Centralization or Decentralization? The Impact of Different Distributions of Authority on China's Environmental Regulation

Xiao-hui Yang
Associate Professor of Management
Postal address: School of Accounting
Hunan University of Finance and Economics, Changsha, Hunan, 410205, China
217032@csu.edu.cn

Ji Yan
Associate Professor of Marketing
Postal address: Durham University Business School, Mill Hill Lane, Durham, DH1 3LB, UK
ji.yan@durham.ac.uk

Kun Tian*
Associate Professor of Economics
Postal address: Hunan University of Technology and Business,Yuelu Avenue, Changsha, Hunan, 410205, China
Email: kun_tian@outlook.com

Zihao Yu
PhD candidate in Durham University Business School
Postal address: Durham University Business School, Mill Hill Lane, Durham, DH1 3LB, UK
Zihao.yu@durham.ac.uk

Rebecca Yu Li
Lecturer of Marketing
Essex University Business School
University of Essex, Southend Campus, Gateway Building, Southend-On-Sea, SS1 1LW, UK
Email: yu.li@essex.ac.uk

Senmao Xia
Associate Professor
International Center for Transformational Entrepreneurship & Center for Business in Society
Coventry University, Coventry, CV1 5FB, UK
Email: Senmao.Xia@coventry.ac.uk

*Correspondence author

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Abstract: How to balance the central government and local governments' political authority relating to environmental governance has long been a topic of intense debate in China. Since both environmental and economic regulations are regulatory tools of governments, political authority and systems must be considered in deciding to what extent to empower local governments. Central government needs to find a tradeoff point when being placed under the dual pressure of environmental protection and maintaining the economic growth rate. Based on a two-level principal–agent model, our research compares the effects of centralized and decentralized governance on the efficiency of environmental regulation. Our results suggest that under decentralized environmental governance, the local governments' incentives increase, which results in either "race to the top" or "race to the bottom" competition in environmental regulation. Moreover, such governance prompts local governments to reduce their investment in economic development and environmental protection. However, decentralization in environmental governance will become more beneficial to the central government if the benefits of reducing information asymmetry surpass enhanced agency costs; otherwise, centralized environmental governance is preferred. Our research proposes a hybrid model of centralized and decentralized environmental governance to help cushion firms against high agency costs and local government–firm collusion.

Keywords: centralization of authority, decentralization, environmental protection, economic growth, two-level principal–agent model

1. Introduction

Since China implemented its reform and opening up policy in 1978, its economy has been experiencing exponential growth, which is regarded as almost unprecedented in human history (Wang and Luo, 2019). However, this growth is coupled with intensified environmental issues as a result of the long period of industrialization. According to the Chinese Environmental and Economic Accounting Report released by China's Ministry of Ecology and Environment and the National Bureau of Statistics (2009), the ratio of environmental degradation costs to gross domestic product increased dramatically from 3.05% in 2004 to 3.50% in 2008. Such high environmental costs prompted the State Council of the People's Republic of China to emphasize the importance of environmental protection in the central government's strategic plan, China's Twelfth Five-Year Plan," which aimed to achieve an overall emission reduction. Nevertheless, the severity of the environmental issues continues to cause concerns in the general public as well as policymakers (Lin, 2011). There is an urgent need for the Chinese government to find a balance between relieving the pressures of environmental deterioration and achieving economic growth in the economic transformation process.

The extant literature suggests that national governments' decisions on economic development and environmental protection are largely driven by regulative and normative pressures within the country (Dobbin and Dowd, 1997; Campbell and Lindberg, 1990; DiMaggio and Powell, 1983). However, increasing attention is being paid to the complexity of national and internal institutions, such as different levels of government (Luo et al., 2017; Zheng et al., 2015; Choi et al., 2014), branches of government (Hiatt and Park, 2013), and rival political parties (Zhu and Chung, 2014; Kozhikode and Li, 2012; Siegel, 2007), which can influence the achievement of national economic and environmental goals. In fact, whether the competition is between different levels of government or political parties, it involves the distribution of government power. There are two forms of distribution of authority between the central government and local governments: centralization and

decentralization (Zhao and Percival, 2017). This also applies to the case of environmental regulations.

Previous studies examined the advantages and disadvantages of centralization and decentralization of authority in environmental protection and economic development. The main advantage of decentralization is seen in local governments' increased autonomy and accelerated local economic development (Sanogo, 2019; Kamp et al., 2017; Blanchard and Shleifer, 2001). The main disadvantage of decentralization is reflected in reduced standards of environmental governance—a "race to the bottom" approach often led to increased emissions and pollution (Zhang et al., 2017; Fredriksson and Wollscheid, 2014). Regarding centralization, in terms of environmental protection, its advantage is that the central government imposes a strong constraint on environmental regulation on local governments, which saves local governments' resources that otherwise need to be directed to manage environmental pollution (Luo et al., 2019). The disadvantage of centralization is that as it increases the information asymmetry between the central government and local governments, local governments prefer to meet local economic growth goals over guaranteeing environmental quality (Hong et al., 2019). In terms of economic development, centralization fails to generate local governments' interests and efforts in regional economic development due to low responsibilities and subsequent low incentives. However, centralization is beneficial to local governments in terms of reducing the mismatch among different regional resources, promoting regional industrial productivity, and thus improving the overall productivity (Bo, 2020).

The tradeoffs between centralization and decentralization are important, as they compete for scarce resources governments withheld. One stream of literature examined how to achieve a balance between the two (Luo et al., 2019; Liu et al., 2013). Taking emission trading schemes as an example, Liu et al. (2013) compared linked (national) and separated (provincial) markets to discuss the tradeoff between efficiency and equity. The above findings give us important inspiration: while both centralization and decentralization have

deficiencies, the two methods can be combined to improve the incentive efficiency.

Our research draws on a theoretical lens from principal–agent theory based on Laffont and Tirole's (1993) work "A Theory of Incentives in Procurement and Regulation." This theory is based on an assumption that there is information asymmetry between principal and agent. From the perspective of time, information asymmetry mainly includes two types—ex ante and ex post. The former exists between the principal and the agent before signing the contract, and the latter happens after signing the contract. The two lead to adverse selection and moral hazard. Adverse selection means that agents hide their own information, including cost and output, before signing contracts for their own interests, which leads to contract price distortion and reduces market efficiency. Moral hazard refers to the behavior of the agent that damages the interests of the principal to maximize its own benefits after signing the contract, such as collusion between the local government and firms. This suggests that governance relationships concerning environmental regulation can be treated as a type of contractual relationship between agent and principal.

Principal–agent theory has been widely applied in research on environmental regulations, and it is used to explain mechanisms to solve information asymmetry in environmental regulation (Voss and Lingens, 2018; Zheng et al., 2017; Zhang, 2015; Gomez and Diego, 2012; Davide et al., 2009). However, the above-mentioned studies mainly focused on a single goal, namely environmental protection, without simultaneously considering another goal—economic development. None of these studies took both goals into account when they analyzed how regulators choose coping strategies for multi-object tasks (Voss and Lingens, 2018; Zhang, 2015). This research draws on principal–agent theory to consider how to best achieve two goals (i.e., economic growth and environmental protection) simultaneously in centralized and decentralized authority distribution systems. It aims to provide a better understanding of the mechanism to achieve a balance between environmental protection and economic growth. Our findings offer important implications for policymakers in China and other developing countries that pursue sustainable economic growth.

Most previous environmental regulation research that drew on principal–agent theory focused on a single-level principal–agent model, as the researchers assumed that local governments only have a single role as a policy executor (Voss and Lingens, 2018; Zhang, 2015; Laffont and Tirole, 1993). For example, Laffont and Tirole (1993) assumed that local governments are the only supervisors of the implementation of central government policies. We argue that this assumption is accurate in the case of centralization but is incorrect in the case of decentralization. This is due to the fact that in the system of decentralization, local governments not only play the role of central policy executor, but also are responsible for formulating local policies and regulations that directly affect firms. To address this important gap, we propose a two-level principal–agent model to reflect the dual roles local governments play.

Our research contributes to the existing literature in several important ways. **First**, it provides a solution to the central government by optimizing incentive mechanisms to achieve a dual goal: economic growth along with environmental improvement. Thus, it adds to the principal–agency literature that mainly focused on a single goal. Our analysis based on the dual goal helps policymakers respond with a sustainable governance strategy that is appropriate for the uniqueness of the Chinese economic development context. Based on the information asymmetry assumption of the principal–agent model, we derive a win-win solution for the central government and local governments to achieve a balance between the dual goal. **Second**, our research adds to the principal–agent theory in that it constructs a two-level model to investigate the interaction among the central government, local governments, and local firms. Previous studies emphasized a single-level relationship, in which the local government is considered as a policy executor not a policymaker. In the case of centralization, the local government indeed plays a single role as policy executor. In the case of decentralization, however, it acts as both a policy executor and a policymaker. Therefore, our research expands the existing literature by analyzing two roles of the local government in a two-level principal–agent model. Our findings indicate that the local government's dual role has a significant impact on the strategic formation of governments. **Third**, this research examines the effects of

information superiority of the central government in relation to the local governments on distribution of authority. Our findings show that in a decentralized system, the central government should empower local governments in such way that environmental regulatory regime can be benefited from improved information transparency. Therefore, our research provides policymakers with a theoretical framework to design a more efficient authority distribution structure (e.g., centralization or decentralization) of environmental regulation.

The remainder of this paper is structured as follows. The second part constructs a principal–agent model for firms' incentives under the systems of centralization and decentralization of authority. The third part presents a comparative analysis. Specifically, it compares the advantages and disadvantages of the centralization and decentralization of authority in terms of the hierarchical effects of incentives, government investment, collusion level between government and enterprise, incentive strength, and social welfare. The implications and conclusions are discussed in the final part.

2. Empirical Setting and Model Building

2.1 Chinese empirical context

China provides a good context for our research, as its decentralization of authority has unique features that differentiate it from the federal fiscal decentralization of Western countries. First, the state has maintained strong involvement in the country's economy and society, which results in the state having—and needing to reconcile—goals related to economic development and social stability (Lin, 2011; Su and He, 2010). To achieve such goals, the state is closely linked to and regularly intervenes in the business sector (Oi, 1995). Therefore, political influence can be particularly important for corporate strategies. Second, the heterogeneity and complexity of China's state bureaucracy allows us to test the structural boundary conditions for political incentives. Described as a "party-state," meaning rule by a single party (Lin, 2011; Nee et al., 2007; Li and Zhou, 2005), China's state bureaucracy nevertheless has power dualism

within its elite (Lieberthal, 1995). Both party officials and government officials are appointed and subject to the influence of the bureaucracy, but they have functional differentiation and, therefore, different priorities (Zang, 2004). The regional diversity in China also gives rise to variation in provincial priorities in response to different pressures (Wang and Luo, 2019). The local governments aim to maximize their political performance, which often conflicts with the central government's macro goal in both economic development and environmental protection For instance, when the central government's performance evaluation focuses on economic development, local governments will sacrifice environmental protection to develop the economy; conversely, local governments may sacrifice economic development to strengthen environmental protection. All these extreme choices would conflict with the central government's goal of balancing economic development and environmental protection. In other words, local governments are motivated to adopt behaviors that are not fully consistent with the national environmental policy (Kamp et al., 2017). Third, Chinese-style decentralization means that the central government empowers local governments to supervise the environmental actions of local firms. This arrangement usually means that the enforcement of environmental law is slack (Zhao and Percival, 2017), as local governments have self-serving and interest-oriented behaviors. For example, under a decentralized system, local governments are strongly motivated to reduce the strength of environmental regulation for their pursuit of foreign direct investment (Wang et al., 2017). Empirical research has revealed a "green paradox," namely the stronger environmental regulation is, the more pollution emissions there are. Therefore, Chinese-style decentralization strengthens the positive impact of environmental policy on carbon emissions, and this effect is contingent on geographical characteristics (Liu et al., 2017; Zhang et al., 2017). Moreover, fiscal decentralization will depress green innovation (You et al., 2018) and increase emissions and pollution.

2.2 Problem description and model assumptions

In the framework of this research, the government has the goals of both economic growth and

environmental protection when formulating a strategy. The forms of the revenue function of local firms are characterized by economic and environmental regulations from the central government and local governments. Consequently, they induce firms to achieve the maximum profits while balancing economic growth and environmental protection. With complete information, the government can leverage tools such as taxes to regulate and control local firms' returns from their economic and environmental efforts. Thus, through reasonable regulatory tools, the government can induce firms to obtain maximum profits under the objectives of economic growth and environmental protection. However, information asymmetry exists in both the central government's supervision of local governments and local governments' supervision of local firms. When the local government cannot fully supervise firms, they have the tendency to contribute less effort (e.g., reduce investment) to developing the economy and protecting the environment. This type of behavior would cause moral risks. Principal–agent theory suggests that the firms which take moral risks can be regarded as agents, and then the other party (i.e., the government) is the principal. Therefore, this research draws on the principal–agent model to explore the optimal strategy under two different systems, namely centralization and decentralization of authority. Specifically, under centralization, the principal–agent relationship is a type of single-level governance relationship, namely the central government over local firms, and local governments only take the role of policy executors of the central government; under the decentralization system, the relationship changes to a two-level relationship, namely the central government over local governments, and local governments over local firms. Before building the models, this research makes the following basic assumptions.

Assumption 1: The government has to undertake two tasks. It not only supervises firms' activities, but also makes efforts to promote economic growth and environmental protection. These efforts include improving communities' infrastructure and introducing advanced technologies. All these efforts require governments to bear some costs. Whether governments undertake these two tasks depends on the power systems. Specifically, under centralization, the central government simultaneously undertakes these two tasks, and local governments only

undertake one task, which is executing the policy of the central government; under decentralization, the central government only plays the role of supervising local governments, while local governments need to undertake these two tasks. Under decentralization, local governments have information advantages over the central government in supervising local firms' activities.

Assumption 2: In every area of China, economic and environmental output are determined jointly by firms and the government. Returns and costs can be measured in monetary terms. It is assumed that the government's efforts in economic development and environmental protection are e_1 and e_2, respectively. The government's financial costs for economic development and environmental protection are $\frac{\theta_1 e_1^2}{2}$ and $\frac{\theta_2 e_2^2}{2}$, respectively. Moreover, it is assumed that firms' efforts in economic development and environmental protection are e_3 and e_4, respectively, and the corresponding costs are $\frac{\theta_3 e_3^2}{2}$ and $\frac{\theta_4 e_4^2}{2}$, respectively. It should be noted that $\theta_i (i = 1 \ldots 4)$ is the cost coefficient, which reflects the ability of the government or firms to protect the environment and grow the economy. The smaller θ_i is, the greater the ability of the government or firms.

Assumption 3: Both firms and local governments are risk averse, while the central government is risk neutral. It is assumed that all the incentive methods have a linear relationship. They include two parts—the fixed reward and the proportional shared revenue.

2.3 Principal–agent model under centralization

Under the system of centralization, on the one hand, the central government aims to promote economic growth and environmental protection; on the other hand, it introduces policies to incentivize firms to develop the economy and protect the environment. In this case, it is a type

of single-level principal–agent model, while local governments only execute policies.

2.3.1 Optimal behavior of companies

The government's efforts concerning economic growth and environmental protection are e_1 and e_2, respectively, and the companies' corresponding efforts are e_3 and e_4; thus, the total outputs of these two parties in terms of economic growth and environmental protection are e_1+e_3 and e_2+e_4, respectively. On the one hand, the central government can utilize such economic regulations as taxes to determine the returns per unit of economic output. On the other hand, it can utilize environmental regulation tools to determine the returns per unit of environmental output. In other words, the form of the firms' revenue function is characterized by the regulatory mechanisms (i.e., economic regulation and environmental regulation) of the central government. Under centralization, we assume that the incentive (or punishment) function of the central government for companies is:

$$S(Y)=b_0+b_1(e_1+e_3+\varepsilon_1)+b_2(e_2+e_4+\varepsilon_2) \quad (1)$$

where b_0, b_1 and b_2 are the incentive coefficients of the central government to firms. Specifically, b_0 is the fixed returns of the central government to firms; b_1 and b_2 are the incentive parts of the central government to firms in terms of economic growth and environmental protection, respectively; and ε_1 and ε_2 are random variables with a normal distribution where mean values are 0 and variances are σ_1 and σ_2, respectively. Furthermore, ε_1 and ε_2 represent the observation errors of the central government on firms' output. The larger σ_1 and σ_2 are, the more serious the information asymmetry is between the central government and companies. Thus, the functional form of firms' returns can be written as:

$$\pi_1=S(Y)-C(e_3,e_4)=b_0+b_1(e_1+e_3+\varepsilon_1)+b_2(e_2+e_4+\varepsilon_2)-\frac{\theta_3 e_3^2}{2}-\frac{\theta_4 e_4^2}{2} \quad (2)$$

Companies are risk averse, and their utility function has consistent risk aversion, $u = -e^{-\delta w}$, where δ ($\delta > 0$) is the Arrow–Pratt measure of absolute risk aversion. The risk cost that companies bear is $\frac{1}{2}\delta Var(Y) = \frac{1}{2}\delta b_1^2\sigma_1^2 + \frac{1}{2}\delta b_2^2\sigma_2^2$. Thus, companies' deterministic revenue (without the uncertain part) is:

$$CE(\pi_1) = \pi_1 - \frac{1}{2}\delta Var(Y) = \\ b_0 + b_1(\mathrm{e}_1 + e_3 + \varepsilon_1) + b_2(\mathrm{e}_2 + e_4 + \varepsilon_2) - \frac{\theta_3 e_3^2}{2} - \frac{\theta_4 e_4^2}{2} - \frac{1}{2}\delta b_1^2\sigma_1^2 - \frac{1}{2}\delta b_2^2\sigma_2^2 \quad (3)$$

The firm's objective is to maximize profits. Thus, the optimization equation is:

$$\max_{e_3, \mathrm{e}_4} CE(\pi_1) \\ \mathrm{st}: CE(\pi_1) \geq \mathrm{u}_1 \quad (4)$$

where u_1 represents the firm's reserved returns. The results of the first derivation are $e_3 = \frac{b_1}{\theta_3}$ and $e_4 = \frac{b_2}{\theta_4}$. Therefore, once b_0, b_1 and b_2 are determined, the firm's incentive–compatibility constraint is $e_3 = \frac{b_1}{\theta_3}$, $e_4 = \frac{b_2}{\theta_4}$; that is, when maximum profits are achieved, the firm's efforts are $e_3 = \frac{b_1}{\theta_3}$, $e_4 = \frac{b_2}{\theta_4}$.

2.3.2 The optimal behavioral decision of local governments

Under centralization, local governments only need to be the policy executors of the central government. Because of the limited supervision ability of the central government, while local governments and firms were motivated by the self-interest, both sides would prefer to collude with each other while executing policies developed by the central government (Qian and Roland, 1998). Based on the existing theory on the analysis of collusion equilibrium (Suzuki, 2007; Tiroll, 1993), we assumed that due to collusion between the local governments and firms,

h_1 and

h_2, which means the local governments transfer payment received from the central government is:

$$S(\mathrm{X}) = b_0 + b_1(\mathrm{e}_1 + e_3 + \varepsilon_1 + h_1) + b_2(\mathrm{e}_2 + e_4 + \varepsilon_2 + h_2) \tag{5}$$

Moreover, to avoid collusion, the central government would randomly conduct irregular inspections of collusion between local governments and firms, and it would impose penalties such as fines or dismissal of local government officials. The degree of penalties is directly related to the level of collusion between local governments and firms (shown as $b_1 h_1$ and $b_2 h_2$). The higher the income from collusion between local governments and firms, the higher the penalty that will be imposed by the central government. The collusion penalty is a convex function of the collusion income; therefore, the collusion penalty is: $\frac{\lambda_1 (b_1 h_1)^2}{2} + \frac{\lambda_2 (b_2 h_2)^2}{2}$, where λ_1 and λ_2 are the central government punishment coefficients for local government collusion behavior. Thus, the monetary revenue of local governments is:

$$\pi_2 = S(X) - S(Y) - \frac{\lambda_1 (b_1 h_1)^2}{2} - \frac{\lambda_2 (b_2 h_2)^2}{2} \tag{6}$$

The local governments' objective is to maximize profits. Thus, the optimization equation is:

$$\begin{aligned} &\max_{e_3, \mathrm{e}_4} CE(\pi_2) = b_1 h_1 + b_2 h_2 - \frac{\lambda_1 (b_1 h_1)^2}{2} - \frac{\lambda_2 (b_2 h_2)^2}{2} \\ &\mathrm{st}: CE(\pi_2) \geq \mathrm{u}_2 \end{aligned} \tag{7}$$

where u_2

$h_1 = \frac{1}{\lambda_1 b_1}$ and $h_2 = \frac{1}{\lambda_2 b_2}$. Therefore, once b_1 and b_2 are determined, the

local governments' incentive–compatibility constraint is $h_1 = \frac{1}{\lambda_1 b_1}$, $h_2 = \frac{1}{\lambda_2 b_2}$; that is, when maximum profits are achieved, the local governments' collusion levels are $h_1 = \frac{1}{\lambda_1 b_1}$ and $h_2 = \frac{1}{\lambda_2 b_2}$.

2.3.3 The optimal behavioral decision of the central government

Since the central government is risk neutral, its expected utility is its expected revenue:

$$\pi_3 = E(V(Y - S(\mathrm{X})) = (1-b_1)(\mathrm{e}_1 + e_3) + (1-b_2)(\mathrm{e}_2 + e_4) - b_0 - \frac{\theta_1 e_1^2}{2} - \frac{\theta_2 e_2^2}{2} - b_1 h_1 - b_2 h_2 + \frac{\lambda_1 (b_1 h_1)^2}{2} + \frac{\lambda_2 (b_2 h_2)^2}{2} \quad (8)$$

The target of the central government is to find a combination of (b_1, b_2, e_1, e_2) to solve the following optimization problem:

$$\begin{aligned} &\max \pi_3 \\ &\mathrm{st}: CE(\pi_1) \geq \mathrm{u}_1; \quad CE(\pi_2) \geq \mathrm{u}_2 \\ &e_3 = \frac{b_1}{\theta_3}; e_4 = \frac{b_2}{\theta_4} \\ &h_1 = \frac{1}{\lambda_1 b_1}; \quad h_2 = \frac{1}{\lambda_2 b_2} \end{aligned} \quad (9)$$

where the constraints include two parts—a firm's incentive–compatibility constraint and incentive–participation constraint. After introducing these constraint conditions into the target function, this optimization problem can be reformulated as follows:

$$\max \pi_3 = (\mathrm{e}_1 + \frac{b_1}{\theta_3}) + (\mathrm{e}_2 + \frac{b_2}{\theta_4}) - \frac{\theta_1 e_2^2}{2} - \frac{\theta_2 e_2^2}{2} - \frac{b_1^2}{2\theta_3} - \frac{b_2^2}{2\theta_4} - \frac{1}{2}\delta b_1^2 \sigma_1^2 - \frac{1}{2}\delta b_2^2 \sigma_2^2 - \frac{1}{2\lambda_1} - \frac{1}{2\lambda_2} - u_1 - u_2 \quad (10)$$

Taking the first derivative with respect to b_1, b_2, e_1, and e_2, we can obtain the optimal behaviors of the government and firms given the incentive–compatibility constraint:

$$\begin{cases} b_1^* = \dfrac{1}{1+\theta_3\delta\sigma_1^2}; b_2^* = \dfrac{1}{1+\theta_4\delta\sigma_2^2} \\ e_1^* = \dfrac{1}{\theta_1}; e_2^* = \dfrac{1}{\theta_2} \\ h_1^* = \dfrac{1}{\lambda_1 b_1} = \dfrac{1+\theta_3\delta\sigma_1^2}{\lambda_1}; h_2^* = \dfrac{1}{\lambda_2 b_2} = \dfrac{1+\theta_4\delta\sigma_2^2}{\lambda_2} \\ e_3^* = \dfrac{b_1}{\theta_3} = \dfrac{1}{\theta_3(1+\theta_3\delta\sigma_1^2)}; e_4^* = \dfrac{b_2}{\theta_4} = \dfrac{1}{\theta_4(1+\theta_4\delta\sigma_2^2)} \end{cases} \quad (11)$$

Given that total social welfare is the sum of the principal's and agent's social welfare, the total social welfare can be calculated as follows:

$$WS^* = \pi_1^* + \pi_2^* + \pi_3^* = \frac{1}{2}\left(\frac{1}{\theta_1} + \frac{1}{\theta_2} + \frac{1}{\theta_3(1+\theta_3\delta\sigma_1^2)} + \frac{1}{\theta_4(1+\theta_4\delta\sigma_2^2)}\right) \quad (12)$$

2.4 Principal–agent model under local decentralization

Under the system of local decentralization, the central government takes responsibility for supervising local governments, while local governments not only supervise local firms, but also make efforts to improve local economic and environmental performance. In this case, we have a two-level principal–agent model.

2.4.1 The optimal behavioral decision of local firms

Under the system of local decentralization, firms face the same incentive policy as under the centralized system. However, under decentralization, the responsible entity has changed from the central government to local governments. Since local governments have information advantages over the central government, the incentive contracting function between local governments and firms is:

$$S(Y) = b_0 + b_1(e_1 + e_3 + \varepsilon_3) + b_2(e_2 + e_4 + \varepsilon_4) \quad (13)$$

where b_0, b_1 and b_2 are incentive coefficients of local government to firms, and ε_3 and ε_4 are random variables with normal distribution and mean values of 0, and their variances are σ_3 and σ_4, respectively. Furthermore, ε_3 and ε_4 represent the observation errors of local governments regarding companies' output. Moreover, we have $\sigma_3 \le \sigma_1$ and $\sigma_4 \le \sigma_2$, which reflect the information advantages that local governments have relative to the central government. Then, the risk cost that local firms bear is $\frac{1}{2}\delta Var(Y) = \frac{1}{2}\delta b_1^2\sigma_3^2 + \frac{1}{2}\delta b_2^2\sigma_4^2$. Firms' deterministic reward is:

$$CE(\pi_1) = \pi_1 - \frac{1}{2}\delta Var(Y) = \\ b_0 + b_1(e_1 + e_3 + \varepsilon_1) + b_2(e_2 + e_4 + \varepsilon_2) - \frac{\theta_3 e_3^2}{2} - \frac{\theta_4 e_4^2}{2} - \frac{1}{2}\delta b_1^2\sigma_3^2 - \frac{1}{2}\delta b_2^2\sigma_4^2 \quad (14)$$

Here, companies' incentive–compatibility constraint and incentive–participation constraint are unchanged.

2.4.2 The optimal behavioral decision of local governments

Under the system of local decentralization, local governments act as the agent of the central government and as the principal of local firms. Local governments' revenue depends on both their incentive-based contractual relationships with the central government and profits generated from collusion with firms. The revenue function can be characterized in the following way:

$$S(X) = a_0 + a_1(e_1 + e_3 + \varepsilon_3) + a_2(e_2 + e_4 + \varepsilon_4) + b_1h_1 + b_2h_2 \quad (15)$$

The local government revenue includes two parts: the incentive contract given by the central government and the revenue from collusion with firms. The local government collusion

revenue is similar to that in the centralization situation, which is most likely obtained by making a false report of political performance. Local governments' expenditures have three parts. The first part is the expenditures of their efforts to achieve economic growth and environmental protection, the second part is the expenditures of the collusion cost between local government and firms, and the last part is the transfer payment (i.e., expenditures spent in building incentive-based contractual relationships with firms). Therefore, a local government's monetary revenue is:

$$\pi_2 = S(X) - S(Y) - \frac{\lambda_1 (b_1 h_1)^2}{2} - \frac{\lambda_2 (b_2 h_2)^2}{2} - \frac{\theta_3 e_3^2}{2} - \frac{\theta_4 e_4^2}{2} \quad (16)$$

Local governments are also risk averse, and their utility function has constant risk aversion $u = -e^{-\delta w}$, where δ ($\delta > 0$ is the Arrow–Pratt measure of absolute risk aversion. The risk cost that local governments face is $\frac{1}{2}\delta Var(\mathrm{X}) = \frac{1}{2}\delta a_1^2 \sigma_3^2 + \frac{1}{2}\delta a_2^2 \sigma_4^2$. Thus, the fixed revenue of local governments is:

$$\begin{aligned} CE(\pi_2) &= \pi_2 - \frac{1}{2}\delta Var(\mathrm{X}) = a_0 - b_0 + (a_1 - b_1)(\mathrm{e}_1 + e_3) + (a_2 - b_2)(\mathrm{e}_2 + e_4) + b_1 h_1 \\ &+ b_2 h_2 - \frac{\lambda_1 (b_1 h_1)^2}{2} - \frac{\lambda_2 (b_2 h_2)^2}{2} - \frac{\theta_3 e_3^2}{2} - \frac{\theta_4 e_4^2}{2} - \frac{1}{2}\delta a_1^2 \sigma_3^2 - \frac{1}{2}\delta a_2^2 \sigma_4^2 \end{aligned} \quad (17)$$

Here, a_0, a_1 and a_2 are exogenous variables. The objective of local governments is to find a combination of (b_0, b_1, b_2, e_1, e_2) to solve the following optimization problem:

$$\begin{aligned} &\max \mathrm{CE}(\pi_2) \\ &\mathrm{st}: CE(\pi_1) \geq \mathrm{u}_1 \\ &e_3 = \frac{b_1}{\theta_3}; e_4 = \frac{b_2}{\theta_4} \end{aligned} \quad (18)$$

where the constraints consist of two parts: firms' incentive–compatibility constraint and incentive–participation constraint. After incorporating these constraints into the target function,

this optimization problem can be reformulated as follows:

$$\max CE(\pi_2) = S(X) - S(Y) - \frac{\theta_3 e_3^2}{2} - \frac{\theta_4 e_4^2}{2} - \frac{1}{2}\delta Var(\mathrm{X}) = a_0 + a_1(\mathrm{e}_1 + \frac{b_1}{\theta_3}) + a_2(\mathrm{e}_2 + \frac{b_2}{\theta_4})$$
$$-\frac{b_1^2}{2\theta_3} - \frac{b_2^2}{2\theta_4} - \frac{\theta_1 e_1^2}{2} - \frac{\theta_2 e_2^2}{2} - \frac{1}{2}\delta a_1^2\sigma_3^2 - \frac{1}{2}\delta a_2^2\sigma_4^2 - -\frac{1}{2}\delta b_1^2\sigma_3^2 - \frac{1}{2}\delta b_2^2\sigma_4^2 - u_1 + b_1 h_1 \qquad (19)$$
$$+b_2 h_2 - \frac{\lambda_1 (b_1 h_1)^2}{2} - \frac{\lambda_2 (b_2 h_2)^2}{2}$$

Taking the first derivative with respect to b_1, b_2, e_1 and e_2, we can obtain the optimal behavioral decisions of local governments and firms given the incentive–compatibility constraint:

$$\begin{cases} b_1^{**} = \dfrac{a_1}{1+\theta_3\delta\sigma_3^2}; b_2^{**} = \dfrac{a_2}{1+\theta_4\delta\sigma_4^2} \\ h_1^{**} = \dfrac{1}{\lambda_1 b_1} = \dfrac{1+\theta_3\delta\sigma_3^2}{\lambda_1 a_1}; h_2^{**} = \dfrac{1}{\lambda_2 b_2} = \dfrac{1+\theta_4\delta\sigma_4^2}{\lambda_2 a_2} \\ e_1^{**} = \dfrac{a_1^{**}}{\theta_1}; e_2^{**} = \dfrac{a_2^{**}}{\theta_2} \\ e_3^{**} = \dfrac{b_1^{**}}{\theta_3} = \dfrac{a_1^{**}}{\theta_3(1+\theta_3\delta\sigma_3^2)}; e_4^{**} = \dfrac{b_2^{**}}{\theta_4} = \dfrac{a_2^{**}}{\theta_4(1+\theta_4\delta\sigma_4^2)} \end{cases} \qquad (20)$$

2.4.3 The optimal behavioral decision of the central government

The central government is risk neutral, and its expected utility (revenue) is:

$$\pi_3 = E(V(Y - S(X)) = (1-a_1)(\mathrm{e}_1 + e_3) + (1-a_2)(\mathrm{e}_2 + e_4) - a_0 - \frac{1}{2\lambda_1} - \frac{1}{2\lambda_2} \qquad (21)$$

The objective of the central government is to find a combination of (a_0, a_1, a_2) to solve the following optimization problem:

$$\max \pi_3 = E(V(Y - S(Y)) = (1-a_1)(e_1+e_3) + (1-a_2)(e_2+e_4) - a_0 - \frac{1}{2\lambda_1} - \frac{1}{2\lambda_2}$$

$$st: CE(\pi_2) \geq u_2$$

$$b_1^{**} = \frac{a_1}{1+\theta_3\delta\sigma_3^2}; b_2^{**} = \frac{a_2}{1+\theta_4\delta\sigma_4^2}$$

$$h_1^{**} = \frac{1}{\lambda_1 b_1} = \frac{1+\theta_3\delta\sigma_3^2}{\lambda_1 a_1}; h_2^{**} = \frac{1}{\lambda_2 b_2} = \frac{1+\theta_4\delta\sigma_4^2}{\lambda_2 a_2} \quad (22)$$

$$e_1^{**} = \frac{a_1^{**}}{\theta_1}; e_2^{**} = \frac{a_2^{**}}{\theta_2}$$

$$e_3^{**} = \frac{b_1^{**}}{\theta_3} = \frac{a_1^{**}}{\theta_3(1+\theta_3\delta\sigma_3^2)}; e_4^{**} = \frac{b_2^{**}}{\theta_4} = \frac{a_2^{**}}{\theta_4(1+\theta_4\delta\sigma_4^2)}$$

After incorporating these constraints into the target function and taking the first derivatives, we can derive the government's contractual strategy given the incentive–compatibility constraint:

$$\begin{cases} a_1^{**} = 1 - \dfrac{\theta_1\theta_3\delta\sigma_3^2 + \theta_1\theta_3^2\delta^2\sigma_3^4}{\theta_1 + \theta_3 + \theta_3^2\delta\sigma_3^2 + \theta_1\theta_3\delta\sigma_3^2 + \theta_1\theta_3^2\delta^2\sigma_3^4} \\ a_2^{**} = 1 - \dfrac{\theta_2\theta_4\delta\sigma_4^2 + \theta_2\theta_4^2\delta^2\sigma_4^4}{\theta_2 + \theta_4 + \theta_4^2\delta\sigma_4^2 + \theta_2\theta_3\delta\sigma_4^2 + \theta_2\theta_4^2\delta^2\sigma_4^4} \end{cases} \quad (23)$$

Then, the total social welfare is:

$$WS^{**} = \pi_1^{**} + \pi_2^{**} + \pi_3^{**} = \frac{1}{2}\left(\frac{a_1^{**}}{\theta_1} + \frac{a_2^{**}}{\theta_2} + \frac{a_1^{**}}{\theta_3(1+\theta_3\delta\sigma_3^2)} + \frac{a_2^{**}}{\theta_4(1+\theta_4\delta\sigma_4^2)}\right) \quad (24)$$

3. Comparative analysis of centralization and decentralization

Authors have discussed the optimal contractual designs of government economic and environmental regulations under both centralization and decentralization. According to the incentive theory proposed by Laffont and Tirole (2014), designing the optimal contract should consider the impact on all the policy participants (e.g., the central government, local governments, and firms) and the impact on the total social welfare. Therefore, this section will analyze the incentive hierarchy effects (impact on the central government), the degree of

government effort (impact on both the central government and local governments), collusion between government and enterprise (impact on local governments), incentive intensity (impact on firms) and social welfare to compare the optimal designs under centralization and decentralization. In doing so, the authors provide a clear understanding of the advantages and disadvantages of the different systems with the aim of highlighting the implications for policymakers.

3.1 Comparative analysis of incentive hierarchy effects

Under centralization, the supervisory relationship between the central government and firms is a single-level principal–agent model. Under the system of local decentralization, the strength of the local government's incentives to local firms for economic growth and environmental protection satisfy the following conditions:

$\frac{b_1^{**}}{b_2^{**}} = \frac{a_1^{**}}{a_2^{**}} \frac{1+\theta_4\delta\sigma_4^2}{1+\theta_3\delta\sigma_3^2}$ (see Appendix 1 for the mathematical proof). When $\frac{a_1^{**}}{a_2^{**}} > 1$, we have $\frac{1+\theta_4\delta\sigma_4^2}{1+\theta_3\delta\sigma_3^2} > 1$. This suggests that when the strength of the central government's incentives to local governments for economic growth exceeds that for environmental protection, the local governments' incentives to local firms for economic growth are higher than those for environmental protection. Specifically, the strength of local governments' incentives for economic growth is $\frac{1+\theta_4\delta\sigma_4^2}{1+\theta_3\delta\sigma_3^2}$ times that of the central government; otherwise, (i.e., when $\frac{a_1^{**}}{a_2^{**}} < 1$), the strength of local governments' incentives to firms for environmental protection is $\frac{1+\theta_4\delta\sigma_3^2}{1+\theta_3\delta\sigma_4^2}$. This analysis led us to conclusion 1, which is outlined below.

Conclusion 1: Under the system of local decentralization, if the incentives from the central government to local governments to encourage economic effort are greater than those for

$\frac{1+\theta_4\delta\sigma_4^2}{1+\theta_3\delta\sigma_3^2}$; otherwise, if the strength of the central government's incentives to local governments for environmental protection is higher than those for economic growth, the strength of the local government's incentives to firms for environmental protection is multiplied by $\frac{1+\theta_4\delta\sigma_3^2}{1+\theta_3\delta\sigma_4^2}$.

Conclusion 1 suggests that the effects of central governments' preference for economic growth or environmental protection will be multiplied when considering local governments' incentives to local firms. This is consistent with Zhou's (2007) argument regarding the role of local governments in promoting economic development. Moreover, this conclusion indicates that these multiplier effects exist not only for economic growth, but also for environmental protection. The ultimate result depends on which task the central government emphasizes over the other. Specifically, if the central government prefers to regard economic development as a more important indicator than environmental protection, it will lead local governments to "race to the bottom" in environmental regulation; conversely, if environmental protection is regarded as the superior objective, it will result in a "race to the top" in environmental regulation. Therefore, conclusion 1 also helps to resolve the debates on environmental regulation in existing research and clarify the mechanisms of "race to the bottom" and "race to the top" (Deng and You, 2019).

3.2 Comparative analysis of the government's efforts

Under centralization, the central government takes the main responsibility for developing the economy and protecting the environment (assume that the efforts are $e_1^* = \frac{1}{\theta_1}; e_2^* = \frac{1}{\theta_2}$

$e_1^{**} = \frac{a_1^{**}}{\theta_1}; e_2^{**} = \frac{a_2^{**}}{\theta_2}$). Considering equation (23), we know that $a_1^{**} < 1$, $a_2^{**} < 1$, and $e_1^{*} < e_1^{**}$, $e_2^{*} < e_2^{**}$. This analysis led us to conclusion 2, which is outlined below.

Conclusion 2: Under the system of local decentralization, the government's total efforts devoted to economic growth and environmental protection are relatively lower than those under the centralized system.

Conclusion 2 also suggests that under the decentralized system, the government's total input is lower than that under the centralized system. There are two reasons for this. First, under decentralization, some of the local governments' revenues will be transferred as a payment to the central government, whereas under centralization, all revenues belong to the central government. Consequently, the central governments is more motivated to exert effort than local governments. Second, the central government and local governments have different risk-taking attitudes. The central government, being responsible for the entire country and society, should be risk neutral. However, local governments are risk averse, as they compete to obtain promotions and pursue maximum performance. Therefore, local governments need to bear the additional costs of taking risks and thus have lower investment motivations.

3.3 Comparative analysis of the collusion between local governments and firms

Under centralization, the collusion level of local governments on economic development and environmental protection (fake reports on political performance) is $h_1^{*} = \frac{1}{\lambda_1 b_1^{*}} = \frac{1+\theta_3\delta\sigma_1^2}{\lambda_1}$

$h_2^{**} = \frac{1}{\lambda_2 b_2^{**}} = \frac{1+\theta_4\delta\sigma_4^2}{\lambda_2 a_2^{**}}$

$\sigma_i (i = 1 \ldots 4)$. According to the above-mentioned assumption 1 that $\sigma_3 \le \sigma_1$, $\sigma_4 \le \sigma_2$, first, we consider an extreme case, namely

$\sigma_3 = \sigma_1$, $\sigma_4 = \sigma_2$. When the level of information asymmetry under two systems is equal, from equation (23), it can be calculated that $a_1^{**} < 1$, $a_2^{**} < 1$; therefore, $h_1^{**} > h_1^*; h_2^{**} > h_2^*$. Furthermore, when $\sigma_3 < \sigma_1$ and $\frac{(1+\theta_3\delta\sigma_3^2)}{(1+\theta_3\delta\sigma_1^2)} \le a_1^{**}$, it can be calculated that $h_1^{**} \le h_1^*$; when $\sigma_4 < \sigma_2$ and $\frac{(1+\theta_3\delta\sigma_4^2)}{(1+\theta_3\delta\sigma_2^2)} \le a_2^{**}$, the calculated result showed that $h_2^{**} \le h_2^*$. This analysis led us to conclusion 3, which is outlined below.

Conclusion 3: While facing the same information asymmetry level, decentralization will cause a higher collusion degree between local governments and firms than centralization. When local governments have information superiority ($\frac{(1+\theta_3\delta\sigma_3^2)}{(1+\theta_3\delta\sigma_1^2)} \le a_1^{**}$, $\frac{(1+\theta_3\delta\sigma_4^2)}{(1+\theta_3\delta\sigma_2^2)} \le a_2^{**}$), decentralization will cause a lower collusion degree between local governments and firms than centralization.

Conclusion 3 suggests that information superiority is the key issue to determine whether decentralization can have a lower collusion degree than centralization, and when local governments have significant information superiority, decentralization has a higher efficiency rate in avoiding collusion between local governments and firms than centralization. Laffont and Martimort (1998) and Faure-Grimaud (2003) highlighted that decentralization is more efficient in the disintegration of collusion. In this paper, the authors theoretically explain the reason decentralization can disintegrate collusion, which is the information superiority of local governments.

3.4 Comparative analysis of incentive strength

Under centralization, the government's incentives to firms for economic growth and environmental protection are $b_1^* = \frac{1}{1+\theta_3\delta\sigma_1^2}; b_2^* = \frac{1}{1+\theta_4\delta\sigma_2^2}$

$b_1^{**} = \frac{a_1}{1+\theta_3\delta\sigma_3^2}; b_2^{**} = \frac{a_2}{1+\theta_4\delta\sigma_4^2}$. Thus, the comparison of the strength of incentives under the two systems depends on the value of $\sigma_i (i = 1 \ldots 4)$. According to equation (23), we know that $a_1^{**} < 1$ and $a_2^{**} < 1$ when $\sigma_3 = \sigma_1$, $\sigma_4 = \sigma_2$. When the level of information asymmetry under two systems is equal, it can be calculated that $b_1^{**} < b_1^*; b_2^{**} < b_2^*$. Furthermore, as analyzed in section 3.3, when $\sigma_3 < \sigma_1$ and $\sigma_4 < \sigma_2$, the relationship between b_1^{**} and b_1^* depends on the relative size of $a_1^{**}, \frac{(1+\theta_3\delta\sigma_3^2)}{(1+\theta_3\delta\sigma_1^2)}$ and a_2^{**}. This analysis led us to conclusion 4, which is outlined below.

Conclusion 4: When the information asymmetry faced by both the central government and local governments is the same, incentives are weaker under centralization than under decentralization. In this way, firms will lose motivation to exert effort. When local governments have an information advantage over the central government (i.e., $\frac{(1+\theta_3\delta\sigma_3^2)}{(1+\theta_3\delta\sigma_1^2)} \le a_1^{**}$, $\frac{(1+\theta_3\delta\sigma_4^2)}{(1+\theta_3\delta\sigma_2^2)} \le a_2^{**}$), incentives are stronger, and therefore firms will be more motivated to exert effort.

Conclusion 4 suggests that whether decentralization has higher incentive efficiency than centralization depends on whether local governments have an information advantage. When local governments have a sufficient information advantage, local decentralization has higher incentive efficiency than centralization. This is the key when considering whether centralization or decentralization should be chosen.

3.5 Comparative analysis of social welfare

When clarifying the mechanisms of regulations, it is necessary to consider both economic

$a_1^{**} < 1$, $a_2^{**} < 1$, when $\sigma_3 = \sigma_1, \sigma_4 = \sigma_2$, it can be calculated that $WS^* > WS^{**}$. Following the methodology used in section 3.3, when $\sigma_3 < \sigma_1$, $\sigma_4 < \sigma_2$, the comparison of values between WS^* and WS^{**} is contingent on the comparison of $\frac{(1+\theta_3\delta\sigma_3^2)}{(1+\theta_3\delta\sigma_1^2)}$ and a_1^{**}, as well as the comparison of $\frac{(1+\theta_3\delta\sigma_4^2)}{(1+\theta_3\delta\sigma_2^2)}$ and a_2^{**}. This analysis led us to conclusion 5, which is outlined below.

Conclusion 5: When the information asymmetry that both the central government and local governments face is the same, the centralized system has higher total social welfare than the decentralized system. Conversely, when local governments have a greater informational advantage, the decentralized system has higher total social welfare than the centralized system.

Taken together, conclusion 4 and conclusion 5 suggest that the benefits and weaknesses of the two systems (i.e., centralized and decentralized systems) depend on the comparative values of $\sigma_i (i = 1 \ldots 4)$, a_1^{**} and a_2^{**}. Based on principal–agent theory, we can conclude that the result is suboptimal because of the existence of information asymmetry between the principal and agent. Adding one more level to the principal–agent relationship would add extra costs. However, adding a level to the principal–agent relationship can efficiently reduce the information asymmetry between principal and agent. In this way, adding a level to the principal–agent relationship can reduce the loss from information asymmetry. Therefore, $1 - a_1^{**}$ and $1 - a_2^{**}$ can be regarded as extra regulation costs caused by the addition of one more level to the principal–agent relationship. Subsequent information advantages resulting from adding one more level to the principal–agent relationship are $\theta_3\delta\sigma_1^2 - \theta_3\delta\sigma_3^2$ and $\theta_3\delta\sigma_2^2 - \theta_3\delta\sigma_4^2$, which can therefore be regarded as saving costs on economic and environmental regulations. This led us to the inference below.

Inference 1: Compared to the centralized system, local decentralization adds one level to the principal–agent relationship regarding the government's supervision of firms' activities in economic growth and environmental protection. The results are not only increased principal–agent costs, but also increased returns from the reduced information asymmetry. If the increased principal–agent costs are lower than the increased returns from the reduced information asymmetry, the incentive efficiency and total social welfare in the centralized system are higher than those in the decentralized system. Under this circumstance, centralization has advantages over decentralization; otherwise, decentralization performs better because of its higher incentive efficiency and higher total social welfare.

4. Discussion

4.1 Theoretical implications

This research investigates the strategic interactions among multiple players in the governance system concerning the central government, local governments and local firms in terms of achieving a balance between goals of economic development and environmental protection. We construct a two-level principal–agent model and conclude that under decentralization, local governments' revenues rely solely on the central government. This is due to the fact that the level of incentives the central government offer determines whether local governments choose advancing the economy development or protecting the environment. Due to the fact that pursuing maximum profits is local governments' ultimate goal, local governments' total efforts devoted to economic growth and environmental protection under a decentralized governance mode are less than their total efforts under a centralized governance mode. Decentralization and centralization differ in terms of incentive efficiency and total social welfare. The results of studies that compared the two governance systems have been inconclusive. This is due to the fact that a decentralized governance mode contains an extra level in the principal–agent relationship in addition to the incentive-based relationship between the government and firms under a centralized governance mode. Although a

decentralized governance mode reduces information asymmetry between the central government and firms, it leads to increased principal–agent costs. When increased principal–agent costs surpass returns, a centralized system achieves better incentive efficiency and total social welfare; otherwise, the decentralized system is better.

Our research contributes to the literature on how the government shapes firm behavior from a fresh political incentives perspective. This new angle associates firm behavior with distribution of government authority, which unravels the mechanisms in the "black box"—how political goals are implemented within the governments (Guillén and Capron, 2016). Previous studies emphasized the regulative and normative pressures from the government (Campbell and Lindberg, 1990; DiMaggio and Powell, 1983; Meyer and Rowan, 1977). They did not conduct an in-depth investigation of different levels within a government system, which differ substantially in terms of autonomous goals and administrative capacity (Guillén and Capron, 2016; Kalev et al., 2008). More importantly, scholars have increasingly recognized the complexity of the government and agencies of various organizations within the government, such as different levels of government (Luo et al., 2017; Zheng et al., 2015; Choi et al., 2014), branches of government (Hiatt and Park, 2013), and rival political parties (Zhu and Chung, 2014; Kozhikode and Li, 2012; Siegel, 2007). Nevertheless, how the distribution of authority affects the achievement of heterogeneous goals of different governments is missing from the current debate.

By determining how incentives change within local governments that implement central government-imposed policies, our research extends the Weberian state literature, which assumes that high-quality bureaucratic structures are equally effective in incentivizing government officials and therefore focuses only on the empirical relationship between bureaucratic features and a country's macroeconomic outcomes (e.g., Evans and Rauch, 1999). Our research reveals that how to balance the dual goals of the government may vary as a result of the differences in the distribution of authority. Under decentralization, local governments reduce investment in environmental protection and economic development to maximize their interests. In addition, to achieve short-term political benefits (e.g., promotions and

remunerations), local governments are more likely to act opportunistically and subsequently increase the incentives to firms. This has often led to local governments deviating from the expected goals of the central government. This unintended consequence cannot be anticipated without considering the strategic behavior of local governments. Therefore, our view of political incentives helps to better explain when and why state goals can be fully accomplished.

Our research also extends the research on political incentives by investigating the interaction mechanism among the central government, local governments, and firms. We focus on the incentive role of the government in environmental protection and economic development, and we find that the results of different authority distribution systems vary greatly. Our proposed framework integrated the two environmental regulation approaches often regarded as oppositions, namely "race to the top" and "race to the bottom", to gain a better understanding of local governments' pursuit of profit maximization. Our findings emphasize the importance of national characteristics in shaping political incentives and distribution of authority in environmental governance. Specifically, our research suggests that the diversity of goals is an important structural condition contributing to local governments' judgment and incentives policy when distributing authority. Moreover, the priority of a goal restricts local governments' discretion power and results in different political incentives under different authority distribution systems.

Although our research is based on the Chinese context, it has strong implications regarding how institutional arrangements in Western democracies may determine their political incentives. In the Western contexts, the legislative and administrative branches of the government function independently (Hiatt and Park, 2013). However, elected politicians are more accountable to voters than appointed administrators are to their superiors. In fact, local governments in Western democracies are often more powerful than those in China in the distribution of authority. In other words, Western democratic countries also implement a decentralized system of central government and local governments; the major difference is the entity responsible for each government issue (voters or the central government). Our finding

indicates that the incentives based on the power distribution system are suitable for both political systems, one with appointed government officials and the other with elected politicians. Future research could extend our research to different state bureaucracies to gain a further understanding of the role of political incentives.

In summary, our research extends principal–agent theory in political economy. This theory is the core of contract design in institutional economics. In modern political economy, there is also a principal–agent relationship between the government and voters, as well as between the government and firms (Voss and Lingens, 2018). Traditional principal–agent theory is based on the assumption of information asymmetry, and most of the theories feature principal–agent problems occurring at the single level. This research analyzes the interaction between the government and firms under the pressure of a dual goal: economic development and environmental protection. It adopts the principal–agent theory and explains the system failure and social welfare loss that information asymmetry causes. Moreover, this paper highlights the problem of collusion between local governments and firms in the cases of centralization and decentralization, respectively. It provides insights into how the decentralized governance mode is able to resolve the collusion problem (Faure-Grimaud, 2003; Laffont and Martimort, 1998) by empowering local governments with information superiority.

4.2 Practical implication

In the early round of the Chinese reform and opening up, decentralization is prevalent across environmental regulation; however, it causes severe environmental problems. For example, local governments make great efforts to attract investment and develop the economy, which has led to the “race to the bottom” approach in environmental regulation. This approach is skewed toward gaining economic benefits rather than maintaining environmental sustainability. Moreover, a “race to the top” approach has been adopted recently, as the central government attaches great importance to environmental protection. Evidence shows that local governments even shut down businesses to meet the central government’s

environmental requirements. This approach harms the local economy and is unsustainable in environmental regulation. In addition, under the decentralization system, collusion between firms and local governments is common as a result of the pressure of environmental protection assessment imposed by the central government. This collusion, however, results in negative incidents due to conflicting goals and mismatched incentives between the two parties.

To address these problems, our research offers the central government and local governments advice on improving the effectiveness of the current incentive systems in three ways. The first is integrating principal–agent levels through vertical management. For example, it would be efficient to reduce principal–agent costs by implementing vertical management (i.e., direct governance by the central government) on issues concerning public livelihood, such as environmental protection. The second way is reducing information asymmetry through public involvement. Since obtaining information is costly and regulatory targets usually have no intention of disclosing information, third parties such as the public can be introduced into the governance system to reduce the costs of information access or mandatory disclosure of the environmental performance of firms. The third way is adopting a hybrid centralization and decentralization governance approach. For relatively flexible tasks (e.g., promoting economic growth), it would be better to adopt decentralization to enhance local governments' motivations. However, for compulsory tasks (e.g., protecting the environment), it would be better to adopt a centralized system that can not only reduce principal–agent costs, but also prevent regulatory issues such as government–entrepreneur collusion.

The effort of the Chinese government in centralized environmental governance can be seen in the introduction of Environmental Protection Law of People's Republic of China in 2015. This law strengthens the power of the central government in establishing standards, making information disclosure on environmental practices compulsory, and facilitating public supervision. The exploration of a hybrid form of centralized and decentralized governance

can be found in the introduction of the Central Environmental Inspection Group in 2016, which conducts regular inspection on various levels of government bodies on behalf of the central government. We suggest that other forms of public involvement should be encouraged to reduce information asymmetry due to their low-cost advantage.

4.3 Future research and limitations

It should be noted that in our research, we assume that government efforts to achieve economic growth and environmental protection are independent. This is due to the fact that a consensus has not been reached on whether their relationship is complementary or substitutive (see, for example, the debate on Porter's hypothesis [Porter and Linder, 1995]). Further analysis of their relationship to improve incentive efficiency is valuable, which provides opportunities for future research. Moreover, we believe it is important for future research to take contingency factors such as differences in industry types and firm sizes (Jian et al., 2020; Meng et al., 2018) into account to further enrich our understanding of the authority of distribution based on the two-level principal–agent model.

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Appendix 1.

To justify the conclusions in the study, we compare the values of $\theta_i(i=1\ldots4)$. From the perspective of economic implications, we know that $\theta_i(i=1\ldots4)$ represents governments' abilities in economic development and environmental protection. We assume that the government's ability and firms' ability in economic growth and environmental protection are similar, namely, $\frac{\theta_1}{\theta_2}\approx\frac{\theta_3}{\theta_4}$. We let $\frac{\theta_1}{\theta_3}\approx\frac{\theta_2}{\theta_4}=k$, $\theta_3\delta\sigma_3^2=T$ and $\theta_3\delta\sigma_4^2=L$, and then we have

$$a_1^{**}=1-\frac{k(\mathrm{T}+\mathrm{T}^2)}{1+k+T+kT+kT^2}$$

$$a_2^{**}=1-\frac{k(L+L^2)}{1+k+L+kL+kL^2}$$

We construct the function $f(x)=1-\frac{k(x+x^2)}{1+k+x+kx+kx^2}$; then, we can conclude that $a_1^{**}=f(T)$, $a_2^{**}=f(L)$. This is because $f'(x)=-\frac{k(1+\mathrm{k}+2x+2kx+x^2)}{[1+k+x+kx+kx^2]^2}<0$, namely, $f(x)$ is a monotonically decreasing function. Thus, when condition $f(T)>f(L)$ is fulfilled, then $T<L$ can be inferred.