How Does E-Government Affect Corruption? Provincial Panel Evidence From China

SHAOWEN LI\textsuperscript{1,2}, WEI WEI\textsuperscript{1,3,4}, AND MIN MA\textsuperscript{5}

\textsuperscript{1}College of Tourism Management, Zhengzhou University, Zhengzhou 450000, China
\textsuperscript{2}School of Politics and Public Administration, Zhengzhou University, Zhengzhou 450000, China
\textsuperscript{3}Center for Energy Environment & Economy Research, Zhengzhou University, Zhengzhou 450000, China
\textsuperscript{4}Yellow River Institute for Ecological Protection and Regionally Coordinated Development, Zhengzhou University, Zhengzhou 450001, China
\textsuperscript{5}School of Economics and Management, Liupanshui Normal University, Liupanshui 553000, China

Corresponding author: Wei Wei (weiwei123@zzu.edu.cn)

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ABSTRACT To investigate whether and how e-government affects corruption, this study collects longitudinal data (2006-2015) from 29 Chinese provinces for empirical analysis by adopting Feasible Generalized Least Squares (FGLS) and Panel Threshold Regression (PTR) model. The results of analysis show that e-government has a restraining effect on corruption and presents a significant threshold characteristics. Specifically, the restraining effect of e-government on corruption shows a dynamic non-linear characteristic, with a trend of first rising and then declining. Besides, the restraining effect is more obvious in provinces with lower e-government level.

INDEX TERMS Corruption, e-government, feasible generalized least squares, panel threshold regression.

I. INTRODUCTION Corruption is widely defined as “the abuse of public authority for private benefits” [36], [40]. It severely impede social development by distorting market, undermining democracy, destroying social stability, and changing the proper use of government expenditure. Therefore, controlling corruption has become an important topic for managers and scholars in various countries [15]. An increasing number of regions are committed to their varying anti-corruption campaigns, including e-government strategies, open government initiatives, and efforts on transparency of data, information, and policy processes. To interact with the general citizens or organizations more effectively, governments around the world have launched a variety of e-government initiatives to enhance internal operations and improve online service level, such as the Open Procedure Online Procedures (OPEN) launched by the Seoul Metropolitan Government of South Korea and the Open Government Directive proposed by Obama in 2009. The directive aim of these procedures is to make governments more transparent, participatory, and collaborative through the use of Information and Communication Technology (ICT). Given the advantages of e-government, studies on the relationship between e-government and corruption is also emerging, they all emphasize that the higher the level of e-government, the more opportunities for the public to monitor government actions closely, thereby increasing the risk of corruption [6], [26], [28], [39].

Although scholars have done an extensive body of researches on the anti-corruption effect of e-government, and these cumulated evidences underscore substantial relationship of e-government services with anti-corruption performances to a certain extent, however, to the authors’ best knowledge, past studies focus on qualitative aspects such as case-study or theoretical analysis, a research gap lies in the dearth of empirical and rigorous research addressing the effects and characteristics of e-government on corruption [3], [7], [27], [32]. Based on these theoretical studies, a few scholars have conducted empirical research to investigate whether e-government can reduce corruption by using national-level panel data. For example, [43] and [37] found that there is a u-curve relationship between e-government and corruption, this indicates that with the improvement of
e-government level, its marginal impact on corruption will change for different stages of e-government, while previous studies rarely provide additional evidence to confirm this situation. Therefore, the purpose of this study is to discuss and capture the dynamic nonlinear effect of e-government level at different stages on corruption. For this purpose, this study collects longitudinal data from 2006 to 2015 from 29 Chinese provinces, and explores the impact of e-government on corruption and its nonlinear threshold characteristics by adopting Feasible Generalized Least Squares (FGLS) and Panel Threshold Regression (PTR) model. This research not only contributes to the existing literature by further shedding light the impact of e-government level on corruption, but also provides important insight on the policies which can be appropriate to fight corruption.

The remaining parts of this study are organized as follows. Section II introduces the literature on the relationship between e-government and corruption and provides a summary of the various factors that affect corruption. Section III briefly presents the methodological approach, data sources, and variable definitions. Section IV discusses the empirical findings. Section V concludes this study, remarks on theoretical and practical implications, and outlines its future prospects.

II. LITERATURE REVIEW

A. DETERMINANTS OF CORRUPTION

Corruption is a widespread problem and has been considered one of the greatest challenges in various countries [11], [41]. Its emergence can be explained by principal-agent model [34]. In this model, the principals (the elected officials) cannot deliver services themselves in most cases, they have no choice but to employ agents to work for them, this employment decision usually leads to a typical situation in which the agents are far more knowledgeable on administration information than either the principals or the clients, the agents will take more action for their own interest by taking advantage of their go-betweens statuses and the power entrusted to them, thus the asymmetry of information and incentive mechanisms between government officials (agents) and the public (clients) provides opportunities for corruption to grow. Corruption has various forms, such as bribery, favoritism, abuse of discretion, and improper political contributions. It can occur either at the macro-level or at the micro-level [14]. Macro-level corruption, or grand corruption, refers to the distortion of government expenditure and resource allocation by politicians or higher-level government authorities for their own interests. Micro-level corruption or bureaucratic corruption is usually implemented by lower-level government authorities responsible for providing citizens with public services (such as health care, permits, licenses, etc.). Considering the dangers of corruption, different disciplines, including economics, politics, social psychology, and criminology, have discussed the causes, mechanisms, and countermeasures of corruption in detail [14]. Corruption and measures for reducing it are one of the most cited and discussed issues in social science.

A series of cross-country studies have emphasized the macro factors of corruption and attributed the causes of corruption to multiple factors [1], [2], [5]. This section briefly introduces some main factors that affect corruption.

1) ECONOMIC FACTORS

Previous research has proven that a negative correlation exists between economic development level and corruption [17] pointed out that stable and developed countries are likely to have effective political systems, corruption will not be tolerated in a more institutionalized political system. Reference [15], [25] also proved that economically developed countries have enough resources to fight corruption, which has been demonstrated in different empirical studies. Besides, compared with the less developed countries, highly developed countries can provide citizens with better education and higher cultural literacy according to modernism, so the highly developed countries are prone to detecting corruption behaviors [11], [26]. Similarly, as described by [13] and [42], education is also one of the important socio-economic factors affecting corruption. People with higher education have a better understanding of the operation mode of government, they are more likely to take advantage of their own rights and responsibilities to monitor government officials, besides, education can also improve the communication and expression of citizens, making it easier for them to strengthen citizenship and build social networks and organizations, and so on. These all help to further eradicate corruption.

2) POLITICAL FACTORS

Political factors are also closely linked to corruption. The political motivations for corruption are also diversified. Reference [12] explained the causes and sources of corruption from the perspective of institutions and the suppression of political rights. Reference [26] acknowledged that politics-based corruption primarily stems from coercive power in a closed and non-competitive political environment for developing countries. [37] stated that the influence of e-government in curbing corruption will be affected by the level of democratic development. Reference [11] and [41] demonstrated that the democratic development level has an inverted U-shaped moderating effect on the relationship between e-government and corruption perception. Similarly, empirical research in Asia, Africa, and Latin America have proven that democracy has a dual effect on perceptions of corruption: in terms of direct effect, the higher the degree of democracy, the higher the average level of people’s perception of corruption; however, for moderating effects, democracy would enhance the negative impact of self-economy evaluation on corruption perceptions [24]. In addition, corruption may also be related to a number of other political factors, such as government effectiveness and government scale [42].
3) CULTURAL FACTORS
Cultural factors also have an impact on corruption to some extent, wherein different cultures in countries are another common explanation of varying corruption [41]. Among all the cultural factors, religion has attracted great attention from scholars. Religious data can be used to explain why religion has always been considered a cultural representative. Some researchers have shown that areas with higher protestant proportions tend to have a lower corruption level [8], [30]. In addition, some scholars have also pointed out the judicial and technological factors that affect corruption, including punishment for corruption, Internet, and mobile subscriptions. They have further argued that an effective criminal justice system may add on potential cost and punishment of corruption, which in turn, helps to reduce corruption ([6], Relly, 2012; [28]).

B. E-GOVERNMENT AND CORRUPTION: THEORETICAL DISCUSSION
By introducing the agency-delegation theory, [34] explained the relationship between government (as agents working for public) and public (as a principals). Since government has greater control than public over the flow of information, government members are prone to corruption. In order to reduce the distance between public and government, it is necessary to supervise government’s work and provide citizens with information about administrative procedures. E-government is developed based on information and communication technology. It provides a flexible and convenient channel for citizens to interact with government agencies and monitor the performance of government employees. According to research methods, previous studies on corruption and e-government can be divided into case studies and empirical studies. As for case studies, [29] proved e-government initiatives alone cannot curb corruption. [22] used Online Procedure Enhancement (OPEN) as a case study and demonstrated that e-government can enhance government transparency and combat corruption. They also pointed out that information systems and organizational, sociocultural, and environmental factors need to be considered when controlling corruption. [35] acknowledged that e-government has deleted some intermediate links between the public and government officials and could be an effective measure for ending corruption. In addition to the above case studies, there are a few empirical studies on corruption and e-government. Reference [4] analyzed the panel data from 149 countries and confirmed the positive correlation between e-government and corruption reduction. Similarly, [23] draw similar conclusions by counting correlation analysis. [25] found that the impact of Internet adoption on reducing corruption is statistically significant, but the extent is relatively small. Reference [15] also examined the impact of e-government and Internet applications on corruption reduction. They concluded that e-government is a powerful tool for reducing corruption. Specifically, the reasons include internal and external meanings. Internally, based on scientific management and traditional bureaucratic paradigm, e-government is being used to reduce human intervention and supervise the service delivery process of government staff. At this time, the focus of e-government is internal management. Externally, e-government can reduce corruption by strengthening external relations with citizens. Government organizations are required to increase transparency so that netizens can supervise government employees and detect corruption. At this time, the focus of e-government is external management.

However, a few scholars have questioned the effectiveness of e-government in reducing corruption in reality. For example, Reference [44] mentioned that many developing countries and underdeveloped countries, it is very common for government officials to plunder budgets for public projects such as infrastructure and military expenditures, they may collude with bidders or suppliers to allow them to overestimate the costs of materials to exchange for bribes. Reference [43] showed that the investment in ICT have both negative and positive effect on corruption. On the one hand, the increase in ICT investment improves the technology infrastructure that can effectively monitor and control corruption, however, on the other hand, increased transparency helps potential bidders identify relevant officials to bribe, which will facilitate corruption to some extent. Reference [5] pointed out that ICT has been used to curb corruption in developed countries, while it is questionable whether the same methods will produce similar results in developing countries. Given this possibility, the universal applicability of e-government remains doubtful and whether it can really reduce corruption is still a controversial issue.

Despite the mix findings in these existing literatures, our study notes that there are strong theoretical grounds to believe that e-government can be an essential tool to fight against corruption by modifying the implementation of rules, reducing the discretion of officials and increasing transparency. Moreover, considering the U-shaped relationship between e-government and corruption found by [43] and [37], that is the marginal impact of e-government on corruption will change for different stages of e-government, while previous studies rarely provide additional theoretical proof. In view of this, the Panel Threshold Regression (PTR) model is proposed by our study to further capture the dynamic nonlinear effect of e-government level at different stages on corruption.

III. METHODOLOGY AND VARIABLE
A. DATA SOURCES AND VARIABLE DEFINITIONS
Given the existing pool of research and the acquirable data, this study collects the data from January 2006 to December 2015 from Chinese 29 provinces. The dependent variable is corruption. The core explanatory variable is e-government, and the control variables include GDP per capita, trade openness, government scale, and education level. The summary of the data sources and the variable definitions are described in Table 1.
TABLE 1. Variables sources and definitions.

| Variable   | Definitions                                                                 | Sources                        |
|------------|-----------------------------------------------------------------------------|--------------------------------|
| Corruption | The number of corruption cases per 10,000 public officials                   | Procuratorial Yearbook of China |
| E-government | E-government development level                                                | [https://www.cciggroup.com](https://www.cciggroup.com) |
| GDP per capita | The regional per capita GDP                                                  | Statistical Yearbook of China  |
| Trade openness | Regional trade openness                                                       | Statistical Yearbook of China  |
| Government Scale | The number of public officials per 10,000 people                             | Statistical Yearbook of China  |
| Education | Average years of schooling in each province                                  | Statistical Yearbook of China  |

1) DEPENDENT VARIABLE

a: CORRUPTION

According to the existing research [9], [10], [20], this study uses the number of corruption cases per 10,000 public officials to measure the corruption level of each province. The sum of the number of corruption, bribery, and malfeasance cases represents the number of corruption cases. The data can be obtained from the China Inspection Yearbook, wherein the higher the index, the worse regional corruption.

2) CORE EXPLANATORY VARIABLE

a: E-GOVERNMENT

To measure e-government, this study uses the performance evaluation results published by Chinese Electronic Information Industry Development Research Institute. Since 2003, the Chinese Electronics Information Industry Development Research Institute has evaluated the performance of government portals according to various indicators. These indicators are updated with the current hotspots, such as the introduction of mobile government and Internet government services. This indicator is scored from 0 to 100, in which high score indicates greater e-government level. This paper believes that the provinces with better e-government level have lower corruption.

3) CONTROL VARIABLES

In a related discussion, it is argued that corruption should not be considered in isolation as it is strongly correlated with political, economic, and cultural factors. Based on the existing research, four control variables are used in this empirical study (As shown in Table 1). The first control variable is GDP per capita [11], [15], [41], which measures the development level of each province. The second control variable is trade openness [42], which is expressed by the ratio of regional import and export volume (converted to RMB) to regional GDP. The regional per capita GDP and the regional trade openness may have a negative correlation with corruption. The third control variable measure the government scale ([41]) which is calculated by the number of public officials per 10,000 people in each province. The last control variable is the education level [41], [42], which is expressed by the average number of schooling years in each province.

B. METHODOLOGY

This study examines the linear effect and threshold effect of e-government on corruption by adopting Feasible Generalized Least Squares (FGLS) and Panel Threshold Regression (PTR) model, respectively. The basic econometric model is constructed as shown in Eq. (1).

\[
\text{Corruption}_{i,t} = \varphi_0 + \varphi_1 \text{e-government}_{i,t} + \sum_{i=1}^{P} \beta_i \text{control}_{i,t} + \mu_{i,t} \tag{1}
\]

where \(\text{e-government}_{i,t}\) represents the e-government level in province \(i\) and past period \(t\), \(\text{control}_{i,t}\) denotes control variables in province \(i\) and past period \(t\), \(\varphi_0\) is a constant term and \(\mu_{i,t}\) denote the error term which is assumed to obey the independent normal distribution with \(\mu_{i,t} ~ N(0, \sigma^2_{\mu})\).

Threshold regression model is one of the important panel data models [46] its basic model is shown in Eq. (2):

\[
y_{i,t} = \begin{cases} 
\theta_1 x_{it} + \epsilon_{it}, & q_{it} < \gamma, \\
\theta_2 x_{it} + \epsilon_{it}, & q_{it} \geq \gamma. 
\end{cases} \tag{2}
\]

where \(x_{it}\) represents the explanatory variable, \(q_{it}\) and \(\epsilon_{it}\) represent the threshold variable and residual term, respectively. According to the relationship between threshold variable and threshold value, we combined Eq. (2) by introducing index function \(I(\cdot)\). The specific form is shown in Eq. (3)

\[
y_{i,t} = \theta_1 x_{it} I(q_{it} \leq \gamma) + \theta_2 x_{it} I(q_{it} > \gamma) + \epsilon_{it}. \tag{3}
\]

According to the theoretical analysis, the impact of e-government on corruption may not be a simple linear relationship. Considering the validity and rationality of Hansen’s panel threshold model [21], this study takes e-government as threshold variable, and constructs single threshold regression model (as shown in Eq. (4)) and double threshold regression model (as shown in Eq. (5)) to further explore the dynamic nonlinear impact of e-government on corruption.

\[
\text{Corruption}_{i,t} = \beta_0 + \beta_1 \text{e-government}_{i,t} * I(\text{e-government}_{i,t} \leq \gamma) + \beta_2 \text{e-government}_{i,t} * I(\text{e-government}_{i,t} > \gamma) + \alpha X + \epsilon_{it} \tag{4}
\]

\[
\text{Corruption}_{i,t} = \beta_0 + \beta_1 \text{e-government}_{i,t} * I(\text{e-government}_{i,t} \leq \gamma_1) + \beta_2 \text{e-government}_{i,t} * I(\gamma_1 < \text{e-government}_{i,t} \leq \gamma_2) + \beta_3 \text{e-government}_{i,t} * I(\text{e-government}_{i,t} > \gamma_2) + \alpha X + \epsilon_{it} \tag{5}
\]

where \(I(\cdot)\) is index function, \(X\) represents all the control variables.
IV. EMPIRICAL ANALYSIS
A. DESCRIPTIVE STATISTICAL ANALYSIS

Table 2 presents the descriptive statistics of all variables. According to Table 2, corruption is mainly distributed in 7.98 to 46.32, with an average value of 24.91. The overall e-government score is distributed in 14.42 to 89.4, with an average score of 50.79. By performing Pearson correlation coefficient analysis, this paper finds that the correlation coefficient between corruption and e-government is -0.23, the P-value is 0.01 at 95% confidence interval suggests that corruption and e-government is negatively correlated based on the similar research findings by [23]. Next, the influence of e-government on corruption is explored by this study. In addition, the results of multicollinearity analysis show that the variance inflation factor (VIF) of explanatory variables is distributed in 1.25 to 4.02, which is less than the maximum tolerance (10) and indicates that there is no multicollinearity problem among the variables.

| Variable            | mean  | Std.Dev. | Min  | Max  |
|---------------------|-------|----------|------|------|
| Corruption          | 24.91 | 6.81     | 7.98 | 46.32|
| E-government        | 50.79 | 16.68    | 14.42| 89.40|
| GDP per capita      | 37085.97 | 21777.41 | 3759 | 107960.10 |
| Trade openness      | 0.34  | 0.40     | 0.04 | 1.76 |
| Government scale    | 114.51| 29.20    | 70.93| 216.78|
| Education           | 8.69  | 0.97     | 6.59 | 12.15|

B. PANEL DATA REGRESSION ANALYSIS

Panel data is prone to emerging heteroscedasticity problem, which may lead to biased estimation results if this study adopt Ordinary Least Squares (OLS) method. To eliminate the influence of heteroscedasticity and obtain effective parameter estimator, this study first performs Hausman test to determine whether to build the fixed effect model or the random effect model. Subsequently, Wald statistics is used to test whether there is intergroup heteroscedasticity, FGLS method is used to correct the heteroscedasticity problem, if the result of Hausman test is to choose fixed effect model, this study will introduces the time effect to realize the fixed effect model estimation of FGLS [38]. In addition, regarding the problem of endogeneity between e-government and corruption, this study adopts the “Durbin-Wu-Hausman (D-W-H)” statistic and uses lagging e-government (lag = 1) as the instrumental variable to conduct endogenous test, and result indicates that there is no endogenous problem in the model (the P-value is 0.25).

The empirical results of FGLS method are described in Table 3. Specifically, Model (1) provides the estimation results for the effect of e-government on corruption without considering control variables; Model (2), Model (3), Model (4) and Model (5) show the estimation results after adding GDP per capita, government scale, education and trade openness in turn. For models (1) to (5), as expected, the coefficients of e-government are negative and statistically significant at 5% level. Before explaining these results, we need to emphasize some major conditions that make corruption more likely to occur. Usually, corrupt transactions are carried out in secret because they are not easily monitored or audited by public. For example, when information about government budgets and expenditures is only provided to a few authorities responsible for a project, their ability to control and hide private information provides them with an opportunity to distort fund allocation for their own benefit [47]. [48] explains the reason why ICT can be used as a means to reduce corruption by using network society theory, which assumes that when more information is available to public, the power within society can be dispersed among citizens. When information about government activities is not easily audited by public, the power is often held by government agencies, and almost no one can question their actions. Conversely, when information about government transactions is transparent and accessible to all citizens, the risk of government corruption is greater because those who commit corruption are more likely to be caught and prosecuted [43]. Combined with existing research, this conclusion can be explained from the following two aspects. On the one hand, the maturity of e-government is necessarily improve transparency by increasing interaction with the government. Transparency increased by anytime and anywhere online access to transactions, services, documents, and databases makes it difficult for government bureaucrats to engage in corrupt behaviors [23]. By using computerized systems and information technology, most government transactions can be conducted through the Internet instead of manually processed by government officials, which not only increases the transparency of the public affairs process, but also improves accuracy and reduces reliance on government officials for transactions, thereby minimizing their opportunities for bribery negotiations with citizens. On the other hand, according to [49] and [45], the main characteristics of social media are participation, openness, dialogue, participation and connectivity, it allows citizens to express their ideas without being affected by money and politics and/or corruption.

### Table 2. Descriptive statistics of the variables.

| Variable            | mean  | Std.Dev. | Min  | Max  |
|---------------------|-------|----------|------|------|
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| Government scale    | 114.51| 29.20    | 70.93| 216.78|
| Education           | 8.69  | 0.97     | 6.59 | 12.15|

### Table 3. Descriptive statistics of the variables.

| Variable            | Model 1 | Model 2 | Model 3 |
|---------------------|---------|---------|---------|
| E-government        | -0.064586*** | -0.031026*** | -0.019463*** |
| GDP per capita      | -0.000334*** | -0.000452*** |
| Government scale    | -0.0633699*** |
| Education           |         |         |         |
| Trade openness      |         |         |         |
| Corruption (-1)     | Constant | 27.7732*** | 19.92389*** | 19.44557*** |

| Variable            | Model 4 | Model 5 | Model 6 |
|---------------------|---------|---------|---------|
| E-government        | -0.0194683*** | -0.0180475*** | -0.020623*** |
| GDP per capita      | -0.000677*** | -0.0005041*** | -0.0005097*** |
| Government scale    | -0.091010121*** | -0.1087219*** | -0.0990453*** |
| Education           | 1.581056*** | 2.001351*** | 2.0834345*** |
| Trade openness      | -0.4474994 | -1.909305 |
| Corruption (-1)     | Constant | 21.28891*** | 22.34251*** | 21.71333*** |

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These technologies are redefining the understanding and practices related to democratic participation, and help to improve the structure of public sphere [50]. E-government is developed in the context of social media, it has the typical characteristics of social media and enables citizens to easily express their concerns and provide citizens’ opinions. Therefore, it plays a vital role in fighting corruption by increasing public access to information, empowering civil society to oversee the state, enabling citizens to track government decisions and actions, so our study concludes that the improvement and deepening of e-government level is helpful to reduce the incidence of corruption in China.

The coefficients of GDP per capita and government scale are negative and statistically significant at 5% level in all specifications. These results indicate that the provinces with a good economy and a large government have a lower corruption, thus the GDP per capita and government scale have a significant inhibitory effect on the spread of corruption. Specifically, for every 10000 yuan increase in per capita GDP and for every 1 point increase in government scale, under other conditions unchanged, corruption will be reduced by 0.334-0.677 points and 0.063-0.108 points, respectively. This result is consistent with the conclusions of existing research. For example, [19] argued that great economic prosperity is linked to good control and great opportunity costs of corruption. Reference [16] found that economically developed countries with higher per capita GDP have a lower incidence of corruption. [41] proved that countries with larger government scale have lower corruption level by performing a longitudinal analysis on various countries. Reference [18] argued that large government scale reduces people’s awareness of corruption by linking with great checks and balances.

Generally speaking, richer regions are usually able to devote more resources to the prevention and detection of corruption [16]. Specifically, regions with higher GDP tend to increase investment in ICT, which increases the opportunities for citizens to monitor the use of government funds, enabling them to detect any improper allocation or irregularities by politicians and government officials, this increases the probability of them being caught, thereby inhibiting rent-seeking behavior. In addition, the modernist view holds that highly developed economies are more likely to detect corruption than less developed countries because the former can provide citizens with more educational opportunities, higher literacy rates, and more objective relationships than the latter. Similarly, countries with stable and developed economies are more likely to establish institutionalized and efficient political systems, a more institutionalized political system will recognize the difference between public roles and private interests and will not tolerate corruption. [11]. [51] argued that corruption is often high in local areas, because there is no warning signal when abuses are accumulating in the absence of competitive elections and freedom of the press. Moreover, in countries where social power is strongly dominated by politicians and those associated with them, those who witness the corruption of politicians are often threatened, another reason why politicians’ corrupt activities are not easily exposed is lack of security, which makes whistleblowers reluctant to report the case without being able to ensure that they are protected from retaliation [52]. As we all know, China is a highly centralized country, political power can be considered monopolistic. Since the reform and opening up, China has experienced a series of government institutional reforms, such as streamlining administration, decentralizing power, continuously improving public service capacity, and making government functions more clear. The expansion of the government scale is not completely equivalent to the overstaffing and inefficiency, it means that the government has more human, material and financial resources to fight corruption. At the same time, the more functional departments of the government, the stronger the balance of power between departments, and the less opportunities for a certain department to abuse power, which indirectly suppressed corruption. In short, it can be argued economic development and the expansion of the government scale exerts a major control on corruption by increasing the chance of identifying and punishing illicit rents appropriations and lowering the governants’ incentives to behave dishonestly.

This study also come to conclusions contradicting with other previous studies. For example, this study finds that the coefficients of education are always positive and significant, the coefficient of trade openness is positive but is not significant. Thus, provinces with better-educated people are prone to have higher level of corruption, and the degree of trade openness of provinces does not directly affect the occurrence of corruption at the provincial level. However, [13] acknowledged that education can improve the communication and expression of citizens, making it easier for them to strengthen citizenship and build social networks and organizations. These all help to further eradicate corruption. Reference [25] also proved that countries with better-educated people have low levels of corruption. According to the findings of the population change survey in 2016 in China, the education rate reached 94.3% among the 1077322 people over 6 years old. Among them, primary education accounted for 27.2%, junior high school accounted for 41.2%, ordinary high school accounted for 13.5%, undergraduate students accounted for 5.8%, and graduate students accounted for 0.6%. As pointed out by [25], people with higher education can better understand the operation of the government and its rights and responsibilities. They are more likely to accept the responsibility of monitoring the government and demand greater transparency in order to contribute to anti-corruption efforts. Besides, people with higher education will help improve the level of social capital, countries with higher levels of social capital are more likely to have a culture of balancing government power and have a lower tolerance for government corruption. However, based on the above statistics in 2016, we can find that the education situation of Chinese population is unpromising, the education level of most people is still below junior high school, and there are few people with high education. This dilemma of the current education
situation leads to the fact that most of the public in China do not have strong civic awareness, they don’t know how to use information technology to report government corruption. This situation aggravates the fluke psychology of corrupt officials and promotes the occurrence of corruption to some certain extent.

To further verify the stability of the preliminary estimation results, the robustness test is carried out by using system-generalized method of moments (SYS-GMM) method. As shown in Model (6), the coefficient of lagged corruption (lag = 1) is negative and statistically significant at 1% level. This conclusion proves the persistence of corruption, thus, corruption is a function of its initial level. The reason for the inertia of corruption can be explained in two aspects. The first aspect is the psychological factors caused by habit. For corrupt officials, they are used to obtaining extraordinary income through rent-seeking opportunities, which may involve high costs (the benefits of corrupt behavior are greatly reduced) in the process of behavioral change. Thus, despite the improvement in e-government, information disclosure, and e-participation and the increasing cost of corruption, some officials may still not stop engaging in corrupt practices immediately. Moreover, compared with the time when a country implements new reforms, the actual implementation of reforms by public officials is relatively lagging behind. This situation is another possible explanation for the corruption inertia. Besides, the estimated coefficients of all variables of SYS-GMM are consistent with FGLS, which demonstrates the robustness of the FGLS method, and further confirm the important role of e-government in anti-corruption.

### C. ESTIMATION RESULTS OF THE THRESHOLD REGRESSION

As shown in Table 4, the F-values of single threshold model and double threshold model are significant at 0.01 level. Therefore, this study selects the double threshold model to analyze the nonlinear relationship between e-government and corruption. According to the two threshold values of e-government, this study makes statistics about the threshold distribution of e-government level in each province in each year (as shown in Table 5). For the first threshold value (47.4), 86.2% of provinces crossed it by 2015, except for Qinghai, Ningxia, Chongqing, Henan and Shanxi provinces. While for the second threshold value (70.3), only 34.48% of provinces crossed it by 2015, Beijing and Shanghai have always been in the leading position in the development of e-government. This conclusion indicates that the e-government level in most provinces is still in a rapid rising stage, and the average e-government level of 29 provinces is gradually improving, from 40.51 in 2006 to 68.26 in 2015; In addition, the regional differences of e-government is always existed, the e-government level in the eastern region is higher than that in the central and western regions.

The results of double threshold regression model are shown in Table 6, it can be seen that e-government has a significant negative impact on the corruption and shows obvious threshold effect characteristics. Specifically, when the e-government crosses the first threshold value (47.4), the regression coefficient of e-government on corruption decreases from \(-0.0387248\) to \(-0.0647969\); when the e-government is further improved and crosses the second threshold value (70.3), the regression coefficient of e-government on corruption increases from \(-0.0647969\) to \(-0.0233699\). Our findings can explain why the studies by [43] and [37] found the U-shaped relationship between e-government and corruption. As we mentioned earlier, the national investment in e-government projects, especially the Internet and communication equipment, has created an infrastructure that allows information to flow freely in society. Greater access to information enables public to understand the behavior of politicians and have the right to monitor how the government uses their taxes. Besides, investment in e-government projects allows transactions about...
government services to be processed and provided to public more effectively, thereby reducing personal contact opportunities which government officials more prone to corruption. Our study firmly believe that investment in e-government projects is important for policy makers to consider as a tool to reduce government corruption in a country. Nevertheless, the results in Table 6 reveal another important finding. We find that when the e-government crosses the second threshold value (70.3), although e-government can still suppress the occurrence of corruption, its inhibition effect on corruption has declined, compared with the inhibition effect of e-government in the range of 47.4 to 70.3. Therefore, even if e-government is a very powerful tool to reduce the occurrence of corruption, there is no need for the government to over invest, which wastes resources compared with its effectiveness. This phenomenon can be explained from the following two aspects. On the one hand, in the early stage of e-government, information disclosure in China is not timely and comprehensive, the phenomenon of the “scratching of the ball” of information disclosure restricts its important role in anti-corruption to a certain extent. With the rapid development of “Internet+” and the improvement of public democracy awareness, e-government at all levels has been greatly improved, at this stage, e-government’s ability to combat corruption is further strengthened. On the other hand, when the e-government level continues to increase until it reaches a certain level, the marginal effect of its impact on corruption begins to decline, but it still has a significant negative impact on the corruption.

V. DISCUSSION AND CONCLUDING REMARKS

Recently, anti-corruption organizations and researchers have emphasized the importance of e-government in combating corruption. A series of cross-country studies have revealed the relationship between e-government and corruption. As opposed to this well-developed stream of research, this study contributes to another potential but under-developed stream of research: adopting the evidence of local-level government data to explore the influence of e-government on corruption. By collecting longitudinal data from 2006 to 2015 from 29 provinces of China, this study proves that the improvement and deepening of e-government level is helpful to reduce corruption from the perspective of local-level government. Our findings are consistent with studies by [23], [41] and [11], all of which found that the higher the e-government, the lower the level of corruption. As mentioned in these studies, through computerized systems and information technology, most government transactions can be conducted through the Internet instead of manually processed by government officials, which not only increases the transparency of the process of public affairs, but also improves accuracy and reduces reliance on government officials for transactions, thereby minimizing their opportunities for bribery negotiations with citizens. The maturity of e-government is necessarily improve transparency by increasing interaction with the government. Transparency increased by anytime and anywhere online access to transactions, services, documents, and databases makes it difficult for government bureaucrats to engage in corrupt behaviors. Therefore, our study believes that e-government is important for policy-makers and can be used as a way for a country to reduce government corruption.

In addition, this study provides additional evidence for the significant threshold characteristics between e-government and corruption by using Panel Threshold Regression model. We find that with the improvement of e-government level, its influence on reducing corruption will change at different stages of e-government, the restraining effect of e-government on corruption shows a dynamic non-linear characteristic, with a trend of first rising and then declining. Besides, the restraining effect is more obvious in provinces with lower e-government level. Our findings can explain why the studies by [43] and [37] found the U-shaped relationship between e-government and corruption. The research conclusions can also help assess the current level of e-government, and allow practitioners to formulate evidence-based anti-corruption strategies, especially for Chinese government managers. Specifically, when the level of e-government reaches a certain level, it cannot play its best role in anti-corruption. At this time, we suggest that policy makers should not excessively increase investment in e-government projects, but should emphasize that e-government is a solution to anti-corruption. Besides, we recommend that control mechanisms and policies designed to monitor how budgets are used for e-government projects should be implemented to ensure that taxpayers’ funds are used most effectively. For example, control mechanisms, such as bottom-up monitoring through the citizens participation at the grassroots level, should be implemented together with top-down monitoring by government auditors to increase the transparency in budgetary expenditures on e-government projects. This grassroots mechanism allows citizens to participate in auditing and tracking the investment activities of e-government projects, thereby providing double protection against corruption by politicians.

Moreover, many scholars believe that the effectiveness of e-government in reducing corruption depends on many factors. Based on the findings of this empirical study, we find that economy and government scale have strong and significant effects on reducing corruption. This result is consistent with the researches proposed by [16] and [41],

| Variable         | Regression coefficient |
|------------------|------------------------|
| GDP per capita   | -0.0000703***          |
| Government scale | -0.0913016***          |
| Education        | 1.711245***            |
| Trade openness   | -1.8327***             |
| E-government < 47.4 | -0.0387523***       |
| 47.4 < E-government < 70.3 | -0.0647960***       |
| E-government > 70.3  | -0.0235696***         |
| Constant         | 14.87836***            |
As they demonstrated, regions with higher GDP tend to increase investment in ICT, which increases the opportunities for citizens to monitor the use of government funds, enabling them to detect any improper allocation or irregularities by politicians and government officials. The expansion of the government scale means that the government has more human, material and financial resources to fight corruption. At the same time, the more functional departments of the government, the stronger the balance of power between departments, and the less opportunities for a certain department to abuse power, which indirectly suppressed corruption. Besides, we also come to conclusions contradicting with the researches proposed by [13] and [25], they supported that people with higher education are more likely to accept the responsibility of overseeing the government and demand greater transparency in order to contribute to anti-corruption efforts. However, based on the statistics in 2016 in China, we can find that the education situation of Chinese population is unpromising, the education level of most people is still below junior high school, and there are very few people with high education. This dilemma of the current education situation leads to the fact that most of the public in China do not have strong civic awareness, they don’t know how to use information technology to report government corruption. This situation aggravates the fluke psychology of corrupt officials and promotes the occurrence of corruption to some certain extent. Therefore, we recommend that policies aimed at promoting education should also be implemented to help citizens understand how to use information technology so that they can participate in the fight against corruption. If citizens are not properly educated in the use of technology, investment in e-government projects may eventually become a loophole for politicians to steal taxpayers’ money.

This study reveals the relationship between e-government and corruption by conducting an empirical study of China and provided new evidence to further understand the e-government level and other anti-corruption mechanisms. All research has shortcomings that can be mitigated in future research. This study is certainly no exception. For example, this study only discusses the relationship between e-government and corruption, whether this relationship is affected by other factors is also an issue worth exploring. Moreover, the future research will expand the scope of sample selection and explore the relationship between e-government and corruption from the prefecture-level city level.

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**SAOWEN LI** received the B.S. degree from the School of Mathematics and Information Science, Henan University, in 2014, and the Ph.D. degree from the Institute of Systems Engineering, Dalian University of Technology, in 2018. He is currently an Associate Professor with the Center for Energy, Environment and Economy Research, College of Tourism Management, Zhengzhou University. His research interests include energy policy analysis, text mining, and artificial intelligence.

**WEI WEI** received the B.S. degree from the School of Mathematics and Information Science, Henan University, in 2012, and the Ph.D. degree from the Institute of Systems Engineering, Dalian University of Technology, in 2018. He is currently an Associate Professor with the Center for Energy, Environment and Economy Research, College of Tourism Management, Zhengzhou University. His research interests include energy policy analysis, text mining, machine learning, and artificial intelligence.

**MIN MA** received the bachelor’s degree in management from the Guizhou University of Finance and Economics, in 2016, and the master’s degree in management from the College of Public Administration, Huazhong University of Science and Technology, in 2019. He is currently the Deputy Director of the Urban Management Department, School of Economics and Management, Liupanshui Normal University, Liupanshui, Guizhou, China. His research interests include public policy and political corruption.