.828	0.000
Trade	Pesaran WCsD test	16.780	0.000
Tpop	Pesaran WCsD test	55.560	0.000
Apd	Pesaran WCsD test	23.555	0.000
GDPk	Pesaran WCsD test	61.519	0.000
Corruption	Pesaran WCsD test	-0.68	0.498
GovEff	Pesaran WCsD test	7.46	0.000
PolStability	Pesaran WCsD test	0.00	0.996
RegQuality	Pesaran WCsD test	3.55	0.000
Rulelaw	Pesaran WCsD test	1.95	0.052
VoiceAcc	Pesaran WCsD test	4.08	0.000
Phone/hab	Pesaran WCsD test	116.98	0.000
	Breusch-Pagan LM test	2498.81	0.0000
	Cross-sectional Correlation test	173.111	0.0000

Source: Authors' calculations using Stata version 14.

The results presented in Table I reject the null hypothesis and confirm the existence of strong inter-country dependence in Africa, with the exception of control of Corruption (*Corruption*) and political Stability (*Polstability*). They also observed heteroskedasticity and cross-sectional correlation of residuals, which are necessary conditions of applying Lewbel's estimator. We're continuing our analysis be run the Pesaran and Yamagata (2008) slope homogeneity test. The results are reported in table II.

Table II: Slope homogeneity test

	Statistic	P-value
Delta (Δ)	-5.866	0.000

Note: Ho: Cross-sectional independence and slope coefficients are homogeneous.
Source: Authors' calculations using Stata version 14.

Table II shows that the heterogeneity is confirmed for African countries (P-value less than 5%). To account for these properties (cross-sectional dependence and heterogeneity), we use a second-generation unit root test named the Covariate Augmented Dickey-Fuller (CADF) test developed by Pesaran (2007) to test the unit root null hypothesis. As noted by Blomquist and Westerlund (2013), Ditzen and Bersvendsen (2020), CADF panel unit root test is the only second-generation unit root test able to consider cross-sectional dependency and heterogeneity simultaneously among countries. The results of CADF test is presented in table III.

Table III: Pesaran (2007)'s unit root test.

	CADF t-stat	P-value
AIDI	-3.939	0.000***
Dext	-5.262	0.000***
$Dext^2$	-9.114	0.000***
InflationCP	-8.184	0.000***
TnaturalRess	-3.701	0.000***
Trade	-9.888	0.000***
Tpop	-3.659	0.000***
Apd	-6.854	0.000***
GDPk	-2.375	0.009***
Corruption	-2.030	0.033**
GovEff	-2.404	0.000***
PolStability	-2.100	0.012**
RegQuality	-3.498	0.000***
Rulelaw	-3.650	0.000***
VoiceAcc	-2.005	0.045**
Phone/hab	-2.759	0.003***

Note: Significance levels: (***) 1%; (**) 5%.
Source: Authors' calculations using Stata version 14.

Looking at the Table III, the unit root null hypothesis is rejected for all variables, which means that all our variables are stationary, despite weak cross-sectional dependence concerning control of Corruption (*Corruption*) and political Stability (*Polstability*).

This established, it is important to verify how related our variables are. In this respect, the correlation matrix is established as indicated in the appendix (tableVII). It shows that the explanatory variables are more or less correlated, which could hide a problem of multicollinearity, which is reduced by estimating several models that incorporate less related variables. To this end, we take into consideration the governance indexes in the estimations. These composite indexes are then further introduced one after the other, as independent variable (Prabir 2012), to see their effects on Infrastructure indicator. The last step of this baseline approach is to estimate the effects of external debt on infrastructure by taking in consideration heteroskedasticity and cross-sectional autocorrelation. To this end, we rely on Driscoll and Kraay's fixed effects estimator that corrects bias that was initially observed and allows us to control for cross-sectional dependence. The results are presented in table IV.

Table IV: Fixed-effects regression of external debt on infrastructure development

Dependent variable: Africa Infrastructure Development Index (AIDI)						
variable	(1)	(2)	(3)	(4)	(5)	(6)
Dext	0.0743***	0.0694***	0.0591***	0.0643***	0.0757***	0.0786***
	(0.00625)	(0.00421)	(0.00592)	(0.00891)	(0.00536)	(0.00632)
InflationCP	0.000824	0.000126	0.000286	-2.68e-05	0.000750	0.00113
	(0.00133)	(0.00119)	(0.000911)	(0.00134)	(0.00117)	(0.00126)
TnaturalRess	0.0116	0.000271	0.00171	0.0116	0.00629	0.0207
	(0.0150)	(0.0119)	(0.0101)	(0.0136)	(0.0135)	(0.0138)
trade	-0.0631**	-0.0547**	-0.0550**	-0.0682**	-0.0582**	-0.0708**
	(0.0286)	(0.0268)	(0.0272)	(0.0284)	(0.0267)	(0.0298)
Tpop	1.846***	1.807***	1.800***	1.785***	1.854***	1.834***
	(0.0956)	(0.0956)	(0.106)	(0.0986)	(0.0970)	(0.0900)
APD	-0.00596	-0.00494	-0.00378	-0.00655	-0.00652	-0.0184*
	(0.0125)	(0.0108)	(0.00993)	(0.0102)	(0.00989)	(0.00960)
GDPk	0.171***	0.158***	0.162***	0.180***	0.179***	0.179***
	(0.0345)	(0.0322)	(0.0342)	(0.0368)	(0.0369)	(0.0341)
corruption	-0.0505					
	(0.0316)					
GovEff		-0.254***				
		(0.0326)				
PolStability			-0.0903***			
			(0.0216)			
RegQuality				-0.229***		
				(0.0531)		
RuleLaw					-0.101**	
					(0.0438)	
VoiceAcc						0.103**
						(0.0420)
Constant	-27.89***	-27.34***	-27.12***	-27.02***	-28.12***	-27.42***
	(1.324)	(1.414)	(1.520)	(1.318)	(1.323)	(1.174)
Observations	548	548	548	548	548	548
Number of groups	40	40	40	40	40	40
F-stat	735.95	791.87	2123.69	934.07	1517.54	1419.14
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
within R-squared	0.8133	0.8326	0.8253	0.8294	0.8157	0.8188

Note: Standard errors in parentheses. *** p<0.01; ** p<0.05; * p<0.1.
Source: Authors, from the collected data, using Stata.

Table IV shows that the results obtained are generally robust, with R-squared within located in the interval [0.81 - 0.84] and p-values associated with the Fisher statistic less than 1%. There is a positive and significant effect at 1% of external debt (Dext) on infrastructure development index (AIDI). But according to the reasoning of Raffinot (1998), Patillo et al. (2002), Ali and Sadraoui (2013), Kenkouo and Chuisseu (2019), the positive effect of external debt on economic development indicators should not be linear due to the constraint of unsustainable long-term debt. It is therefore important to capture the debt sustainability threshold for infrastructure financing. This involves taking into account a dynamic panel and introducing the *Dext* variable squared ($Dext^2$).

These results also show that trade openness (trade), population growth (Tpop) and growth in GDP per capita (GDPk) are factors that significantly explain the level of infrastructure development in Africa. Regarding governance variables, we observe a negative and significant impact of Government Effectiveness (Goveff), Political Stability (Polstability), Regulatory quality (RegQuality), Rule of Law (Rulelaw) on infrastructure development index; while the effect is positive and significant for Voice and Accountability (VoiceAcc).

The dynamic nature of the model under consideration cannot be captured through the Driscoll and Kraay's fixed estimator. This is because the lagged dependent variable in equation 1 is likely to correlate with specific effects, thereby, generating an endogeneity bias (Gnangnon 2019). Moreover, several regressors in the model could develop a bidirectional problem (particularly inflation and GDP per capita). In order to address this potential endogeneity, we use Lewbel's estimator.

3.2. Effects of External Debt on Infrastructure using Lewbel's Estimator

Table V summarises the results of the estimation of the effect of external debt on the level of infrastructure in Africa by Lewbel's estimator. It shows R-squares greater than 50%. The p-value associated with Hansen over-identification test (*P-value OID*) is above the 5% threshold. We therefore accept the hypothesis that instruments are valid. Furthermore, the probability associated with Fisher statistic (*Prob >F*) is below 5% threshold. These implies that the selected variables significantly explain the variations of AIDI in the sample.

These results provide room for more commentaries. The level of Infrastructure lagged by one period ($AIDI_{it-1}$) has a significantly enhancing effect on AIDI. This indicate that the past hevaviours of the level of infrastructure influence the present level of infrastructure in the same direction. In this sense, investment in infrastructure in a period increases economic growth and productivity, thereby increasing national income that is used for further infrastructure development in the next period.

External debt stock/GDP ratio (*Dext*) and the same variable squared ($Dext^2$) have the significant signs. Indeed, external debt negatively affects AIDI, while the sign is positive for external debt squared. This result is in contradiction with the virtual debt burden theory (Cohen and Sachs 1986, Krugman 1988, Cohen 1995, Pattillo et al. 2002). Indeed, the negative sign of the *Dext* variable shows that under current debt management conditions, the impact on the level of infrastructure is compromised and closely linked to poor performance in terms of governance indicator in Africa. The funds that should be allocated to the investment project are being used to settle the debt service. But it is accepted in the present study that for a certain debt level, the positive impact of external debt on infrastructure is observed (coefficient $Dext^2$ positive). This threshold is obtained by equation 2 (Pattillo et al. 2002; Njamen et al. 2020).

$$\text{Debt threshold} = -\frac{\text{coefficient Dext}}{2\times\text{coefficient Dext}^2} \times 100 \qquad (2)$$

The various sustainable external debt thresholds, taking into account governance indicators, are around 99%. Beyond the calculated bearable thresholds, external debt negatively affects AIDI. This result corroborates Reinhart and Rogoff (2010); Ali and Sadraoui (2013); Kenkouo and Chuisseu (2019) which outline a sustainable debt threshold. These debt threshold, which are slightly higher than that of the 70% of GDP threshold defined by the CEMAC multilateral convergence criteria (CEMAC, 2018), offers additional budgetary margin of manoeuvre to the countries to face with investment financing constraints. But authors such as Fouda (2009), Barat and Ehrhart (2020), draw the attention of governments and international financial institutions to the speed at which states are re-indebting themselves.

Table V: Estimated coefficients by Lewbel's estimator

Dependent variable: Africa Infrastructure Development Index (AIDI)						
variable	(1)	(2)	(3)	(4)	(5)	(6)
L.AIDI	0.934***	0.922***	0.932***	0.938***	0.933***	0.931***
	(0.0171)	(0.0182)	(0.0175)	(0.0175)	(0.0172)	(0.0178)
Dext	-1.491**	-1.626**	-1.425**	-1.605**	-1.481**	-1.497**
	(0.685)	(0.684)	(0.688)	(0.727)	(0.681)	(0.684)
$Dext^2$	0.751**	0.819**	0.717**	0.808**	0.746**	0.754**
	(0.344)	(0.344)	(0.346)	(0.365)	(0.342)	(0.344)
InflationCP	0.000783**	0.000685*	0.000771*	0.000826**	0.000770**	0.000787**
	(0.000388)	(0.000391)	(0.000394)	(0.000394)	(0.000390)	(0.000389)
TnaturalRess	0.00586	0.00471	0.00551	0.00584	0.00518	0.00646
	(0.00392)	(0.00390)	(0.00393)	(0.00388)	(0.00388)	(0.00395)
trade	0.0252**	0.0256**	0.0252**	0.0257**	0.0252**	0.0244**
	(0.0100)	(0.0100)	(0.0100)	(0.0100)	(0.0100)	(0.0100)
TPOP	0.0366	0.0578	0.0393	0.0330	0.0406	0.0402
	(0.0348)	(0.0359)	(0.0350)	(0.0349)	(0.0350)	(0.0351)
APD	0.00328	0.00370	0.00332	0.00326	0.00334	0.00221
	(0.00397)	(0.00382)	(0.00382)	(0.00377)	(0.00379)	(0.00386)
GDPk	0.0826***	0.0829***	0.0823***	0.0818***	0.0834***	0.0835***
	(0.00964)	(0.00965)	(0.00968)	(0.00977)	(0.00979)	(0.00973)
corruption	-0.00171					
	(0.0122)					
GovEff		-0.0296**				
		(0.0118)				
PolStability			-0.00402			
			(0.00524)			
RegQuality				0.00776		
				(0.01000)		
RuleLaw					-0.0112	
					(0.0112)	
VoiceAcc						0.00989
						(0.00768)
Observations	514	514	514	514	514	514
R-squared	0.979	0.979	0.979	0.979	0.979	0.979
Number of i	40	40	40	40	40	40
P-value OID	0.7593	0.6087	0.7600	0.7763	0.6667	0.8567
F-stat	2490.53	2482.97	2447.14	2495.27	2466.35	2566.76
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Threshold	99.33%	99.26%	99.37%	99.31%	99.26%	99.27%

Note: Standard errors in parentheses. *** p<0.01; ** p<0.05; * p<0.1.
Source: Authors, from the collected data, using Stata.

Concerning other variables, inflation (InflationCP) and trade openness (trade) significantly enhances infrastructure development in this study. Openness to the world economy facilitates infrastructure development (Prabir 2012). This is specifically evident when openness leads to technological spill overs, which are used in the production process leading to economic of scale, increase in economics of scale leads to further investments in more production and trading infrastructure that will be able to facilitate the exportation of increase output. This is particularly true as international trade agreements, free continental trade agreements and sub-regional trade agreements which have been sign across the continent in numbers have seen the developments of port, road, railway lines and communication infrastructures to further ease transactions across the continent and with the rest of the world. The development of trade openness within a legal framework then leads, as the results suggests, to the control of inflationary pressures (Chatri et al. 2019). But if the legal framework is not well defined, increased trade openness could lead to inflation (Onyeka 2016).

Estimated GDPk has a significantly enhancing effect on the level of infrastructural development. This result can be explained by the fact that the increase in the growth rate creates favourable conditions for the increase of infrastructures in terms of access to NICTs, road development, increased supply of electricity and drinking water (Adeleke et al. 2011).

Looking at the various governance variables, only government effectiveness has a significant effect on infrastructure, an effect which is damaging. This is in contradiction with the results of Prabir (2012) for Asia. Contrary to expectations, our results indicate that institution governance has no effect on infrastructural development in Africa except of Government effectiveness. This can be explain based on the fact that lack of proper follow-up by the government and the design implementation of poor economic policies lead to a decrease in the level of infrastructure. This is because poor economic policies are detrimental on economic growth which consequently will be detrimental to infrastructural development. This is peculiar to Africa because the public service in most countries are not fully neutral; political pressure especially from the ruling political party mostly lead to biased decisions mostly to satisfy the party's political interest and not the public interest.

The nature of the above results especially the non-significance of most institutional governance variables, requires a robustness test using alternative measures of infrastructure development.

3.3. Robustness Checks

Five regressions as robustness check are performed by analysing the effect of external debt on Mobile cellular subscriptions (Phone/hab) and the different infrastructure composite indexes (transport index, electricity index, ICT index and Water and Sanitation index) using Lewbel's estimator. The results are presented in the appendix. The Phone / hab variable is used in the literature by some authors as an indicator of infrastructure development (Calderon 2009, Avom et al. 2020); it will then be interesting to test the robustness of the results obtained previously by considering this variable as a dependent variable.

By taking into account composite infrastructure indices as dependent variables, it is possible to assess the specific impact of external debt on infrastructure components. The results are more or less in accordance with our main results (see table IX and table X with Transport index and Electricity index as dependent variables, respectively). However, when Dext is significantly positive, $Dext^2$ has a significant negative effect on infrastructure (see table VIII and table XI with Phone/hab and ICT index as dependent variables). This result is only further convincing given that the number of mobile phone subscribers is a sub-component of the ICT composite index. This indicates that there exists an opposite Laffer curve for the external debt effect on ICT infrastructure. The effect of external debt on Water and Sanitation index (WSS_index) is not significant (see table XII).

As to the governance variables, the result varies depending on the type of infrastructure. While *PolStability* and *RegQuality* are detrimental on the number of telephone subscribers per 100 people (see table VIII), the effects are non-significance in the overall ICT infrastructure development (see table XI). It is also worth noting, the enhancing effect the *APD* has on the development of ICT infrastructure. As regards the transport index (see table IX)*,* the results are very similar to our main estimations except for *RuleLaw* and *VoiceAcc* which were significantly enhancing. This indicate that the good judicial system with contract enforcements and property protection and the participation of citizens in choosing their leaders and holding them accountable are very important in developing transport infrastructures in Africa.

4. Conclusion

The main objective of this paper was to analyse the effect of external debt on infrastructure development in Africa over the 2003-2018 periods. After noting the existence of cross-sectional dependence, the study uses the Pesaran (2007)'s unit root test to determine the variables' level of integration. As all variables were integrated at level and considering the heterogeneous nature of the data, the study apply the fixed effects Driscoll and Kraay's estimator and the Lewbel's estimator to verify the effect of external debt on infrastructure development in Africa. The results show that, the effect of external debt on the level of infrastructure in Africa is negative, due to the fact that the effect on infrastructure development is compromised and closely linked to poor performance in terms of governance indicators. The findings also show that for a sustainable level of debt, the positive impact of the debt on infrastructure is observed (coefficient $Dext^2$ positive). This sustainable external debt thresholds, taking into account governance indicators, are around 99%. Concerning the other variables, inflation, trade and GDP per capita significantly enhance infrastructure development in Africa. Looking at the various governance variables, only government effectiveness has a significant effect on infrastructure; but the robustness checks show the result varies depending on the type of infrastructure. In order to control external debt flows in Africa and enhancing infrastructure level's, the recommendations suggest to maintain external debt at sustainable rate; otherwise this would be likely to create a "snowball effect" (borrowing to pay debt charges). It is also necessary to place emphasis on the control of external debt because, despite reaching the HIPC Initiative, countries' foreign debt continues to increase. There is also a need for the states to increase on the quality of governance in order to improve the business climate, a necessary condition for the development of infrastructure investments.

References

Adeleke, S., Stampini, M., Kamara, A. B. (2011) "Aide au développement et accès à l'eau et à l'assainissement en Afrique subsaharienne", Banque Africaine de Développement.

AfDB. (2018) *Africa Infrastructure Development Index*, African Development Bank.

Agénor, P. R. (2010) "A Theory of Infrastructure-led Development" *Journal of Economy Dynamics and Control* 34(5), 932-950.

Agyapong, D. (2020) "External debt stock, foreign direct investment and financial development Evidence from African economies" *Journal of Asian Business and Economic Studies* 27(1), 81-98.

Ali, T. B., Sadraoui T. (2013) ''External debt and financing of economic developmeent: evidence from North Affrican Countries'' *Journal of North African Researchin Business*. Doi:10.5171/2013.335933

Aschauer, D. A. (1989) "Is Public Expenditure Productive?" *Journal of Monetary Economics*2 (23), 177-200.

Avom, D., Nkengfack, H., Kaffo, F. H., Totouom, A. (2020) "ICT and environmental quality in Sub-saharan Africa: Effects and transmission channels" *Technological Forecasting & Social Change* 155, 120028, 1-12.

Barat, C., Ehrhart, H. (2020) "Le dilemme des Etats africains : entre besoin d'investir et risque de surendettement" *L'ECONOMIE AFRICAINE 2020, Coll. Repères, La Decouverte* 2, 21-40.

Behrens, K., Bougna, L.T., Brown, W. M. (2015) "The world is not yet flat: Transport costs matter!" *CEPR Discussion Papers 10356*.

Benedict, C., Bhattacharya, R., Nguyen, T. Q. (2003) "External Debt, Public Investment, and Growth in Low-Income Countries" *IMF Working Paper WP/03/249*.

Blomquist, J., Westerlund, J. (2013) "Testing slope homogeneity in large panels with serial correlation" *Economics Letters* 121, 374-378.

Bond, J. (2016) "Infrastructure in Africa" *Global journal of Emerging market Economies* 3(8), 309-333.

Briceno-Garmendia., Cecilia, M., Foster, V. (2009) "Africa's infrastructure: a time for transformation" Africa development forum, 2009, Washington, DC : World Bank.

Buchanan, J. M., Wagner, R. E. (1978) "*Fiscal Responsibility in Constitutional Democracy*" Martinus Nijhoff Social Sciences Division, Leiden, Boston.

Calderon, C. (2009) "Infrastructure and growth in Africa" *The World Bank Policy Reseach Paper 4914*.

Calderon, C., Serven, L. (2004) "The effects of infrastructure development on growth and income distribution" *Policy Research Working paper WPS3400*, Central Bank of Chile.

Carrera, J., Gnimassoun, B., Mignon, V., Restout, R. (2020) "Currency Misalignelents and exchange rate regimes in Latin American countries: A trade-off issue" *CEPII Working Paper*.

CEMAC. (2018) *Rapport Intérimaire de Surveillance Multilatérale 2017 et Perspectives pour 2018*. 34e édition, Communauté Économique et Monétaire de l'Afrique Centrale, Mars.

Chatri, A., Zouiri, H., Zenati, A., Chouati, M. (2019) ''Ouverture commerciale, accumulation du capital humain et croissance : analyse en données de panel sur les pays en développement'' In A. Chatri (éd). *Ouverture, productivité et croissance économique au Maroc. Laboratoire d'Économie Appliquée & Policy Center for the New South*, Rabat,10, 167-182.

Chipumbu, G. M. (1993) "The impact of external debts on the African economies" *International Journal on World Peace* 1(10), 43-56.

Chukwuemeka, V.O., Richardson, K.E., Chinanuife, E. (2018) "Economic Analysis of Capital Expenditure and Infrastructural Development in Nigeria" *Journal of Infrastructure Development* 10(1-2), 52-62. Doi: 10.1177/0974930618809173.

Cohen, D. (1995) "Large external debt and (slow) domestic growth A theoretical analysis" *Journal of Economics Dynamis and Control*19, 1141-1163.

Cohen, D., Sachs, J. (1986) "Growth and external debt under risk of debt repudiation" *European Economic Review* 30, 437-472.

Ditzen, J., Bersvendsen, T. (2020) "XTHST: Stata module to test slope homogeneity in large panels" *CEERP Working Paper Series no. 011*.

Driscoll, J. C., Kraay, A. C. (1998) "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data" *Review of Economics and Statistics* 80, 549-560.

Eaton, J. (1993) "Sovereign debt: A primer" *The World Bank Economic Review*2(7), 137-172.

Estache, A., Perrault, J-F., Savard, L. (2012) ''The impact of infrastructure in subsaharan Africa: a CGE modeling approachc'' *Economics Research International*, Article ID 875287. Doi: 10.1155/2012/875287

Fouda, O. J-P. (2009) "La convergence des politiques économiques dans la zone Franc : où en est-on 15 ans après ? " *L'Actualité économique* 85(3), 319-354.

Gnangnon, S. K. (2019) "Tax Reforms and Trade Openness in Developing Countries" *Journal of Economic integration* 3(34), 498-519.

Hakimi, A., Boussaada, R., Karmani, M. (2019) "External debt, investment, and economic growth: A seemingly unrelated regression model for low-income countries" *Journal of Economic Integration*34(4), 725-745.

Hansen, L. P. (1982) “Large Sample Properties of Generalized Method of Moments Estimators” *Econometrica* 4(50), 1029-1054.

Hoechle, D. (2007) “Robust Standard Errors for Panel Regressions with Cross-Sectional Dependence” *The Stata Journal*3(7), 281-312.

IMF. (2014) *Perspectives économiques régionales, Afrique Subsaharienne pour une croissance durable et plus solidaire*. Etudes Economiques et Financières, avril.

Kapindula, M. G., Kaliba, C. (2019) The effects of external debt servicing on infrastructure spending: a case of Zambia” *International journal of Construction management*. Doi: 10.1080/15623599.2019.1615753

Kaufmann, D., Kraay, A., Mastruzzi, M. (2011) “The Worldwide Governance Indicators: Methodology and analytical issues” *Hague Journal on the Rule of Law*3, 220-246.

Kenkouo, G. A., Tchuisseu, S. F. (2019) ‘‘Quel seuil d’endettement supportable dans la zone CEMAC ?’’ *Lettre de la Recherche N°06*, 1er semestre 2019, Banque des Etats de l’Afrique Centrale (BEAC).

Krugman, P. (1988) “Financing versus forgiving a debt overhang” *NBER working paper 2486*.

Laborda, L., Sotelsek, D. (2019) “Effects of Road Infrastructure on Employment, Productivity and Growth: An Empirical Analysis at Country Level” *Journal of Infrastructure Development* 11(1-2), 81-120. Doi: 10.1177/0974930619879573.

Lewbel, A. (2012) “Using heteroscedasticity to identify and estimate mismeasured andendogenous regressor models” *Journal of Business and Economic Statistics*1(30), 67-80.

Mathur, S. M. (2009) “Financial Analysis of the ICT Industry: A Regulatory Perspective” *Journal of Infrastructure Development*1(1), 17-43. Doi: 10.1177/097493060900100103.

Njamen, K. A. A., Nembot, N. L., Avom, D. (2020) “The effect of external debt on domestic investment in sub-Saharan African sub-regions” *The Economic Research Guardian*10(2), 69-82.

O’Brien, D. P. (2004) *The Classicals Economists Revisited*. Princeton University Press, Princeton, New Jersey.

Omodero, C. O. (2019) “External debt financing and public capital investment in Nigeria: A critical evaluation” *Economics and Business*33, 111-126.

Onyeka, V. N. (2016) “Impact of inflation on infrastructural investment in Nigeria” *Journal of Social Sciences Research*2(10), 2047-2052.

Otaki, M. (2015) “Public debt as a burden on the future generation: A Keynesian approach” *DBJ Discussion paper series*. No. 1502.

Pattillo, C., Poirson, H., Ricci, L. (2002) “External Debt and Growth” IMF Working Paper *WP/02/69/2002*.

Pesaran, H. M. (2007) “A panel Unit Root Test in the Presence of Cross-Sectional Dependence” *Journal of Applied Econometrics*2(22), 265-312.

Pesaran, H. M. (2015) “Testing Weak Cross-Sectional Dependence in Large Panels” *Econometric Reviews*34, 1089-1117.

Pesaran, M. H., Yamagata, T. (2008) “Testing slope homogeneity in large panels” *Journal of Econometrics*142(1), 50-93.

Prabir, D. (2012) “Does governance matter in infrastructure development? Empirical evidence from Asia” *Journal of Infrastructure Development*2(4), 153-180.

Raffinot, M. (1998) ‘‘Soutenabilité de la dette extérieure de la théorie aux modèles d’évaluation pour les pays à faible revenu’’ *Working Paper DT/98/01*.

Reinhart, M. C., Reinhart, V. R., Rogoff, K. S. (2012) “Public Debt Overhangs: Advanced-Economy Episodes since 1800” *Journal of Economic Perspectives*3(26), 69-86.

Reinhart, M. C., Rogoff, K. S. (2010) "Growth in a time of debt" *American Economic Review*2(100), 573-578.

Roodman, D. (2009) "How to do xtabond2: An introduction to difference and system GMM in Stata" *The Stata Journal*1(9), 86-136.

Sachs, J. (1989) "The debt overhang of developing countries" *in Debt, Stabilization and development:* essays in memory of Carlos Diaz Alejandro, Oxford and Basil Blackwell.

Tumbare, M. J. (2015) "Infrastructure for Water Resource Management in Southern Africa" *Journal of Infrastructure Development*7(2), 116-135.

Vinayagathasan, T. (2012) "Inflation and economic growth: a dynamic panel threshold analysis for Asian Economies" *Journal of Asian* Economics26, 31-41.

WDI. (2019) *World Development Indicators Data*. www.worldbank.org/data

WGI. (2019) *The Worldwide Governance Indicators*. www.govindicators.org

Yapo, L. (2002) ''Déterminants de l'endettement extérieur des PPTE'' *Discussion paper n°2002/14-World institute for development Economics Research*, 27p.

Appendix

Table VI. Description of Variables

Variables	Description	Expected signs	
AIDI	Africa Infrastructure Development Index is calculated on the basis of a weighted average of the sub-indexes obtained on four sectors: transport, electricity, ICT and WSS		
Phone/hab	Mobile cellular subscriptions (per 100 people)		
Transportindex	Transport composite Index		
ElectricityIndex	Electricity composite Index		
ICTindex	ICT composite Index		
WSSindex	WSS composite Index		
Dext	External debt stocks as percentage of GDP	+	Sachs (1989) ;
$Dext^2$	Dext Squared	-	Njamen et al. (2020)
inflationCP	Inflation consumer prices in percent	+	Chatri et al. 2019
TnaturalRess	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents, as percentage of GDP	+	IMF (2014)
Trade	sum of exports and imports of goods and services measured as a share of GDP	+	Sare et al. (2018)
Tpop	logarithm of total population	+	Njamen et al. (2020)
APD	net official development assistance and official aid received, as a percentage of GDP	+	Nafiou (2009)
GDPk	logarithm of GDP per capita (US$)	+	Adeleke et al. (2011)
corruption	Control of Corruption	-	Prabir (2012)
GovEff	Government Effectiveness	+	Prabir (2012)
PolStability	Political Stability and Absence of Violence/Terrorism	+	Prabir (2012)
RegQuality	Regulatory Quality	+	Prabir (2012)
Rulelaw	Rule of Law	+	Prabir (2012)
VoiceAcc	Voice and Accountability	+	Prabir (2012)

Source: authors

Table VII: Correlation matrix

	AIDI	Dext	$Dext^2$	InflationCP	TnaturalRess	trade	Tpop	APD
AIDI	1							
Dext	-0.219	1						
$Dext^2$	-0.219	1	1					
InflationCP	-0.0859	0.0182	0.0182	1				
TnaturalRess	-0.277	-0.0741	-0.0738	0.130	1			
trade	0.0345	0.246	0.246	-0.0698	0.149	1		
Tpop	0.153	-0.251	-0.251	0.0959	0.207	-0.247	1	
APD	-0.132	-0.185	-0.186	0.218	0.0566	-0.351	0.259	1
GDPk	0.629	-0.279	-0.279	-0.103	-0.0228	0.171	0.547	-0.275
corruption	0.436	-0.141	-0.141	-0.140	-0.485	0.220	0.0218	-0.112
GovEff	0.505	-0.193	-0.193	-0.0740	-0.378	0.0860	0.245	0.0692
PolStability	0.248	-0.0175	-0.0182	-0.179	-0.285	0.305	-0.0173	-0.340
RegQuality	0.367	-0.192	-0.193	-0.123	-0.343	0.0513	0.222	0.0683
RuleLaw	0.470	-0.160	-0.160	-0.108	-0.441	0.104	0.154	-0.00510
VoiceAcc	0.245	-0.157	-0.157	-0.119	-0.413	0.0968	0.105	0.0564

	GDPk	corruption	GovEff	PolStability	RegQuality	RuleLaw	VoiceAcc
GDPk	1						
corruption	0.373	1					
GovEff	0.456	0.829	1				
PolStability	0.352	0.657	0.564	1			
RegQuality	0.352	0.771	0.866	0.583	1		
RuleLaw	0.388	0.895	0.879	0.701	0.851	1	
VoiceAcc	0.228	0.758	0.646	0.619	0.685	0.759	1

Source: Authors' calculations using Stata

Table VIII. Effects of external debt on Mobile cellular subscriptions (per 100 people)

Dependent variable: Mobile cellular subscriptions (Phone/hab)						
variable	(1)	(2)	(3)	(4)	(5)	(6)
L.Phone/hab	0.682***	0.680***	0.674***	0.681***	0.680***	0.680***
	(0.0730)	(0.0742)	(0.0740)	(0.0724)	(0.0733)	(0.0736)
Dext	17.16***	16.90***	17.87***	14.66***	16.94***	16.85***
	(3.872)	(3.891)	(3.881)	(4.397)	(3.912)	(3.919)
$Dext^2$	-8.637***	-8.507***	-9.000***	-7.379***	-8.528***	-8.484***
	(1.945)	(1.954)	(1.950)	(2.210)	(1.966)	(1.969)
InflationCP	0.00239	0.00204	0.00209	0.00251	0.00209	0.00212
	(0.00183)	(0.00178)	(0.00175)	(0.00183)	(0.00177)	(0.00177)
TnaturalRess	0.0221	0.0195	0.0158	0.0198	0.0194	0.0194
	(0.0323)	(0.0326)	(0.0323)	(0.0321)	(0.0322)	(0.0320)
trade	0.183***	0.178***	0.181***	0.178***	0.177***	0.178***
	(0.0586)	(0.0590)	(0.0582)	(0.0580)	(0.0577)	(0.0574)
Tpop	0.533	0.527	0.541	0.566	0.535	0.538
	(0.402)	(0.401)	(0.402)	(0.408)	(0.404)	(0.408)
APD	0.0395**	0.0448**	0.0463**	0.0460**	0.0448**	0.0465**
	(0.0188)	(0.0194)	(0.0193)	(0.0198)	(0.0188)	(0.0191)
GDPk	0.278**	0.275**	0.279**	0.268**	0.277**	0.275**
	(0.117)	(0.116)	(0.116)	(0.113)	(0.116)	(0.116)
corruption	0.0791					
	(0.0513)					
GovEff		-0.0305				
		(0.0701)				
PolStability			-0.0422*			
			(0.0233)			
RegQuality				0.110*		
				(0.0634)		
RuleLaw					-0.0193	
					(0.0556)	
VoiceAcc						-0.0212
						(0.0359)
R-squared	0.965	0.965	0.965	0.965	0.965	0.965
P-value OID	0.7898	0.6871	0.6672	0.6888	0.6751	0.6806
Threshold	99.34%	99.32%	99.27%	99.33%	99.31%	99.30%

Table IX: Effects of external debt on transport index

Dependent variable: Transport index (Trans_index)						
variable	(1)	(2)	(3)	(4)	(5)	(6)
L.Trans_index	0.768***	0.769***	0.765***	0.770***	0.773***	0.774***
	(0.0549)	(0.0546)	(0.0548)	(0.0547)	(0.0531)	(0.0543)
Dext	-2.368*	-2.420*	-2.250*	-2.928**	-2.528*	-2.318*
	(1.353)	(1.356)	(1.361)	(1.481)	(1.394)	(1.346)
$Dext^2$	1.202*	1.228*	1.142*	1.483**	1.282*	1.177*
	(0.680)	(0.681)	(0.684)	(0.744)	(0.701)	(0.677)
InflationCP	0.000691	0.000668	0.000596	0.000738	0.000740	0.000658
	(0.00105)	(0.00104)	(0.00105)	(0.00106)	(0.00105)	(0.00106)
TnaturalRess	0.0100	0.0102	0.00909	0.00958	0.0138*	0.0120
	(0.00768)	(0.00747)	(0.00755)	(0.00753)	(0.00728)	(0.00776)
trade	-0.0255	-0.0275	-0.0271	-0.0266	-0.0269	-0.0288
	(0.0229)	(0.0228)	(0.0230)	(0.0229)	(0.0230)	(0.0230)
Tpop	-0.0288	-0.0293	-0.0357	-0.0220	-0.0355	-0.0419
	(0.0550)	(0.0563)	(0.0556)	(0.0550)	(0.0567)	(0.0577)
APD	-0.000963	-0.000214	0.000279	0.000295	-0.000984	-0.00386
	(0.00967)	(0.00929)	(0.00938)	(0.00935)	(0.00924)	(0.0100)
GDPk	0.0880***	0.0875***	0.0861***	0.0853***	0.0836***	0.0883***
	(0.0320)	(0.0318)	(0.0316)	(0.0312)	(0.0306)	(0.0313)
corruption	0.0153					
	(0.0246)					
GovEff		0.0112				
		(0.0248)				
PolStability			-0.00866			
			(0.0129)			
RegQuality				0.0252		
				(0.0232)		
RuleLaw					0.0660*	
					(0.0364)	
VoiceAcc						0.0372**
						(0.0160)
R-squared	0.594	0.594	0.595	0.595	0.598	0.597
P-value OID	0.1294	0.1218	0.1141	0.1151	0.1821	0.1519
Threshold	98.50%	98.53%	98.51%	98.71%	98.59%	103.76%

Source: Authors, from the collected data, using Stata. Standard errors in parentheses. *** p<0.01; ** p<0.05; * p<0.1.

Table X: Effects of external debt on electricity index

Dependent variable: Electricity index (Elec_index)						
variable	(1)	(2)	(3)	(4)	(5)	(6)
L.Elec_Index	0.625***	0.623***	0.623***	0.624***	0.622***	0.622***
	(0.135)	(0.136)	(0.134)	(0.133)	(0.134)	(0.134)
Dext	-12.25***	-12.57***	-12.11***	-14.79***	-12.48***	-12.67***
	(4.410)	(4.375)	(4.350)	(4.427)	(4.337)	(4.351)
$Dext^2$	6.165***	6.327***	6.096***	7.446***	6.282***	6.376***
	(2.217)	(2.199)	(2.187)	(2.225)	(2.180)	(2.188)
InflationCP	0.00145	0.00115	0.00111	0.00163	0.00109	0.00118
	(0.00192)	(0.00188)	(0.00186)	(0.00189)	(0.00187)	(0.00182)
TnaturalRess	0.0186	0.0174	0.0160	0.0168	0.0140	0.0158
	(0.0387)	(0.0391)	(0.0389)	(0.0385)	(0.0416)	(0.0394)
trade	-0.125	-0.133	-0.133	-0.132	-0.133	-0.131
	(0.0895)	(0.0854)	(0.0858)	(0.0855)	(0.0858)	(0.0850)
Tpop	0.512**	0.503**	0.493**	0.543***	0.510**	0.516**
	(0.200)	(0.200)	(0.202)	(0.200)	(0.205)	(0.207)
APD	0.00246	0.00686	0.00733	0.00826	0.00755	0.0104
	(0.0194)	(0.0188)	(0.0188)	(0.0188)	(0.0191)	(0.0196)
GDPk	0.0249	0.0207	0.0177	0.0135	0.0245	0.0197
	(0.0603)	(0.0596)	(0.0601)	(0.0609)	(0.0616)	(0.0595)
corruption	0.0694					
	(0.0927)					
GovEff		-0.0141				
		(0.0798)				
PolStability			-0.0211			
			(0.0246)			
RegQuality				0.112*		
				(0.0651)		
RuleLaw					-0.0654	
					(0.0777)	
VoiceAcc						-0.0370
						(0.0452)
R-squared	0.511	0.510	0.510	0.512	0.511	0.510
P-value OID	0.0777	0.1102	0.1074	0.1071	0.1382	0.1141
Threshold	99.35%	99.33%	99.32%	99.31%	99.33%	99.35%

Table XI: Effects of external debt on ICT index

Dependent variable: ICT index (ICT_index)						
variable	(1)	(2)	(3)	(4)	(5)	(6)
L.ICT_index	0.794***	0.793***	0.794***	0.795***	0.793***	0.797***
	(0.0268)	(0.0280)	(0.0269)	(0.0269)	(0.0270)	(0.0275)
Dext	16.51*	16.91*	17.62*	17.72*	17.05*	16.83*
	(9.551)	(9.634)	(9.685)	(10.18)	(9.406)	(9.479)
$Dext^2$	-8.304*	-8.506*	-8.867*	-8.915*	-8.578*	-8.465*
	(4.796)	(4.838)	(4.864)	(5.114)	(4.724)	(4.760)
InflationCP	0.0123***	0.0126***	0.0126***	0.0126***	0.0124***	0.0127***
	(0.00462)	(0.00457)	(0.00456)	(0.00455)	(0.00455)	(0.00457)
TnaturalRess	0.0474	0.0472	0.0466	0.0499	0.0398	0.0466
	(0.0606)	(0.0612)	(0.0610)	(0.0607)	(0.0621)	(0.0608)
trade	0.523***	0.533***	0.530***	0.529***	0.532***	0.532***
	(0.125)	(0.126)	(0.125)	(0.125)	(0.125)	(0.125)
Tpop	1.509**	1.556**	1.516**	1.508**	1.552**	1.471**
	(0.610)	(0.631)	(0.609)	(0.608)	(0.617)	(0.618)
APD	0.101**	0.0966*	0.0968*	0.0946*	0.0963*	0.100*
	(0.0503)	(0.0500)	(0.0501)	(0.0500)	(0.0497)	(0.0515)
GDPk	0.895***	0.901***	0.894***	0.901***	0.910***	0.891***
	(0.155)	(0.156)	(0.156)	(0.158)	(0.158)	(0.157)
corruption	-0.106					
	(0.132)					
GovEff		-0.0522				
		(0.139)				
PolStability			-0.0328			
			(0.0621)			
RegQuality				-0.0309		
				(0.137)		
RuleLaw					-0.154	
					(0.157)	
VoiceAcc						-0.0531
						(0.101)
R-squared	0.979	0.979	0.979	0.979	0.979	0.979
P-value OID	0.6280	0.6755	0.6887	0.7061	0.5954	0.6831
Threshold	99.40%	99.40%	99.35%	99.38%	99.38%	99.40%

Source: Authors, from the collected data, using Stata. Standard errors in parentheses. *** p<0.01; ** p<0.05; * p<0.1.

Table XII: Effects of external debt on water and sanitation index

Dependent variable: Water and sanitation index (WSS_index)						
variable	(1)	(2)	(3)	(4)	(5)	(6)
L.WSS_index	0.914***	0.913***	0.910***	0.915***	0.909***	0.913***
	(0.0524)	(0.0524)	(0.0541)	(0.0513)	(0.0539)	(0.0528)
Dext	-0.107	-0.147	-0.0194	-0.567	-0.0944	-0.149
	(0.524)	(0.528)	(0.536)	(0.641)	(0.544)	(0.533)
$Dext^2$	0.0541	0.0741	0.00936	0.285	0.0474	0.0751
	(0.264)	(0.266)	(0.269)	(0.322)	(0.274)	(0.268)
InflationCP	-0.000121	-0.000161	-0.000188	-8.36e-05	-0.000201	-0.000166
	(0.000461)	(0.000450)	(0.000453)	(0.000465)	(0.000452)	(0.000456)
TnaturalRess	-0.0243	-0.0245	-0.0255	-0.0245	-0.0267	-0.0248
	(0.0173)	(0.0173)	(0.0179)	(0.0172)	(0.0181)	(0.0176)
trade	0.0216*	0.0206	0.0214*	0.0205*	0.0217*	0.0209*
	(0.0126)	(0.0127)	(0.0129)	(0.0123)	(0.0130)	(0.0127)
Tpop	0.0234	0.0223	0.0198	0.0288	0.0248	0.0226
	(0.0286)	(0.0284)	(0.0280)	(0.0298)	(0.0291)	(0.0292)
APD	0.00203	0.00276	0.00305	0.00303	0.00322	0.00294
	(0.00287)	(0.00285)	(0.00302)	(0.00296)	(0.00301)	(0.00315)
GDPk	-0.00300	-0.00350	-0.00416	-0.00511	-0.00201	-0.00359
	(0.0108)	(0.0109)	(0.0107)	(0.0104)	(0.0112)	(0.0108)
corruption	0.0120					
	(0.0107)					
GovEff		0.00171				
		(0.0101)				
PolStability			-0.00563			
			(0.00544)			
RegQuality				0.0204		
				(0.0148)		
RuleLaw					-0.0223*	
					(0.0135)	
VoiceAcc						-0.00142
						(0.00628)
R-squared	0.910	0.910	0.910	0.910	0.910	0.910
P-value OID	0.2589	0.2177	0.2151	0.2200	0.1831	0.2245

Note: Standard errors in parentheses. *** p<0.01; ** p<0.05; * p<0.1.
Source: Authors, from the collected data, using Stata.