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Natural Resource Dependence, Corruption, and Tax Revenue Mobilization

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Abstract This paper explores the dynamic interactions between natural resource dependence, corruption, and tax revenue mobilization worldwide. The empirical analysis used a cross-section augmented autoregressive distributed lag (CS-ARDL) approach that accounts for time dynamics, cross-sectional heterogeneity, and cross-sectional dependence. The results show that the interaction between natural resource dependence, corruption, and tax revenue mobilization is complex and depends on the type of tax revenue. For example, reducing corruption stimulates non-resource tax revenue mobilization compared to total tax revenue; however, tax revenue mobilization is sometimes a source of corruption and evasion of natural resource rents. The results suggest that tax administration institutions need to be strengthened to limit predatory and rent-seeking behavior.

Keywords: natural resource dependence, tax revenue mobilization, non-resource revenue, corruption, CS-ARDL, heterogeneity

JEL Classifications: O13, H20, H24, D73, C31

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I. Introduction

Countries highly endowed with natural resources have economic growth potential from natural resource rents. Revenue from natural resources can help mobilize fiscal resources and finance productive investments to diversify economies; however, exploiting natural resources requires authorizations and permits, sometimes in environments with complex regulations, which can embolden officials to resort to corruption. For example, the prevalence of bargaining power through bribes and taxes may partly reflect institutional development in resource-rich countries (Goyette, 2019). Additionally, the accelerating rate of natural resource depletion and the degradation of environmental quality are global and national concerns. These concerns are even more important for countries with high dependencies on natural resources. According to data from the Extractive Industries Transparency Initiative, from 2000 to 2017, the share of extractive revenue as a part of total government revenue was 93% in Iraq, 83% in the Democratic Republic of the Congo

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(DRC), 82% in Nigeria, 81% in Timor-Leste, and 70% in Chad.

Furthermore, natural resource revenues are a source of financing often characterized by high volatility (OCDE/UCA/ATAF, 2021). Over the past decade, Chad, Equatorial Guinea, Mauritania, Nigeria, and the DRC have experienced declining resource revenues, ranging from 38% to more than 64%. This volatility leads to instability in tax collection, limiting the scope of natural resources in terms of tax effort. Moreover, a tax system that favors multinational resource firms paying taxes in the countries where they are headquartered leads to a shrinking tax base, especially in resource-dependent countries (CNUCED, 2020); however, tax revenues are an essential source of income for most developing countries. As of 2010, tax and non-tax revenues from natural resources accounted for 10% of the GDP in Africa (CNUCED, 2020). Coulibaly and Gandhi (2018) estimated that by improving tax efficiency and reducing the tax gap—estimated to be 20% on average—African countries could increase the tax-to-GDP ratio by 3.9%; however, from 2000 to 2019, the average contribution of tax revenue to GDP was lower in African (16%) and Latin American and Caribbean countries (21%) than in OECD countries (33%).

Natural resource rents have been detrimental in countries like Nigeria and the DRC, where rents fuel corruption, and a blessing in countries like Botswana and Norway that invest the income in development. From 1996 to 2020, high levels of corruption were recorded in Somalia (-1.63), Equatorial Guinea (-1.58), South Sudan (-1.54), Afghanistan (-1.43), and the DRC (-1.43), compared to low levels in Norway (2.12) and Botswana (0.90).

Based on the above, natural resources can reduce incentives to invest in anti-corruption measures in favor of rent-seeking, resulting in institutional weakening, which affects the tax effort. In this context, this paper determines the interactions between natural resource rents, corruption, and tax efforts by analyzing the dynamic interactions between natural resource dependency, corruption, and tax efforts worldwide.

Our contribution is threefold. First, unlike most empirical work that focused on the effects of natural resources on growth (Sachs & Warner, 1997; Auty, 2000; Mehlum, Moene, & Torvik, 2006; Havranek, Horvath, & Zeynalov, 2016), our approach explored the interactive effects of natural resources on corruption and tax revenue mobilization. Second, the existing literature (Dong, Zhang, & Song, 2019; Mawejje, 2019; Prichard, Salardi, & Segal, 2018; Pappa, Sajedi, & Vella, 2015) typically considered natural resource abundance, institutional development, and tax revenue mobilization separately, or at best in pairs. In contrast, this paper combined all three concepts to examine where natural resources affect corruption and tax revenue mobilization, so the three components interact mutually. Finally, our methodological approach differed from previous studies by jointly incorporating dynamics, heterogeneity, and cross-sectional dependence. The evidence shows that the interactive effects between resource dependence, corruption, and tax effort vary depending on country-specific factors. Therefore, this heterogeneity across countries should be considered. Moreover, previous work used econometric models based on panel data, which assumed cross-sectional independence in the distribution of errors; however, omitting common factors, possibly correlated to the regressors, can lead to a correlation of cross-sectional errors. Neglecting such dependencies can also lead to biased estimates and erroneous inferences. Therefore, we applied the cross-section augmented autoregressive distributed lag (CS-ARDL) model to simultaneous equations.

The rest of the paper is organized as follows. First, a brief overview of the existing literature is provided. Next, the data and the analysis method are outlined, followed by the results and discussions. Last, the conclusion presents some economic policy implications.

II. Literature Review

Analysis of the interrelationships between resource rents, corruption, and tax revenue mobilization is embedded in the theoretical framework of the rentier state. According to rentier state theory (Sachs & Warner, 1997; Ross, 2015), resource-rich countries derive substantial amounts of their budgets from resource rents, which exert three primary effects on governments of resource-rich countries: the taxation effect, the expenditure effect, and the protest effect. The taxation effect suggests that when governments generate sufficient revenues from natural resources, the population is taxed less, making it less likely to hold the government accountable (Isham, Woolcock, Pritchett, & Busby, 2005), encouraging rent capture and corruption. The expenditure effect implies that rents lead to patronage, undermining latent pressure for democracy (Vicente, 2010). The protest effect suggests that the government uses resource rents to prevent the formation of protest groups (Andersen & Aslaksen, 2013). Therefore, the rentier state theory argues that resource rents can prevent government accountability by decoupling taxation and spending (Ross, 2015), encouraging corruption, and reducing incentives to invest in tax administration.

The empirical literature shows that resource-rich countries generate higher rents and exhibit more rent-seeking behavior (Ross, 2015; Mawejje & Sebudde, 2019). Tax policy is often linked to corruption, with entrepreneurs bribing public officials to obtain private gains, such as avoiding taxes and regulations or obtaining public contracts (Fjeldstad, 2003). Thus, fiscal pressure affects institutional development, especially corruption (Dreher & Siemers, 2009; Dreher & Schneider, 2010). Arezki and Brückner (2011) showed that increased oil rents significantly increase corruption in oil-exporting countries. Baum et al. (2017) used a large sample of 147 countries from1995 to 2014, indicating that corruption is negatively associated with overall tax revenues, and Gauthier and Goyette (2016) showed that it might be optimal for a revenue-maximizing government to tolerate corruption. An increase in tax rates increases enforcement costs because incentives for corruption also increase. In this light, Mawejje and Sebudde (2019) indicated a marked heterogeneity in individual country outcomes; however, countries operating closer to their fiscal potential have high-income levels, high human capital, and lower tax rates. As a result, dependence on natural resources reduces incentives to develop an efficient tax system, providing an alternative source of low-cost financing.

Although most previous work considers institutions to be exogenous, resource endowments can influence the evolution of institutional structures (Goujon & Mabali, 2016). Natural resources, such as diamonds and oil, are sources of institutional degradation in the form of lower levels of democracy and increased corruption. Sen et al. (2018) showed that following resource discoveries, political elites can sabotage the process of institutional reform by creating conditions that favor rent capture. In particular, abundant natural resources discourage governments from building effective fiscal institutions, including robust tax systems (Ross, 2001). Indeed, oil revenues are a much larger and more easily collected windfall than personal or corporate taxes. From this perspective, Jensen (2011) showed that, based on a panel of 30 hydrocarbon-rich economies, a 1% increase in hydrocarbon revenues leads to a 1.5% decrease in non-resource tax effort.

Beyond the corruption effects, some empirical work has also shown that resource dependence underpins poor tax revenue performance. James (2015) found an offset of about 12% on income tax revenues for every one percent increase in resource revenues in the United States. Crivelli and Gupta (2014) found similar results in a sample of 35 resource-rich countries. Thus, an additional percentage point in resource revenues reduces about 0.3 points in non-resource revenues. As a result, countries that are highly dependent on resource revenues experience higher levels of corruption and tend to have low tax mobilization capacities. Furthermore, Bothole et al. (2012) examined a panel of 46 sub-Saharan African countries and found that an increase in resource revenues reduces tax revenues when institutions are poor. The previous works show that the relationships between natural resource dependence, corruption, and tax revenue mobilization are not unambiguous and cannot be treated separately.

III. Methodology

A. Data and descriptive analyses

This paper's analysis sample covers a broad panel of 166 countries from 1996 to 2018. The selection of countries was based primarily on data availability. Tax revenue data were taken from the International Center for Tax and Development (ICTD), while data on human capital and corruption indices were taken from the Penn World Table and the Worldwide Governance Indicators (WGI). Data on business freedom were obtained from the Heritage Foundation, and finally, data on resource rents, GDP per capita, and public expenditure were taken from the World Development Indicators (WDI). Tables A1 and A2 in the appendix list the countries and describe the variables.

Figure 1 shows a positive relationship between total tax revenues and rents and a negative relationship between non-resource tax revenues and rents. These relationships support the idea that resource-dependent countries make less effort in revenue collection than countries without resources. Figure 2 reveals that corruption control is negatively related to total tax revenue mobilization and natural resource rents. In contrast, there is a positive relationship between control of corruption and non-resource tax revenues. The descriptive analysis in Table A3 in the appendix shows that the average total and non-resource tax revenues are 4.12% and 23.66%, respectively, from 1996 to 2018; however, total tax revenues are less variable (8.7%) than non-resource tax revenues (13.87%). Moreover, resource rents vary from 0% for some periods in countries like Malta, Iceland, and Montenegro to 86.25% for Turkmenistan. Corruption is very high in some countries, such as Equatorial Guinea, Congo, Liberia, and Haiti, and very low in others like Denmark and Finland.

Figure 1. Distribution of tax revenue according to natural resource rents

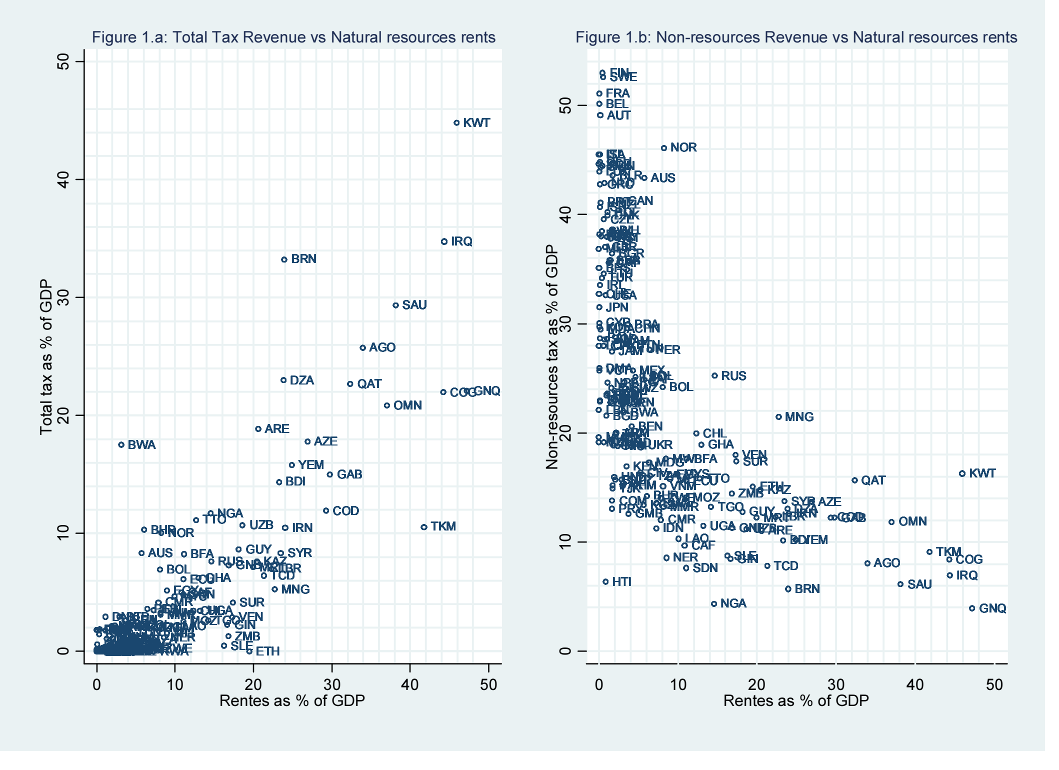
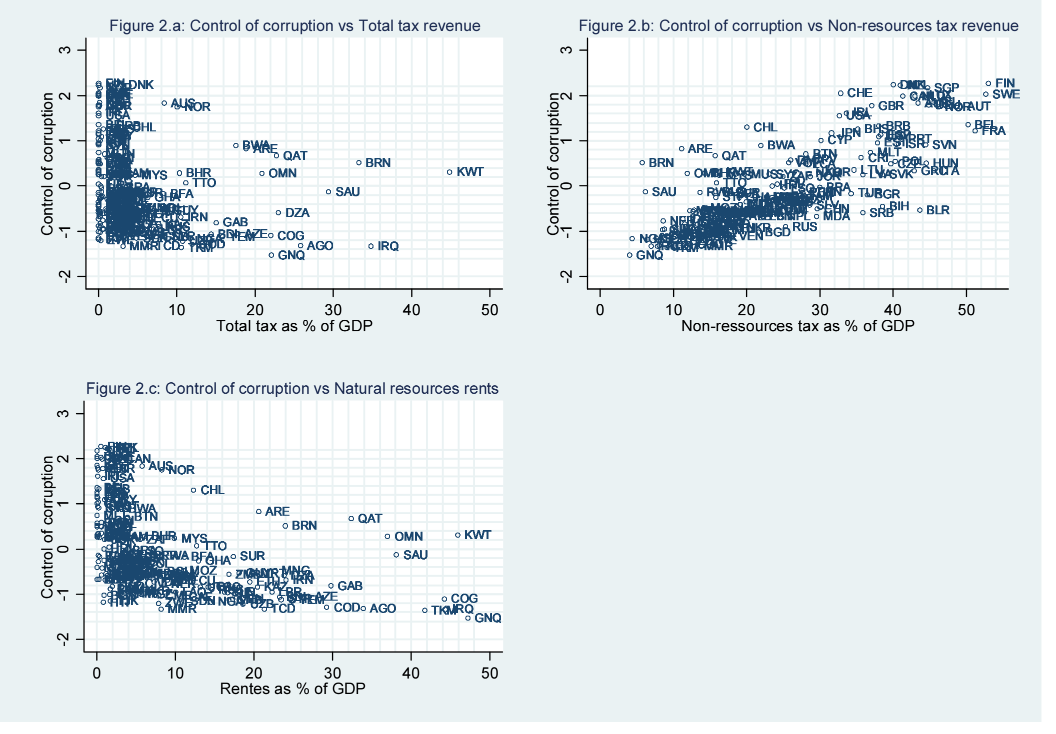


Figure 2. Control of corruption vs. tax revenue and natural resource rents



B. Diagnostic tests and choice of estimator

1. Dependency test

This study used the Pesaran (2015) test for the hypothesis of independence between individuals. The Cross-section Dependence (CD) test statistic presented in Table 1 shows a strong cross-sectional dependence for the sample countries, considered at the 1% threshold, implying that the cross-sectional units depend on each other by sharing a common factor.

Table 1. *Results of the Cross-sectional Dependency Test*

Variables	***CD Test***
Tax revenues	34.689***
	(0.000)
Resource rents	64.560***
	(0.000)
Corruption	11.867***
	(0.000)

(Source) Author
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

If this dependence is ignored, the estimation results may be biased and inconsistent; therefore, methods robust to cross-sectional dependence should be used.

2. Unit root tests

Given the cross-sectional dependence between observations, we used the Pesaran (2007) test to determine the presence of unit roots, which allows for inter-individual dependence in heterogeneous panels. Moreover, unlike most second-generation tests (Moon & Perron, 2004; Phillips & Sul, 2003), the Pesaran (2007) test is based on the raw series corrected for individual means of lagged variables and first differences. The test was performed for the three cases of specification of the model's deterministic form. A variable was stationary whenever the statistic was lower than the distribution's critical value at the 5% threshold for all specifications. Otherwise, there was the presence of a unit root. The Pesaran (2007) test results in Table 2 show that all variables are stationary except for total resource rents, GDP per capita, human capital, and freedom of business, integrated into order 1.

Table 2. *Results of Stationarity Tests*

Variables	Values of the t-CIPS statistic at the 5% threshold			Order of integration I()
	Case 1	Case 2	Case 3	
	Level stationarity			
CIPS (166, 23)	(-1.5)	*(-2.05)*	*(-2.54)*	
Log Total resources rent	-2.092	-2.272	-2.785	I(0)
Total resource revenue	-1.385	-1.970	-2.512	I(≥1)
Control of corruption	-1.632	-2.998	-3.822	I(0)
Log GDP per capita	-1.032	-1.825	-1.906	I(≥1)
Public expenditure	-1.919	-2.082	-2.527	I(0)
Human capital index	-1.484	-2.517	-2.300	I(≥1)
Business freedom	-1.859	-1.882	-2.338	I(≥1)
	First difference			
CIPS (166, 22)	(-1.5)	*(-2.05)*	*(-2.54)*	
Total resource revenue	-2.723	-3.179	-3.512	I(1)
Log GDP per capita	-3.206	-3.378	-3.567	I(1)
Human capital index	-4.146	-4.073	-4.266	I(1)
Business freedom	-4.146	-4.629	-4.737	I(1)

(Source) Author

Notes: Critical values of CIPS at the 5% level are in parentheses; Case 1: models without intercepts or trends; Case 2: models with individual-specific intercepts; Case 3: models with incidental linear trends.

Some variables were not stationary, and as a result, it was necessary to test for a long-term relationship between the series.

3. Cointegration and slope heterogeneity test

Since the Pedroni (2004) test imposes independence between the observations, we used the Westerlund (2007) cointegration test, postulating a possible dependence. The results in Table 3 show that the hypothesis of non-cointegration was rejected at the 1% threshold for all models. Therefore, the estimation technique must consider the cross-sectional dependence and the existence of a long-term relationship between the variables in the model.

Table 3. *Cointegration and Slope Heterogeneity Test*

Variables	*Slope heterogeneity test*		*Westerlund cointegration test*
	Delta test	Adj Delta test	Variance ratio
Tax revenues	-5.550***	-6.957***	-6.0635***
	(0.000)	(0.000)	(0.0000)
Resource rents	-3.162 ***	-4.114***	3.9211***
	(0.002)	(0.000)	(0.0000)
Corruption	2.860***	4.045***	-7.6011***
	(0.004)	(0.000)	(0.0000)

(Source) Author
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Several econometric models exist depending on whether the slope is homogeneous (fixed effects, random effects, generalized method of moments, etc.) or heterogeneous (seemingly unrelated regression equations, mean group estimator, etc.). Not considering the heterogeneity of the slope leads to biased results (Pesaran & Smith, 1995); therefore, the test for slope heterogeneity is essential for model selection. For this purpose, we used the Delta test (Pesaran & Yamagata, 2008; Blomquist & Westerlund, 2013), which allowed us to test for slope heterogeneity in panels with many observations on cross-sectional units and periods.

Table 3 indicates that the assumption of slope homogeneity was rejected for all three model equations. Therefore, the different specifications must consider the heterogeneity of the slopes.

C. Specification of the CS-ARDL simultaneous equation model

We started with a simultaneous equation model to capture the interactions between natural resource rents, corruption, and tax revenue mobilization. The basic model was formulated using the following equations (1):

$$\begin{cases} fiscal_{it} = \alpha_{i0} + \phi_i fiscal_{i,t-1} + \alpha_{i1} res\_rent_{i,t} + \alpha_{i2} corr_{i,t} + \alpha_{i3} F_{i,t} + \epsilon_{it} \\ res\_rent_{it} = \lambda_{i0} + \rho_i res\_rent_{i,t-1} + \lambda_{i1} fiscal_{i,t} + \lambda_{i2} corr_{i,t} + \lambda_{i3} R_{i,t} + \eta_{it} \\ corr_{it} = \beta_{i0} + \phi_i corr_{i,t-1} + \beta_{i1} res\_rent_{i,t} + \beta_{i2} fiscal_{i,t} + \beta_{i3} C_{i,t} + \mu_{it} \end{cases} \quad (1)$$

Where $fiscal_{it}$ indicates tax revenue, $corr_{it}$ represents control of corruption, res_rent_{it} signifies resource rents, and $F_{i,t}$; $R_{i,t}$ and $C_{i,t}$ denotes the control variables for tax revenue mobilization, resource rents, and corruption, respectively. ϵ_{it}, η_{it} and μ_{it} denote the error terms.

When modeling the relationship between the dependent variable and the regressors in a panel context, we needed to consider slope heterogeneity, dynamics, and cross-sectional dependence. Based on these conditions, Chudik et al. (2016) defined the general form of the $CS-ARDL(p_y,p_x)$, in which the dependent variable is given the following specification:

$$y_{it} = \mu_i + \sum_{l=1}^{p_y} \lambda_{l,i} y_{i,t-l} + \sum_{l=0}^{p_x} \beta_{l,i} x_{i,t-l} + \sum_{l=0}^{p} \gamma_{l,i} \overline{Z}_{t-l} + e_{it} \tag{2}$$

Where $\overline{Z}_{t-l} = \left(\overline{y}_t, \overline{x}_t'\right)'$, $p_z = [T^{1/3}]$ and the two options for the delay orders to be determined. The individual long-term coefficients were calculated as follows: $\hat{\theta}_{CS-ARDL,i} = \dfrac{\sum_{l=0}^{p_x} \hat{\beta}_{l,i}}{1-\sum_{l=1}^{p_y} \hat{\lambda}_{l,i}}$

By incorporating the cross-sectional dependence and the long-run relationship, each of the equations in system (1) can be rewritten as a CS-ARDL model, as developed by Chudik et al. (2016). This approach provides a complete set of estimates for both the long- and short-run coefficients. The system of equations (1) becomes:

$$\begin{cases} fiscal_{it} = \mu_i + \sum_{l=1}^{p_y} \lambda_{l,i} fiscal_{i,t-l} + \sum_{l=0}^{p_{x1}} \alpha_{l,i}^1 res\_rent_{i,t-l} + \sum_{l=0}^{p_{x2}} \alpha_{l,i}^2 corr_{i,t-l} \\ \qquad + \sum_{l=0}^{p_{x3}} \gamma_{l,i}' X_{i,t-l} + \sum_{l=0}^{p} \phi_{l,j}' \overline{Z}_{t-l} + \epsilon_{it} \\ res\_rent_{it} = \omega_i + \sum_{l=1}^{p_y} \tau_{l,i} res\_rent_{i,t-l} + \sum_{l=0}^{p_{x1}} \theta_{l,i}^1 fiscal_{i,t-l} + \sum_{l=0}^{p_{x2}} \theta_{l,j}^2 corr_{i,t-l} \\ \qquad + \sum_{l=0}^{p_{x3}} o_{l,j}' X_{i,t-l} + \sum_{l=0}^{p} \psi_{l,j}' \overline{Z}_{t-l} + \epsilon_{it} \\ corr_{it} = \upsilon_i + \sum_{l=1}^{p_y} \rho_{l,i} corr_{i,t-l} + \sum_{l=0}^{p_{x1}} \beta_{l,i}^1 res\_rent_{i,t-l} + \sum_{l=0}^{p_{x2}} \beta_{l,i}^2 fiscal_{i,t-l} \\ \qquad + \sum_{l=0}^{p_{x3}} \delta_{l,i}' X_{i,t-l} + \sum_{l=0}^{p} \phi_{l,i}' \overline{Z}_{t-l} + \eta_{it} \end{cases} \tag{3}$$

The estimation method to account for cross-sectional dependence, heterogeneity, and the cointegrating relationship between observations could be discussed with the model specified.

D. Estimation method

Today, most countries are interconnected through globalization, primarily through trade relations, technological cooperation, and the development of information and communication technologies. As a result, there is significant potential for cross-cutting dependence between countries worldwide. The recent Covid-19 health crisis, marked by the spread of illness between countries, illustrates this strong interdependence.

The cross-country error terms in our model exhibit a considerable degree of cross-sectional dependence, as the reported CD statistics are highly significant with very large test statistics. Cross-sectional dependence implies that estimates obtained using standard panel ARDL models could be biased. To overcome this problem, we used the CS-ARDL approach developed by Chudik et al. (2016), which augments ARDL regressions with the cross-sectional means of the regressors, the dependent variable, and a defined number of lags. In addition, this approach also allowed weakly exogenous regressors to capture dynamic behavior and developed an error correction model (ECM). This approach used unit-specific ARDL specifications to screen out the effects of unnoticed common factors, from which long-run effects could be estimated indirectly. Chudik et al. (2016) showed that this technique is most effective when examining unobserved common factors. This approach also addressed long- and short-term cross-sectional dependencies.

The CS-ARDL model can be estimated using the mean group (MG) and pooled mean group estimators; however, the time dimension (T) must be large enough for the model to be estimated for each cross-sectional unit (Chudik & Pesaran, 2015). In addition, a sufficient number of lagged cross-sectional means should be included to ensure the validity of these estimators. Therefore, data with sufficiently large temporal and cross-sectional dimensions should be used to allow for heterogeneity in the cross-sectional slope and residual cross-sectional dependence (Cavalcanti, Mohaddes, & Raissi, 2014; Samargandi, Fidrmuc, & Ghosh, 2015). This justifies using a large panel based primarily on the availability of data.

Estimation of the CS-ARDL model requires setting maximum lag lengths for the cross-sectional means, and the number of lagged cross-sectional means must be sufficient to overcome problems of cross-sectional dependence of the residual. Several approaches have been used to determine the optimal lag lengths in empirical work. Chudik et al. (2013) imposed a common lag structure for all countries, while Cavalcanti et al. (2014) suggested selecting the lag lengths through an information criterion. Moreover, Eberhardt and Presbitero (2015) suggested an optimal lag length equal to 2, while Chudik and Pesaran (2015) stated the maximum lag lengths should not exceed 3. To determine the optimal lag lengths, we used the Bayes Information Criterion, subject to a maximum lag length of 3 $\left(p_z = \left[T^{1/3}\right] = \left[23^{1/3}\right] \approx 2.83\right)$ on each explanatory variable. This resulted in estimating a CS-ARDL model with an optimal lag length of 1.

IV. Main Results

A. Basic results

Table 4 presents the primary results of the interaction between natural resource dependence, corruption, and tax revenue mobilization.

Table 4. *Results of the Cross-Section Augmented ARDL (CS-ARDL) Specification*

Variables	*Tax revenues*	*Resources rents*	*Control of corruption*
Short-Run			
Log total resource rent	2.003**		0.185**
	(2.07)		(2.16)
Log total resource rent lag	3.085***	-0.369***	0.029
	(2.86)	(-7.53)	(0.70)
Total resource revenue		-0.122*	-0.018*
		(-1.86)	(-1.65)
Total resource revenue lag	-0.333***	-0.076**	-0.035
	(-7.07)	(-2.40)	(-1.55)
Control of corruption	-4.184**	0.036	
	(-2.48)	(0.18)	
Control of corruption lag	-0.852	-0.411*	-0.484***
	(-0.98)	(-1.78)	(-16.39)
Log GDP per capita	-3.592	0.085	-0.074
	(-1.12)	(0.19)	(-0.42)
Log GDP per capita lag	-0.477	-0.149	0.047
	(-0.58)	(-0.33)	(0.28)
Public expenditure	-0.125	0.017***	0.007
	(-0.36)	(2.79)	(0.47)
Public expenditure lag	-0.053	0.034	0.035**
	(-0.13)	(0.91)	(2.17)
Human capital index	0.413	1.872	0.144
	(0.93)	(0.28)	(0.08)
Human capital index lag	-0.287	-7.894	3.088
	(-0.54)	(-1.07)	(1.48)
Business freedom		0.009	
		(0.82)	
Business freedom lag		0.002	
		(0.28)	
Long-Run			
Error correction term	-0.333***	-0.369***	-0.484***
	(-28.29)	(-27.92)	(-50.24)
Log total resource rent	2.248***		0.212**
	(2.68)		(2.54)
Total resource revenue		-0.141***	-0.047**
		(-2.67)	(-2.24)
Control of corruption	-2.909**	-0.351**	
	(-2.23)	(-2.18)	
Log GDP per capita	-0.477	-0.576**	0.004
	(-0.58)	(-2.46)	(0.06)

Table 4. *Continued*

Variables	*Tax revenues*	*Resources rents*	*Control of corruption*
Public expenditure	-0.405*	0.058	0.032**
	(-1.88)	(0.89)	(2.22)
Human capital index	-0.477	0.737**	2.061
	(-0.58)	(2.06)	(0.93)
Business freedom		0.018	
		(0.41)	
Constant	8.452	-2.097	-0.486
	(0.77)	(-0.49)	(-0.86)
Observations	3,281	3,281	3,279
Number of groups	165	165	165
R2a	0.293	0.278	0.500
Pesaran CD statistic	27.40	21.52	4.88
CD p-value	0.000	0.000	0.000

z-statistics in parentheses
**** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$*
(Source) Author

The results of the Pesaran (2015) dependence test confirm a cross-sectional dependence in the data at the 1% level for all model equations. The error correction coefficients are negative and significant at the 1% level for the model's three equations, which validates the long-run relationship.

Under tax revenue mobilization, the results in column 2 of Table 4 show that total resource rents improve tax revenue mobilization, while public expenditure and control of corruption hinder tax revenue mobilization. A 1% increase in resource rents is associated with a 2.25% improvement in tax revenue, indicating that the exploitation of natural resources contributes to increasing tax revenue, especially in resource-rich countries. This outcome challenges Crivelli and Gupta (2014) and James (2015), who argued that rents reduce tax effort. It also shows that a 1% increase in corruption control (corruption reduction) leads to a 2.91% decrease in tax revenue, implying that fighting corruption leads to significant tax resource losses. In this case, reducing corruption demotivates tax officials who might use the practice to enrich themselves and replenish the state's coffers, which confirms Gauthier and Goyette (2016), who found that it may be optimal for a revenue-maximizing government to tolerate corruption. Finally, the results indicate that a 1% increase in public spending leads to a 0.41% decrease in tax revenue. The financing of public expenditure can explain this result through additional taxes and by channeling public expenditures into unproductive activities. Thus, tax financing of public expenditure distorts factor productivity, which can eventually lead to the crowding out of certain activities and, in turn, a decline in tax revenues. This result is similar to the Laffer curve, which posits that too much taxation is detrimental to tax revenue mobilization above a certain threshold. As for the financing of unproductive activities, increasing public spending degrades the capacity of governments to raise additional taxes, thereby posing a risk to the sustainability of public debt.

Resource rents are driven by the level of human capital and constrained by corruption, tax revenues, and per capita income. Control of corruption impedes the mobilization of resource rents. This result indicates that increasing the level of corruption could be conducive to resource rent capture behavior. Consequently, political elites use corruption to accelerate the exploitation of natural resources, increasing natural resource rents. This result confirms those of Sen et al. (2018) and Mawejje and Sebudde (2019), who showed that corruption promotes rent capture. Furthermore, tax revenues negatively impact resource rents, implying that an improvement in tax efforts leads to low reliance on resource rents as an instrument for tax revenue mobilization; the level of development proxied by per capita income negatively affects resource rents. In this case, improvement in the development level leads countries to progressively abandon resource rents, especially concerning exhaustible resources as the basis for their development policies. This result is consistent with evidence that resource rents occupy a central place in tax revenues in most developing countries, which differs from developed countries (Crivelli & Gupta, 2014; James, 2015). Moreover, low-income countries rely more on resource rents, while high-income countries mobilize non-resource revenues accordingly. The results also support the argument that an improvement in the human capital index is accompanied by better use of natural resource rents in a sustainable development situation, confirming the results of Mawejje and Sebudde (2019). Indeed, countries with high levels of human capital reinvest rents to compensate for decreases in natural resources to keep the capital stock constant. In this context, exploiting natural resources is beneficial for resource-rich countries.

Finally, the results in column 4 of Table 4 show that corruption increases with tax revenue and decreases with resource rents and public expenditure. Thus, 1% increase in tax revenue leads to 0.05% increase in corruption control (decreased corruption) at the 5% threshold. This results because an increase in tax revenue is sometimes derived from either a widening tax base or greater enforcement of tax levies. In this case, the risks of collusion are enormous, and very often, tax officials have an incentive to accept bribes, especially when the risk of being caught or sanctions is low. Our results validate Dreher and Siemers (2009) and Dreher and Schneider (2010), who found that tax pressure increases corruption. Furthermore, a 1% improvement in rents and public expenditure increases corruption control by 0.21% and 0.032%, respectively, at the 5% threshold. This finding supports the results of Bhattacharyya and Hodler (2010) and Ross (2015), who showed that rents promote corruption. This result illustrates that increased public expenditure and rents can improve civic-mindedness and worker integrity, especially when ex-post control structures are effective. This can limit the acceptance of bribes, and in this case, the level of corruption decreases as a result.

Ultimately, the results show that resource rents stimulate tax revenue mobilization, while control of corruption hinders tax revenue mobilization in the first instance. Furthermore, tax revenue mobilization and corruption control decrease resource rents. Finally, tax revenue mobilization increases corruption, while resource rents reduce corruption.

In the short-run, the results in Table 4 indicate that past and current resource rents improve tax revenue mobilization, while corruption control and previous tax revenue mobilization hinder tax revenue mobilization. Resource rents increase with public expenditure and decrease with past rents, present and past tax revenue, and the previous level of corruption. Finally, corruption decreases with previous levels of public expenditure and resource rents. Conversely, increased tax revenues and the previous level of corruption are accompanied by a decrease in corruption control, thereby increasing corruption.

These results show that the relationship between natural resource dependence, corruption, and tax revenue mobilization is complex. Moreover, the stylized facts reveal that different countries have had different experiences with natural resource exploitation, anti-corruption efforts, and tax efforts. As a result, the results' robustness must be tested by changing the estimators and using an alternative tax revenue measure.

B. Robustness tests

To check the robustness of the results, we successively resorted to a change in the measure of tax revenues and then used alternative estimators. For the sake of brevity, only the long-run effects were analyzed. First, non-resource-related tax revenues were used as an alternative measure of tax effort. The results of this regression are presented in Table 5 below. An alternative tax revenue measure shows that the dynamic interactions between resource rents, corruption, and tax revenue are complex and depend on the type of tax revenue considered. Thus, when considering non-resource tax revenues, only the depressive effect of corruption on rents remains unchanged.

Table 5. *Robustness Test using an Alternative Measure of Tax Effort*

Variables	*Tax Revenue*	*Resource Rents*	*Control of Corruption*
Error correction term	-0.361***	-0.083***	-0.531***
	(-54.66)	(-36.64)	(-72.78)
Log total resource rent	-2.190**		-0.045**
	(-2.18)		(-2.30)
Total non-resource revenue		0.004**	0.003**
		(2.45)	(2.11)
Control of corruption	2.104***	-0.147**	
	(3.27)	(-2.15)	
Public expenditure	0.404*	-0.039***	-0.003
	(1.82)	(-2.68)	(-0.49)
Log GDP per capita	5.846***	-0.419**	0.066
	(2.75)	(-2.56)	(1.07)
Human capital index	-31.202	-0.101	0.716
	(-1.24)	(-0.04)	(0.94)
Business freedom		-0.001	
		(-0.20)	
Constant	-0.056	0.027**	-0.154**
	(-0.07)	(2.09)	(-2.17)
Observations	3,445	2,791	3,281
Number of groups	165	165	165
R2a	0.292	0.242	0.418
Pesaran CD statistic	2.269	34.93	3.481
CD p-value	0.023	0.000	0.000

z-statistics in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
(Source) Author

In contrast, reducing corruption improves non-resource tax revenues, while resource rents reduce tax effort, confirming the results of Crivelli and Gupta (2014). Moreover, non-resource tax revenues boost rents, while controlling corruption reduces rents. Finally, natural resource rents are a source of corruption, while non-resource revenues limit corruption. Therefore, the primary outcomes depend, to a large extent, on whether or not resource-related tax revenues are used.

We also used other alternative specifications to test the robustness of our results. These are the heterogeneous parameter models, namely, the cross-sectional error correction model (CS-ECM) and the dynamic common correlated effects estimator-mean group (CCE-MG), which incorporate both parameter heterogeneity and cross-sectional dependence (Pesaran, 2006; Pesaran & Smith, 1995). Table 6 provides these two alternative specifications, and the overall results largely confirm our basic results. Thus, our results remain robust to an alternative specification.

Table 6. *Results using Two Alternative Estimators*

Variables	Error Correction Models (CS-ECM)			Dynamic Common Correlated Effect		
	Tax Revenue	*Resource Rents*	*Control of Corruption*	*Tax Revenue*	*Resource Rents*	*Control of Corruption*
Error correction term	-0.587***	-0.352***	-0.871***	-0.838***	-0.816***	-0.483***
	(-34.33)	(-32.58)	(-59.50)	(-8.55)	(-24.81)	(-7.19)
Log total resource rent	1.278**		0.028*	1.013**		0.190*
	(2.53)		(1.70)	(2.24)		(1.94)
Total resource revenue		-0.071*	-0.016*		-0.056**	-0.052*
		(1.88)	(-1.94)		(2.16)	(-1.77)
Control of corruption	-0.864**	-0.134**		-3.550*	-0.138**	
	(-2.11)	(-2.18)		(-1.77)	(2.07)	
Public expenditure	-0.104	-0.044**	0.054	-0.053	-0.025**	-0.050
	(-1.34)	(-2.26)	(0.97)	(-1.01)	(-1.97)	(-0.54)
Log GDP per capita	1.841**	-0.446**	-0.119	0.156*	-0.487**	-1.324
	(2.03)	(-1.98)	(-0.67)	(1.89)	(-2.55)	(-1.61)
Human capital index	-4.736	4.204*	0.468	0.487	-1.790	1.799
	(-0.81)	(1.90)	(0.72)	(0.88)	(-0.71)	(0.59)
Business freedom		0.006			0.006	
		(1.35)			(1.56)	
Constant	4.613	1.430	-0.059	0.264	0.083	5.354
	(0.79)	(1.27)	(-0.89)	(0.70)	(0.05)	(1.30)
Observations	3,445	3,281	3,279	3,281	3,611	3,447
Number of groups	165	165	165	165	165	165
R2a	0.467	0.122	0.401	0.523	0.689	0.637
Pesaran CD statistic	1.930	14.47	7.255	5.638	4.725	-2.643
CD p-value	0.054	0.000	0.000	0.000	0.000	0.008

z-statistics in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
(Source) Author

V. Conclusion and Policy Implications

This paper examined the long-run interactive effects between natural resource dependence, corruption, and tax effort worldwide using a staggered lag autoregressive model, augmented with cross-sectional dependence, over a large panel of countries from 1996 to 2018. The results provide further empirical evidence that resource rents hinder the development of quality institutions and undermine the fiscal effort. More importantly, corruption and tax revenue mobilization interact with resource rents so that these two components undermine each other. These results suggest that countries should simultaneously strengthen investments in fiscal transition and anti-corruption efforts in tax administration and resource rent capture.

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Appendix

Table A1. *List of Countries*

Albania	Dominica	Latvia	Saint Lucia
Algeria	Dominican Republic	Lebanon	Saint Vincent and the Grenadines
Angola	Ecuador	Lesotho	Sao Tome and Principe
Argentina	Egypt	Liberia	Saudi Arabia
Armenia	El Salvador	Lithuania	Senegal
Australia	Equatorial Guinea	Luxembourg	Serbia
Austria	Estonia	Madagascar	Seychelles
Azerbaijan	Eswatini	Malawi	Sierra Leone
Bahamas	Ethiopia	Malaysia	Singapore
Bahrain	Fiji	Maldives	Slovakia
Bangladesh	Finland	Mali	Slovenia
Barbados	France	Malta	South Africa
Belarus	Gabon	Mauritania	South Korea
Belgium	Gambia	Mauritius	Spain
Belize	Georgia	Mexico	Sri Lanka
Benin	Germany	Moldova	Sudan
Bhutan	Ghana	Mongolia	Suriname
Bolivia	Greece	Montenegro	Sweden
Bosnia and Herzegovina	Guatemala	Morocco	Switzerland
Botswana	Guinea	Mozambique	Syria
Brazil	Guinea-Bissau	Myanmar	Tajikistan
Brunei	Guyana	Namibia	Tanzania
Bulgaria	Haiti	Nepal	Thailand
Burkina Faso	Honduras	Netherlands	Togo
Burundi	Hungary	New Zealand	Trinidad and Tobago
Cabo Verde	Iceland	Nicaragua	Tunisia
Cambodia	India	Niger	Turkey
Cameroon	Indonesia	Nigeria	Turkmenistan
Canada	Iran	Norway	Uganda
Central African Republic	Iraq	Oman	Ukraine
Chad	Ireland	Pakistan	United Arab Emirates
Chili	Israel	Panama	United Kingdom
Chine	Italy	Paraguay	United States
Chypre	Ivory Coast	Peru	Uruguay
Colombia	Jamaica	Philippines	Uzbekistan
Comoros	Japan	Poland	Venezuela
Costa Rica	Jordan	Portugal	Vietnam
Croatia	Kazakhstan	Qatar	Yemen
Czech Republic	Kenya	Republic of Congo	Zambia
Democratic Republic of Congo	Kuwait	Romania	Zimbabwe
Denmark	Kyrgyz Republic	Russia	
Djibouti	Lao	Rwanda	

Table A2. *Description of Variables and Data Sources*

Variables	Description of variables	Data sources
Total resources rent	The total natural resource rent is the sum of oil rents, natural gas rents, coal rents, mineral rents, and forest rents.	World Development Indicators (WDI, 2021)
Total Resource Revenue	Total tax revenue is generally equal to the sum of the sub-components of tax revenue, i.e., total taxes on income, profits, and capital gains.	International Center for Tax and Development (ICTD, 2021)
Total Non-Resource Revenue	Total non-tax revenue is defined as the difference between total revenue and total non-resource tax revenue.	ICTD
Control of corruption	It expresses the extent to which public action linked to the rules and functioning of public administration promotes corruption. A higher ranking is assigned to countries that control corruption better.	Worldwide Governance Indicators (WGI, 2021)
GDP per capita	The gross domestic product (GDP) per capita in current dollars obtained by dividing GDP by the current year's population.	WDI
Public expenditure	Expenses are cash payments for the operations of the government to provide goods and services. They include employee compensation, interest and grants, employee benefits, and other expenses such as rent and dividends.	WDI
Human Capital Index	This human capital index per worker is taken from the Pen World Tables. The index is constructed using average years of schooling data and an assumed rate of return for primary, secondary, and tertiary education.	Pen World Table 10.0
Business freedom	It helps to understand if the economic environment is conducive to business. It also helps measure the degree of business freedom of businesses and households.	Heritage Foundation

(Source) Author

Table A3. *Descriptive Statistics*

	N	Mean	Std. Dev.	Min	Max
Total natural resources rent as % of GDP	3818	8.01	11.765	0	86.252
Total tax as % of GDP	3818	4.123	8.7	-.039	65.268
Non-resources revenue as % of GDP	3818	23.664	13.871	.881	59.074
Control of corruption	3818	-.058	1.011	-1.816	2.47
Public expenditure as % of GDP	3818	15.592	5.672	.911	43.484
Logarithm of GDP per capita	3818	8.205	1.585	4.631	11.685
Human capital index	3818	.617	.183	.116	.946
Business freedom	3818	64.199	14.976	20	100