## Digital Infrastructure and Corruption: Identifying the Mechanisms

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### 2. Abstract

This paper investigates how digital access—proxied by mobile cellular subscriptions—affects corruption across countries, and under what conditions this relationship arises from. Leveraging a panel dataset spanning up to 176 countries from 1980 to 2023, the study employs fixed-effects regressions using two dependent variables: (1) the CPIA Transparency and Accountability score and (2) the World Governance Indicators (WGI) Control of Corruption estimate.

Results reveal a consistent and statistically significant association between increased mobile subscriptions and improved corruption outcomes, particularly when measured using the WGI index. These effects persist across multiple specifications, including region-by-year fixed effects, and remain robust when controlling for demographic and institutional mechanisms such as urbanization, working-age population, and women's legal rights (WBL Index). Interaction models suggest that the anti-corruption impact of digital infrastructure is amplified in more urbanized and institutionally inclusive contexts.

While endogeneity and measurement limitations remain, the findings underscore the promise of mobile-based technologies in reducing corruption—especially when deployed alongside particular country characteristics. This study contributes to a growing literature on technology and governance, offering practical insights for policymakers seeking to leverage digital transformation in support of institutional accountability.

### 3. Introduction

Corruption remains a significant barrier to economic development and effective governance worldwide. In response, governments and development institutions have increasingly promoted digital systems as tools to reduce corruption by enhancing transparency, accountability, and traceability. While empirical evidence broadly supports an association between digital adoption

and lower corruption levels (Guriev et al., 2021), the mechanisms through which this relationship operates remain underexplored.

This paper seeks to fill that gap by empirically investigating the channels through which digital systems—proxied by mobile cellular subscriptions—affect corruption outcomes across countries. Specifically, it asks: through what institutional, demographic, or infrastructural conditions do digital payment systems most effectively reduce corruption? We focus on mechanisms including geographic composition (e.g. urban infrastructure), demographic dynamics (e.g., share of working-age population), and institutional quality (e.g., legal protections for women's participation in the economy).

To strengthen the credibility of our findings, we conduct a series of fixed-effects regressions using two complementary corruption metrics: the CPIA Transparency and Accountability score and the World Governance Indicators' Control of Corruption estimate. We construct a country-year panel covering 1980 to 2023 and 176 countries. With a complete dataset, we conduct multiple robustness checks including region-year fixed effects and alternate dependent variable specifications.

By disentangling the conditions under which digital information systems reduce corruption, this study not only contributes to a growing literature on governance and digitization but also offers practical insights for policymakers, especially in emerging economies undergoing rapid digital transformation.

### 4. Literature Review

Existing literature provides strong evidence for a negative correlation between digital services and corruption but offers limited insight into the mediating mechanisms. Ahmed and Mohanty (2021) confirm this general relationship through an extensive panel data analysis of 111 developing countries, revealing a significant association between increased digital payment transactions and reduced corruption levels. While their work establishes the empirical foundation, it does not examine the specific channels or contextual factors that underpin this relationship.

A potential mechanism explored by Mackey, T. K., & Cuomo (2020) highlights the role of transaction costs and information asymmetries. Their research in the pharmaceutical industry suggests that digital technologies can detect and prevent fraud and corruption, which are particularly important to address barriers to access, such as availability and affordability. The findings can be transcribed to the topic of this study as minimizing the burdens placed upon citizens through effective taxpayer dollar use and minimal rent extraction from incumbents. This works through the mitigation of corruption by reducing the scope for rent-seeking behaviors and enhancing transparency in the practices of incumbents, particularly within low-infrastructure environments. This implies that mechanisms such as improved information flow and reduced transaction costs could be critical to understanding how digital payments curb corruption.

Further, La Porta and Shleifer (2014) emphasize the importance of informality in shaping governance outcomes. They argue that high levels of economic informality contribute significantly to corruption and weak governance by limiting the state's reach and ability to pose transparency. Extending their logic, digital payment systems could potentially disrupt informal economic networks, reducing cash dependency and thereby narrowing opportunities for corruption. However, empirical tests of this hypothesis remain relatively sparse.

Recent research by Guriev et al. (2021) further deepens the theoretical rationale for investigating the technological mechanisms behind corruption reduction. Their cross-country study shows that the expansion of 3G mobile broadband networks enhances citizens' ability to detect and respond to corruption by increasing exposure to both factual and political information, thereby poking at the similar underlying mechanism shown in Mackey et. al and La Porta et. al through a greater information environment. By examining heterogeneity in corruption perceptions across areas with and without 3G coverage, the study provides empirical evidence that digital infrastructure enables greater public awareness of misgovernance. This aligns closely with the mechanism explored in the present paper: improved technological access—captured through mobile cellular subscriptions and urbanization—as a potential pathway linking digital payment adoption to reduced corruption.

This paper extends the existing literature by explicitly examining the potential mechanisms—such as urbanization, demographic composition, and legal frictions to business as proxies for digital infrastructure access, and technological penetration—that may mediate the relationship between digital payment adoption and corruption reduction. By explicitly focusing on these channels rather than simply establishing a correlation, the research addresses a critical gap identified in prior studies. This nuanced understanding will offer valuable contributions to both academic literature and practical policy development.

## 5. Data & Methodology

This study constructs a panel dataset covering up to 176 countries from 1980 to 2023 to empirically examine how digital infrastructure influences corruption, and through what mechanisms this relationship operates. The dataset integrates variables from multiple open-access sources - mostly the World Bank- with the goal being to capture a distinct aspect of the theoretical framework. Additionally, region and sub-region classifications are merged from the United Nations Statistics Division's M49 standard to enable regional fixed-effects modeling and robustness checks (United Nations Statistics Division, 2023).

The primary dependent variables are two measures of corruption (to act as a robustness check). (1) the CPIA Transparency, Accountability, and Corruption in the Public Sector rating, which scores countries from 1 to 6 based on expert institutional assessments and is published by the World Bank for IDA-eligible (i.e., lower- and middle-income) countries. (2) the World Governance Indicators (WGI) Control of Corruption estimate, which ranges from –2.5 (highly corrupt) to +2.5 (very clean) and is globally available. These two indicators allow for cross-validation of findings and provide robustness across different corruption definitions, sampling frames, and measurement philosophies. Both come courtesy of the publicly available World Bank World Development Indicators.

The primary independent variable is Mobile Cellular Subscriptions per 100 people, sourced from the World Bank's World Development Indicators. This is used as a proxy for the diffusion of digital infrastructure. Due to its right-skewed distribution in many low- and middle-income countries, a log transformation is applied for selected specifications. The distribution of this variable, alongside the dependent variables and mechanism proxies, is shown in *Figure 1*.

To provide temporal context, *Figure 2* presents time trend plots for key variables. Mobile subscriptions, urban population percentage, and working-age population percentage all show steady global growth over the decade, suggesting structural shifts in both digital capacity and demographics. Meanwhile, CPIA corruption scores exhibit a slight decline over time, while WGI corruption estimates remain relatively stable before rising in recent years. The reasoning for such divergence is likely a testament to the difference in sampling of both variables, in that neither capture the population (all the countries in the world between 1980-2023), but rather, represent their respective samples to which they reflect.

To investigate mechanisms, three additional covariates are included in the study:

- (1) Urban Population (% of total population) Do greater urbanization rates reflect greater technological adoption, thereby reducing corruption?
- (2) Working-Age Population (% of total population ages 15–64) Does a stronger workforce demonstrate greater technological preparedness, thereby reducing corruption?
- (3) WBL Index (0–100) sourced from the World Bank's *Women, Business, and the Law* dataset, this serves as a proxy for institutional quality and economic inclusiveness, particularly around women's legal rights. The most esoteric of the three, this covariate asks whether greater democratic freedoms and stronger business environments correlate with technological adoption and thereby whether that channels an influence to corruption.

Descriptive statistics for all variables used in the analysis are presented in Table 1. This summary statistics table includes the number of observations, mean, standard deviation, minimum, and maximum for each key variable. Notably, the mean corruption score from the WGI dataset is approximately -0.02, while the mean CPIA score is 2.9. Mobile subscriptions range widely from 0 to 421 per 100 people, with an average of 42, underscoring the global disparity in digital infrastructure access.

To provide intuition around the relationship of interest, *Figure 3* and *Figure 4* provide bivariate scatterplots of mobile subscriptions against each corruption metric (CPIA and WGI respectively), illustrating a clear positive association between digital infrastructure and reduced corruption. These visuals motivate the regression analyses that follow.

All data sources are merged using ISO3 country codes and matched on the calendar year. Observations with missing dependent variable values are dropped from the corresponding estimation sample. The regression-ready panel for the CPIA-dependent models includes approximately 1,300–1,400 observations, while the WGI-based models draw on a much larger sample of over 4,600 country-year pairs.

To examine how digital infrastructure affects corruption—and under what conditions—this study employs a series of linear panel regression models, progressing from baseline specifications to more complex designs that isolate potential mechanisms. The primary goal is to test whether higher rates of mobile subscription (used as a proxy for digital access) are associated with lower corruption scores, while also investigating whether this relationship varies across institutional, infrastructural, or demographic contexts.

We begin with a pooled OLS regression of corruption on mobile subscriptions. While this model offers an initial view of the relationship across countries, it does not account for persistent differences across countries or global year-specific shocks. To address this, we next introduce country and year fixed effects in a two-way fixed effects (TWFE) specification. The TWFE model absorbs all time-invariant country characteristics—such as geography, historical institutions, and long-run legal capacity—and global shocks or policy trends that affect all countries simultaneously in a given year (e.g., major international anti-corruption efforts or digital infrastructure policy shifts). This specification therefore strengthens the plausibility of causal inference by relying only on within-country, over-time variation.

Formally, the fixed-effects model is expressed as:

Corruption<sub>it</sub> = 
$$\beta_1$$
 \* MobileSubs<sub>it</sub> +  $\alpha_i$  +  $\lambda_t$  +  $\epsilon_{it}$  (1)

where  $\alpha_i$  are country fixed effects,  $\lambda_t$  are year fixed effects, and  $\epsilon_{it}$  is the idiosyncratic error term. This model leverages within-country, over-time variation in mobile adoption while controlling for time-invariant characteristics and global shocks. Cluster-robust standard errors are used throughout, done so at the country level to account for serial correlation in error terms.

To gauge mechanistic effects, we extend the TWFE model by introducing both direct mechanism variables (e.g., urban population %, working-age population %, and the WBL Index) and interaction terms between these variables and mobile subscriptions. These interactions allow us to examine whether the anti-corruption effects of digital infrastructure are conditional on the level of geographic composition, demographic composition, or institutional inclusivity. This step explicitly engages with the theoretical claim that digital tools reduce corruption not uniformly, but more effectively under certain enabling conditions.

We also estimate a model with region-by-year fixed effects in place of country fixed effects, offering a more thorough robustness check that controls for regional-level shocks (e.g., regional trade agreements or NGO initiatives in a given region) while retaining more cross-country variation. Comparing these models allows us to assess how robust the observed patterns are to different specifications and sampling assumptions.

Finally, to ensure that our findings are not specific to any single corruption measurement approach, we replicate all specifications using two separate dependent variables: the CPIA Transparency and Accountability score (institutional, lower-income sample) and the WGI Control of Corruption estimate (perception-based, global sample). *Tables 1* and *2* report results from these complementary models, respectively.

Regression results are in *Table 2* for the CPIA models and *Table 3* for the WGI models. These include OLS, fixed-effects, and mechanism interaction specifications. The inclusion of both region-year and country-year fixed effects further supports robustness and improves model precision.

### 6. Results

This section presents the results from the regression analyses examining the relationship between mobile financial infrastructure (proxied by mobile subscriptions per 100 people) and corruption outcomes, as measured by both the CPIA Transparency and Accountability score and the WGI Control of Corruption estimate. Full regression outputs are reported in *Table 2* for CPIA-based models and *Table 3* for WGI-based models.

#### 6.1 Baseline OLS Results

We begin by estimating a pooled OLS regression of corruption on mobile subscriptions. In both specifications, the coefficient on mobile subscriptions is positive and statistically significant at the 1% level, suggesting that greater mobile infrastructure is associated with lower levels of corruption. Specifically, the coefficient in the CPIA model (*Table 2, Column 1*) indicates that a one-unit increase in mobile subscriptions (per 100 people) is associated with a 0.004-point increase in the CPIA score. Similarly, in the WGI model (*Table 3, Column 1*), mobile subscriptions are positively associated with improved corruption scores, an associated .007-point increase in WGI rating, even when using a broader and perception-based corruption index. A crucial point worth noting here is the nature of which both DV's are standardized (1 - 6 for CPI and -2.5 - 2.5 for WGI).

While informative, these results may be biased by unobserved country characteristics or global trends.

#### **6.2 Fixed Effects Models**

To address unobserved heterogeneity, we estimate two-way fixed effects (TWFE) models that control for country and year effects. Once fixed effects are introduced, the coefficient on mobile subscriptions in the CPIA model becomes statistically insignificant (*Table 2, Column 2*), suggesting that the observed correlation may be driven by structural country-level differences.

However, in the WGI-based specification, the coefficient remains positive and significant at the 5% level even under fixed effects (*Table 3, Column 2*). This supports the robustness of the association between mobile infrastructure and perceived corruption control, even when accounting for time-invariant country traits and global year-specific factors. This may be due to the variation in data capture of both dependent variables, as neither reflects a complete population picture of all country-years between 1980-2023, but rather a select sample in each.

#### 6.3 Mechanism Variables and Interactions

To explore potential mechanisms, we introduce urban population share, working-age population share, and the WBL Index into the fixed effects models. In the CPIA specification ( $Table\ 2$ ,  $Column\ 3$ ), neither urbanization, working-age population, nor the WBL Index show consistently significant associations with improved corruption outcomes. However, in the interaction model ( $Table\ 2$ ,  $Table\ 2$ ), the interaction term between mobile subscriptions and urban population share is marginally significant (p < 0.1), suggesting that the anti-corruption impact of mobile infrastructure may be amplified in more urbanized environments. This result echoes theories from the literature review about enhanced information environments and city-level "network effects" supporting transparency and digital access.

In contrast, the WGI-based models ( $Table\ 3$ ) provide stronger and more consistent insights. When mechanism variables are added ( $Column\ 3$ ), the WBL Index is positively and significantly associated with improved corruption control (p < 0.01), and becomes even more pronounced in the region-year fixed effects specification ( $Column\ 6$ , p < 0.001). While interaction terms remain statistically insignificant across WGI models ( $Column\ 4$ ), the underlying mechanism variables themselves—especially the WBL Index and urban population share—exhibit clearer patterns of significance, especially under broader sample coverage.

#### 6.4 Interpretation and Robustness

Across specifications, the association between mobile subscriptions and reduced corruption holds most strongly in the WGI models, which benefit from broader global coverage ( $N \approx 4,600$ ) compared to the more institutionally narrow CPIA sample ( $N \approx 1,300$ ). The effect of mobile infrastructure remains statistically significant in the OLS, two-way fixed effects, and notably, in the region-by-year fixed effects model (*Table 3, Column 5*, p < 0.001), even without the inclusion of mechanisms. This demonstrates robust evidence that mobile infrastructure is independently associated with improved corruption outcomes in the WGI sample.

Once mechanisms are added (*Table 3, Column 6*), the relationship between mobile subscriptions and corruption remains highly significant (p < 0.001), and the inclusion of institutional and infrastructural mechanisms such as the WBL Index and urban population share further improves model fit ( $R^2$  within increases from 0.183 to 0.350). This supports the interpretation that while mobile infrastructure is effective on its own, it is even more impactful when embedded within enabling institutional and urban contexts for all citizens in a given country.

In the CPIA specifications, results are weaker but directionally consistent. The effect of mobile subscriptions falls off with fixed effects and becomes statistically insignificant until region-by-year fixed effects are introduced (*Table 2, Column 5*), where the coefficient regains significance at the 5% level. This points to meaningful between-country variation being absorbed in strict country-level models, but also hints at the value of regional shocks or development patterns that support digital adoption.

These patterns are further visualized in *Figures 3 and 4*, which depict positive associations between mobile subscriptions and both corruption scores. Taken together, the results suggest a robust and policy-relevant relationship between digital infrastructure and effective governance—particularly in contexts where urbanization, demographic capacity, and institutional inclusion support the effectiveness of technological tools.

## 10. Conclusion

This paper investigates the relationship between digital infrastructure and corruption, focusing specifically on how the expansion of mobile technology may reduce corruption through demographic, institutional, and infrastructural mechanisms. Using a multi-source panel dataset covering up to 176 countries from 1980 to 2023, we find robust and consistent evidence that higher mobile subscription rates are associated with improvements in corruption outcomes—especially when measured using the World

Governance Indicators (WGI) Control of Corruption index, which offers broader global coverage and perception-based measurement.

While the association between mobile subscriptions and corruption appears weaker in the CPIA-based fixed effects models, it becomes statistically significant once regional-time variation is introduced through region-by-year fixed effects. More notably, the WGI models retain strong significance across all specifications—including both two-way and region-year fixed effects—and remain robust to the inclusion of mechanism variables - the key finding of this study. This suggests that digital infrastructure may independently reduce corruption, but its effects are amplified in environments characterized by higher urbanization, inclusive legal frameworks (as proxied by the WBL Index), and favorable demographic composition (greater working-age population share).

These findings reinforce the idea that mobile-enabled systems do not reduce corruption in isolation—they are most effective when layered atop additional network effects, favorable demographic composition, and inclusive governance. In particular, the significance of mobile infrastructure in region-year models indicates that anti-corruption effects may emerge in response to broader regional reforms or digital ecosystem spillovers, not simply within-country trends.

That said, the analysis is not without limitations. (1) Endogeneity remains a concern: rising mobile adoption may co-evolve with governance improvements, making it difficult to isolate causal direction. While fixed effects help address some forms of bias, reverse causality and omitted variable bias cannot be fully ruled out. (2) The measurement error in cross-national indices such as WGI and CPIA may dilute effect sizes - as they are only reflective of their respective samples. (3) The study relies on mobile subscriptions as a proxy for digital access, which may overlook more modern innovations like broadband, social media, or internet access.

Future research could address these limitations by adopting dynamic panel models or instrumental variable strategies to sharpen causal inference. Additionally, incorporating subnational or user-level

data—such as household access to media platforms, open internet access, or similar proxies—could reveal how corruption outcomes shift with digital inclusion on the ground. Finally, scholars should further explore how state capacity, trust in institutions, and digital literacy shape the effectiveness of mobile financial infrastructure as an anti-corruption mechanism - that is, how effective it is and how to optimize levels of effectiveness through education .

In sum, this study provides strong support for the role of mobile-based digital infrastructure in reducing corruption—particularly when implemented alongside complementary institutional and infrastructural investments. As global momentum for digital public goods accelerates, aligning such tools with accountable, inclusive systems will be critical to unlocking their full governance potential.

### 11. Citation List

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# 12. Appendix

**Table 1: Summary Statistics** 

Variable	N	Mean	SD	Min	Max
<chr></chr>	<db1></db1>	<db1></db1>	<dbl></dbl>	<db1></db1>	<db1></db1>
1 corruption	<u>4</u> 702	-0.02	1.01	-1.94	2.46
2 cpi	<u>198</u> 999	2.9	0.62	1	4.5
3 log	<u>10</u> 704	2.28	2.06	0	6.04
4 mobile	<u>10</u> 704	42.0	52.2	0	421.
5 urban	<u>990</u> 787	43.6	18.7	2.08	100
6 wbl	<u>851</u> 073	76.5	10.9	17.5	100
7 working	1 <u>010</u> 803	59.3	5.85	45.4	85.2

Figure 1: Distribution of Key Variables

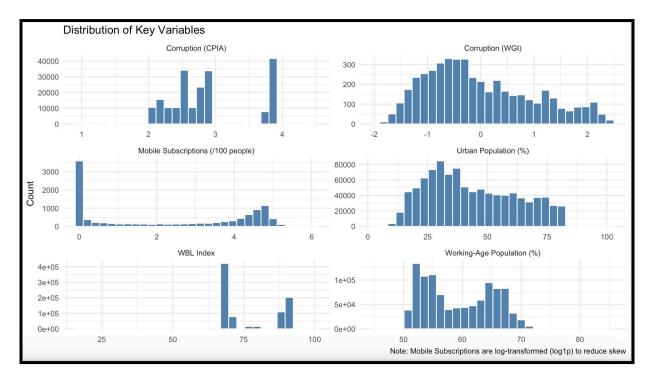


Figure 2: Variables Histogram

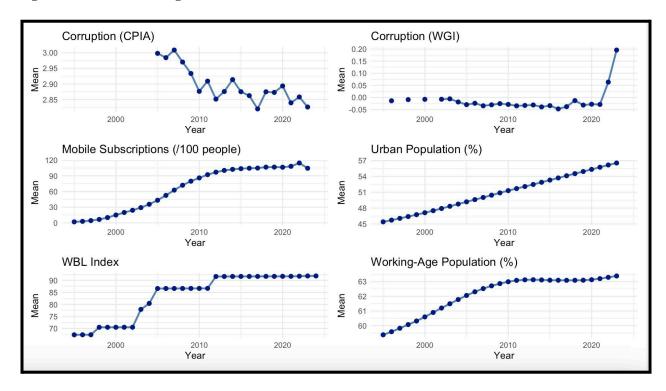
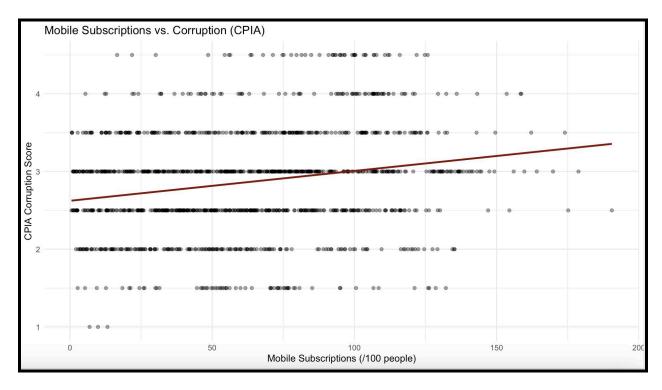


Figure 3: Corruption (CPI) vs. Mobile Subscriptions



**Table 2: CPI-Based Models** 

	OLS	FE	FE + Mechanism	FE + Interactions	Region + Year FE	Region & Year FE + Mechanism
(Intercept)	2.623***					
	(0.037)					
mobile_subs	0.004***	0.001	0.001	-0.005	0.007*	0.004
	(0.001)	(0.001)	(0.001)	(0.006)	(0.002)	(0.003)
urban_pct			-0.028+	-0.039*		-0.000
			(0.016)	(0.018)		(0.003)
working_age_pct			0.009	0.018		0.044+
			(0.018)	(0.022)		(0.018)
wbl_index			0.001	-0.006		0.010
			(0.003)	(0.004)		(0.006)
mobile_subs × urban_pct				0.000+		
				(0.000)		
mobile_subs ×				-0.000		
working_age_pct						
				(0.000)		
mobile_subs × wbl_index				0.000*		
	_			(0.000)		
Num.Obs.	1303	1303	1293	1293	1303	1293
R2	0.043	0.853	0.856	0.864	0.225	0.338
R2 Adj.	0.043	0.840	0.843	0.852	0.212	0.325
R2 Within		0.004	0.024	0.080	0.091	0.226
R2 Within Adj.		0.003	0.021	0.075	0.090	0.224
AIC	2681.1	445.8	420.4	349.9	2447.8	2233.9
BIC	2691.4	983.7	967.9	912.8	2566.8	2368.2
RMSE	0.68	0.27	0.26	0.25	0.61	0.56
Std.Errors	IID	by: iso3	by: iso3	by: iso3	by: region	by: region
FE: year		X	X	X	Х	X
FE: region					×	×
		X	X	×		

**Table 3: WGI-Based Models** 

	wgi_OLS	wgi_FE	wgi_FE + Mechanism	wgi_FE + Interactions	wgi_Region + Year FE	wgi_Region + Year FE: Mechanisms
(Intercept)	-0.555***					
	(0.024)					
mobile_subs	0.007***	0.001**	0.002**	-0.001	0.011***	0.006***
	(0.000)	(0.000)	(0.001)	(0.003)	(0.001)	(0.001)
urban_pct			0.002	0.004		0.011***
			(0.004)	(0.005)		(0.003)
working_age_pct			-0.005	-0.008		0.023*
			(0.006)	(0.007)		(0.009)
wbl_index			0.005**	0.004+		0.017***
			(0.002)	(0.002)		(0.003)
mobile_subs × urban_pct				-0.000		
				(0.000)		
mobile_subs × working_age_pct				0.000		
				(0.000)		
mobile_subs × wbl_index				0.000		
				(0.000)	100	
Num.Obs.	4609	4609	4354	4354	4603	4354
R2	0.134	0.954	0.954	0.954	0.403	0.517
R2 Adj.	0.134	0.951	0.951	0.952	0.399	0.514
R2 Within		0.019	0.034	0.040	0.183	0.350
R2 Within Adj.		0.019	0.033	0.039	0.183	0.349
AIC	12461.7	-588.4	-630.9	-653.6	10795.4	9216.7
BIC	12474.6	885.4	740.5	737.0	10982.0	9420.8
RMSE	0.93	0.22	0.21	0.21	0.78	0.69
Std.Errors	IID	by: iso3	by: iso3	by: iso3	by: iso3	by: iso3
E: year		X	X	x	X	X
E: region					X	X
E: iso3		x	X	X		
+ p < 0.1, * p < 0.05, *			ruption (WGI)			