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Threshold Effect of Corruption on Income Inequality in Sub-Saharan Africa

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Abstract

We exploit a panel data set on Sub-Saharan for the period 1996 to 2017 on a sample of 22 SSA countries to re-examine the effect of corruption on income inequality in SSA. We apply a threshold model approach as the Panel Smooth Transition regression (PSTR) originally developed by Gonzales and al. (2005) to conciliate inconclusive results on that relationship. Two major results emerge from this analysis. First, the relationship between corruption and income inequality in SSA confirms the non-linearity character of this relationship. These results give reason to the mixed result between corruption and income inequality obtained by the empirical analysis. Second, we obtained strong evidence that corruption increases income inequality in SSA only if the level of corruption is above the threshold of corruption otherwise the effect of corruption is non detrimental. Our results are robust taking alternative measures of corruption.

JEL Classification: C13; E25; O10
Keywords: Income inequality; PSTR, Corruption.

1. Introduction

Since the famous Kuznets curve (1955), economic growth has played a key role in reducing inequality. Following the runoff effect, Kuznets has shown that a high level of economic growth tends to reduce inequalities. While Nissim (2007) empirically validates the curve of Kuznets, Bourguignon (2004), Stiglitz (2015) and Piketty (2015) showed that a high economic growth is not systematically associated with reducing inequalities. The persistence and rise of global inequality have put into question the role of economic growth in reducing inequality. For example, China and Rwanda experienced high economic growth but inequality has not declined. Since then, the rise in inequality has been interpreted as a result of institutional factors, particularly a high level of corruption. Indeed, the work of Gupta and *al*. (2002); Aperghis and *al*. (2010) demonstrated that inequality is high in countries with high level of corruption.

The empirical literature on the relationship between corruption and inequality yields contradictory results. There are two streams of thought in this debate. The first stream shows that corruption exacerbates inequality. Specifically, corruption distorts the allocation of resources, increases bureaucracy and favors private interests. Defenders of this view include Gupta and *al*. (2002), Aperghis and *al*. (2010) and Pedauga and *al*. (2016). The second school of thought relativizes this result and rather shows that corruption contributes to reducing inequalities. Indeed, in a context marked by poor institutional quality, Dobson and Ramlogan-Dobson (2012) suggest that corruption negatively affects inequality. Where the informal sector is important, corruption helps to overcome bureaucratic rigidities and maintain efficient allocation of resources. Thus, corruption would be a lubricant in the face of an invasive and ineffective bureaucracy to ensure the well-being of individuals (Leff, 1964; Lui, 1985).

One way to reconcile these two schools of thoughts is to rely on the theoretical argument of Murphy (1993). Indeed, using a theoretical model, the author shows that the effects of corruption can be both positive and negative, depending on the level of corruption. Numerous studies have empirically verified this theory and have shown that the relationship between corruption and inequality forms an inverted "U" curve. We can cite the studies of Chong and Calderon (2000) and Li and *al*. (2000). As an illustration, using a sample of 62 countries, with 26 being OECD countries, Li and *al*. (2000) find a global level of corruption of 4.34. Chong and Calderon (2000) identify several levels of corruption including 4.38 in South Africa, 4.47 in Spain, 4.56 in Portugal, 4.80 in Taiwan and 4.82 in Hong Kong.

A fundamental criticism of the above-mentioned research is the heterogeneous nature of the samples which could hide disparities between different countries. It is to avoid this pitfall that our attention is focused only on Sub Saharan African countries (SSA). The following three reasons justify our choice. Firstly, SSA appears to be the region of the world with the largest concentration of countries with high inequality. Indeed, according to Odusola and *al*. (2017), of the 19 countries with the highest inequality, 10 are SSA. In addition to that, according to the IMF (2015), SSA is the most unequal region in world, the exception of Latin America and the Caribbean. Secondly, if we look at data from Transparency International, SSA appears to be the region of the world with the highest level of corruption. Actually, on a scale ranging from 0 to 100, where 0 indicates a very high level of corruption and 100 very low level of corruption, the SSA records a score of 33, unlike Eastern Europe and South America, which score 67 and 43 respectively. Thirdly, the stylized facts reveal an ambiguity in the relationship between corruption and inequality in SSA. Some of the most unequal countries such as South Africa, Seychelles, Comoros and Namibia with GINI index of 63, 65, 64 and 63 respectively have the lowest levels of corruption. While the least unequal countries such as Mali, Burundi, Niger and Ethiopia with the GINI index of 33, 33, 34 and 33 respectively have the highest levels of corruption.

From these developments, a question emerges: does the high level of corruption in SSA explain the high level of inequalities in SSA? The objective of this study is to analyze the threshold effect of corruption on inequalities in SSA. This main objective is subdivided into two specific objectives: (i) on one hand, to determine the threshold of corruption at which the level of income inequality decreases in SSA (ii) on the other hand, to analyze the effects of corruption on inequalities below and above this threshold. Although this issue has already been discussed in the literature, our study is of interest at four levels. In the first place, the samples of most of the work on this subject consist of countries with heterogeneous structures in terms of corruption and inequality; this may bias the estimation results. Secondly, to the best of our knowledge, there are no studies that have highlighted forms of corruption in relation to inequality. According to the work of Jain (2001), the effect of corruption on the dimensions of economic development varies according to the form of corruption chosen. To this end, we proceed with the decomposition of corruption following Jain (2001) who identifies four forms: executive corruption, legislative corruption, judicial corruption and public corruption. We therefore use alternative measures of corruption to analyze their effect on income inequalities. Thirdly, reducing inequality is a priority for governments and International organizations as well, tackling inequality is one of the Sustainable Development Goals (SDGs) which has as main objective the eradication of poverty and inequality so that "no one is left behind." This article shares this point of view and aims to eradicate poverty and inequality.

Finally, our interest can be seen at the methodological level. We use the "Panel Smooth Transition regression (PSTR)" threshold model, originally developed by Gonzales and *al*. (2005). This methodology is recent and not yet used in literature to determine the effect of corruption on inequality. The advantage of this methodology is that it allows the elasticity of the explained variable compared to the explanatory variable to vary not only over time, but also according to space, as a function of the threshold variable. Thus, the PSTR modelling takes into account the heterogeneity in the relationship to be estimated. In addition, this model highlights several regimes of a relationship between two or more variables. Unlike some threshold models where the transition from one regime to another is abrupt, the peculiarity of the PSTR is that the transition from one regime to another is made gradually through a continuous transition function which mitigates the loss of information. The rest of the article is organized as follows. Section 2 presents the methodological strategy. Section 3 presents and discusses the results while section 4 concludes.

2. Methodological strategy

This section is centered on three articulations. The first is devoted to the presentation of the econometric model, the second deals with estimation techniques and the third presents the data.

2.1. The econometric model

To verify the effect of corruption on inequalities in SSA, we use the non-linear empirical model called Panel Smooth Transition regression (PSTR), originally developed by Gonzales and *al*. (2005).

To assess the effect of corruption on income inequality, many works have used linear models (Chong and Calderon, 2000; Gupta et al. 2002; Dobson and Ramlogan-Dobson 2012; Sulemana and Kpienbaareh, 2018). However, if the models used can also be adapted within the framework of the nonlinear approach, it should be noted that other methods are more efficient like the

PSTR. This model allows the implementation of several regimes of a relationship between two or more variables. In addition, it promotes a smooth or gradual transition from one regime to another through a transition function. PSTR has other advantages as well. For example, according to Gonzales and *al*. (2005) the PSTR considers the heterogeneity of the sample. Also, the PSTR model constitutes a fixed effects model which allows the variation of the coefficients according to individuals and over time. Many studies have made use of this approach. We can cite the work relating to misalignments and growth (Béreau and *al*. 2009), resources abundance and economic growth (Tiba, 2019) or effects of globalization on material consumption (Ulucak and *al*, 2020). To the best of our knowledge, our study is the first study to have used the PSTR in the relationship between corruption and income inequality.

Theoretically, the model is as follows:

$$y_{it} = u_i + \beta_0^{'} X_{it} + \beta_1^{'} C_{it} g(s_{it}, \gamma, c) + \varepsilon_{it} \; (1)$$

Where $i = 1,...., N$ the number of individuals, $t = 1,...., T$ determines the period of study. y_{it} is the dependent variable. u_i refers to the individual fixed effects vector and $g(q_{it}, \gamma, c)$ is the transition function that depends on the transition variable (S_{it}), the threshold parameter (c)and a smoothing parameter (γ). X_{it} is the control variable matrix. The variable C_{it} represents corruption and ε_{it} is a random disruption. Theoretically, this transition function is a continuous and integrable function on [0 1]; it permits the process to move gradually from one regime to another. Following the work of Gonzales and *al*. (2005), we retain the following logistic form of transition function:

$$g(q_{it}, \gamma, c) = \left[1 + \exp\left(-\gamma \prod_{j=1}^{m} (s_{it} - c_j) \right) \right]^{-1} \text{Avec } \gamma \succ 0 ,\; c_1 \prec ... \prec c_m \; (2)$$

Where $c = (c_1 ... c_m)$ is a vector grouping the possible threshold parameters γ represents the assumed positive smoothing parameter, of which its value permits to determine the speed of transition from one speed to another. Thus, when the transition function gets closer to an indicator function $I(s_{it} \succ c_j)$ that takes the value, the PSTR is reduced to a PTR as developed by Hansen (1999). On the other hand, when $\gamma \to 0$, the transition function becomes a homogeneous linear panel with fixed effects. The summary of the (1) and (2) leads to equation 3 below:

$$y_{it} = u_i + \beta_0^{'} X_{it} + \sum_{j=1}^{m} \beta_1^{'} C_{it} g_j (s_{it}^{j}, \gamma_j, c_j) + \varepsilon_{it} \; (3)$$

In equation (3), the dependent variable (Y_t) measures inequality. It is captured by the Gini coefficient. In this study, we use the Gini index as a measure of income inequality for several reasons. First, Gini's index is widely reported in official sources. In fact, almost all international organizations regularly report on the level of income inequality through the Gini index. Then, the Gini coefficients can be used to compare the distribution of income between different population sectors as well as countries. For example, we can determine the Gini index in both rural and urban areas. Finally, another advantage of this index is that it is simple and comparable.

(Cj) represents the matrix of corruption variables. This matrix integrates the different forms of corruption according to the Jain typology (2001). They include executive corruption (EXE_CORR) which is the corruption of executive members. This indicator includes bribes, misappropriation of public funds or other state resources for private purposes. Public Corruption (PUB_CORR), which refers to the extent to which favors are given by the public sector employees in exchange for bribes, bonuses and material incentives. Legislative corruption (LEG_CORR) captures the financial gains received by members of the legislative system. Judicial Corruption (JUDI_CORR) refers to additional undocumented payments or bribes paid by individuals or businesses to expedite legal proceedings or obtain court decisions in their favor. Control of corruption (Corr WGI) which according to Kaufmann and al. (2010) control of corruption reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. And the last measure of corruption used in this study is for ICRG (corr ICRG).

The X_{it} matrix represents the following explanatory variables: Income per capita *(Gdp)* measured by GDP per capita. This variable is retained given that, in accordance with Kuznets theory, the reduction of inequalities depends on the increase in household incomes. Natural resources (*NRs*), captured by the ratio of natural resource rents to GDP. Indeed, Buccellato and Alessandrini (2009) find a link between natural resources and inequalities. They find that when natural resources and their extraction processes are controlled by a limited number of households, increasing dependence on these resources can exacerbate inequalities. Trade openness *(Open)* taken as the sum of exports and imports on GDP. Following the work of Avom and Carmignani (2010), commercial openness contributes to the deepening of inequalities through the reallocation of human and financial resources. Inflation *(Infla)*, measured by the Consumer Price Index (IPC). This variable is integrated given that it creates macroeconomic distortions that worsen inequalities (Piketty and Saez 2003). The model to be estimated is as follows:

$$y_{it} = u_{it} + \beta_0^{'} X_{it} + \beta_1^{'} C_{it} g_{it} + \varepsilon_{it} \quad (4)$$

2.2. PSTR Estimation Technique

The estimation of equation (4) is done in three steps following the procedures of the PSTR model which includes: the linearity test, the number of regimes test and the estimation of model's parameters.

2.2.1. The linearity test

It allows to determine the nature of the relationship. In other words, this test checks whether the relationship between corruption and income inequality is linear or not. To do this, we formulate the following null hypothesis $H_0 : \beta_1 = 0$: against the alternative. However, this test has deficiencies, which are; unidentified nuisance parameters (Hansen 1996). To address these deficiencies, we are replacing the transition function $g(s_{it}, \gamma, c)$ with Taylor's first-order limited development at point $\gamma = 0$. The null hypothesis of the test becomes $H_0 : \gamma = 0$ as initiated by Luukkonen and *al*. (1988) confirmed by Seleteng and *al*. (2013). We get the following regression:

$$y_{it} = \mu_i + \beta_0^{'*} X_{it} + \beta_1^{'*} X_{it} s_{it} + ... + \beta_m^{'*} X_{it} s_{it}^m + \varepsilon_{it}^* \qquad (5)$$

Where parameter vectors $\beta_1^{'*}, ..., \beta_m^{'*}$ are multiples of γ and $\varepsilon_{it}^* = \varepsilon_{it} + R_m \beta^* X_{it}$ where R_m is the residue of Taylor's developmental. The null hypothesis of the linearity test becomes $H_0 : \beta_1^{'*} = ... = \beta_m^{'*} = 0$. The linearity hypothesis is tested from the standard tests. We use Wald's statistics (LM_w)[5]. The small sample size compels the use of Fisher's statistics (LM_F)[6] (González and *al*. 2005).

2.2.2. Test for the number of regimes

This test consists of verifying the null hypothesis that the PSTR model has a single transition function ($m = 1$) against the alternative hypothesis that the PSTR model has at least two transition functions or two regimes ($m = 2$). Test decisions are based on statistics LM_w and LM_F. If the coefficients are statistically significant at the critical threshold of 5%, the null hypothesis is rejected and it is accepted that there are at least two transition functions.

2.2.3. Estimation of the Model's Parameters

The estimation of the parameters of equation 4 requires the use of the non-linear least squares technique. This technique makes it possible to estimate the level of corruption below and above which the trend of inequality changes.

2.2.4. System GMM Robustness Test

The estimation by the Generalized method of moments (GMM) in system allows us to test the robustness of our results. The estimation of this equation is as follows:

$$Y_{it} = \alpha X_{it} + \beta C_{it} + \delta C_{it}^2 + \mu_i + \varepsilon_{it} \quad (6)$$

The variables in this equation are those defined in Equation 1. The adopted quadratic form (δC_{it}^2) reflects the hypothesis of non-linearity between inequality and corruption. In accordance with the work of Murphy and *al*. (1993), the parameter β must be negative and the parameter δ positive; this makes it possible to validate the non-linearity hypothesis. The determination of the corruption threshold is given by the following relationship:

$\frac{\partial \mathrm{Y_{it}}}{\partial \mathrm{C_{it}}} = \beta + 2\delta C_{it}$ So $C^{*} = -\frac{\beta}{2\delta}$

The advantage of this estimation method is that it makes it possible to control endogenous variables. However, GMMs pose two problems. Endogeneity of variables on one hand and double causality on the other. To overcome these deficiencies, we used an approach with instrumental variables. To this end, we opt for the GMM in system method which integrates the instrumental variable approach. Ultimately, this method of estimation allows us to solve the problems of endogeneity of our model. The choice of this technique is justified insofar as we suspect an endogeneity between certain variables. For example, corruption influences inequality. Also, in a context of high-income inequalities, households can resort to corruption to reduce these income inequalities. Indeed, the work of Chong and Gradstein (2007) and Sulemana and Kpienbaareh (2018) have highlighted a double causality between corruption and income inequality. Drawing inspiration from the work of Gupta and *al*. (2002), the instrumental variable chosen is democracy. According to these authors, democratic countries are implementing strict measures for effective control of corruption. Furthermore, Barro (1999) has shown that democracy is not correlated with income inequality.

2.3. Presentation of data

This study covers the period 1996 to 2017 on a sample of 22 SSA countries. The Gini Index is taken from the World bank. Corruption indicators are taken from the 2018 Varieties of Democracy database. These indices of corruption range from 0 (for countries with low corruption) to 4 (for countries with high corruption). In order to demonstrate the relevance of our results, we use alternative measures of corruption. As such, we use corruption indices from the International country Risk guide (ICRG) database. In this database, the corruption index is between 1 and 6 where, 1 indicates a high level of corruption and 6 a very low level of corruption. In addition, we also use the World Bank's corruption index from the worldwide governance indicators (WGI) database. The corruption index in this database is between -2.5 and 2.5 where, -2.5 indicates a high level of corruption and 2.5 refers to a low level of corruption. Regardless of the corruption index used, the performance of SSA countries in terms of corruption is negative. On average, SSA countries show 1.25 with the ICRG index and -0.601 with the corruption control index of the Worldwide governance indicators. The control variables presented come from the World Bank's World Development Indicators database.

The list of countries and descriptive statistics are given in Tables 1 and 2:

Table 1: List of countries

Angola	Guinea	Nigeria
Benin	Guinea Bissau	Rwanda
Botswana	Ethiopia	Senegal
Burundi	Kenya	Seychelles
Burkina Faso	Lesotho	South Africa
Cameroon	Malawi	Sierra Leone
RD Congo	Mali	Swaziland
	Tanzania	

Sources : Author

Table 2: Descriptive statistics

Variables	Obs	Mean	St. Deviation	Min	Max
Gini	528	44,00	7,48	29,20	63
Gdp	528	2,85	0,44	1,84	3,79
Open	528	0,83	0,66	0,09	12,62
Csp	528	19,18	16,54	3,09	84,72
Infla	528	140,86	1687,08	-9,61	24411,04
NRs	528	11,26	11,67	0	82,58
Exe_corr	528	0,57	0,19	0,11	2,40
Leg_corr	528	1,64	0,68	0,08	3,40
Jud_corr	528	1,58	0,83	0,45	3,35
Pub_corr	528	0,60	0,24	0,04	1,94
Corr ICRG	528	1.25	0,74	1	4
Corr WGI	528	-0,601	0,606	-2,046	1,253

Sources: Author

3. Estimations and discussion of results

In this section, we present on one hand, the results of the linearity test and the number of regimes and, on the other hand, we present the results of the PSTR model.

3.1. Linearity and Number of regimes test results

The LM test analyzes the existence of a threshold effect against the null hypothesis of global linearity for each threshold variables where the p-value determines their statistical significance calculated using the bootstrap method with 1500 replications and 10% trimming percentage. The results of the linearity test and the number of regimes are respectively documented in Tables 3 and 4. For the linearity test, the results of the LMF statistic, leads to the rejection of the null hypothesis of linearity at 1% critical threshold. In other words, this result indicates that there is a non-linear relationship between the different forms of corruption and income inequality in SSA. It also involves determining the number of regimes and thresholds for executive, legislative, judicial corruption, public corruption and the two other alternatives measures of corruption.

Table 1 : linearity Test Results

Threshold variables	Wald test	Fisher test	LRT test	Bootstrap P-Value
Exe_corr	25.46***	4.21***	26.32***	
	(0.00)	(0.00)	(0.00)	0.000
Leg_corr	30,41***	5.10***	31.64***	
	(0.00)	(0.00)	(0.00)	0.000
Jud_corr	12.49**	1.99*	12.69***	
	(0.05)	(0.06)	(0.00)	0.000
Pub_corr	26.38***	4.37***	27.30***	
	(0.00)	(0.00)	(0.00)	0.000
Corr ICRG	17.35***	6.22***	18.1***	
	(0.00)	(0.00)	(0.00)	0.000
Corr WGI	19.76***	5.73***	17.6***	
	(0.00)	(0.00)	(0.00)	0.000

Notes: (***), (**) and (*) give the significance at the critical threshold of 1%, 5% and 10%. The values in brackets give the probabilities

According to the results of the regime test (Table 4), there exist a transitional function and regime for executive, legislative, judicial and public corruption, control of corruption (Corr WGI) and corruption (Corr ICRG). Thus, below these thresholds, the effect on inequalities is positive (reduction of inequalities), the effect is zero on the threshold and negative above this threshold.

Table 4: Number of regimes test

Threshold variable	Wald test	Fisher test	LRT test	Threshold
Exe_corr	9.00	1.38	9.11	1
	(0.17)	(0.22)	(0.16)	
Leg_corr	-00.00	-00.00	-00.00	1
	(1.00)	(1.00)	(1.00)	
Jud_corr	14.92**	2.32**	15.21***	1
	(0.02)	(0.03)	(0.01)	
Pub_corr	24.51***	3.84***	25.30***	1
			(0.00)	
Corr ICRG	(0.00)	(0.00)	14.8**	1
	13.32**	6.89**	(0.04)	
Corr WGI	(0.04)	(0.05)	13.9***	1
	11.87***	4.87***	(0.00)	
	(0.00)	(0.00)		

Sources: Author. Notes: (***) and (**) give the significance at the critical threshold of 1% and 5%. The values in brackets give the probabilities

3.2. Results of the PSTR model

The results of our estimate are recorded in Table 5 below. With respect to this, three major lessons can be drawn.

First, our results show that corruption affects income inequality with respect to a certain level or threshold in SSA. These thresholds, although relatively close, differ according to the type of corruption considered. For an index between 0 and 4 where 0 indicates a very low level of corruption and 4 a very high level, we find the thresholds of 0.77, 1.02, 1.89, and 0.31for executive, legislative, judicial and public corruption respectively. These results corrobates with the of work of Li et al. (2000) Chong and Calderon (2000) who estimated a non-linear relationship between corruption and income inequality. If they have not used similar value scales, the significance of their studies is consistent with ours. For an indicator between 0 and 6 where 0 indicates a very low level of corruption and 6 indicates a high level of corruption, Li et al. (2000) find, in a sample of 62 countries, with 26 being OECD countries, a threshold of 4.34. Chong and Calderon (2000) find thresholds of 4.38, 4.47, 4.56, 4.80 and 4.82 for South Africa, Spain, Portugal, Taiwan and Hong Kong respectively.

Furthermore, our results show that, the effect of corruption on inequality differs depending on whether one is below or above the corruption threshold. With regards to the first model (executives' corruption), the threshold is 0.77 in a situation of low corruption. Below this threshold, a reduction of 1 point of corruption tends to reduce income inequality by 0.39%. This result is significant at the critique threshold of 1%. The finding that emerges, shows that the economy admits a very low level of executive corruption. This result implies that up to a certain level, corruption could play a positive role in a context of poor institutional quality as estimated by Dobson and Ramlogan-Dobson (2012). This Reasoning is a continuation of the greases in the Wheels theory which considers corruption as a lubricant for the economy.

Above this threshold, that is, in a period of high executive corruption, an increase of 1 point in the level of corruption increases income inequality by 0.12%. This result is significant at a critical threshold of 10%. A similar result is obtained in the fourth model (Public Corruption). Indeed, the corruption threshold here is the weakest 0.31. This result suggests that the sensitivity of inequalities to corruption is more marked by public corruption. In this respect, a one-point reduction in corruption below the threshold tends to reduce income inequality to the by 0.7%. Conversely, any increase of one point of corruption above the corruption threshold increases income inequality by 1.10%. Our results are significant at a 1% threshold. The fact that executive and public corruption is significantly more sensitive to reducing inequalities in SSA confirms Odusola's (2018) empirical predictions, which shows that income inequality is the result of public and government policy. Moreover, the executive is at the heart of decision-making in any public policy. The results of the second model on legislative corruption reveal a corruption threshold of 1.02. However, the sign assigned to the coefficient of this form of corruption (negative), opposes the theoretical and empirical prediction that, the reduction of corruption will tend to reduce income inequality. The result tends to show that any reduction in legislative corruption is counterproductive to the reduction of inequalities. Such a result has already been verified by some authors. For example, Dobson and Ramlogan-Dobson (2012) have demonstrated that corruption overcomes the rigidity of bureaucracy in an environment of poor institutional quality. To this end, any reduction in corruption is likely to increase income inequality. Legislative corruption in SSA therefore plays a re-distributive role.

The estimate of the third model related to judicial corruption gives a threshold of 1.89. This threshold which is higher than the other forms of corruption suggests that the SSA economy gives some flexibility to this corruption. This result can be justified by the role played by this type of corruption. Indeed, this form of corruption is more significant when it comes to social inequalities, such as gender inequalities. A court decision that discriminates against one sex at the expense of another amplifies this form of inequality, whereas the effect on income inequality seems less immediate. Our results on this form of corruption are not significant. The other corruption measures, relating to the control of corruption by the WGI and the perception of corruption by the ICRG database, also show us that corruption has a threshold effect on income inequalities. The thresholds for these corruption measures are respectively 3.2 and 0.75. When the level of corruption falls below these thresholds, income inequalities can decrease. In fact, corruption plays a redistributive role in this case. It enables market rigidities to be overcome. Such a role of corruption can only be observed in case of poor-quality institutions. In SSA, institutional indicators show that the quality of institutions is low. This institutional weakness is reflected in low inflow of FDI, non-inclusive economic growth, massive unemployment and the expansion of the informal sector. In such a context, households' resort to corrupt practices in order to increase their level of income. However, when the level of corruption is above these thresholds, it means that corruption is spreading in all sectors of the economy and is amplifying. Such a level of corruption indicates in this regard that corruption generates costs which lead to a crowding out effect. The amounts allocated for the establishment of policies aimed at reducing poverty and inequalities through schools, hospitals and infrastructural development are diverted. This partial or total diversion of allocated funds perpetuates income inequalities. Ultimately, corruption compromises the fight against income inequalities in SSA.

Finally, the estimation of our five control variables gives mixed results and confirms the existing discrepancy in results in the empirical literature. The results of the first variable, economic growth per capita, shows that in times of high executive and legislative corruption, economic growth accentuates inequalities. This counterproductive effect of growth can be explained by the fact that this growth benefits an already wealthy minority. This is consistent with the works of Stiglitz (2015) and Piketty (2015), who challenged the role of growth in reducing inequality. Whereas, the effect of growth from judicial and public corruption on inequality confirms Kuznets' theoretical and empirical predictions. For the latter, reducing inequality depends on increasing the output of an economy. This converges with our results.

The case of commercial openness leads us to similar results. Model 1 and 2 show us that commercial openness significantly reduces inequality. This result is explained by the fact that such an opening creates job opportunities, the creation of new markets and the attractiveness of investments. According to the theory of international trade, opening a country to the rest of the world changes household incomes. Moreover, the HOS[8] model has shown that a commercial opening implies the specialization of countries which leads to an increase in income. Thus, countries with a skilled workforce benefit from a reduction of inequalities through this openness. The work of Daymon (2012) supports these findings by showing that exports and their diffusion effects in the economy significantly reduce inequalities. However, the facts very often, limit the scope of international trade theories. Indeed, models 3 and 4 on judicial and public corruption show us that trade opening accentuates inequalities. Such an outcome is based on a context of technological development, which requires a skilled workforce. In this respect, commercial openness does not benefit low-income or unskilled households.

Table 2: Estimation by PSTR

	Executive Corr	**Legislative Corr**	**Judicial Corr**	**Public Corr**	**Corr ICRG**	**Corr WGI**
Exe_corr (β0)	-0.39*** (-2.50)		--	-		
Exe_corr (β1)	0.12* (1.69)	--	--	--	--	--
Leg_corr (β0)		1.47*** (3.44)	-			
Leg_corr (β1)		-2.94*** (-3.44)	--	--		

Jud_corr (β0)			-1.51 (-1.13)	-		
Jud_corr (β1)		--	3.49 (1.57)	--		
Pub_corr (β0)		--	--	-0.71*** (-2.92		
Pub_corr (β1)				1.10*** (3.62)		
Corr ICRG (β0)		--	--	--	-0.47** (2.7)	
Corr ICRG (β1)		--	--	--	0.87** (1.23)	
Corr WGI (β0)		--	--	--	--	-1.32*** (2.87)
Corr WGI (β1)						1.1*** (3.26)
Gdp	1.44 (0.34)	3.57*** (5.14)	5.80*** (-3.23)	-8.30*** (-4.25)	0.97** (2.17)	1.8* (3.11)
Open	-8.13*** (-2.29)	-4.43*** (-2.71)	5.35** (2.32)	15.00*** (5.09)	-3.8** (4.29)	-2.05** (0.85)
Csp	0.02 (0.20)	-0.03 (-0.54)	-0.11** (-1.97)	-0.12*** (-2.16)	-1.8** (3.17)	-3.1** (1.53)
Infla	0.004*** (3.21)	0.0028*** (5.62)	0.001* (1.76)	0.02 (1.50)	-0.07* (1.26)	-0.049** (2.43)
NRs	0.33*** (3.32)	0.15*** (3.69)	0.34*** (5.04)	0.04 (0.32)	0.008 (0.35)	0.037* (0.57)
γ	10.79	-3.55	6.12	34.84	17.12	8.93
Threshold	**0.77**	**1.02**	**1.89**	**0.31**	**3.2**	**0.75**

Note: The values in brackets represent t-statistic. (***), (**), (*) give significance to the threshold of 1%; 5% and 10%respectively. β0 and β1 represent the coefficients before and after the threshold.

Concerning credit to the private sector, the results obtained are generally satisfactory. These results show that an expansion of credit to the private sector tends to significantly reduce inequalities. When all social class have access to credit, the most vulnerable households undertake income-generating activities. They help reduce income gaps between households. Another explanation is the runoff effect. If credit expansion is captured by a high-income minority, the investment made by that minority provides employment opportunities for vulnerable groups, allowing them to increase their income levels. However, our results are opposed to a series of studies that have evaluated the effect of credit on inequalities and found that credit is likely to accentuate these inequalities. By illustration, Denk and Cazenave-Lacroutz (2015) find that the provision of credit is more geared towards high-income households, so that they are in a better position to finance the opportunities available to them, so as to further increase their income and widen the gap with low income households.

Inflation results are consistent with the literature. For example, the work of Piketty and Saez (2003) has shown that inflation creates macroeconomic distortions that can lead to worsening inequalities. Our results reinforce this work by demonstrating in our various models that a high level of inflation is systematically associated to an increase in inequality. This result reflects the view point that, a high level of inflation reduces the purchasing power of households and restricts them to a limited range of goods and services. Finally, the results related to natural resources indicate that, whatever be the type of corruption considered, an increase in natural resources leads to an increase in inequalities. This can be explained when the extraction or exploitation of natural resources is carried out by a minority elite who benefit from the gains of an abundant wealth of natural resources to the detriment of low-income households. This result is consistent with the work of Buccellato and Alessandrini (2009).

Our results are robust. We verify the robustness of our result by the system GMM estimator. One of the advantages of this technique is that it solves the problem of endogeneity of our model, but it has the disadvantage of losing information in a quadratic model. This observation is particularly verified by the thresholds obtained, which are slightly lower than those of the PSTR model. The threshold is determined by the following formula: $*=-\beta/2\delta$. The results of this estimate are recorded in Table 6 below. To resolve the endogeneity in our model, we used democracy as instrumental variable. This choice has been inspired by the work of Gupta and *al*. (2002), which found that democratic countries are implementing strict measures for effective control of corruption.

Table 6: Estimation by GMM in System

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Gdp	-1.996 (1.456)	-1.898 (1.487)	-2.220* (1.309)	-1.363 (1.280)	-3.11* (1.54)	-1.4 (2.13)
Open	-1.945* (1.048)	-1.916* (1.016)	3.457** (1.407)	1.913* (1.045)	2.37* (1.70)	0.53* (1.304)
CSP	0.0525* (0.0305)	0.0557* (0.0310)	0.0506* (0.0281)	0.0407 (0.0259)	0.236* (0.23)	0.153 (0.49)
INFLA	7.34 (6.05)	6.06 (6.05)	5.06 (6.05)	5.09 (6.05)	3.11 (8.43)	4.02 (3.12)
NRs	0.0288* (0.0152)	0.0305** (0.0152)	0.0199 (0.0183)	0.0279* (0.0149)	0.91 (1.272)	1.392* (0.191)
Exe_CORR	-1.91* (6.433)					
(Exe_CORR) ^{2}	1.42** (5.771)					
LEG_CORR		-0.95* (5.521)				
(LEG_CORR) ^{2}		1.71** (4.656)				
JUD_CORR			-0.689*** (1.989)			
(JUD_CORR) ^{2}			0.928*** (0.497)			
(PUB_CORR)				-0.871 (3.769)		
(PUB_CORR) ^{2}				1.407		

				(1.211)		
Corr ICRG					-0.37* (1.9)	
Corr ICRG^2					0.61** (2.36)	
Corr WGI						-1.48*** (1.78)
Corr WGI^2						0.38** (2.56)
Threshold	**0.62**	**1.01**	**2.14**	**0.39**	**2.85**	**0.66**
Sargan	19.14	20.40	20.66	21.39	23.45	27.17
P-Value	0.42	0. 45	0.48	0.41	0.65	0.54
Test AR1	0.00	0.00	0.00	0.00	0.00	0.00
Test AR 2	0.524	0.517	0.541	0.528	0.701	0.693

The values in brackets represent t-statistic. (***), (**), (*) give significance to the threshold of 1%; 5% and 10%respectively. Sources: Author The values in brackets represent t-statistic

4. Conclusion

The analysis of the threshold effect of corruption on income inequality in sub-Saharan Africa was the subject of this article. To achieve this, we estimated corruption thresholds on one hand, and on the other, we examined the effect of corruption on income inequality, below and above these thresholds. The results obtained are particularly interesting. On one hand, they attest that the relationship between corruption and income inequality in SSA is non-linear. This non-linearity leads to thresholds 0.77, 1.02, 1.89, 0.33, 3.2 and 0.75 respectively for executive, legislative, judicial public corruption, corruption from ICRG and control of corruption (WGI). These results seem to demonstrate the inadequacy of government authorities to effectively combat corruption to the extent that, to date, anti-corruption policies have not integrated the types and levels of corruption. Thus, such a result enriches the literature by showing in the first place that corruption constitutes a major obstacle to the reduction of income inequality in SSA. Secondly, it highlights the need to consider the various forms of corruption in the fight against these inequalities. On the other hand, our results prove the existence of a threshold effect on the relationship between corruption and income inequality in SSA. More specifically, the different types of corruption reduce income inequality in SSA when the different levels of corruption fall below these thresholds. Whereas, above these thresholds, these types of corruption tend to significantly increase income inequality. Our results are robust and close to the empirical predictions of Chong and Calderon (2000) and Li et *al*. (2000). Main lessons derived from these results show us that below the estimated corruption thresholds, corruption confirms the greases wheels hypothesis. Indeed, in a context marked by weak institutions as in SSA, corruption increases the income of certain households and therefore plays a redistributive role. On the other hand, the explanation above the estimated corruption thresholds tends to show that corruption is a brake. This is because, corruption generates public mistrust of the government and reduces the capacity of public resources to fulfill its essential functions. Moreover, as corruption increases, it undermines the effectiveness of public policies. This result thus confirms the sand the wheels hypothesis. Corruption in this sense is seen as a grain of sand in the cogs. Because, it generates harmful effects on the distribution of income and generates additional costs that compromise public policies. To fight against income inequalities in SSA, our study therefore suggests the implementation of anti-corruption policies. Without being exhaustive, we can cite the establishment of independent institutions to fight against corruption, transparency and regular control of public resources and the strict application of laws relating to the fight against corruption. Our study thus contributed to enriching the literature both on the factual and methodological level. However, the debate on measures of income inequality is the subject of an emerging literature. World Bank statistics on income inequality indices are mostly based on survey data from consumer spending. These data present the inadequacy of not taking household savings into account, although in Africa savings are more pronounced in the informal than formal sector. Further research may focus on constructing an indicator of income inequality that considers the specificities of Africa. In addition, it may be important in subsequent research to assess the effectiveness of anti-corruption policies implemented so far and to adapt them to the current context.

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