Corruption's Shadow: The Uneven Impact on Global Economic Growth

A panel data approach

Ann Mary James

University of Cincinnati

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Prof. Iryna Topolyan

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1. INTRODUCTION

Corruption, a pervasive issue, has undermined economic development and governance and has impacted the world significantly. This study examines corruption's effects on economic output by conducting a comparative analysis across developed, developing, and least-developed countries. The primary hypothesis is that corruption inversely affects the economic development of developed countries. In contrast, its impact on the developing and least developed countries may vary as there might be other factors, like its institutional quality and governance structures, that might alter the effect of corruption on the GDP.

This study will use panel data analysis to examine data from 33 countries from 2010 to 2020. The dependent variable is GDP per capita, and the independent variable is the Corruption Perception Index. The analysis will incorporate various control variables, including the Human Capital Index, Population density, Internet Penetration Rate, to show the digital infrastructure, the categorical variable of whether the country is developed, developing, or least developed, Political Stability, and absence of violence/terrorism index, and Foreign Direct Investment (net inflows). By analyzing these variables, the study seeks to identify regional patterns and trends in the correlation between corruption and economic output.

2. LITERATURE REVIEW

Corruption is a topic that has been studied extensively, with most research indicating a negative relationship. Mauro (1995) highlighted that corruption has an inverse impact on economic development due to low investment levels. This finding echoed Tanzi and Davoodi (1998), who also stated that corruption distorts public expenditure. These papers emphasize the undermining nature of corruption in economic stability and output, especially in countries with weak institutional frameworks.

Other studies have provided insights into the regional variations of corruption's effects. Spyromitros and Panagiotidis (2022) analyzed the influence of corruption on the output of the economy in developing countries and used panel data methods to conclude the results. The results of the comprehensive analysis of the developing countries determined the negative connection between corruption and economic output by distorting public investments and reducing government spending. Similarly, Agale-Kolgo's (2018) analysis of 101 developing countries revealed that while the direct impact of corruption on the output of the economy was insignificant, the impact was significantly mediated by other economic conditions and institutional factors. Farrage and Ezzat (2020) studied the effect through a comparative analysis between the MENA countries and Europe, and the research highlighted the impact varies significantly between regions, with the MENA countries having more negative effects.

Overall, the literature highlights the complexity of corruption's impact on the output of the economy while considering regional and institutional variations in understanding the relationship.

3. DATA

This study utilizes a dataset containing 33 countries from 2010 to 2020 to understand the effect of corruption on the output of the economy. The dataset includes various variables that help understand the correlation between corruption and economic output across different countries. The variable description is given below:

Variable Description	
GDP (dependent variable)	GDP per Capita, (constant 2015 US$). This is the dependent variable representing the economic output of a country per person.
Corruption (independent variable)	Corruption Perception Index, a measure of perceived levels of public sector corruption. Index varies from 0 to 100, 0 indicating highly corrupt and 100 indicating very clean.
HDI (control variable)	Human Development Index, reflecting the overall human development in the country.
Pop den (control variable)	Population density (people per sq. km of land area)
develop (control variable)	Categorical variable determining the development status of the country: 1 = Developed, 2 = Developing, 3 = Least Developed
internet (control variable)	Percentage of the population using the Internet, representing digital infrastructure

political (control variable)	Political Stability and Absence of Violence/Terrorism Index, capturing the political climate of the country.
fdi (control variable)	Foreign direct investment, net inflows (% of GDP)

Table 1: Variable Description

The summary statistics for each variable are given below:

Summary Statistics				
Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
GDP	25681.11666	24053.45398	445.182336	87123.66044
Corruption	44.9110193	29.55930718	1.4	91
HDI	0.76947658	0.175367023	0.41	0.96
Pop den	381.493747	1321.143804	2.84	8185.41
develop	1.75757576	0.81874899	1	3
internet	56.1656749	33.39560427	0	100
political	-0.1400551	1.239309644	-3	1.62

fdi	3.14961433	7.470496656	-32.64	81.08
Number of observations: 363				

Table 2: Summary Statistics

The data sources used for the collection of data were:

- World Bank
- United Nations Development Programme
- Transparency International

These variables provide a robust framework for analyzing the impact of corruption on economic output. This dataset enables a detailed examination of how corruption affects economic output differently across developed, developing, and least developed countries.

4. EMPIRICAL METHODOLOGY

This paper implements an econometric approach to investigate the impact of corruption on the output of the economy across different countries. Utilizing panel data from 33 countries over a period from 2010 to 2020, the study controls for unobserved heterogeneity and time effects. A primary panel data model can be specified for this study.

The primary model for this study is a linear regression model, specified as follows:

$$GDP_{it} = \alpha_i + \beta_0 + \beta_1 Corruption_{it} + \beta_2 HDI_{it} + \beta_3 PopDen_{it} + \beta_4 Developed_{it} + \beta_5 Developing_{it} + \beta_6 5Internet_{it} + \beta_7 Political_{it} + \beta_8 FDI_{it} + \beta_9 Corruption_{it} *Developed_{it} + \beta_{10} Corruption_{it} *Developing_{it} + D_t + \epsilon_{it}$$

- GDP_{it} is the Gross Domestic Product per Capita of country *i* at year *t*.
- $Corruption_{it}$ is the Corruption Perception Index of country *i* at year *t*.
- HDI_{it} is the Human Development Index of country *i* at year *t*.
- $PopDen_{it}$ is the population density of country *i* at year *t*.
- $Developed_{it}$ is a dummy variable indicating the development status of a country as developed.
- $Developing_{it}$ is a dummy variable indicating the development status of a country as developing.
- $Internet_{it}$ is the percentage of individuals using the internet in country *i* at year *t*.
- $Political_{it}$ is the political stability and absence of violence/terrorism index of country *i* at year *t*.
- FDI_{it} is the foreign direct investment, net inflows as a percentage of GDP for country *i* at year *t*.

- $Corruption_{it}$ *$Developed_{it}$ is the interaction term between corruption and developed dummy variable
- $Corruption_{it}$ *$Developing_{it}$ is the interaction term between corruption and developing dummy variable
- α_i is the unobserved heterogeneity.
- D_{it} is the time dummy variable
- ϵ_{it} is the error term.

The time dummy variable can be defined as:

$D_t = \delta 1 D2011 + \delta 2 D2012 + \delta 3 D2013 + \delta 4 D2014 + \delta 5 D2015 + \delta 6 D2016 + \delta 7 D2017 + \delta 8 D2018 + \delta 9 D2019 + \delta 10 D2020$

The primary model can be estimated using various methods. This paper employs four panel data econometric methods, which are Pooled Ordinary Least Squares (OLS), First Differenced estimator (FD), Fixed Effect estimator (FE), and Random Effect estimator (RE). The log of the GDP was taken to maintain the scale among all the other variables. The categorical variable for the Develop variable was converted to dummy variables for ease of analysis.

4.1 Pooled OLS

The Pooled Ordinary Least Square estimator correlates to running Ordinary Least Squares on the observations pooled across countries and years. The Pooled OLS treats the panel data as extensive pooled cross-sectional data to get a bigger sample size, ignoring the panel structure. This model assumes homogeneity, meaning no unobserved heterogeneity and individual-specific effects exist.

Assumptions

1. Zero Conditional Mean Assumption: This assumption states that the expectation of the error term is zero, and the error term does not depend on the independent variables.
2. Homoscedasticity: This assumption states that the variance of the error term is constant across all observations.

The Pooled OLS econometric model can be set up as follows:

$GDP_{it} = \beta_0 + \beta_1 Corruption_{it} + \beta_2 HDI_{it} + \beta_3 PopDen_{it} + \beta_4 Developed_{it} + \beta_5 Developing_{it} + \beta_6 5Internet_{it} + \beta_7 Political_{it} + \beta_8 FDI_{it} + \beta_9 Corruption_{it} * Developed_{it} + \beta_{10} Corruption_{it} * Developing_{it} + D_t + \epsilon_{it}$

The Pooled OLS model can be used if there is no variance in the unobserved heterogeneity. While it's easy to implement, the results produced by the Pooled OLS may be biased. The estimates do not account for the unobserved heterogeneity that may influence the dependent variable, resulting in biased results.

4.2 First Differenced Estimator

The First Differenced estimator addresses the problem of non-stationarity while eliminating the unobserved heterogeneity. This method helps remove the unit root issues existing in the model.

Assumptions

1. Zero Conditional Mean Assumption or strict exogeneity assumption: This assumption states that the idiosyncratic errors are uncorrelated with the independent variables in each

time period, in this case, in each year. The independent variables are strictly exogenous in nature after eliminating the unobserved heterogeneity, α_i.

2. Homoscedasticity or no serial correlation assumption: This assumption states that the variance of the differenced errors, conditional on all the explanatory variables, is constant.

The First Differenced estimator econometric model can be set up as follows:

$GDP_{it} = \beta_1 \Delta \text{Corruption}_{it} + \beta_2 \Delta \text{HDI}_{it} + \beta_3 \Delta \text{PopDen}_{it} + \beta_4 \Delta \text{Developed}_{it} + \beta_5 \Delta \text{Developing}_{it} + \beta_6 \Delta \text{Internet}_{it} + \beta_7 \Delta \text{Political}_{it} + \beta_8 \Delta \text{FDI}_{it} + \beta_9 \Delta \text{Corruption}_{it} * \text{Developed}_{it} + \beta_{10} \Delta \text{Corruption}_{it} * \text{Developing}_{it} + \Delta D_t + \Delta \epsilon_{it}$

The First Differenced estimator can be used if the differenced errors are serially uncorrelated. While the First Differenced estimator accounts for the non-stationarity, the estimates may be imprecise if the independent variable doesn't change much over time.

4.3 Fixed Effect Estimator

The Fixed Effect estimator controls all the variables in the model by time-demeaning the variables. The variables are time-demeaned after subtracting the variables by their means or averages.

Assumptions

1. Zero Conditional Mean Assumption and strict exogeneity assumption: This assumption states for each time t, the expectation of the idiosyncratic error conditional on the independent variables and the unobserved heterogeneity is zero.

2. Homoscedasticity and no serial correlation assumption: This assumption states for each time t, the variance of the idiosyncratic error conditional on the independent variables and the unobserved heterogeneity is zero, and the errors are uncorrelated with each other.

The Fixed Effect estimator econometric model can be set up as follows:

$$\overline{GDPit} = \alpha_i + \beta_0 + \beta_1\overline{Corruptionit} + \beta_2\overline{HDIit} + \beta_3\overline{PopDenit} + \beta_4\overline{Developedit} + \beta_5\overline{Developingit} + \beta_6\overline{Internetit} + \beta_7\overline{Politicalit} + \beta_8\overline{FDIit} + \beta_9\overline{Corruptionit * Developedit} + \beta_{10}\overline{Corruptionit * Developingit} + \overline{Dt} + \overline{\epsilon it}$$

The Fixed Effect estimator can be used if the errors are serially uncorrelated, but the differenced errors are serially correlated. While the fixed effect estimator allows for control for the time-invariant variables, the key limitation is the need to estimate extra parameters, which may lead to the loss of degrees of freedom.

4.4 Random Effect Estimator

The Random Effect estimator is considered a feasible Generalized Least Square or Weighted Least Square to account for the serially correlated errors.

Assumptions

1. Zero Conditional Mean Assumption: This assumption states that the expectation of the unobserved heterogeneity conditional on independent variables is zero, and the expectation of the error term conditional on the unobserved heterogeneity and the independent variables is zero.
2. Homoscedasticity assumption: This assumption states that the variance of the error term conditional on the unobserved heterogeneity and the independent variables is constant.

The Random Effect estimator econometrics model can be set up as follows:

$GDP_{it} = \alpha_i + \beta_0 + \beta_1 Corruption_{it} + \beta_2 HDI_{it} + \beta_3 PopDen_{it} + \beta_4 Developed_{it} + \beta_5 Developing_{it} + \beta_6 5Internet_{it} + \beta_7 Political_{it} + \beta_8 FDI_{it} + \beta_9 Corruption_{it} * Developed_{it} + \beta_{10} Corruption_{it} * Developing_{it} + D_t + \epsilon_{it} + u_i$

A random effect estimator is preferred when the unobserved heterogeneity and each independent variable are uncorrelated. While it relies on this assumption, it may not always hold. If there is no correlation between the unobserved heterogeneity and the independent variables, the Random Effect estimator is preferred as it is more efficient than the Fixed Effect estimator.

The four approaches were employed to estimate the primary panel data model with the assumptions made. This comprehensive empirical methodology ensures a rigorous analysis of the relationship between corruption and economic output, leveraging various econometric techniques to provide robust and reliable results.

5. RESULTS

This section presents the results of the empirical analysis conducted using the Pooled OLS, First Differenced estimator, Fixed Effect estimator, and Random Effect estimator. The study covers the impact of corruption on GDP per capita, controlling for various factors across 33 countries from 2010 to 2020. Several tests were conducted to determine the best model among the ones specified for the model.

Several tests were conducted to determine which approach was better for the specified model.

The first test is to determine the presence of unobserved heterogeneity. The null hypothesis for the test to determine the presence of unobserved heterogeneity is:

$$H_0: \sigma_\alpha^2 = 0$$

The first test to determine the presence of the unobserved heterogeneity is the Breusch Pagan test. The test result is given below:

```
> bptest(pols)

	studentized Breusch-Pagan test

data:  pols
BP = 35.07, df = 18, p-value = 0.009261
```

Figure 1: Breusch Pagan test for serial correlation

The p-value is 0.009261. At the 1% significance level, since the p-value is less than 0.05, we reject the null hypothesis. Therefore, there is a variance in the unobserved heterogeneity. Hence, we cannot consider Pooled OLS to be the best model. The next test to determine the presence of unobserved heterogeneity is the Serial Correlation test. The null hypothesis for the test to determine the presence of unobserved heterogeneity is:

$$H_0: \sigma_\alpha^2 = 0$$

The test result is given below:

```
> summary(sc.pols)

Call:
lm(formula = pols.res ~ pols.lres, data = data)

Residuals:
       Min         1Q     Median         3Q        Max 
-1.492e-14  1.670e-17  4.240e-17  6.440e-17  8.320e-16 

Coefficients:
             Estimate Std. Error   t value Pr(>|t|)    
(Intercept) 7.223e-32  4.593e-17 0.000e+00        1    
pols.lres   1.000e+00  4.165e-17 2.401e+16   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 8.319e-16 on 326 degrees of freedom
Multiple R-squared:      1,     Adjusted R-squared:      1 
F-statistic: 5.764e+32 on 1 and 326 DF,  p-value: < 2.2e-16
```

Figure 2: Serial Correlation test

The p-value is <2e-16. At the 1% significance level, since the p-value is less than 0.05, we reject the null hypothesis. Therefore, there is a variance in the unobserved heterogeneity. Hence, we drop the Pooled OLS as the best model.

Since we determined the presence of the unobserved heterogeneity, the best approach must be chosen between the First Differenced, Fixed Effect, and Random Effect estimators. The Hausman test can determine the best model among Random Effect estimators and Fixed Effect estimators. The null hypothesis for the Hausman test is given below:

$$H_0: E(x_{it}\ \alpha_i) = 0$$

The test results are as follows:

```
> phtest(fe,re)

	Hausman Test

data:  lgdp ~ corr + hdi + pop + factor(develop) + internet + political +  ...
chisq = 0.9768, df = 16, p-value = 1
alternative hypothesis: one model is inconsistent
```

Figure 3: Hausman Test

The p-value is 1. At the 5% significance level, since the p-value is greater than 0.05, we fail to reject the null hypothesis. This means there is no correlation between the unobserved heterogeneity and the independent variables. Therefore, the Random Effect estimator is preferred and is the most efficient.

Hence, it can be concluded that the Random Effect estimator is the most efficient and best approach to estimating the specified model.

Since the Random Effect estimator was chosen as the best estimator, the interpretation can be done for the best model. The summary result for the random effect estimator is given below:

At the 1% significance level, the Human Development Index has a direct impact on the GDP per capita. Therefore, as the Human Development Index increases by 1 unit, GDP per capita increases by 497.58%. The population density is insignificant but has a positive impact on the GDP per capita. The Internet Penetration Rate is insignificant but has a positive impact on the GDP per capita. At the 1% significance level, the Political Stability and Absence of Violence/Terrorism Index has a positive impact on the GDP per capita. Therefore, as the Political Stability and Absence of Violence/Terrorism Index increases by 1 unit, the GDP per capita increases by 6.3861%. The Foreign Direct Investment is insignificant but has a negative impact on the real GDP.

```
> summary(re1)
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = lgdp ~ corr + hdi + pop + .data_1 * corr + .data_2 *
    corr + .data_3 * corr + internet + political + fdi + factor(year),
    data = data.panel, model = "random")

Balanced Panel: n = 33, T = 11, N = 363

Effects:
                   var  std.dev share
idiosyncratic 0.004151 0.064425 0.046
individual    0.086409 0.293954 0.954
theta: 0.9341

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-0.178470 -0.036356 -0.004720  0.026138  0.328426

Coefficients: (2 dropped because of singularities)
                    Estimate  Std. Error z-value  Pr(>|z|)
(Intercept)       4.4978e+00  2.0133e-01 22.3411 < 2.2e-16 ***
corr              4.4389e-03  1.5547e-03  2.8552 0.0043014 **
hdi               4.9758e+00  3.2442e-01 15.3373 < 2.2e-16 ***
pop               3.3613e-05  3.4279e-05  0.9805 0.3268148
.data_1           1.5165e+00  1.8063e-01  8.3957 < 2.2e-16 ***
.data_2           6.0099e-01  1.5889e-01  3.7825 0.0001553 ***
internet          5.3842e-04  7.4060e-04  0.7270 0.4672196
political         6.3861e-02  2.0129e-02  3.1726 0.0015108 **
fdi              -7.6362e-04  6.7967e-04 -1.1235 0.2612192
factor(year)2011 -1.8406e-02  1.6434e-02 -1.1200 0.2627162
factor(year)2012 -1.7193e-01  3.5692e-02 -4.8171 1.457e-06 ***
factor(year)2013 -1.7495e-01  3.5351e-02 -4.9490 7.460e-07 ***
factor(year)2014 -1.8664e-01  3.5609e-02 -5.2414 1.593e-07 ***
factor(year)2015 -1.7809e-01  3.5480e-02 -5.0194 5.184e-07 ***
factor(year)2016 -1.8123e-01  3.5881e-02 -5.0509 4.398e-07 ***
factor(year)2017 -1.9146e-01  3.6323e-02 -5.2712 1.355e-07 ***
factor(year)2018 -1.9060e-01  3.6239e-02 -5.2595 1.444e-07 ***
factor(year)2019 -1.9729e-01  3.6878e-02 -5.3498 8.803e-08 ***
factor(year)2020 -2.3292e-01  3.7677e-02 -6.1820 6.331e-10 ***
corr:.data_1     -2.0770e-03  1.1905e-03 -1.7446 0.0810515 .
corr:.data_2     -7.7441e-04  1.0161e-03 -0.7621 0.4459731
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    8.2504
Residual Sum of Squares: 1.5
R-Squared:      0.81819
Adj. R-Squared: 0.80755
Chisq: 1539.05 on 20 DF, p-value: < 2.22e-16
```

Figure 4: Summary result

The interaction terms give the average effect of corruption on the GDP per capita of developed, developing, or least developed countries. The first interaction coefficient, corr:.data_1, can be interpreted as the average effect of corruption on the GDP per capita of developed countries. That is, for developed countries, the corruption perception index is correlated, on average, with a decrease of 0.207% on GDP per capita in comparison to developing and least–developed countries. Therefore, for developed countries reducing corruption (increasing CPI) has a negative impact on GDP per capita. The second interaction coefficient, corr:.data_2, can be interpreted as the average effect of corruption on the GDP per capita of developing countries. That is, the corruption perception index, for developing countries, is correlated, on average, with a decrease of 0.07741% on GDP per capita in comparison to developed and least developed countries. Therefore, for developing countries reducing corruption (increasing CPI) has an inverse impact on GDP per capita. The average effect of corruption for least developed countries is given by the coefficient of corr alone. For least-developed countries, the corruption perception index is correlated, on average, with an increase of 0.23619% on GDP per capita in comparison to developed and developing countries. Therefore, for least-developed countries reducing corruption (increasing CPI) has a positive impact on GDP per capita.

Hence, there is a subtle but differential effect of corruption on GDP per capita based on their development status.

CONCLUSION

This paper aims to establish the effect of corruption on GDP per capita for 33 countries from 2010 to 2020, utilizing panel data and different techniques. The findings show that corruption impacts growth in the economy in a manner that depends on the status of development of the country in question.

For countries categorized under the least developed, corruption has a negligible positive effect on the GDP per capita perhaps because they ease economic activities in otherwise inefficient structures. In the developed countries context, corruption reduces GDP per capita; in this case, a 1 unit increase in the Corruption Perception Index equals a 0.207 percent decline, which means that corruption is much worse in stronger institutional settings. For developing countries, corruption also negatively affects GDP per capita, with a 1-unit increase in the Corruption Perception Index linked to a 0.07741% decrease, indicating that corruption distorts public investments and reduces government spending efficiency. These results imply that there is a necessity for anti-corruption policies that would consider the economic and institutional environments of the particular countries. More studies should be conducted to compare the effects of policies on different groups as this information would be useful for policymakers.

LIMITATIONS

The following limitations are found in this study, and they should be noted. First, the data sample covers 33 countries for the period of 2010-2020, thus lacking generalizability to the global population. Also, the quality and extent of data, especially for Least developed countries, may be an issue, which may influence the accuracy of the outcomes. In addition, there may be some endogeneity problems since corruption and economic growth may be affected by other factors, including political stability, history, and culture, which have not been captured in this study.

In terms of the methods, the study uses econometric models that have some underpinning assumptions like homoscedasticity and no serial correlation. If any of these assumptions are not met, then the accuracy of the results will be affected. Yet another complication is that corruption can be endogenous to economic output, so it is often difficult to determine which factor influences which. The generalization of the study is also restricted to the selected countries and the time period under consideration. Some parts of the world or some years may show different relationships between corruption and economic growth.

Finally, it is important to note that the study does not establish the impacts of corruption on the process of economic growth in the long run. These effects may take time and perhaps the ten-year period was not enough to capture the effects fully, and more long-term studies are needed. These limitations suggest that the results should be interpreted with caution and indicate where future research could develop on the findings of the present study.

FUTURE RESEARCH PROSPECTS

Future research should continue the analysis from 2010 to 2020 and further investigate deeper into the correlation between corruption and economic growth. Generalizability could, however, be enhanced if more countries were involved, especially from other parts of the world.

Such additional control variables as judicial efficiency, regulatory quality, and education levels incorporated would give a better-nuanced view of corruption's effects. Extending the study to non-linear models and interaction terms could open up non-linear relationships. Sector wise studies might reveal that some sectors were most prone to corruption.

There should also be an investigation into how corruption is moderated by institutional quality and governance structures. Perhaps, specific country examples with large fluctuations in corruption could be used to explain successful approaches to combating corruption. Researching the effects of culture on corruption and economic development would be beneficial to the region, and assessing the effectiveness of the measures against corruption might provide recommendations to the authorities.

Thus, the further improvement of knowledge in these fields can be viewed as the further development of existing research, which will offer a more accurate and specific vision of the interaction between corruption and economic growth.

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