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Nexus Between Corruption and Economic Growth in Ethiopia: An Auto Regressive Distributed Lag Bounds Test Method

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Abstract: Ethiopian economic growth and corruption were examined over the long and short terms using annual time series data from 1996 to 2021. After taking into consideration human capital and the public sector, it has expanded Solow's (1956) neoclassical model of economic growth to include corruption by using a particular functional form for the entire factor of productivity. government spending on education, total fixed capital formation, and public spending. The Auto-Regressive Distributed Lag Bounds Test has been used to investigate the possibility of an ongoing relationship between corruption and real GDP per capita. The findings of the co-integration test confirmed the presence of a sustained correlation between corruption, real GDP per capita, and other variables influencing real GDP per capita. According to long-term evaluations, corruption has a significant impact on real GDP per capita. Real GDP was positively and significantly impacted by public investment in education, spending by governments on finances, and the creation of gross fixed assets. Model for Error Correction: The imbalance brought on by the shock of the previous year converges to the long-run equilibrium in the current year at a rate of -52%. The policy conclusion is that to ensure robust economic growth, Ethiopian governments at all levels need to develop efficient systems for combating corruption.

Keywords: Corruption, Granger Causality, Gross Fixed Capital Formation, Real GDP Per Capita

1. Introduction

World Bank defines corruption as the abuse of public office for private gain. It is the use of public power for private profit, preferment of prestige, or for the benefit of a group or class, in a way that constitutes a breach of law or standards of high moral conduct [63]. It is the misuse of entrusted political power for personal gain [55]. It includes a large set of illegal activities ranging from 'bribery' to 'extortion', from 'embezzlement' to 'nepotism'. Thus it is the exploitation of public resources and avoidance of public gains. Some other scholars claim that corruption is pervasive in the private sector [6]. People perceive corruption differently depending on their cultural background, discipline, and political leaning. Many scholars believe that defining corruption is difficult as it is a complex phenomenon and thus its notion varies across countries, cultures, societies, and of course over time. An activity that is considered corruption in developing countries might not be perceived in developed countries [65, 13, 29].

The impacts of corruption include undermining democratic institutions, fuelling political unpredictability, unfair personal gains, encouraging greater inequality of income and facilitating gory conflicts, blocking foreign direct investment, impeding economic growth, and making it easier for the improper use of public authority for private gain in nations all over the world [2]. In developing countries, its impacts are major causes of poverty, violent conflicts, and development barriers [54]. Moreover, most developing countries continue to struggle with the ever-changing trends in global politics, and economic and technological advancements having little or nothing to do due to the exhausting effects of corruption on their very existence [1]. It has a detrimental impact on investment [40, 15, 9, 24]. Corruption favors a specific class of individuals and creates opportunity disparities [56]. Some other scholars argue that corruption may be necessary [33, 26, 11]. They believe that corruption encourages more effective delivery of public services and frees business people from inefficient regulations. They argue that corruption acts like grease, facilitating business transactions and boosting an economy's productivity [51]. On the other hand, because innovators require more government-provided goods than established producers do, like licenses and import quotas, corruption frequently hinders ground-breaking initiatives. Because there is a high and elastic demand for these goods, they become the main targets of corruption, and innovators who have no established lobbies and networks are subject to mostly substantial bribes and expropriations [63].

The study carried out by [40] revealed a negative impact of corruption on GDP. [39] found out that corruption reduced economic growth by distorting government expenditure. [59] findings revealed that corruption caused low investment; low government spending on public infrastructure and low government revenues. [41] the result showed that corruption reduced economic growth and political instability was a channel through which corruption affected economic growth. [50] study on African countries depicted that corruption reduced the growth rate of GDP and per capita income. [49] the result showed that corruption affected income distribution and reduced growth per capita. [3, 30 60] found out that corruption negatively affected economic growth. [18, 61] used a meta-analysis and the result revealed that corruption adversely affected economic growth, investment, public expenditures, and human capital. In contrast, [33, 26, 14, 12, 16, 20] found out that corruption enhanced GDP growth rate, per capita income, and investment.

As per the Corruption Perception Index (CPI), Ethiopia ranked 59/102, 92/133, and 114/146 countries in 2002, 2003, and 2004, respectively. This has risen to 87/180 in 2021 [23]. In the same years, Ethiopia scored 3.5, 2.5, and 2.3 against a clean score of 10 in the years, respectively. The 2004 index revealed that countries that scored less than 3 out of 10 were considered to have rampant corruption. Thus Ethiopia has been listed as among the most corrupt countries by Transparency International. This is because the government controls a large portion of Ethiopia's economy, and the impact of the private sector on the overall economy is little. Since it has not been fully determined if the change in the corruption index has a good or negative impact on economic growth in Ethiopia, future action requires empirical documents. This is because corruption's causes and effects are getting worse every year. Additionally, in terms of methodology, previous empirical research examined the impact of corruption on economic development, investment, and income distribution using ordinary least squares regression, two-stage least squares regression, conventional multivariate regression, meta-analysis, and fixed effect regression. Furthermore, time series data for a single country were only occasionally used in empirical studies most of them instead used cross-sectional or panel data [52, 51]. With this limitation, this paper used time series data from 1996-2021 to investigate the nexus between corruption and the economic growth of Ethiopia. It employed a more robust Auto-Regressive Distributed Lag (ARDL) Bounds Test technique, which offers certain advantages over typical co-integration techniques for small sample sizes on the relationship between corruption and economic growth in Ethiopia.

2. Methodology

2.1. Theoretical Framework

The term "corruption" has come to refer to a variety of actions, such as bribery, clientelism, nepotism, illegal gifts, favors, patronage, unofficial and undeclared contacts, and more. It is regarded as the primary cause of the failure of numerous initiatives aimed at raising the standard of living, especially those addressing environmental challenges [50]. Theoretical studies of corruption, according to [11, 17], can aid in understanding what corruption is, the forms and dimensions it takes, and how it affects economic growth, investment, and income distribution. Thus it can be theorized from principal-agent theory, rent-seeking theory, institutional economics theory, and redistribution theory.

Regarding the principal-agent theory, it appears when a good principal gives decision-making authority to a bad agent who engages in corruption, specifically the helping hand form of corruption [2, 10]. The grabbing-hand form of corruption, often known as the rent-seeking theory of corruption, can also result from the introduction of ineffective policies by uncaring government officials to obtain rents from the private sector [7, 34, 35]. It happens in the form of organized or systematic behavior, which is the result of the institutional design (structure of institutions) of a society, following institutional economics theory. Institutions are "humanly conceived constraints that structure political, economic, and social interactions," according to [45]. It can be separated into official constraints provided by constitutions or laws and informal restraints provided by taboos, conventions, traditions, codes of conduct, and other informal regulations [22, 23 36]. The [44] redistribution system theory looks into the reasons, methods, and effects of redistribution. When a subject receives a different reward for their performance from what would be expected based on their productivity and the demand for their activity, this is referred to as redistribution. When a subject receives a different reward for their performance from what would be expected based on their productivity and the demand for their activity, this is referred to as redistribution. It can be carried out directly when a formal or informal authority decides to take money or resources that belong to one subject and give them to another, or it can be carried out indirectly when there are obstacles that hinder someone from using all of their abilities and resources. The hypothesis [46, 57] highlights that some forms of redistribution are preferable; these are designed to help or protect individuals who are unable to provide for their living, at least in part.

2.2. Study Design, Data Sources, Type and Method of Data Analysis

The research design adopted was quantitative research on secondary data by using time series data from 1996 to 2021. Secondary data were collected from the National Bank of Ethiopia (NBE) and the World Bank Development Indicator Database. Both descriptive statistics and an econometric model were employed in the investigation to estimate the long-run and short-run link, causality, and impulse responses of the variables by applying the ARDL model with the statistics program E-view version 12.

2.3. Econometric Model Specification

This section explains the detailed Solow Model with corruption, econometric regression analysis, the hypothesis, and the Auto regressive distributed lag Model.

2.3.1. A More Detailed Solow Model with Corruption

A more detailed neoclassical economic growth model that takes into account not only the accrual of physical capital but also the build-up of human capital and the public segment was developed based on the classic work of [58]. Later, corruption was included in the augmented model using a particular functional form to demonstrate how it directly impacted the income per capita of the given country under investigation. Advancements in technology are less beneficial to nations with high levels of corruption. Total factor productivity's evolution was given a structural framework to demonstrate how corruption directly affects the rate of productivity. The assumption for the basic specification would take the form:

$$A_{(t)}^{(\ )} = A_{(t)}^{e-nt} \quad (1)$$

Where $0 \leq \Theta \leq 1$, the corruption index is the metric that determines how much corruption has an impact on growth. And it is assumed that $dA_{(t)}/d_{\Theta} < 0$ and $d^2A_{(t)}/d_{\Theta}^2 > 0$. This allows us to construct the Solow Model equation as follows by utilizing the exponents for the public sector, the human capital, population growth, and depreciation:

$$\ln Y_{(t)}/L_{(t)} = \ln(A_0) + \omega_t - [\{(\beta+\lambda+\alpha)/(1-\beta-\lambda-\alpha)\}\ln(n+\omega+\delta)] + \{\beta/(1-\beta-\lambda-\alpha))\ln s_k + (\lambda/(1-\beta-\lambda-\alpha)\} + \ln s_h(\alpha/(1-\beta-\lambda-\alpha))\ln s_z - n\Theta \quad (2)$$

According to the literature justifications for the Solow model, the equilibrium equation for income per worker from equation (2), which includes corruption for disclosing both direct and indirect impacts, can be rebuilt as follows:

$$\ln Y_{(t)}/L_{(t)} = \ln A_{(0)} + \omega_t - [\{(\beta+\lambda+\alpha)/(1-\beta-\lambda-\alpha)\}\ln(n+\omega+\delta)] + \{\beta/(1-\beta-\lambda-\alpha))\ln s_k + (\lambda/(1-\beta-\lambda-\alpha)\} + \ln s_h(\alpha/(1-\beta-\lambda-\alpha))\ln s_z(\tau, yt, \Theta) - n\Theta \quad (3)$$

In economic research, the benefit of creating this kind of model is that it is based on the stylish model, which could aid in the application of contemporary time series analysis, and enables the inclusion of both the direct and indirect effects of corruption on economic growth. Initially, it was estimated that the empirical base model without corruption would be:

$$\ln Y_t = \beta_0 + \beta_1 \ln GFCF_t + \beta_2 GEX_t + \beta_3 \ln EEX_t + \beta_4 \ln Z_t + \mu_t \quad (4)$$

Where $Zt = \ln(\omega_t + \delta + n_t)$, in this case, Real GDP per capita, gross fixed capital formation, spending on government consumption, and spending on public education, which serves as a stand-in for human capital formation, are all represented by the (Y, GFCF, GEX, EEX) respectively. Also, Z stands for the total factor productivity growth rate (ϖ), depreciation rate (δ), and population growth rate (n) added together. Last but not least, (t) is the time index and μ is the typical error term with classical qualities. It is possible to calculate the impact of corruption on economic growth by including corruption as an explanatory variable in the base model. The following empirical model was calculated using the theoretical model shown in equation (3):

$$\ln Y_t = \beta_0 + \beta_1 \ln GFCF_t + \beta_2 GEX_t + \beta_3 \ln EEX_t + \beta_4 \ln Z_t + \beta_5 \ln COR_t + \mu_t \quad (5)$$

The indicator of corruption in this case is denoted by COR.

2.3.2. Econometric Regression Analysis, the Hypothesis, and Autoregressive Distributed Lag Model

The unconditional ARDL-ECM formulation of the empirical equation (4), which is based on the hypothesis that investment, government spending, and educational spending are all related to per capita GDP, can be written as follows:

$$\Delta \ln Y_t = \beta_0 + \beta_1 \ln Y_{t-1} + \beta_2 \ln GFCF_{t-1} + \beta_3 \ln GEX_{t-1} + \beta_4 \ln EEX_{t-1} + \beta_5 \ln Z_{t-1} + \sum_{i=1}^{p} ni ln\Delta Yt-i + \sum_{i=0}^{q1} \Theta i\Delta lnGFCFt-i + \sum_{i=0}^{q2} \alpha i\Delta lnGEXt-i + \sum_{i=0}^{q3} \pi i\Delta lnEEXt-i + \sum_{i=0}^{q4} \lambda i\Delta lnZt-i + Ui \quad (6)$$

Where μ_t represents the white noise error term and β_0 represents the constant as usual. While the long-run multipliers are represented byλ, the terms with summation notation signs signify the short-run dynamics. The assumption that a long-term relationship doesn't exist in the equation is known as the null hypothesis (4).

H_o: $\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = \lambda_5 = 0$

H_1: $\lambda_1 \neq 0$, $\lambda 2 \neq 0$ $\lambda_3 \neq 0$ $\lambda_4 \neq 0$ $\lambda_5 \neq 0$. In this case, H_o is evaluated in comparison to the co-integration of the alternative hypothesis represented as H_1.

Regardless of the order of integration for the time series statistics, the null hypothesis of no long-run association can be rejected if the estimated F-statistic is greater than the upper critical value. On the other hand, the null hypothesis cannot be ruled out if the test statistic is smaller than the lower critical value. However, no inference about co-integration can be made if the test statistics fall between the lower and upper critical levels. The following conditional ARDL (p, q1, q2, q3, q4) long-run model for Y_t was estimated in the second stage once a long-run relationship between the variables was discovered:

$$LnYt = \beta_0 + \sum_{i=1}^{p} \lambda 1ilnYt-i + \sum_{i=0}^{q1} \lambda 2ilnGFCFt-i +$$

$$\sum_{i=0}^{q2} \lambda 3ilnGEXt-i+\sum_{i=0}^{q3} \lambda 4ilnEEXt-i+\sum_{i=0}^{q4} \lambda 5i\Delta lnZt-i+Ut \quad (7)$$

The variable Corruption was calculated as an explanatory variable for the long-run model using the same methodology. The short-run dynamic parameter was finally calculated by estimating an error correction model (ECM) linked to the long-run statistical estimates as under:

$$\Delta LnY_t = \beta_0 + \sum_{i=1}^{p} ni\Delta lnYt-i+\sum_{i=0}^{q1} \Theta i\Delta lnGFCFt-i+\sum_{i=0}^{q2} \alpha i\Delta lnGEXt-i+\sum_{i=0}^{q3} \pi i\Delta lnEEXt-i+\sum_{i=0}^{q4} \lambda i\Delta lnZt-i+ \gamma ECMt-1\,Ut \quad (8)$$

The macroeconomic analysis requirement that the error correction term's sign be negative is the most crucial consideration in this case. The short-run dynamics of the model's convergence to equilibrium and the speed of adjustment for short-run divergence to long-run equilibrium are represented by all of the coefficients of the short-run equation (5). It was all about how the disequilibrium caused by the shock of the prior year is brought back to the long-run equilibrium in the current year.

3. Results and Discussion

3.1. Descriptive Statistics

The descriptive analysis focuses on the fundamental patterns of the study's variables' raw data. 18.9 percent of the total GDP was the average real GDP per person. The real GDP per capita standard deviation, however, accounts for 6.1%. This variation demonstrates the fluctuation in the real GDP per capita during the study period. Average gross fixed capital formation (GFCF) as a percentage of GDP was 18.1. The standard deviation of gross fixed capital formation, on the other hand, was 6.9 percent relative to GDP, with the smallest and largest amounts being 8.9 percent and 34.5 percent, respectively. The average government financial consumption expenditure (GEX), which is calculated as the share of GDP that is spent on consumer goods and services, is 12.2 percent with a standard deviation of 4.1 percent. According to the variance, the government's financial consumption expenditures vary from the mean by 4.1 percent. On average, government expenditure on education (EEX) over the sample period was 6.8 percent of total government expenditure on education, with a dispersion of 3.6 percent. As skewness is the measure of the symmetry of data distribution, the skewness of the data for real GDP per capita is 0.8, which is symmetrically distributed because it is not a positive high value or a negative low value, and the kurtosis shows that as it measures whether the data is heavily tailed or light-tailed relative to the normal distribution, the kurtosis for the normal distribution is 3, and if the kurtosis is greater than 3, then the data set has heavier tails than the normal distribution. The real GDP per capita in Ethiopia during the study period has a kurtosis of 3.2, which is regularly distributed and erratic. (Table 1).

Table 1. *Descriptive Statistics.*

Variables	Obs	Mean	Std.Dev.	Min	Max	Skewness	Kurtosis
Y	25	18.90039	6.09689	15.71361	40.27009	0.8670924	3.21796
GFCF	25	18.13234	6.908398	8.981749	34.52213	-0.145811	2.283173
GEX	25	9.17421	4.008011	2.748458	18.58509	-0.163532	2.643104
EEX	25	6.776194	4.8855	3.392040	17.12134	0.708471	3.620625
COR	25	3.978094	2.6879	2.342066	15.14234	0.908273	2.822627
TFP	25	8.69381	6.31643	3.821324	30.68316	0.165423	1.831509
N	25	7.81065	5.31656	2.821727	19.68316	0.113123	1.831289

Source: Own computations result, 2023

The link between the parameters included throughout the study period was described using the correlation matrix (Table 2). Although the size of the correlation is small and real GDP per capita is positively related, it is clear that the matrix correlation between Y (real GDP per capita) and the levels of GFCF, GEX, and EEX is positive. Additionally, there is an inverse association between the factors that determine economic growth and the level of corruption (-0.56) between real GDP per capita and the levels of GFCF, GEX, and EEX positive. Additionally, there is an inverse association between the factors that determine economic growth and the level of corruption (-0.56 between real GDP per capita and corruption).

Table 2. *The matrix correlation analysis of variables.*

Variables	Y	N	TFP	GFCF	GEX	EEX	COR
Y	1.00						
N	-0.86	1.00					
TFP	0.48	-0.44	1.00				
GFCF	0.79	-0.86	0.55	1.00			
GEX	0.76	-0.82	0.56	0.91	1.00		
EEX	0.87	-0.84	0.68	0.89	0.79	1.00	
COR	-0.56	0.58	-0.71	-0.46	-0.63	-0.58	1.00

Source: Own computations result, 2023

Similarly, Corruption can impede investment activity directly or indirectly, as shown by the negative connection between investment (GFCF) and corruption (-0.46).

3.2. Unit Root Tests

To determine if a series is stationary or non-stationary and the existence of a unit root, the ADF and Phillips-Peron tests were applied. Their results are given in Table 3. The null hypotheses were tested at a 5% significant level to determine whether there is information about the sequence of integration, whether the series has trended and been constant, has just been constant, or has not been both constant and trending. The result of the study shows that all variables, except for lnZ, are stationary when the first difference is taken into account in each test but non-stationary otherwise. The series lnY is non-stationary with a trend and constant, but after taking the first difference, it becomes stationary at the 1% level. At the first difference, lnEEX is also stationary at the 1% level. lnZ is I (0) in the ADF test but I (1) in the PP test. The unit root test results show that none of the chosen series goes beyond (1), hence the ARDL Bounds test was used to look at co-integration between variables.

Table 3. *Augmented Dickey-Fuller and Phillips-Peron unit root test results.*

Test type		lnY	ΔlnY	lnGFCF	ΔlnGFCF	lnGEX	ΔlnGEX	lnEEX	ΔlnEEX	lnCOR	ΔlnCOR	lnZ	ΔlnZ
ADF test in level	Intercept	-	-	-0.029	-1.632	-2.786	-0.132	-1.67	-0.092	-2.689	-2.972	-0.231	-0.356
	Intercept & trend	0.399	-5.717	-1.732	-1.971	-2.881	-0.875	-2.356	-0.483	-2.984	-3.062	-0.484	-0.482
ADF tests in differenced	Intercept	-8.225	-2.283	-6.235	-6.459	-6.918	-0.487	-0.485	-0.381	-5.816	-6.248	-0.683	-0.588
	Intercept & trend	-0.489	-8.489	-6.249	-6.671	-6.974	-0.671	-0.782	-0.349	-5.775	-7.249	-0.487	-0.225
Phillips-Peron in Level	Intercept	1.454	5.186	0.043	-1.423	-2.284	-1.422	-1.349	-1.782	-4.283	2.042	-1333	-1.521
	Intercept & trend	-2.472	-0.933	-1.718	-1.172	-2.352	-1.423	-1.123	-1.477	-4.457	-3.717	-1.145	-1.423
Phillips-Peron in Differenced	Intercept	-8.220	-7.776	-6.235	-6.247	-6.918	-1.890	-1.425	-1.887	-7.818	-5.239	-1.423	-1.572
	Intercept & trend	-8.626	-9.897	-6.249	-6.451	-6.984	-1.423	-1.780	-1.109	-7.676	-6.453	-1.907	-1.531

Note: The ADF and PP critical values are as follows:

The Significance level	With intercept	With intercept & trend
1%	-3.507	-4.068
5%	-2.895	-3.463
10%	-2.585	-3.158

Source: Output from data analysis using E-view-12, 2023

3.3. Autoregressive Distributed Lag Model to Co-integration

3.3.1. Model Fitness and Lag Selection Criteria

Since the sample size is modest and the data frequency is annual, one or two lags typically fit the criterion for lag selection (Wooldridge, 2013; Berhanu and Girma, 2023). For 25 observations, the chosen lag length was the most frugal based on all informational criteria. Therefore, the ARDL model result concluded that the model was significant and specified well due to the F-statistic value in both cases (13.330 and 23.150) even at less than 1% significance level, are higher than the upper bound critical value, strongly suggesting that we may firmly reject the null hypothesis of no co-integration. There is therefore substantial evidence of a long-term link between the variables in the two models. As a result, since there is co-integration, we may move on to the next stage of estimating the long-run (LR) model.

3.3.2. ARDL Bounds Co-integration Test Results

Tables 4 and 5 for the base model (eqn. 4) and model with corruption (eqn. 5), respectively, report the computed F-statistics with the required critical values for assessing long-run relations or co-integration, demonstrating the existence of co-integration.

Table 4. *Bounds co-integration tests for the base model only.*

Calculated F-statistics	1% level of significance		5% level of significance		10% level of significance	
	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)
13.330	4.27	4.84	3.062	4.213	2.362	3.651

Source: Output from data analysis using E-views-12, 2023

Table 5. *Bounds co-integration tests for the model including corruption.*

Calculated F-statistics	1% level of significance		5% level of significance		10% level of significance	
	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)
23.150	4.127	5.784	2.962	4.293	2.462	3.752

Source: Output from data analysis using E-views-12, 2023

3.3.3. ARDL Long-Run Model Estimation Results

Since there were co-integrations established in both models the ARDL long-run model was estimated from equations (i and ii). For comparison, the estimates of the long-run coefficients for the outputs of both models are shown in Table 6. According to the theoretical foundation, all coefficients in the base model have a positive sign. The table clearly shows that the current period's GDP per capita is significantly dependent on the previous years, and it is statistically significant at a level of less than 1%. The output of the base model demonstrates that one of the important factors affecting Ethiopia's GDP is gross fixed capital formation. A 1% increase in physical capital formation would translate into a 0.23% increase in real GDP per person, all else being equal. A 1% increase in GEX causes an approximately 0.5% increase in per capita GDP, and lnGEX is substantial at a level of less than 10%. It demonstrates that public sector spending in Ethiopia is not as important to economic growth as might be anticipated in developing nations. According to statistics, public education spending (lnEEX) has a negligibly small but statistically significant impact on GDP, and its size is equally negligibly small (0.11). Although the estimated cumulative term lnZ is considerable at less than 1%, the economic impact is relatively small (0.09) [48, 62, 20].

After adding corruption to the extended model as an independent variable in the regression analysis, corruption (lnCOR) is found to be highly significant at less than 1% level and its effect on real GDP per capita of Ethiopia during 1996-2021 is negative. It demonstrates how corruption has a long-term negative influence on the economy. The study's findings indicate that a long-term 1% increase in corruption will cause Ethiopia's real per capita GDP to fall by 0.1%. This outcome reflects what [52, 18, 40] found in their cross-sectional investigations. The theoretical framework explains how corruption has an indirect impact on the economy in many ways. In the presence of corruption, the coefficient of physical capital production (lnGFCF) becomes negligible and its value decreases from 0.231 to 0.189. This suggests that corruption significantly lowers the gross fixed capital formation of Ethiopia. Although the size of the coefficient for public sector investment or government final consumption expenditure (lnGEX) has grown, it is now negligible. In this sense, it may be claimed that public sector investment has expanded but has contributed less significantly to Ethiopia's economic expansion. This outcome is consistent with earlier studies that used cross-country analysis, including those by [59, 38, 25]. Investment in human capital is negatively impacted by corruption. The outcome demonstrates that public sector education spending hurts per capita GDP in Ethiopia when there is corruption. Therefore, based on the long-term findings, it can be said that corruption has adverse effects on Ethiopia's economic growth and directly lowers per capita GDP through various transmission mechanisms of economic growth.

Table 6. *Long Run (Static) Model Estimation Results.*

Dependent variable lnYt	**Model without corruption**		**Model with corruption**	
Explanatory variables	**Coefficients**	**t-statistics**	**coefficients**	**t-statistics**
Constant	-0.272***	-4.783	-0.142	-0.802
lnY_{t-1}	1.162***	57.221	0.113	0.231
lnY_{t-2}	0.101	0.221	0.973***	17.653
$lnGFCF_t$	0.231***	6.812	0.189	0.778
$lnGFCF_{t-1}$	0.324***	4.512	0.222***	4.392
$lnGFCF_{t-2}$	-0.523***	-4.183	0.003	0.009
lnGEXt	0.521***	2.851	0.066**	2.312
$lnGEX_{t-1}$	0.321**	2.331	0.043**	2.312
lnEEXt	0.113	0.972	-0.245***	-3.662
$lnEEX_{t-1}$	0.763	0.653	-0.932***	-2.742
lnZ_t5%, 10%,	0.093	0.733	0.228	1.562
$lnCOR_t$	0.001	0.004	-0.436***	-6.752
DI	-0.324***	-7.432	-0.332***	-3.765
	Adj.R^2 = 0.988		Adj.R^2 = 0.987	
	F(9,13) = 5344(0.000)		F(9,13) = 2531(0.000)	

Note: (***), (**) and (*) denote significance at less than 1%, 5%, and 10%, respectively. Source: *own estimation, E-views 12, 2023*

3.3.4. ARDL Short-Run Model Estimation Results

Both models have a significant equilibrium error correction term, ECMt-1, with a negative sign, which highlights the existence of a long-term link between the variables being studied. The estimated ECMt-1 term is a measure of how the previous year's shock-induced disequilibrium in the current fiscal year returns to long-run equilibrium. Therefore, it states that the rate of change from short-run deviation to long-run equilibrium is appropriately high (52% in the corrupted model). It can be said that in the current year, around 52% of the imbalance caused by the shock from the previous year converges back to the long-run equilibrium.

Table 7. *Short-run Results.*

Dependent variable ΔlnY_t	**Model without corruption**		**Model with corruption**	
Explanatory variables	**coefficients**	**t-statistics**	**Coefficients**	**t-statistics**
Constant	-0.113***	-4.744	0.278***	5.980
ΔlnY_{t-1}	1.352***	57.151	0.183***	5.772
ΔlnY_{t-2}	0.941	0.331	0.273***	3.278
$\Delta lnGFCF_t$	0.511***	6.872	0.169	0.338

Dependent variable ΔlnY_t	Model without corruption		Model with corruption	
Explanatory variables	**coefficients**	**t-statistics**	**Coefficients**	**t-statistics**
$\Delta lnGFCF_{t-1}$	0.774***	4.555	0.932***	4.338
$\Delta lnGFCF_{t-2}$	-0.623***	-4.157	0.071	0.152
ΔlnGEXt	0.771**	2.171	0.037**	2.371
$\Delta lnGEX_{t-1}$	0.441**	2.621	0.091***	2.781
ΔlnEEXt	0.233	0.252	-0.244***	-3.159
$\Delta lnEEX_{t-1}$	0.953	0.553	-0.782***	-2.991
ΔlnZ_t	0.323	0.083	0.138	1.371
$\Delta lnCOR_t$	0.261	0.114	-0.448***	-6.752
ECM_{t-1}	-1.298**	-2.899	-0.522***	-4.562
DI	-0.116	-1.072	-0.112***	3.711
	Adj.R^2 = 0.8281		Adj.R^2 = 0.60.6621	
	F(9,12) = 8.231(0.001)		F(8,13) = 2.732(0.180)	

Note: (***), (**) and (*) denote significance at less than 1%, 5%, and 10%, respectively. Source: *own computation, E-views 12, 2023*

3.4. Model Diagnostic Tests

Testing the validity of long-run and short-run simultaneous estimation in the ARDL approach requires post-estimation diagnostic procedures. Additionally, several diagnostic tests were used to evaluate the suitability of the specified model. Thus, the outcome demonstrates that there was no serial correlation (0.86) between the variables in ARDL because the p-value was higher than at less than 5% significance level. The Breusch-Godfrey test provided proof of it. Because the probability value of 0.24 is higher than the 5% significance level, the estimated model was homoscedastic, as determined by the Breusch-Pagan-Godfrey test (Table 8).

Table 8. *Diagnostic Tests.*

Violated OLS Assumptions	Tests	F-statistic	Prob.	Decision
Autocorrelation	Breusch-Godfrey Serial Correlation LM test	2.324	0.864	Accept H_0 = No serial correlation
Heteroscedasticity	Breusch-Pagan-Godfrey Test	0.137	0.244	Accept H_0 = Homokedasticity
Normality	Jarque Bera Test	3.81 (JB)	0.08	Accept H_0 = Normally distributed

Source: Own computation using E-views-12, 2022

3.4.1. Model Stability Test

The study used the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) stability testing approaches to assess the stability of the chosen ARDL model based on an error correction model. Figures 1-3 display the CUSUMSQ and CUSUM plots, respectively. The investigation concluded that the model is structurally stable because both plots remain within critical boundaries at a level of significance lower than 5%. Moreover, the study indicated that all autoregressive roots lie inside the unit circle, which confirms the stability of the model.

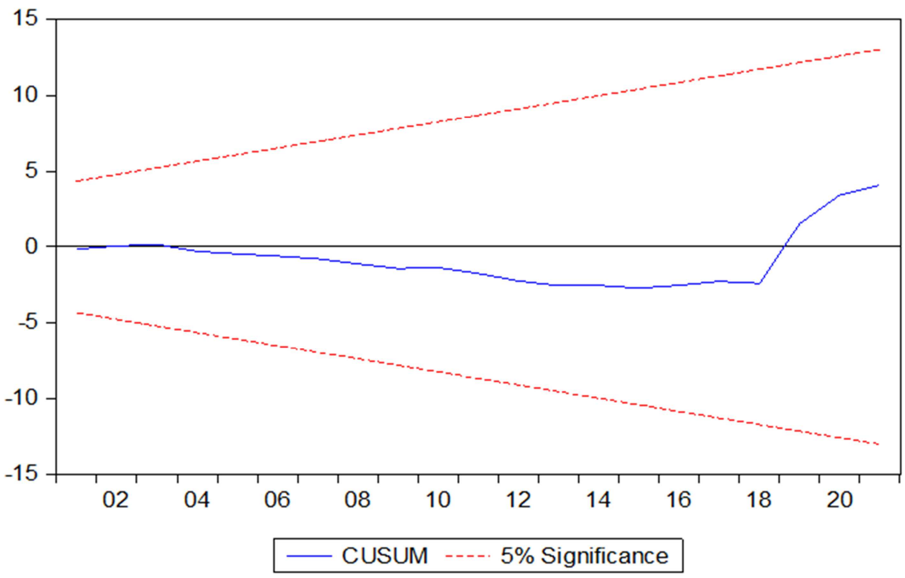


Figure 1. *Long Run Stability Test.*

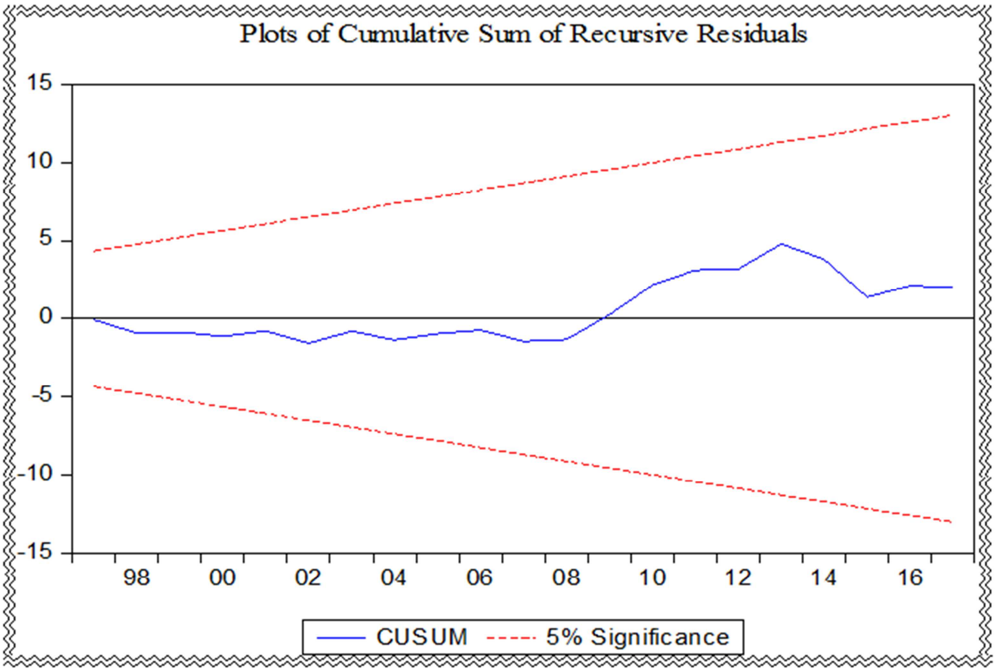
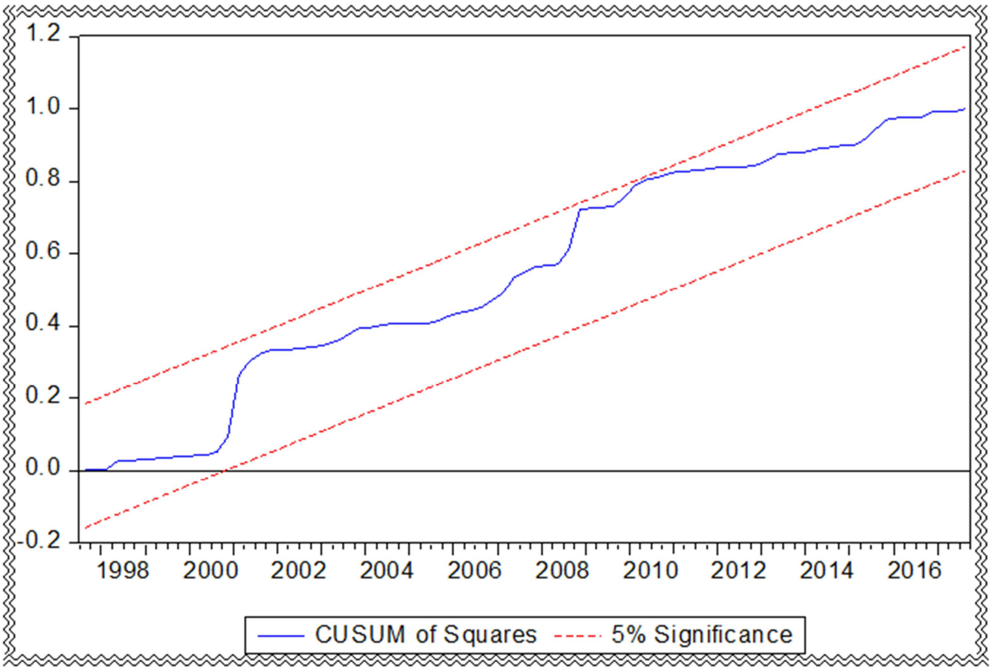


Figure 2. *Short Run Stability Test.*



Source: Own computation using E-views-12, 2023

Figure 3. *Cumulative sum squares of recursive residuals Stability Test.*

3.4.2. Granger Causality Test

Table 9 shows the Pairwise Granger Causality test which mainly examines the causal relations among real GDP per capita (Y) and explanatory variables including an index of corruption. By comparing p-values with less than 5% level of significance, the decision rule was established [51, 31, 46, 21]. It reveals that the availability of gross fixed capital formation leads to real GDP per capita, indicating the existence of unidirectional relation between the two. In general, the Granger causality test result supports a unidirectional relationship between real GDP per capita and explanatory variables including an index of corruption in Ethiopia.

Table 9. *The Granger Causality Test Result.*

Null Hypothesis:	F-statistic	Prob.
DLOGGFCF does not Granger Cause DLOGY	4.60	0.03
DLOGY does not Granger Cause DLOGGFCF	2.45	0.12
DLOGGEX does not Granger Cause DLOGY	6.12	0.02

Null Hypothesis:	F-statistic	Prob.
DLOGY does not Granger Cause DLOGGEX	0.73	0.38
DLOGEEX does not Granger Cause DLOGY	6.43.	0.01
DLOGY does not Granger Cause DLOGEEX	0.73	0.36
DLOGCOR does not Granger Cause DLOGY	6.33	0.01
DLOGY does not Granger Cause DLOGCOR	0.83	0.37
DLOGZ does not Granger Cause DLOGY	4.94	0.01
DLOGY does not Granger Cause DLOGZ	0.30	0.73

Source: own computation result using E-view- 12, 2023

4. Conclusion and Policy Implications

In practically every aspect of life in Ethiopia, corruption has grown to be one of the most pervasive issues. In several global corruption rankings, the nation is regarded as one of the most corrupt nations in the world. There is a lot of discussion about how corruption significantly impedes the nation's economic development. Even in recent years, Ethiopia's corruption perceptions index was at the level of 39 score index points in 2021, up from 38 score previous year (2020), this is a change of 2.63% and the country ranks 87 in corruption perception index in 2021. This study aimed to conduct an in-depth examination of the relationship between corruption and economic growth in Ethiopia using annual time series data for the years 1996 to 2021. To meet the objectives of the study, the Solow model of economic growth has been extended to include the public sector and human capital. Then, to distinguish between the direct and indirect effects of corruption on income per capita, this expanded model includes corruption in a particular functional form.

This model, which is based on the a priori assumption that corruption has negative effects, shows how corruption impacts per capita income both directly and indirectly through the channels of total factor productivity, physical capital, the public sector, and human capital. After that, using the International Country Risk Guide (ICRG) corruption index as a proxy to measure Ethiopia's level of corruption, the long-run relation between corruption and real GDP per capita was examined for the period using the ARDL Bounds method for co-integration.

The co-integration test's findings show that there is a consistent association between real GDP per person over this study period and corruption as well as other factors that affect GDP. The long-term projections show that corruption directly hinders Ethiopia's economic development by lowering real per capita GDP. It demonstrates that a rise in corruption of just 1% over this period has a 10% impact on Ethiopia's actual per capita GDP. Thus, corruption is hurting Ethiopia's economic development. In other words, Ethiopia's economy could grow quicker if rampant corruption were to be reduced. The findings of this study also imply that corruption has a significant detrimental effect on Ethiopia's investments in physical capital and human development. The results suggest that, despite the government's increasing investment in the public sector, high levels of corruption prevent it from having a substantial impact on Ethiopia's economic growth. The policy conclusion is that Ethiopia's government should develop strategies to combat corruption to foster economic progress.

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Conflicts of Interest

The authors declare that no conflicts of interest.

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