RELATIONS BETWEEN ECONOMIC DEVELOPMENT, VIOLENCE AND CORRUPTION: A NONPARAMETRIC APPROACH WITH DEA AND DATA PANEL

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Abstract

This paper analyses the relationship between violence, corruption, and economic development in Colombian government departments. This empirical research explores the trends of violence, corruption, and economic development using various estimation techniques: DEA and econometric analysis with panel data. The DEA is applied to assess socioeconomic performance and interactions of violence, corruption, and economic growth in Colombian, according to the rank and uncertainty of corruption and violence. Econometric models are dynamic panel data estimates to determine the incidence of some institutional and socioeconomic variables on the score range of uncertainty and risk generated by DEA in terms of the level of corruption and violence. Estimates with DEA data envelopment analysis shows that the risk score associated with violence and corruption has different tendencies, socioeconomic and political instability are causes that explain the behavior of this variable over time. The results of the panel data estimation show that there are several hypotheses and theories that explain the effects of corruption and violence on the economic development of countries. This finding indicates the importance of developing effective policies that strengthen public management, the justice system, and social investments and thus break the cycles of corruption and violence that prevent the creation of sustained economic growth and development.

JEL: D73**,** O1, C61, C33

Keywords: Dynamic Panel Data, Violence, Corruption, Economic Development, Data Envelopment Analysis,

1. Introduction

In this complex world, corruption, or the abuse of public power for personal benefit, has become a problem that affects most of the social, political, and economic processes of a society, Morales and Finke (2015). This phenomenon slows economic development, weakens democratic institutions, and generates governmental instability and insecurity, which can lead to violence. Moreover, poverty and corruption is likely to increase because of the lack of opportunities and the decrease in social investments and economic growth, Cieślik and Goczek (2018).

Le Billon (2003) has analysed the role of corruption in armed conflict with various conceptual inter-relations and shows that corruption extends war through two interrelated mechanisms associated with the profitability of a state of war. First, war provides a fertile ground for corruption and unlawful enrichment. Second, corruption can undermine the efficiency and morale of armed forces, especially government forces. Neapolitan (1999) has compared nations with low and high levels of violent crime using a model of cross-national violent crime variation and shows that countries with high levels of violent crime are characterised by a high degree of corruption and inefficiency within the criminal justice system. Hodgson and Jiang (2007) have analysed corruption as an institutional phenomenon that affects both private and public spheres. The erosion of social rules by organisational corruption generates high social costs that may lead to political, social, and institutional instability.

Vaal and Ebben (2011) have investigated the effects of bureaucratic corruption on economic growth using a two-layer model that showed that an institutional vacuum generates corruption, which causes a decrease in growth due to the low productivity of public goods and labour. Shao et al. (2007) have analysed quantitative relations between the level of corruption and economic factors using a time series analysis. They found that less-corrupt countries show significant economic growth, whereas more-corrupt countries display insignificant growth rates. Moreover, Gyimah and Muñoz (2006) have used panel data techniques to study regional differences in the effect of corruption on economic growth and inequality. Their study found that low-income countries are characterised by high rates of corruption and low rates of economic growth.

Blackman et al. (2006) have evaluated corruption using the Colombian environmental authorities and found that corruption was a problem at both the national and regional levels. Thoumi (1999) has

studied the relationship between corruption and drug trafficking and showed both that this relationship is circular and that both are the result of the deterioration of institutions accompanied by the de-legitimation of the state.

This background shows that empirical studies on violence, corruption, and economic development are limited and have focused on specific features of these topics. The main contributions of this study are *i.* to assess social performances in terms of violence, corruption and economic development using DEA to compare the relative efficiency of these variables between the Colombian departments using a set of multiple inputs and outputs in terms of violence, corruption and economic development and *ii.* to establish the key factors that determine social performance based on violence, corruption, and economic development with dynamic panel data techniques. These approaches are singular features of this study.

In this article, we will empirically analyse the connection between violence, corruption, and economic growth for 2001 - 2015. We will focus on the trends and results of violence, corruption, and economic development using various indicators and econometric techniques, Duttaa, N, Kar S and Saha, S (2017). The purpose of this study is to analyse several determinants of corruption and violence and their effects on economic development over time in a developing country such as Colombia. The question that guides this research is: The different resulting interactions between violence and corruption reduce the economic development of the countries.

The paper is structured as follows. In section 2, a description of the data and the methodology used in this study is presented. Section 3 examines social performances in terms of violence, corruption, and economic development using cluster analysis and data envelopment analysis (DEA). Section 4 investigates the main drivers of the variations observed across Colombian departments from the DEA results using an econometric model. Finally, section 5 discusses the conclusions that can be drawn from this research.

2. Data and Methodology

2.1 Data

This paper utilizes the departments of the Colombian government as a case study. We use data published by the National Directorate of Taxes and Customs, Colombian Department of Statistics, Electronic system of Public Contracting, the Office of the Controller General of the Republic of Colombia, The National Center for Historical Memory, Conflict Analysis Resource Center, the Illicit Crop Monitoring System in Colombia of the United Nations Office on Drugs and Crime and National Planning Department. The selection of every variable used in the various techniques and time periods was established by the availability and reliability of detailed data for the Colombian departments from 2001 to 2015.

2.2 Methods

The following sections describe the data and the main methods used in this analysis.

2.2.1 Technique of grouping

In this research, cluster analysis is used. Colombian departments are separated among departments with a moderate level of corruption and violence, and a low level of corruption and violence using k-means clustering, Cotte (2012, 2014). In mathematical terms, we seek to minimise (Types, 2000),

$$SSE = \sum_{i=1}^{K} \sum_{\vec{x} \in C_i} \| \vec{x} - \vec{C}_i \|^2 = \sum_{i=1}^{K} \sum_{\vec{x} \in C_i} \sum_{j=1}^{d} (x_j - c_{ij})^2. \qquad (1)$$

2.2.2 Non-parametric analysis

Data envelopment analysis (DEA) estimates the relative efficiency of a group's decision-making units (DMUs). The CCR DEA model developed by Charnes et al. (1978) is as follows:

$$max\,\lambda_0\,(\mu,\nu) = \frac{\sum_{r=1}^{s}\mu_r y_{r0}}{\sum_{i=1}^{m}\upsilon_i x_{i0},} \qquad (2)$$

subject to

$$\frac{\sum_{r=1}^{s}\mu_r y_{rj}}{\sum_{i=1}^{m}\upsilon_i x_{ij}} \leq 1;\ j = 1,\ldots\ldots,n, \qquad (3)$$

$$\mu_r \upsilon_i \geq 0;\ r = 1,\ldots\ldots,s;\ \ i = 1,\ldots\ldots,m, \qquad (4)$$

The system of equations can be expressed as an ordinary linear programming model through the Charnes–Cooper transformation as follows:

$$\max z = \sum_{r=1}^{s}\mu_r y_{r0},$$

subject to,

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m}\upsilon_i x_{ij} \leq 0 \qquad (5)$$

$$\sum_{i=1}^{m}\nu_i x_{i0} = 1$$

$$\mu_r \upsilon_i \geq 0,$$

In the envelopment model, the number of degrees of freedom will increase with the number of DMUs and decrease with the number of inputs and outputs. A rough rule of thumb which can provide guidance is as follows, Cooper, et al, (2007).

$$\xi \geq \max\{\gamma\ x\ \phi\ ,3\ (\gamma + \phi)\} \qquad (6)$$

Where $\xi = number\ of\ DMUs$, $\gamma = number\ of\ inputs$ and $\phi = number\ of\ outputs$

In this research, following, Cotte (2014), inputs are defined as desirable attributes, and outputs are defined as undesirable attributes. the DEA model is based on three desirable attributes (inputs): education, which is measured as the level of high school education, captures and number of police for each department, i, in the period t. The outputs in this model are defined as homicides, which are measured as the homicide rates per 100.000 in the population and a proxy for the corruption variable,

which is measured as offenses against public administration, including peculation, concussion, bribery, legal prevarication, usurpation of public function and abuse of public function, Cotte (2014:377).

2.2.2.1 The Wilcoxon analysis

We use the Wilcoxon signed ranks test, which is a nonparametric alternative to the two-sample t-test and is solely based on the order in which the observations from the two samples fall. This technique compares other indicators of corruption and violence and the results of the DEA model applied in this study. In other words, it is possible to test the hypothesis that the distribution of X-measurement in population A (ICV and ITD indexes) is the same as in population B, Shahroudi (2009). In this hypothesis, the sample of observations is denominated A (the effectiveness index of the control of violence in Colombian departments (ICV) or the transparency index by department (ITD)) or B (the DEA) scores containing η_A and η_B observations, respectively. The null hypothesis is as follows:

$H_0 \rightarrow$ *The efficiencies of two groups have the same distribution.*

We obtain the statistical index, *S*, by summing the ranking of group *A*. *S* follows an approximately normal distribution with mean $m(m+n+1)/2$ and variance $mn(m+n+1)/12$. By normalising *S*, we obtain the following equation:

$$T = \frac{S - m(m+n+1)/2}{\sqrt{mn(m+n+1)/12}}, \qquad (7)$$

where *S* is the sum of the rankings for one group, *m* is the number of DMUs in that group, and *n* is the number of DMUs in the other group. *T* has an approximately standard normal distribution (Cooper et al. 2007).

2.2.3 Econometric analysis with panel data

The Generalised Method of Moment (GMM) is estimated in this research. Arellano and Bover (1995), Blundell and Bond (1998) encompass a regression equation in differences and levels, each with a specific set of instrumental variables. The use of instrumental variables allows us to consider two issues. First, it can resolve the problem of simultaneity and reverse causation caused by the likely

endogeneity of the regressors used in this type of equation, Cotte (2012). Second, it reduces the estimation bias caused by the underreporting of corruption and violence.

The general regression model for the indicator of violence and corruption is as follows:

$$y_{i,t} = \beta_1 y_{i,t-1} + \beta_2 X_{i,t} + \eta_i + \varepsilon_{i,t}. \qquad (8)$$

Equation (7) and a GMM procedure are applied to obtain consistent estimates of the variables of interest and to correct for bias caused by endogenous explanatory variables. The models estimated in this research are as follows:

$$\widehat{\Omega}_{i,t} = \alpha_1 \widehat{\Omega}_{i,t-1} + \alpha_2 GINI_{i,t} + \alpha_3 UBN_{i,t}\, \alpha_4 \varphi_{i,t} + \xi_i + \varepsilon_{i,t,} \qquad (9)$$

where $\widehat{\Omega}_{i,t}$ is the DEA index of the measure of violence and corruption for each department in time *t* for department *i*, $\widehat{\Omega}_{i,t-1}$ is the lagged index measuring corruption and violence, inequality measure, poverty indicator, in period *t* for department *i*. $\varphi_{i,t}$ is a vector that contains indicators related to the following measurements: budget execution, GDP per capita, hectares under drug cultivation, drugs seized, hectares under drug cultivation eradicated, mining production, political participation, petroleum production, production of metallic minerals, production of other non-metallic minerals and actions common crime and criminal organisations for department *i* in period *t*.

3. Estimates and results.

3.1 Estimates of technique of grouping

The figure 1-2 and table 1 shows the results of the classification of the Colombian government departments by corruption and violence levels using cluster analysis. There are clusters of mid-level corruption and violent activities around a number of departments in different Colombian regions. The economic activities in these departments are somewhat varied, but they predominantly consist of the mining, agriculture and livestock industries. Finally, the departments with a moderate level of

corruption and violence are mainly in charge of the west and centre regions. Several of these departments, which manage large populations, have the highest levels of development, and their primary economic activities include agriculture, livestock, and industry.

These results show that corruption and violence have different patterns within the Colombian departments and that issues such as economic growth and development, economic activities, localisation, natural resources, and political instability may determine higher or lower levels of corruption and violence. Various studies have demonstrated that a culture of impunity, political instability, and low economic growth and development are integral determinants of corruption and violence (Pellegrini and Gerlah 2008, Zaum and Cheng 2008, World Bank, 2003).

3.2 Estimates of the DEA

The results of the DEA analysis are plotted in Figure 1-2, tables 1 and 2. The average score for all Colombian departments during the sample period is 47.04. The departments with the best performance are Arauca, Caquetá, Casanare, Cesar, and Cundinamarca, whereas Antioquia, Sucre, Córdoba, Valle, and Atlántico display the worst performances. The scores of the DEA model are similar for the Colombian regions.

Figure 1-2 and table 1-2 show the results of the DEA model by the level of risk for the Colombian departments. The departments with middle levels of risk for corruption and violence, the average score is 45.54. Caquetá, Risaralda, and Putumayo have the best performance, whereas Nariño, Huila, and Santander show the worst performance. The departments with moderate-to-high levels of risk for corruption and violence have an average score of 40.12. Cundinamarca, San Andrés, and Quindío have the best scores, whereas Antioquia, Atlántico, and Valle show the worst performance. Comparing the two levels of risks for corruption and violence, the majority of the departments with a high level of risk for corruption and violence are above average, whereas the departments with middle and moderate levels of risk for corruption and violence are below average (see Figure 1-2). In other words, these departments may be more inclined towards an increase in the level of risk for corruption and violence.

The results of the DEA model by region show that regions vary in their patterns of the level of risk for corruption and violence. Caribbean and Orinoquía regions have more departments with higher levels of risk for corruption and violence. The middle level of risk for corruption and violence predominates in the Centre-East, Caribbean, and Amazonian regions. Finally, the moderate level of risk for corruption and violence is concentrated in the West, Caribbean, and Centre-East regions. The average scores by region range from 64.83 to 40.76.

Figure 1. Results of DEA analysis for the period 2001 – 2015. Middle level risk of violence and corruption.

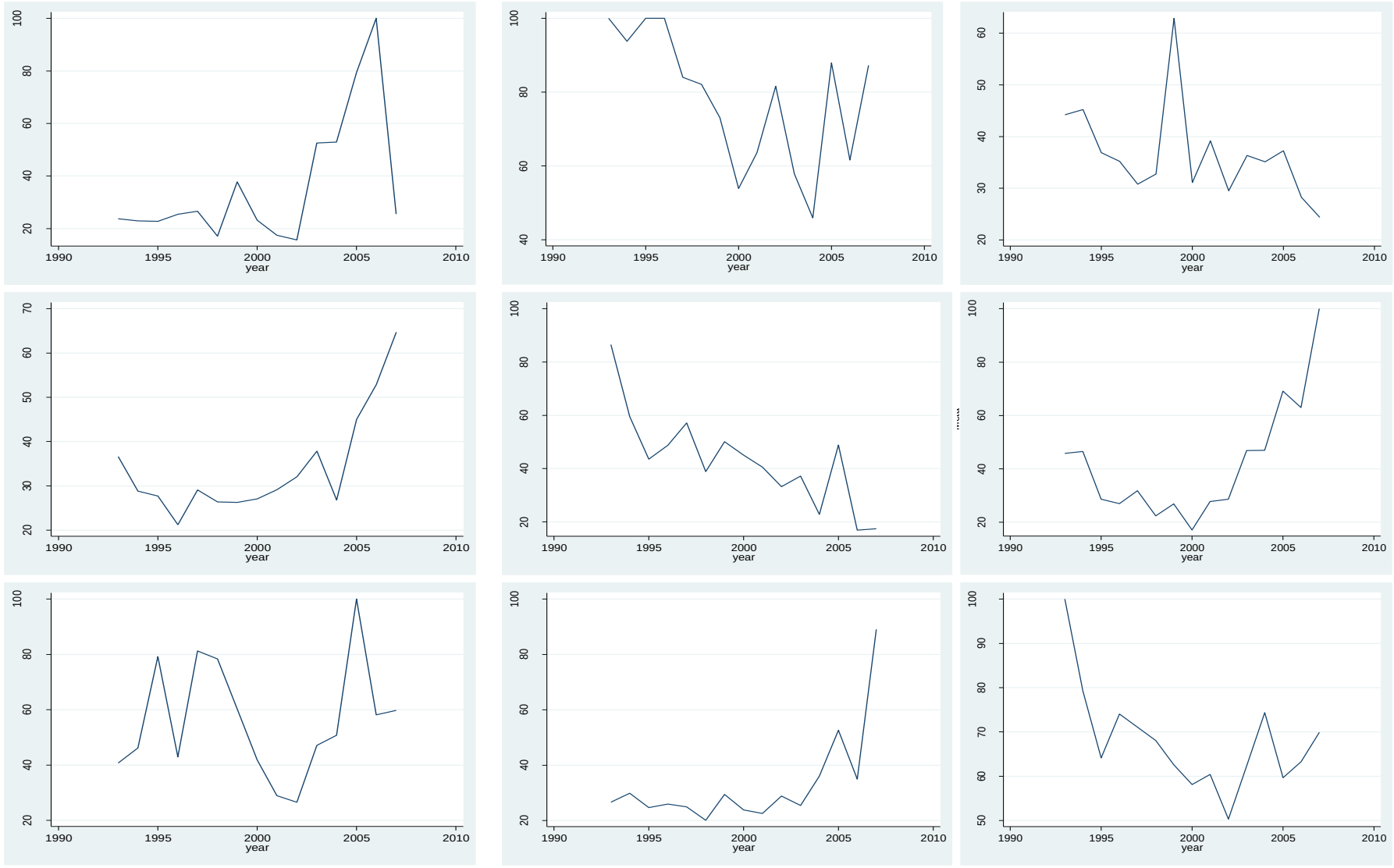

Figure 2. Results of DEA analysis for the period 2001 – 2015. Moderate level risk of violence and corruption.

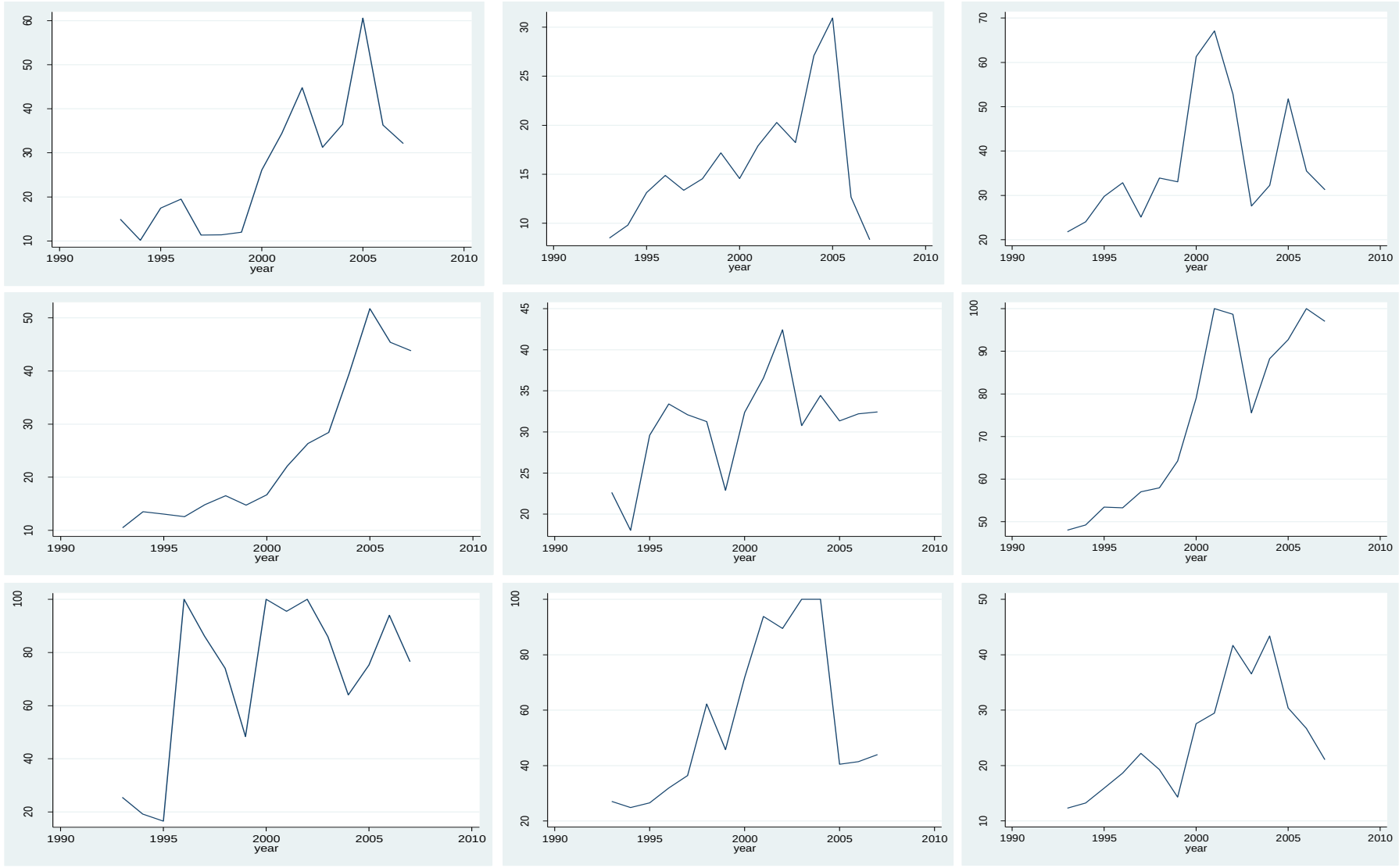

Table 1 Results of the DEA model for Colombian departments by risk level of corruption-violence

Departments	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Mean annual	Rank
Middle-Level Risk of Corruption and Violence																	
Bolivar	23.73	22.91	22.76	25.43	26.57	17.13	37.75	23.15	17.47	15.67	52.53	52.89	79.36	100.0	25.51	36.19	8
Caquetá	100.0	93.76	100.0	100.0	84.01	82.12	73.07	53.88	63.62	81.58	57.82	45.93	87.90	61.61	87.29	78.17	1
Cauca	44.20	45.22	36.91	35.20	30.79	32.74	62.87	31.10	39.16	29.52	36.36	35.12	37.24	28.23	24.36	36.60	7
Huila	36.61	28.80	27.71	21.22	29.07	26.38	26.25	27.07	29.12	32.07	37.86	26.82	45.01	52.86	64.70	34.10	10
Magdalena	86.56	59.50	43.58	48.79	57.15	38.85	50.10	45.04	40.58	33.27	37.22	22.85	48.82	16.93	17.44	43.11	4
Meta	45.78	46.47	28.60	26.94	31.78	22.36	26.88	17.11	27.79	28.61	46.83	46.93	69.13	62.97	100.0	41.88	5
Nariño	26.60	29.82	24.67	25.96	24.92	20.12	29.46	23.78	22.55	28.87	25.41	36.08	52.64	34.95	89.10	33.00	11
Putumayo	40.77	46.20	79.25	42.94	81.23	78.40	60.29	41.84	28.90	26.50	47.11	50.73	100.0	58.14	59.73	56.14	3
Risaralda	100.0	79.28	64.13	74.05	71.06	68.06	62.58	58.13	60.42	50.32	62.38	74.39	59.68	63.27	69.93	67.85	2
Santander	51.69	31.31	25.39	29.44	44.13	38.86	90.39	34.67	27.09	19.21	26.49	24.39	38.43	18.47	27.90	35.19	9
Tolima	42.96	28.81	25.61	24.74	23.90	21.67	34.60	26.05	21.20	18.75	83.97	97.79	55.65	48.40	25.76	38.66	6
Moderate-Level Risk of Corruption and Violence																	
Antioquia	8.49	9.82	13.14	14.87	13.38	14.54	17.18	14.58	17.90	20.29	18.23	27.10	30.93	12.67	8.33	16.10	9
Atlántico	14.96	10.16	17.48	19.52	11.34	11.40	11.98	26.10	34.40	44.78	31.24	36.45	60.55	36.30	32.13	26.59	6
Boyacá	21.77	24.05	29.78	32.86	25.08	33.93	33.04	61.33	67.09	52.83	27.61	32.27	51.73	35.52	31.26	37.34	4
Caldas	22.64	18.03	29.61	33.40	32.08	31.26	22.90	32.39	36.56	42.44	30.78	34.45	31.36	32.22	32.43	30.84	5
Córdoba	10.48	13.52	13.04	12.55	14.82	16.53	14.73	16.69	22.08	26.36	28.43	39.52	51.72	45.42	43.82	24.65	8
Cundinamarca	48.02	49.22	53.43	53.26	57.04	57.97	64.24	78.96	100.0	98.69	75.56	88.28	92.72	100.0	97.05	74.30	1
Quindío	27.05	24.86	26.58	31.87	36.39	62.22	45.76	71.73	93.83	89.47	100.0	100.0	40.45	41.38	43.94	55.70	3
San Andrés	25.46	19.19	16.55	100.0	86.21	74.05	48.33	100.0	95.47	100.0	85.95	64.09	75.33	94.01	76.54	70.75	2
Valle	12.28	13.21	15.92	18.64	22.21	19.25	14.29	27.55	29.46	41.69	36.55	43.39	30.39	26.68	21.04	24.84	7

Table 2 Results of the DEA analysis by Colombian regions

Departments	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Mean annual	Rank	Risk
Amazonian Region																		
Amazonas	18.16	10.99	10.99	4.39	8.86	3.14	99.42	5.51	0.51	2.29	47.84	99.23	36.55	70.64	100.0	34.57	7	H
Caquetá	100.0	93.76	100.0	100.0	84.01	82.12	73.07	53.88	63.62	81.58	57.82	45.93	87.90	61.61	87.29	78.17	1	Mid
Putumayo	40.77	46.20	79.25	42.94	81.23	78.40	60.29	41.84	28.90	26.50	47.11	50.73	100.0	58.14	59.73	56.14	3	Mid
Caribbean Region																		
Atlántico	14.96	10.16	17.48	19.52	11.34	11.40	11.98	26.10	34.40	44.78	31.24	36.45	60.55	36.30	32.13	26.59	6	Mod
Córdoba	10.48	13.52	13.04	12.55	14.82	16.53	14.73	16.69	22.08	26.36	28.43	39.52	51.72	45.42	43.82	24.65	8	Mod
Magdalena	86.56	59.50	43.58	48.79	57.15	38.85	50.10	45.04	40.58	33.27	37.22	22.85	48.82	16.93	17.44	43.11	4	Mid
Bolivar	23.73	22.91	22.76	25.43	26.57	17.13	37.75	23.15	17.47	15.67	52.53	52.89	79.36	100.0	25.51	36.19	8	Mid
Sucre	23.07	27.02	27.02	34.71	30.95	19.95	13.17	19.90	15.04	13.92	14.63	11.32	49.00	7.00	8.80	21.03	9	H
San Andrés	25.46	19.19	16.55	100.0	86.21	74.05	48.33	100.0	95.47	100.0	85.95	64.09	75.33	94.01	76.54	70.75	2	Mod
Guajira	100.0	95.93	95.93	60.43	73.29	60.82	73.35	78.26	80.23	92.21	100.0	100.0	100.0	75.97	100.0	58.32	5	H
Cesar	82.66	72.81	72.81	64.32	62.73	34.58	40.41	48.89	52.99	56.24	65.80	52.46	75.68	35.34	57.07	74.99	3	H
Centre-East Region																		
N. Santander	83.69	71.11	71.11	61.88	54.41	50.50	100.0	71.61	71.82	91.17	84.05	59.17	63.20	47.56	47.51	27.22	8	H
Santander	51.69	31.31	25.39	29.44	44.13	38.86	90.39	34.67	27.09	19.21	26.49	24.39	38.43	18.47	27.90	35.19	9	Mid
Boyacá	21.77	24.05	29.78	32.86	25.08	33.93	33.04	61.33	67.09	52.83	27.61	32.27	51.73	35.52	31.26	37.34	4	Mod
Cundinamarca	48.02	49.22	53.43	53.26	57.04	57.97	64.24	78.96	100.0	98.69	75.56	88.28	92.72	100.0	97.05	74.30	1	Mod
Tolima	42.96	28.81	25.61	24.74	23.90	21.67	34.60	26.05	21.20	18.75	83.97	97.79	55.65	48.40	25.76	38.66	6	Mid
Huila	36.61	28.80	27.71	21.22	29.07	26.38	26.25	27.07	29.12	32.07	37.86	26.82	45.01	52.86	64.70	34.10	10	Mid
West Region																		
Caldas	22.64	18.03	29.61	33.40	32.08	31.26	22.90	32.39	36.56	42.44	30.78	34.45	31.36	32.22	32.43	30.84	5	Mod
Risaralda	100.0	79.28	64.13	74.05	71.06	68.06	62.58	58.13	60.42	50.32	62.38	74.39	59.68	63.27	69.93	67.85	2	Mid
Quindío	27.05	24.86	26.58	31.87	36.39	62.22	45.76	71.73	93.83	89.47	100.0	100.0	40.45	41.38	43.94	55.70	3	Mod
Antioquia	8.49	9.82	13.14	14.87	13.38	14.54	17.18	14.58	17.90	20.29	18.23	27.10	30.93	12.67	8.33	16.10	9	Mod
Pacific Region																		
Nariño	26.60	29.82	24.67	25.96	24.92	20.12	29.46	23.78	22.55	28.87	25.41	36.08	52.64	34.95	89.10	33.00	11	Mid
Valle	12.28	13.21	15.92	18.64	22.21	19.25	14.29	27.55	29.46	41.69	36.55	43.39	30.39	26.68	21.04	24.84	7	Mod
Cauca	44.20	45.22	36.91	35.20	30.79	32.74	62.87	31.10	39.16	29.52	36.36	35.12	37.24	28.23	24.36	36.60	7	Mid
Chocó	35.86	32.27	32.27	41.61	64.98	40.37	22.22	31.19	18.81	31.42	9.40	12.42	19.41	8.84	7.30	68.59	4	H
Orinoquia Region																		
Arauca	89.20	58.96	58.96	66.49	92.40	63.87	62.73	44.57	67.85	94.40	78.33	65.57	100.0	99.47	82.00	85.76	1	H
Meta	45.78	46.47	28.60	26.94	31.78	22.36	26.88	17.11	27.79	28.61	46.83	46.93	69.13	62.97	100.0	41.88	5	Mid
Casanare	74.84	62.81	62.81	60.61	57.34	67.77	51.40	44.62	57.07	49.03	46.28	44.72	48.98	40.85	45.55	77.38	2	H
Guaviare	77.08	74.02	74.02	100.0	90.25	97.00	38.51	58.13	87.49	73.02	68.66	61.72	93.33	67.44	100.0	54.31	6	H

The Wilcoxon test detects the same distribution or a meaningful relationship among the results of the DEA model, ICV, and ITD, which is in accordance with the hypothesis H_0. The null hypothesis in each case is that the median of the coefficients of correlation for one treatment is equal to the median of the coefficients of correlation for another treatment. Table 3 summarises the results of the Wilcoxon tests, which demonstrate that the DEA model applied in this study is adequate to measure violence, corruption, and economic development.

Table 3 The compared efficiency scores from the Wilcoxon signed ranks test

Pairs	Wilcoxon signed ranks test	
	Z	P-value
All Colombian departments		
DEA vs. ICV	-3.903	0.0001
DEA vs. ITD	-3.362	0.0008
High-Level Risk of Corruption-Violence		
DEA vs. ICV	-2.666	0.0077
DEA vs. ITD	-2.666	0.0077
Middle-Level Risk of Corruption-Violence		
DEA vs. ICV	-2.756	0.0058
DEA vs. ITD	-2.490	0.0128
Moderate-Level Risk of Corruption-Violence		
DEA vs. ICV	-2.666	0.0077
DEA vs. ITD	-2.310	0.0209

***Notes**: ICV: Effectiveness index of the control of violence.*
ITD: Transparency index by department.

4. Econometric estimates with dynamic data panels

The estimates with the technique of DEA evidence fluctuation in the DEA index for Colombian departments. To interpret these fluctuations, the DEA model applies Generalised Method of Moment estimations for panel data. Tables 4, 5, and 6, illustrate the estimates of the econometric models with dynamic data panel, including those with middle-level risk, and moderate-level risk of corruption and violence.

Results for all Colombian departments

Table 4 shows the results for all Colombian departments. The lagged homicide-corruption score has a significant impact on the corruption-violence score, which suggests that corruption and violence

persist over time. Several studies have discussed various causes for this persistence of corruption and violence. The main reasons are as follows: (*i*) corruption and violent activities may become more beneficial to criminals and corrupt individuals because these groups gain more expertise, and, especially for criminal individuals, legal labour market opportunities decrease as their criminal records increase; (*ii*) the reduction in the social cost of criminal and corrupt behaviour generates more criminal and corruption activities because of the lack of a proper response from the legal system in the use of appropriate sanctions, penalties and sentences that would discourage criminal and corrupt activities; and (*iii*) the persistence of corruption and violence may reveal links between violence, corruption and other socio-economic conditions that are persistent over time (Glaeser et al., 1996, Fajnzylber et al., 2000, Levinson, 2002, Mocan et al., 2005).

Both the GINI coefficients and the Unsatisfied Basic Needs measurement show that there is a negative and significant relationship between a higher corruption and violence score and departments with higher income inequality and poverty. Various studies have demonstrated that the primary cause of poverty, inequality, and violence is corruption, which is illustrative of poor governance and mismanagement. Indeed, corruption and violence increase transaction costs, making financial aspects more difficult for the poor, and they corrode the trust that a society needs to function effectively. Furthermore, corruption generates and deepens social cleavages while increasing social exclusion and societal fragmentation (Gupta et al., 1998, Narayan et al., 2000, Eberlei and Führmann, 2004).

Variables representing economic development show that departments with lower budget execution and mining production have higher levels of corruption and violence, whereas departments with higher GDP per capita generate lower corruption and violence. These results are consistent with various studies in the Colombian context that argue that budget execution is low in departments with higher mining exploitation. Therefore, criminal and corrupt individuals have more opportunities to pursue criminal activities because these departments receive substantial royalties from the exploitation of mineral resources (Gamarra, 2005, 2006, ESMAP, 2005, Fischer, 2007). Likewise, as illustrated in the results, the presence of armed groups and illegal drug trade in these zones generates a higher level of corruption and violence, although these variables are not significant in the model.

Table 4 Dependent variable: Violence-Corruption DEA score. All Colombian departments

Variables	[1]	[2]	[3]	[4]
Constant	4.046 [a]	3.989 [a]	3.933 [a]	4.171 [a]
	(1.019)	(1.019)	(1.020)	(1.048)
Lagged homicides- corruption score	0.165 [b]	0.173 [b]	0.162 [b]	0.159 [b]
	(0.070)	(0.069)	(0.070)	(0.068)
Budget execution	-0.160 [a]	-0.156 [a]	-0.149 [a]	-0.159 [a]
	(0.056)	(0.055)	(0.055)	(0.056)
GDP per capita	0.121 [a]	0.120 [a]	0.121 [a]	0.120 [a]
	(0.039)	(0.039)	(0.039)	(0.039)
Hectares under drug cultivation	-0.009	-0.005	-0.007	-0.004
	(0.026)	(0.026)	(0.027)	(0.027)
Drugs seized	0.006	0.005	0.005	0.006
	(0.014)	(0.014)	(0.014)	(0.014)
Hectares under drug cultivation eradicated	0.003	0.002	0.002	0.003
	(0.006)	(0.006)	(0.006)	(0.006)
GINI	-2.495 [a]	-2.540 [a]	-2.505 [a]	-2.459 [a]
	(0.719)	(0.722)	(0.723)	(0.723)
Unsatisfied basic needs	-0.012 [b]	-0.014 [b]	-0.012 [b]	-0.013 [b]
	(0.006)	(0.006)	(0.006)	(0.006)
Mining production	-0.074 [c]	-0.064	-0.077 [c]	-0.078 [c]
	(0.041)	(0.042)	(0.041)	(0.041)
Political participation	-0.338	-0.373	-0.318	-0.364
	(0.461)	(0.462)	(0.472)	(0.463)
Armed actions	-0.000			
	(0.001)			
Actions National Liberation Army (ELN)		-0.002		
		(0.001)		
Actions Popular Liberation Army (EPL)			-0.001	
			(0.002)	
Actions Common Crime and criminal organisations				-0.001
				(0.001)
Specification test (p-values)				
Sargan test	0.056	0.071	0.060	0.058
Second-order Correlation	0.229	0.179	0.240	0.231
No. Obs	170	170	170	170

***Notes**: All models are estimated using the Arellano-Bover/Blundell-Bond linear dynamic panel-data system GMM estimations. Figures in parentheses are standard errors. [a] Significant at the 1% level, [b] Significant at the 5% level, [c] Significant at the 10% level.*

Results for Departments with Middle-Level Risk of Corruption-Violence

Table 5 shows the results for departments with a middle-level risk of corruption and violence. In these departments, the lagged homicide-corruption score, the GINI coefficient, the production of coal, lignite, and peat, and the actions of paramilitaries are significantly correlated with the corruption-violence score. This indicates that corruption and violence persist over time and that higher inequality, production of coal lignite and peat and actions of paramilitaries generate higher corruption and violence.

Table 5 Dependent variable: Violence and Corruption DEA score. Departments with middle-level risk of violence and corruption

Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Constant	1.419	4.518 [a]	1.261	3.048 [c]	3.301 [b]	2.832 [c]	3.159 [c]
	(1.719)	(1.604)	(1.375)	(1.707)	(1.676)	(1.641)	(1.705)
Lagged homicides-Corruption score	0.328 [a]	0.298 [a]	0.331 [a]	0.377 [a]	0.368 [a]	0.358 [a]	0.337 [a]
	(0.099)	(0.100)	(0.100)	(0.112)	(0.104)	(0.104)	(0.105)
Drugs seized	0.019	0.021	0.019	0.025	0.027	0.027	0.033
	(0.023)	(0.024)	(0.023)	(0.026)	(0.025)	(0.025)	(0.025)
Hectares under drug cultivation eradicated	0.011	0.009	0.011	0.008	0.009	-0.008	0.009
	(0.009)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
GINI	-3.310 [b]	-0.184	-3.259 [b]	-0.434	-0.418	-0.375	-0.343
	(1.317)	(0.737)	(1.339)	(0.725)	(0.708)	(0.728)	(0.743)
Unsatisfied basic needs	-0.059	-0.376	-0.051	-0.307	-0.370	-0.236	-0.237
	(0.309)	(0.459)	(0.303)	(0.481)	(0.479)	(0.473)	(0.478)
Budget execution	-0.016						
	(0.068)						
Production of coal, lignite and peat.		-0.105 [a]					
		(0.032)					
Production of Metallic minerals		-0.000					
		(0.000)					
Production of other non-metallic minerals		-0.087					
		(0.061)					
Armed actions			-0.019				
			(0.063)				
Actions Revolutionary Armed Forces of Colombia (FARC)				-0.001			
				(0.002)			
Actions National Liberation Army (ELN)				-0.001			
				(0.003)			
Actions Popular Liberation Army (EPL)				-0.004			
				(0.006)			
Actions United Self-Defence Forces of Colombia (AUC) – Paramilitary					-0.014 [c]		
					(0.008)		
Actions Common Crime and criminal organisations						0.001	
						(0.001)	
Political Participation							-0.681
							(0.862)
Specification test (p-values)							
Sargan test	0.129	0.152	0.127	0.101	0.149	0.085	0.111
Second-order Correlation	0.573	0.643	0.576	0.776	0.657	0.826	0.566
No. Obs	99	99	99	99	99	99	99

***Notes**: All models are estimated using the Arellano-Bover/Blundell-Bond linear dynamic panel-data system GMM estimations. Figures in parentheses are standard errors. [a] Significant at the 1% level, [b] Significant at the 5% level, [c] Significant at the 10% level.*

This result illustrates the close relationship between corruption, violence and the illegal drug trade. Because Colombian illegal arms groups principally finance their activities using narcotics trafficking, they become a cause of corruption. Moreover, in Colombia, the corruption that is usually linked to violence and the narcotics trade has implicated powerful legislators, judges, and military officials (Charry, 2002, Rodriguez and Seligson, 2008, Friedman, 2009, Acemoglu et al., 2010), supporting the results of this study.

The variable of political participation shows that an increase in this variable generates a lower corruption-violence score. Thus, in departments with active, effective, and democratic institutions, an effective and independent judicial system, and active political participation, there is an increase in the probability of detection and punishment of corrupt and criminal activities, thereby reducing corruption and violence over time, in accordance with Sandholtz and Koetzle, (2000), Bohara et al., (2004), and Saha and Campbell, (2007), among others.

Results for Departments with a Moderate-Level Risk of Corruption-Violence

The results of the econometric model for departments with a moderate level of risk for corruption and violence are described in Table 6. A lagged homicide-corruption score, the estimates for cocaine and cocaine paste seized and the unsatisfied basic needs are variables with significant effects on the corruption-violence score. Therefore, departments with higher cocaine and cocaine paste trafficking have lower levels of corruption and violence, whereas departments with higher unsatisfied basic needs have higher levels of corruption and violence, which tends to remain for an extended period of time.

Furthermore, the results indicate direct relationships between poverty and inequality and the corruption-violence score, which is characterised by low income, poor health and education status, lack of opportunities in the labour market, insecurity, poor government and public management, and other features that decrease economic growth and development. In the literature, the relationship between poverty, corruption, and violence can be explained by two models. (*i*) The *economic model* argues that corruption and violence affect poverty and inequality by altering and discouraging economic growth and development factors, such as foreign and domestic investments, taxing and dampening entrepreneurship, lowering the quality of public infrastructure, decreasing tax revenue, distorting the composition of public expenditure and budget execution, and forcing households and businesses to pay a higher proportion of their income in bribes, thus lowering the income of both households and businesses. (*ii*) The *governance model* argues that corruption and violence affect poverty because they affect governance factors, leading to a reduction in governance capacity and generating weak political institutions, lower citizen participation, a decrease in productivity, and a lower quality of government management, services, security and infrastructure (World Bank, 2000, Mauro, 2002, 1995, Kaufmann and Kraay, 2002, Chetwynd et al., 2003, Goel and Nelson, 2010).

The results of this study demonstrate that Colombian departments that have low economic development, and socioeconomics circumstances and exploitation of mineral resources, illegal drug trade, and the presence of irregular armed groups are prone to higher corruption and violence. This finding illustrates the importance of building and generating strong, legitimate and effective institutions, and governance and public management systems that provide necessary aspects, such as citizen security, an effective justice system, adequate social investments, and job opportunities, all of which are needed to break the cycle of corruption and violence in Colombia.

Table 6 Dependent variable: Violence-Corruption DEA score. Departments with a moderate level of violence-corruption

Variables	**[1]**	**[2]**	**[3]**	**[4]**	**[5]**
Constant	0.969 [c]	5.921 [a]	5.541 [a]	5.518 [a]	5.546 [a]
	(0.588)	(1.265)	(1.448)	(1.458)	(1.437)
Lagged homicides-corruption score	0.721 [a]	0.630 [a]	0.625 [a]	0.624 [a]	0.604 [a]
	(0.072)	(0.071)	(0.072)	(0.072)	(0.073)
Budget execution	-0.030	-0.035	-0.013	-0.013	-0.017
	(0.040)	(0.038)	(0.053)	(0.054)	(0.053)
Cocaine seized	0.032 [b]	0.031 [b]	0.029 [b]	0.029 [b]	0.028 [b]
	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)
Cocaine paste seized	0.030	0.071	0.074 [b]	0.013	0.080 [a]
	(0.040)	(0.029)	(0.029)	(0.054)	(0.029)
GINI	-0.166	-0.626	-0.583	-0.581	-0.507
	(1.227)	(1.172)	(1.184)	(1.190)	(1.177)
Unsatisfied basic needs		-1.325 [a]	-1.230 [a]	-1.221 [a]	-1.165 [a]
		(0.303)	(0.367)	(0.372)	(0.367)
Mining production			-0.019	-0.019	-0.026
			(0.039)	(0.039)	(0.039)
Armed actions				-0.000	
				(0.001)	
Actions Common Crime and criminal organisations					-0.001
					(0.001)
Specification test (p-values)					
Sargan test	0.110	0.243	0.195	0.201	0.201
Second-order Correlation	0.479	0.452	0.505	0.563	0.561
No. Obs	123	123	123	123	123

***Notes**: All models are estimated using the Arellano-Bover/Blundell-Bond linear dynamic panel-data system GMM estimations. Figures in parentheses are standard errors.* [a] Significant at the 1% level, [b] Significant at the 5% level, [c] Significant at the 10% level.

5. Conclusions

In this research the different dynamic interactions between institutional variables, instability and economic development taking as a case study to Colombia during the 2001-2015 period given the availability of data is displayed. Several measurement techniques are used to contrast the main findings of the work, also the different estimates were presented using different empirical methodologies and consistency tests, including cluster analysis, the DEA, dynamic panel data models, these models are accompanied by evidence of robustness and reliability with the application of the test data envelopment analysis DEA degrees of freedom for DMUs, the Wilcoxon analysis and dynamic panel data with the Sargan test. The techniques used in this research show that models generate consistent estimates applied in the institutional economic analysis of violence, corruption and economic development.

The main findings of the study show consistent estimates with empirical evidence showing how corruption and violence over time have adverse effects on economic development. The results indicate that by not fighting corruption, productivity, investment, capital and, therefore, economic growth and development decreases over time. From this perspective, the regression analysis using panel data techniques showed that poverty, inequality, drug trafficking, the actions of armed agents affect violence. It was also established that corruption negatively affects business growth. From the methodology and techniques employed, it was determined that these variables are suitable to analyze the incidence of corruption and violence in the growth and economic development.

Our framework suggests that appropriate institutional policy is to strengthen the interactions between different economic agents, transparent participation in decision-making adequate and strengthened governance, strengthening the judicial system and adequate efficient resource allocation system. This would greatly decrease the vicious cycle that hampers development and economic growth of countries, Cotte (2011).

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