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Zhe Zhang, Xi'an Jiaotong University

Ming Jia, Wuhan University

Difang Wan, Xi'an Jiaotong University

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For information, contact: Karen N. Eggleston (翁笙和)

Walter H. Shorenstein Asia-Pacific Research Center
Stanford University
616 Serra St., Encina Hall E311
Stanford, CA 94305-6055
(650) 723-9072; Fax (650) 723-6530
karene@stanford.edu

Allocation of control rights and cooperation efficiency in public-private partnerships: Theory and evidence from the Chinese pharmaceutical industry

Zhe Zhang, Ming Jia, and Difang Wan

Abstract This article uses incomplete contract theory to study the allocation of control rights in public-private partnerships (PPPs) between pharmaceutical enterprises and nonprofit organizations; it also investigates how this allocation influences cooperation efficiency. We first develop a mathematic model for the allocation of control rights and its influence on cooperation efficiency, and then derive some basic hypotheses from the model. The results of an empirical test show that the allocation of control rights influences how enterprises invest in PPPs. A proper allocation provides incentives for firms to make fewer self-interested and more public-interested investments. Such an allocation also improves the cooperation efficiency of PPPs.

Keywords Pharmaceutical enterprises • PPPs • Allocation of control rights • Cooperation efficiency

JEL Classifications: H41; L33

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Zhe Zhang, Assistant professor, Xi'an Jiaotong University, School of Management, Box 1843, Shannxi 710049
zhangzhe220@yahoo.com.cn

Ming Jia, Assistant professor, Wuhan University, School of Economics and Management, Hubei 43800
xjtujiaming@163.com

Difang Wan, Professor, Xi'an Jiaotong University, School of Management, Box 1843, Shannxi 710049
wandf@stu.xjtu.edu.cn

Introduction

As regulations become stricter, pharmaceutical enterprises in China face tremendous competitive pressure. Regardless of whether they are state-owned, private, foreign-owned, or joint ventures, such enterprises must take the interests of many stakeholders into account. Even as they grow, they must work toward the goal of sustainable development and demonstrate social responsibility. Private, for-profit pharmaceutical enterprises have a number of potential advantages over nonprofit organizations, including management ability and capital. Meanwhile, since nonprofit pharmaceutical organizations (that is, medical institutes, pharmaceutical institutes, and foundations) are usually linked to the Chinese government, they have their own advantages. Under this situation, public-private partnerships (PPPs) seek to combine the best of both. Through them, pharmaceutical enterprises and nonprofit pharmaceutical organizations can acquire complementary resources and achieve a synergy that benefits both parties.

The research literature on PPPs is in its nascent stages and lacks systematic and thorough analyses (Reich 2002; Hart 2003; Bettignies and Ross 2004; Francesconi and Muthoo 2006; Martimort and Pouyet 2008). Such research mainly focuses on the motivation for cooperation between stakeholders. Some case studies are provided, but there is little in-depth theoretical research or large-scale empirical studies.

This article emphasizes the contractual nature of PPPs and identifies (1) partner characteristics and (2) public outputs as the two key features that differentiate PPPs from traditional interfirm alliances (Zhang, Jia, and Wan 2007). By joining the public and private sectors, PPPs generate alternative interests and motivations. Their output usually consists of pure public goods or quasi-public goods—versus the private goods produced by traditional partnerships.

Based on these factors, and from the perspective of incomplete contract theory, we identify the allocation of control rights as the key variable affecting cooperation efficiency in PPPs. Because PPP output usually consists of public goods (or services), pharmaceutical enterprises and relevant nonprofit organizations make public-interested investments that increase the total benefits of the joint project. However, the profit-seeking nature of private enterprises will drive them to make self-interested investments during the process of cooperation, as well as attempt to secure the benefits of control—thus decreasing societal benefits. Therefore, in order to enhance the cooperation efficiency of PPPs, it is necessary to increase the public-interested investments of both partners and decrease the self-interested investments of enterprises. Specifically, the investments that pharmaceutical enterprises make jointly with nonprofit organizations, or public-interested investments, should be increased, and purely self-interested investments should be decreased. But what kind of investment strategy will reflect enterprises' profit-making incentive? And how does the allocation of control rights affect the self- and public-interested investments of enterprises? In other words, how can control rights be allocated to best meet incentive compatibility conditions?

In the second part of this article, we construct a mathematical model and use it to study the allocation of control rights and its influence on cooperative efficiency in PPPs. We also put forward some basic research hypotheses. Based on these hypotheses, we present data from PPP questionnaires completed by representatives of the pharmaceutical industry. In addition, we present the results of a large-scale empirical study testing our basic research hypotheses. Finally, we provide conclusions and directions for future research.

Model construction and research hypotheses

From the perspective of incomplete contract theory, researchers studying alliances between firms have suggested that the allocation of control rights fundamentally affects cooperation efficiency. Under the framework of an incomplete contract, Hart, Shleifer, and Vishny (1997) study the boundaries of the public sector and put forth a theoretical model that addresses the sole ownership of public outputs or joint ownership of outputs in the public sector through contracts with the private sector (the HSV model). Specifically, the HSV model introduces various types of partners from a theoretical perspective, and then describes how each partner type influences the allocation of control rights. The HSV model, however, does not consider the nature of the output, which also influences the allocation of control rights. Moreover, the HSV model addresses only the investments of the enterprises. These drawbacks might render the HSV model unsuitable for studying control of rights allocation when public and private sectors cooperate to produce a public output in the context of PPPs.

Besley and Ghatak (2001) use some concepts from incomplete contract theory to study the optimal allocation of control rights between public and private sectors when the joint output is a purely public good. They conclude that if two partners both invest in public outputs, the partner who values the output the highest should own full control rights during the cooperation, regardless of the relative importance of investments or other technical factors affecting production. Although both partners invest in Besley and Ghatak's model, the allocation of control rights is modeled as either total (1) or none (0). Thus, only one partner holds all of the control rights; this ignores a realistic situation in which the two partners share control rights.

The present article incorporates investments from both the partners, continuity in the allocation of control rights, and public good outputs into a united model, then takes PPPs' unique features into account to establish a theoretic model. This model yields two innovations. First, it considers two types of investments from both partners. Specifically, enterprises make both self-interested investments (e_E) and public-interested investments (i_E), whereas nonprofit organizations only make public-interested investments (i_N). Second, the model describes control rights as a continuous variable in order to identify their optimal allocation under various conditions.

Basic assumptions of the model

A public sector constituent such as a nonprofit organization (N) and a private sector

constituent such as an enterprise (*E*) both participate in a joint project (*F*). We assume that the two partners are both risk-neutral and that there are three time points, as shown in Figure 1.

[[INSERT FIGURE 1 ABOUT HERE]]

Time 0—allocation of control rights. To simplify, at this stage the allocation of control rights is defined as a specific proportion, and we assume that π ($\pi \in [0,1]$) is the share of control rights owned by the nonprofit organization, with the remaining 1-π owned by the enterprise. Then, if π=1, the nonprofit organization owns all control rights in the joint project; if π=0, the enterprise owns all control rights in the joint project; likewise, if $\pi \in (0,1)$, the partners share ownership of the control rights.

Time 1—investment. At this stage, the two partners invest in the joint project (*F*), and we assume that the total benefits of the joint project range between B^E when π=0, and B^N when π=1. Moreover, we assume that when the nonprofit organization owns total control rights, the enterprise is controlled and supervised strictly enough to discourage self-interested investments (e_E); thus, at this time, the total benefits of the joint project are $B^N(i_E, i_N)$. When the enterprise owns total control rights, it can make not only public-interested investments (i_E) but also self-interested investments (e_E); therefore, the total benefits of the joint project are $B^E(e_E, i_E, i_N)$, and these investments are a function of π.

Furthermore, since enterprises are profit-seeking, they make self-interested investments (e_E) which generate private benefits $\varphi^E(e_E)$; we assume those private benefits are increasing and concave ($\varphi_1^{'E}(e_E) > 0$， $\varphi_{11}^{''E}(e_E) \le 0$). During the PPPs' cooperative process, enterprises' private benefits impose a negative externality on the joint project. We assume that the total benefit of the joint project, *B,* is decreasing in e, with $B_1^{1E} < 0$ and $B_{11}^{''E} > 0$.

Additionally, enterprises can make public-interested investments (i_E); these investments not only increase the benefit of the joint project but also bring about indirect benefits such as enhanced enterprise reputation and social status, which is consistent with the status quo in China. This portion of the benefit is described as $g^E(i_E)$, $g_1^{'E}(i_E) > 0$, and $g_{11}^{''E}(i_E) < 0$. Nonprofit organizations only make public-interested investments (i_N), which can generate overall benefits for the joint project without yielding private benefits.

We also assume that when *N* owns the total control rights, the marginal production rate of public-interested investments owned by *N* is higher than the marginal

production rate of public-interested investments owned by *N* when *E* owns all control rights; this is represented by $B_2^{'N} - B_3^{'E} > 0$. When the second derivative of investment is less than 0 which means that the difference of marginal production rate decreases, then $B_{33}^{"E} - B_{22}^{"N} > 0$. Similarly, we assume that when *E* owns total control rights, the marginal production rate of public-interested investments (i_E) is higher than the marginal production rate (i_E) when *N* owns all control rights; this is represented by $B_1^{'N} - B_2^{'E} < 0$ and $B_{22}^{"E} - B_{11}^{"N} < 0$.

At stage (1), the cost functions for various investments are $C_N(i_N)$ $C_E(e_E)$ and $C_E(i_E)$, and we assume that C_i (*i*=*N, E*) is strictly increasing, convex, and twice continuously differentiable with $C^{'} > 0$, $C^{"} \geq 0$, and $C_i(0) = 0$ that follow the general setting of cost function. If the two partners maintain cooperation only through the initial allocation of control rights, then the total benefits of the joint project are $B(e_E, i_E, i_N)$; if both partners collaborate to make decisions, then the total benefits of the joint project are $b(e_E, i_E, i_N)$, where (similarly) $b_1^{'} < 0$, $b_{11}^{"} > 0$, $b_2^{'} > 0$, and $b_3^{'} > 0$. In this article, the signs of 1, 2, and 3 represent the derivatives of the first, second, and third variables, respectively. We also assume that $b(e_E, i_E, i_N) > B(e_E, i_E, i_N)$; thus, both partners can benefit from the collaboration and we assume that *B* is a linear combination of B^N and B^E. Therefore,

$$B(e_E, i_E, i_N) = m\pi B^N(i_E, i_N) + (1 - m\pi)B^E(e_E, i_E, i_N) \quad (1)$$

Time 2—negotiation. This occurs when both partners negotiate on the surplus. Specifically, at this time, both partners negotiate about whether or not to collaborate and also about the amount of the transferable payment (*t*). Once the two partners make an agreement, the benefits for the nonprofit organization and the enterprise are defined, respectively, as

$$u_N(i_N) = \theta_N b(e_E, i_E, i_N) + t \quad (2)$$

$$u_E(e_E, i_E) = \theta_E b(e_E, i_E, i_N) - t \quad (3)$$

Following Besley and Ghatak (2001), we assume that $\theta_i > 0$ (*i*=*E, N*) is the evaluation coefficient for the joint project, and that $\theta_N + \theta_E = 1$. In addition, *t* is the transfer payment from the enterprise to the nonprofit organization (positive or

negative). If they do not collaborate, then the two partners operate and manage the joint project only through the initial allocation of control rights, after which the default payoffs for both partners are, respectively,

$$\overline{u_N} = \theta_N B(e_E, i_E, i_N) \tag{4}$$

$$\overline{u_E} = \theta_E B(e_E, i_E, i_N) \tag{5}$$

If $b(e_E, i_E, i_N) > B(e_E, i_E, i_N)$, then $u_N(i_N) + u_E(e_E, i_E) > \overline{u_N}(i_N) + \overline{u_E}(e_E, i_E)$; thus, the total benefits from the collaboration are greater than the total benefits obtained with only an initial allocation of control rights. For any value of π, e_E, i_N, and i_E at stage (1) we assume that both partners divide the surplus according to Nash equilibrium. Specifically, they divide the surplus 50/50 and each receives $\frac{(\theta_N + \theta_E)b(e_E, i_E, i_N) - (\overline{u_N} + \overline{u_E})}{2}$. Then, the income functions for the nonprofit organization and the enterprise are, respectively,

$$V^N = \frac{(\theta_N + \theta_E)b(e_E, i_E, i_N) - (\overline{u_N} + \overline{u_E})}{2} + \overline{u_N} \tag{6}$$

$$V^E = \frac{(\theta_N + \theta_E)b(e_E, i_E, i_N) - (\overline{u_N} + \overline{u_E})}{2} + \overline{u_E} \tag{7}$$

Thus, combining private benefits and investment costs, the benefit functions of both partners are, respectively,

$$\begin{aligned} U^N &= V^N - C^N(i_N) \\ &= \frac{1}{2}(\theta_N + \theta_E)b(e_E, i_E, i_N) + \frac{1}{2}(\theta_N - \theta_E)[m\pi B^N(i_E, i_N) + (1 - m\pi)B^E(e_E, i_E, i_N)] \\ &\quad - C^N(i_N) \end{aligned} \tag{8}$$

$$\begin{aligned} U^E &= V^E - [C^E(e_E, i_E) - \varphi^E(e_E) - g^E(i_E)] \\ &= \frac{1}{2}(\theta_N + \theta_E)b(e_E, i_E, i_N) + \frac{1}{2}(\theta_E - \theta_N)[m\pi B^N(i_E, i_N) + (1 - m\pi)B^E(e_E, i_E, i_N)] \\ &\quad + \varphi^E(e_E) + g^E(i_E) - C^E(e_E, i_E) \end{aligned} \tag{9}$$

Model solution

Based on equations (8) and (9), when an enterprise maximizes its benefits and optimizes both its self- and public-interested investments, the optimal investment of the nonprofit organization should satisfy the following conditions:

$$\frac{\partial U^E}{\partial e_E} = \frac{1}{2}(\theta_N + \theta_E)b_1^{'} + \frac{1}{2}(\theta_E - \theta_N)[(1 - m\pi)B_1^{'E}(e_E, i_E, i_N)] + \varphi_1^{'E}(e_E) - C_1^{'E}(e_E, i_E) \tag{10}$$

$$\frac{\partial U^E}{\partial i_E} = \frac{1}{2}(\theta_N + \theta_E)b_2^{'} + \frac{1}{2}(\theta_E - \theta_N)[m\pi B_1^{'N}(i_E, i_N) + (1 - m\pi)B_2^{'E}(e_E, i_E, i_N)] + g_1^{'E}(i_E) - C_2^{'E}(e_E, i_E) \tag{11}$$

$$\frac{\partial U^N}{\partial i_N} = \frac{1}{2}(\theta_N + \theta_E)wb_3^{'} + \frac{1}{2}(\theta_N - \theta_E)[m\pi B_2^{'N}(i_E, i_N) + (1 - m\pi)(B_3^{'E}(e_E, i_E, i_N)] - C^{'N}(i_N) \tag{12}$$

Based on (10), (11), and (12), we derive π, e_E, and i_E, respectively, and assume that

the three types of investments are independent of one another; thus the twice cross-partial derivatives are all 0, such that $B_{ig}^{"}=0$, $b_{ig}^{"}=0$ $C_{ig}^{"}=0$ （$i\neq g$）. Then, after solving and simplifying, we get the following equations:

$$\frac{\partial e_E}{\partial \pi}=\frac{-mB_1^{'E}(\theta_E-\theta_N)}{4(C_{11}^{"E}-\varphi_{11}^{"E})-2b_{11}^{"}(\theta_E+\theta_N)+2B_{11}^{"E}(\theta_E-\theta_N)(m\pi-1)} \tag{13}$$

$$\frac{\partial i_E}{\partial \pi}=\frac{-m(B_2^{'E}-B_1^{'N})(\theta_E-\theta_N)}{4(C_{22}^{"E}-g_{11}^{"E})-2b_{22}^{"}(\theta_E+\theta_N)+2[(m\pi-1)B_{22}^{"E}-m\pi B_{11}^{"N}](\theta_E-\theta_N)} \tag{14}$$

Hypothesis

According to equations (13) and (14), we get Lemma 1 and Lemma 2. According to lemma 1, regardless of how both partners evaluate the joint project, when

$$m\pi<\frac{2b_{11}^{"}(\theta_E+\theta_N)-4(C_{11}^{"E}-\varphi_{11}^{"E})+2B_{11}^{"E}(\theta_E-\theta_N)}{2B_{11}^{"E}(\theta_E-\theta_N)} \tag{15}$$

there exists a relationship $\frac{\partial e_E}{\partial \pi}<0$. But, when

$$m\pi>\frac{2b_{11}^{"}(\theta_E+\theta_N)-4(C_{11}^{"E}-\varphi_{11}^{"E})+2B_{11}^{"E}(\theta_E-\theta_N)}{2B_{11}^{"E}(\theta_E-\theta_N)} \tag{16}$$

there exists a relationship $\frac{\partial e_E}{\partial \pi}>0$.

In Lemma 1, we note the relationship between the allocation of control rights and the enterprise's incentive to make self-interested investments. When granting more control rights to enterprises and satisfying the appropriate condition (15), we obtain $\frac{\partial e_E}{\partial \pi}<0$. Then, when the control rights of the enterprise increase (π decreases), e_E increases; thus, the incentives for the enterprise to make self-interested investments increase. When granting more control rights to the nonprofit organization and satisfying the appropriate condition (16), we obtain $\frac{\partial e_E}{\partial \pi}>0$; e_E increases as the nonprofit's control rights increase (π increases). Thus, the incentives for the enterprise to make self-interested investments increase. Accordingly, we put forward the first hypothesis of our article.

H_1: There exists a nonlinear U-shaped relationship between the allocation of control rights coefficient π and the self-interested investments of the enterprise.

According to Lemma 2, if $\theta_E>\theta_N$, then $\frac{\partial i_E}{\partial \pi}<0$; if $\theta_E<\theta_N$ and

$$m\pi<\frac{b_{22}^{"}(\theta_E+\theta_N)-2(C_{22}^{"E}-g_{11}^{"E})+B_{22}^{"E}(\theta_E-\theta_N)}{(\theta_E-\theta_N)(B_{22}^{"E}-B_{11}^{"N})} \tag{17}$$

then $\frac{\partial i_E}{\partial \pi}<0$.

Lemma 2 shows that when the enterprise evaluates the joint project as a higher priority, it will tend to make public-interested investments by granting itself more

control rights; however, when the enterprise evaluates the joint project as a lower priority, it will tend to make public-interested investments by granting itself more control rights only when a specific condition is satisfied. Accordingly, we get the second hypothesis of our article.

H_2: When the enterprise evaluates the joint project as a higher priority than the nonprofit organization does, there is a negative relationship between the control rights coefficient (π) and the public-interested investments of the enterprise (i_E).

Empirical Method

Samples

Table 1 shows the sample composition used for our investigation. This composition reflects the status quo of pharmaceutical enterprises that participate in Chinese PPPs. In January 2007, we sent out 250 questionnaires. By May 2007, 159 questionnaires were returned, at a response rate of 63.6 percent. Of these 159 questionnaires, 19 were invalid because of incomplete information. Valid questionnaires were obtained from 140 enterprises, yielding an effective response rate of 56 percent. The research subjects in this investigation were pharmaceutical enterprises of various sizes and types that usually cooperate with relevant nonprofit organizations in the pharmaceutical industry.

[[INSERT TABLE 1 ABOUT HERE]]

Measures

Dependent. In our study, the dependent variables were the self-interested investments (e_E) and public-interested investments (i_E) of enterprises. These variables were based on the research, in-depth interviews, and pre-investigation of Hart and Shleifer **and Vishny** (1997).[1] We designed, revised, and modified each scale to include four questions. We adopted Likert 7-point scales to measure self- and public-interested investments. For example, on the side of self-interested investments, we included the statement: "My side has invested a large amount of funds into advertising our drugs during PPPs." On the side of public-interested investments, we included: "During the cooperation process, my side delegated numerous employees and invested substantial funds for the communication and coordination of PPPs." The reliability of the self-interested investments scale was $\alpha = 0.78$, while the reliability of the

[1] Before the formal survey, we conducted large-scale in-depth interviews with principals who ran joint projects in pharmaceutical enterprises. These principals had intimate relationships with company *Y,* and interviews were conducted from September to November 2006. We mainly inquired into what motivated their enterprises to join the cross-sector alliance, the ways in which control rights were allocated, and the types of investments made in PPP projects. We also conducted a pre-investigation of 75 pharmaceutical enterprises that were always members of PPPs. Through this pre-investigation, we tested the scales that we designed in order to identify problems and make modifications.

public-interested investments scale was $\alpha = 0.80$.

Independent. Based on Besley and Ghatak (2001), we revised and modified a control rights scale to include three questions. We adopted Likert 7-point response scales to statements such as "During cooperation, if we encounter major conflicts, my side always makes the final decisions." The reliability of the control rights scale was $\alpha = 0.72$.

Control variables. These included firm size, age, and nature. Specifically, firm size was divided into small, medium, and large firms according to number of employees (fewer than 200, 200–1,000, or more than 1,000; shown as G1, G2, G3, respectively); firm age included four categories (less than 5 years, 5–10 years, 10–20 years, and more than 20 years; shown as T1, T2, T3, and T4, respectively); firm nature was categorized as state-owned, private, solely foreign-owned, and joint venture (depicted as X1, X2, X3, and X4, respectively). Furthermore, the value that each partner placed on the joint project was an important factor affecting the influence of control rights on the investments of enterprises. Therefore, based on Besley and Ghatak (2001), we designed, revised, and modified a valuation scale to include four questions. We adopted Likert 7-point response scales to measure the value placed by the enterprise on the joint project; a sample item in this scale was the statement: "Outputs of cooperation play an important role in my side's development." The reliability of the valuation degree scale was $\alpha = 0.78$.

Analysis

Reliability and validity testing

We used factor analyses to assess the reliability and validity of our scales. Table 2 shows the concrete measurement index, α coefficient, factor loadings, and cumulative deviation percentages. The results show that the scales we adopted exhibited good reliability and validity.

[[INSERT TABLE 2 ABOUT HERE]]

Analyses and results

Using STATA 8.0 software, we performed multiple linear regressions to test hypotheses, with the results displayed in Table 3.

In Table 3, the numbers above the brackets are the regression coefficients and the numbers in the brackets are *t*-test values. Models M1–M4 provide regression analyses for how the allocation of control rights affects the self-interested investments of enterprises; models M5–M8 provide regression analysis results for how allocation of control rights affects the public-interested investments of enterprises. Specifically, in M1, we only considered control variables (firm size, nature, and duration). Only the joint venture enterprise (X4) control variable yielded a significantly positive regression coefficient, suggesting that joint venture enterprises were more likely than

other types of enterprises to make self-interested investments. Model M2 included the allocation of control rights variable and its square after centering. Large enterprises (G3) were significantly less likely to make self-interested investments. Additionally, there was a significant positive relationship between the square of the allocation of the control rights variable and self-interested investments (at the 0.001 level of significance). The regression results thus show a nonlinear U-shaped relationship between the allocation of control rights and the self-interested investments of enterprises. This evidence supports our first hypothesis (H_1).

In M3, we controlled for project valuation and used a subsample in which the valuation by the enterprise was greater than that by the partner. We only included the control variables for public-interested investments. Private enterprises (X2) and joint venture enterprises (X4) showed significantly positive relationships with public-interested investments. On the other hand, a firm aged between 5–10 years (T2) showed a significantly negative relationship with public-interested investments, suggesting that private enterprises and joint venture enterprises were more inclined to make public-interested investments, while enterprises aged between 5–10 years were less likely to make public-interested investments. This could be due to bottleneck problems or survival pressures, as the enterprise life-cycle theory would suggest. M4 included the control rights variable, and there was a negative relationship between the control rights and an enterprise's public-interested investments (at the level of 5 percent significance). M5 included the square of control rights after centering this independent variable. When we studied the subsample in which the valuation by the enterprise was greater than that by the partner, there was no significant relationship between the square of control rights and public-interested investments. We concluded that there was a significantly negative relationship between control rights and public-interested investments at the 0.05 level of significance; this supports our second hypothesis (H_2).

In order to guarantee the robustness of our regression analysis results, we performed a robustness test on the five regression models using three techniques. First, we adopted the Ramsey RESET method to test whether there was an omitted variable problem; if the *p*-value was greater than 0.1, there was no omitted variable problem. Second, we adopted the Breuch-Pagan/Cook-Weisburg method to test whether there was a heteroskedasticity problem; if the *p*-value was greater than 0.1, there was no heteroskedasticity problem. Because direct regression results show heteroskedasticity problems in some models, we modified these models using the function "robust" (or *hc3*) in STATA 8.0. The results obtained using these techniques were not different from our original results. Third, we adopted the method of calculating mean VIFs **[[expand?]]** to test whether there were any multi-colinearity problems; the results showed that there were no significant multi-colinearity problems.

[[INSERT TABLE 3 ABOUT HERE]]

Conclusions and Future Research

Our results show a significant relationship between the allocation of control rights and the investment of enterprises in the PPPs. First, there is a significantly nonlinear

U-shaped relationship between the allocation of control rights and self-interested investments; when control rights held by the enterprise exceed a certain level, self-interested investments will increase as well. But, once control rights held by the nonprofit organization exceed a certain level, self-interested investments will also increase in proportion to the amount of control rights that the nonprofit organization holds. Thus, granting more control rights to a nonprofit organization will decrease the implicit incentive function of control rights. As the enterprise loses its control rights, it will increase its self-interested investments in order to pursue its own interests. This explains why, in order to decrease the self-interested investments of enterprises, control rights in the PPPs should be properly allocated. Second, when the value placed by the pharmaceutical enterprise on the joint project is higher than the value placed on the project by the nonprofit organization, there is a significantly negative relationship between the allocation of control rights and public-interested investments. Under these circumstances, the public-interested investments of the enterprise will increase with the control rights held by the enterprise. Thus, granting more control rights to an enterprise will motivate the enterprise to make public-interested investments.

These results suggest that control rights provide a kind of implicit incentive instrument for motivating an enterprise to make public-interested investments while cooperating with nonprofit organizations. Because enterprises are profit-seeking organizations, their internal drive for participating in PPPs is the maximization of their own interests. In order to satisfy the incentive compatibility condition of enterprises, their public-interested investments should be increased and their self-interested investments decreased. This could be accomplished by carefully considering the total benefits of the joint project and its cooperation effects and by decreasing advertisements related to the image of a drug solely as it pertains to the enterprise.

Public- and self-interested enterprise investments have different effects on PPPs' cooperation efficiency. Further investigation into how to effectively utilize this implicit incentive instrument, as well as how to balance these two types of investments, will increase understanding of the incentive effects of allocating control rights.

This article provides an initial design of a control rights scale and summarizes the results of large-scale empirical research performed in China. Industrial factors may affect the analysis; thus, more work is necessary to test and refine these scales for future research in various industries.

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APPENDIX

(a.) Proof of Lemma 1: In equation (13), if $\theta_E > \theta_N$, because $B_1^{'E} < 0$, $\theta_E - \theta_N > 0$, the numerator $-mB_1^{'E}(\theta_E - \theta_N) > 0$. In the denominator, because $C_{11}^{"E} > 0$ and $\varphi_{11}^{"E} < 0$, $C_{11}^{"E} - \varphi_{11}^{"E} > 0$ exists; if

$4(C_{11}^{"E} - \varphi_{11}^{"E}) - 2b_{11}^{"}(\theta_E + \theta_N) + 2B_{11}^{"E}(\theta_E - \theta_N)(m\pi - 1) < 0$, this can be simplified as follows:

$$m\pi < \frac{2b_{11}^{"}(\theta_E + \theta_N) - 4(C_{11}^{"E} - \varphi_{11}^{"E}) + 2B_{11}^{"E}(\theta_E - \theta_N)}{2B_{11}^{"E}(\theta_E - \theta_N)} \quad \text{and} \quad \frac{\partial e_E}{\partial \pi} < 0; \quad \text{and vice versa.}$$

If $\theta_E < \theta_N$, because $B_1^{'E} < 0$, $\theta_E - \theta_N < 0$, the numerator $-mB_1^{'E}(\theta_E - \theta_N) < 0$. In the denominator, because $C_{11}^{"E} > 0$ and $\varphi_{11}^{"E} < 0$, $C_{11}^{"E} - \varphi_{11}^{"E} > 0$ exists; if

$4(C_{11}^{"E} - \varphi_{11}^{"E}) - 2b_{11}^{"}(\theta_E + \theta_N) + 2B_{11}^{"E}(\theta_E - \theta_N)(m\pi - 1) > 0$, this can be simplified as follows:

$$m\pi < \frac{2b_{11}^{"}(\theta_E + \theta_N) - 4(C_{11}^{"E} - \varphi_{11}^{"E}) + 2B_{11}^{"E}(\theta_E - \theta_N)}{2B_{11}^{"E}(\theta_E - \theta_N)} \quad \text{and} \quad \frac{\partial e_E}{\partial \pi} < 0; \quad \text{and vice versa.}$$

(b.) Proof of Lemma 2: In equation (14), when $\theta_E > \theta_N$ and because $B_2^{'E} > 0$, $B_1^{'N} > 0$, $B_2^{'E} - B_1^{'N} = \frac{\partial B^E}{\partial i^E} - \frac{\partial B^N}{\partial i^E} > 0$, and $\theta_E - \theta_N > 0$ in the numerator, $-m(B_2^{'E} - B_1^{'N})(\theta_E - \theta_N) < 0$. In the denominator, because $C_{22}^{"E} > 0$, $g_{11}^{"E} < 0$, $b_{22}^{"} < 0$, $4(C_{22}^{"E} - g_{11}^{"E}) - 2b_{22}^{"}(\theta_E + \theta_N) > 0$; and because $m\pi - 1 < 0$, $B_{22}^{"E} < 0$, $B_{11}^{"N} < 0$, $\theta_E - \theta_N > 0$, $2[(m\pi - 1)B_{22}^{"E} - m\pi B_{11}^{"N}](\theta_E - \theta_N) > 0$, the denominator is greater than 0, and $\frac{\partial i_E}{\partial \pi} < 0$.

If $\theta_E < \theta_N$, we can easily get $-m(B_2^{'E} - B_1^{'N})(\theta_E - \theta_N) > 0$. Then, when $4(C_{22}^{"E} - g_{11}^{"E}) - 2b_{22}^{"}(\theta_E + \theta_N) + 2[(m\pi - 1)B_{22}^{"E} - m\pi B_{11}^{"N}](\theta_E - \theta_N) < 0$, there exists $\frac{\partial i_E}{\partial \pi} < 0$. Thus, when $m\pi < \frac{b_{22}^{"}(\theta_E + \theta_N) - 2(C_{22}^{"E} - g_{11}^{"E}) + B_{22}^{"E}(\theta_E - \theta_N)}{(\theta_E - \theta_N)(B_{22}^{"E} - B_{11}^{"N})}$, there exists $\frac{\partial i_E}{\partial \pi} < 0$.

(c.) Omitted proof of model solution: Name equation (10) F_1. Based on equation (10), we derive π and e_E and get:

$$\frac{\partial F_1}{\partial \pi}=\frac{1}{2}(\theta_N+\theta_E)[b_{11}^{"}\frac{\partial e_E}{\partial \pi}+b_{12}^{"}\frac{\partial i_E}{\partial \pi}+b_{13}^{"}\frac{\partial i_N}{\partial \pi}]+\frac{1}{2}(\theta_E-\theta_N)[-mB_1^{'E}(e_E,i_E,i_N)+$$
$$(1-m\pi)(B_{11}^{"E}\frac{\partial e_E}{\partial \pi}+B_{12}^{"E}\frac{\partial i_E}{\partial \pi}+B_{13}^{"E}\frac{\partial i_N}{\partial \pi})]+\varphi_{11}^{"E}\frac{\partial e_E}{\partial \pi}-(C_{11}^{"E}\frac{\partial e_E}{\partial \pi}+C_{12}^{"E}\frac{\partial i_E}{\partial \pi})$$

$$\frac{\partial F_1}{\partial e_E}=\frac{1}{2}(\theta_N+\theta_E)b_{11}^{"}+\frac{1}{2}(\theta_E-\theta_N)[(1-m\pi)B_{11}^{"E}(e_E,i_E,i_N)]+\varphi_{11}^{"E}(e_E)-C_{11}^{'E}(e_E,i_E)$$

Then, based on derivative rules of the implicit function, we get:

$$\frac{\partial e_E}{\partial \pi}=-\frac{\frac{\partial F_1}{\partial \pi}}{\frac{\partial F_1}{\partial e_E}}=\frac{\begin{array}{c}\frac{1}{2}(\theta_N+\theta_E)[b_{11}^{"}\frac{\partial e_E}{\partial \pi}+b_{12}^{"}\frac{\partial i_E}{\partial \pi}+b_{13}^{"}\frac{\partial i_N}{\partial \pi}]+\frac{1}{2}(\theta_E-\theta_N)[-mB_1^{'E}(e_E,i_E,i_N)\\ +(1-m\pi)(B_{11}^{"E}\frac{\partial e_E}{\partial \pi}+B_{12}^{"E}\frac{\partial i_E}{\partial \pi}+B_{13}^{"E}\frac{\partial i_N}{\partial \pi})]+\varphi_{11}^{"E}\frac{\partial e_E}{\partial \pi}-(C_{11}^{"E}\frac{\partial e_E}{\partial \pi}+C_{12}^{"E}\frac{\partial i_E}{\partial \pi})\end{array}}{\frac{1}{2}(\theta_N+\theta_E)b_{11}^{"}+\frac{1}{2}(\theta_E-\theta_N)[(1-m\pi)B_{11}^{"E}(e_E,i_E,i_N)]+\varphi_{11}^{"E}(e_E)-C_{11}^{"E}(e_E,i_E)}$$

Similarly, name equation (11) F_2. Based on this equation, we derive π and i_E and get:

$$\frac{\partial F_2}{\partial i_E}=\frac{1}{2}(\theta_N+\theta_E)b_{22}^{"}+\frac{1}{2}(\theta_E-\theta_N)[m\pi B_{11}^{"N}(i_E,i_N)+(1-m\pi)B_{22}^{"E}(e_E,i_E,i_N)]+g_{11}^{"E}(i_E)-C_{22}^{"E}(e_E,i_E)$$

$$\begin{aligned}\frac{\partial F_2}{\partial \pi}=&\frac{1}{2}(\theta_N+\theta_E)[b_{21}^{"}\frac{\partial e_E}{\partial \pi}+b_{22}^{"}\frac{\partial i_E}{\partial \pi}+b_{23}^{"}\frac{\partial i_N}{\partial \pi}]+\frac{1}{2}(\theta_E-\theta_N)[mB_1^{'N}(i_E,i_N)+\\ &m\pi(B_{11}^{"N}\frac{\partial i_E}{\partial \pi}+B_{12}^{"N}\frac{\partial i_N}{\partial \pi})-mB_2^{'E}(e_E,i_E,i_N)+(1-m\pi)(B_{21}^{"E}\frac{\partial e_E}{\partial \pi}+B_{22}^{"E}\frac{\partial i_E}{\partial \pi}+B_{23}^{"E}\frac{\partial i_N}{\partial \pi})]\\ &-(C_{21}^{"E}\frac{\partial e_E}{\partial \pi}+C_{22}^{"E}\frac{\partial i_E}{\partial \pi})+g_{11}^{"E}\frac{\partial i_E}{\partial \pi}\end{aligned}$$

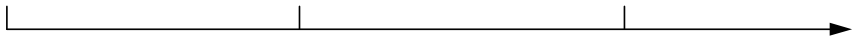
Then, based on derivative rules of the implicit function, we get:

$$\frac{\partial i_E}{\partial \pi}=-\frac{\frac{\partial F_2}{\partial \pi}}{\frac{\partial F_2}{\partial i_E}}=\frac{\begin{array}{c}\frac{1}{2}(\theta_N+\theta_E)[b_{21}^{"}\frac{\partial e_E}{\partial \pi}+b_{22}^{"}\frac{\partial i_E}{\partial \pi}+b_{23}^{"}\frac{\partial i_N}{\partial \pi}]+\frac{1}{2}(\theta_E-\theta_N)[mB_1^{'N}(i_E,i_N)+\\ m\pi(B_{11}^{"N}\frac{\partial i_E}{\partial \pi}+B_{12}^{"N}\frac{\partial i_N}{\partial \pi})-mB_2^{'E}(e_E,i_E,i_N)+(1-m\pi)(B_{21}^{"E}\frac{\partial e_E}{\partial \pi}+B_{22}^{"E}\frac{\partial i_E}{\partial \pi}+B_{23}^{"E}\frac{\partial i_N}{\partial \pi})]\\ -(C_{21}^{"E}\frac{\partial e_E}{\partial \pi}+C_{22}^{"E}\frac{\partial i_E}{\partial \pi})+g_{11}^{"E}\frac{\partial i_E}{\partial \pi}\end{array}}{\begin{array}{c}\frac{1}{2}(\theta_N+\theta_E)b_{22}^{"}+\frac{1}{2}(\theta_E-\theta_N)[m\pi B_{11}^{"N}(i_E,i_N)+(1-m\pi)B_{22}^{"E}(e_E,i_E,i_N)]\\ +g_{11}^{"E}(i_E)-C_{22}^{"E}(e_E,i_E)\end{array}}$$

Similarly, when the nonprofit organization maximizes its benefits, its optimal public-interested investment should satisfy the following condition:

$$\frac{\partial i_N}{\partial \pi}=-\frac{\frac{\partial F_3}{\partial \pi}}{\frac{\partial F_3}{\partial i_N}}=-\frac{\begin{array}{c}\frac{1}{2}(\theta_N+\theta_E)[b_{31}^{"}\frac{\partial e_E}{\partial \pi}+b_{32}^{"}\frac{\partial i_E}{\partial \pi}+b_{33}^{"}\frac{\partial i_N}{\partial \pi}]+\frac{1}{2}(\theta_N-\theta_E)[mB_2^{'N}(i_E,i_N)\\ +m\pi(B_{21}^{"N}\frac{\partial i_E}{\partial \pi}+B_{22}^{"N}\frac{\partial i_N}{\partial \pi})-mB_3^{'E}(e_E,i_E,i_N)+(1-m\pi)(B_{31}^{"E}\frac{\partial e_E}{\partial \pi}+B_{32}^{"E}\frac{\partial i_E}{\partial \pi}+B_{33}^{"E}\frac{\partial i_N}{\partial \pi})]-C_{11}^{"N}\frac{\partial i_N}{\partial \pi}\end{array}}{\frac{1}{2}(\theta_N+\theta_E)b_{33}^{"}+\frac{1}{2}(\theta_N-\theta_E)[m\pi B_{22}^{"N}(i_E,i_N)+(1-m\pi)B_{33}^{"E}(e_E,i_E,i_N)]-C_{11}^{"N}(i_N)}$$

Figure 1 Time axis of the model



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The allocation o
control rights

Table 1 Sample composition table

Classification	Number	Composition (%)	Accumulation (%)
Firm nature			
State-owned	39	27.86	27.86
Private	55	39.29	67.14
Solely foreign-owned	33	23.57	90.71
Joint venture	13	9.29	100.00
Firm size			
Less than 200 employees	51	36.43	36.43
200–1,000 employees	51	36.43	72.86
More than 1,000 employees	38	27.14	100
Firm age			
Less than 5 years	25	17.86	17.86
5–10 years	40	28.57	46.43
10–20 years	18	12.86	59.29
More than 20 years	57	40.71	100

Table 2 Reliability and validity table

Scales	α coefficient	Factor loadings	Cumulative deviation percentage
Allocation of control rights (ACR)	0.72		64.09
1. During cooperation, my side has mastered the process of the joint project		0.84	
2. During cooperation, my side decides the resource allocation of the joint project (for example, outputs attachment)		0.84	
3. During cooperation, if we encounter major conflicts, then my side always makes the final decision		0.72	
Self-interest investment of enterprise (ESI)	0.78		60.33
1. My side has invested a large amount of funds to advertise our drugs during PPPs		0.75	
2. My side delegates numerous employees to advertise our drugs during PPPs		0.80	
3. In all conditions of cooperation, my side pays more attention to showing the effects of our drugs		0.76	
4. In all conditions of cooperation, my side always mentions our relevant drugs		0.80	
Public-interest investment (EPI)	0.799		62.73
1. If the joint project is in need of funds, then my side will provide enough funding for it		0.79	
2. During process of cooperation, my side delegates numerous employees and invests great amounts of funds to communication and coordination in PPPs		0.82	
3. My side will spare no effort to overcome various difficulties during cooperation in order to achieve the expected goals		0.81	
4. My side delegates numerous employees and great amounts of funds to actively join in communication with the third party in order to achieve the expected goals		0.75	
Partner's evaluation towards the project	0.77		61.69
1. Outputs in cooperation play an important role in developing my side		0.86	
2. Outputs of cooperation can create (economic or social) benefits for my side		0.84	
3. Outputs of cooperation bring more value to my side than others		0.71	
		0.80	

4. The value of cooperation is well recognized by my side			

Table 3 Multiregression results table

Dependent variable / Independent variable		Cooperation efficiency				
		Self-interest investment of the enterprise		Public-interest investment of the enterprise		
		OLS M1	OLS M2	OLSM3	OLS M4	OLS M5
Constant		0.21 (0.69)	0.23 (0.75)	-0.02 (-0.05)	0.10 (0.30)	0.07 (0.20)
Control rights		–	0.04 (1.39)		-0.13 (-1.52)*	-0.16 (-1.82)*
Square of control rights			0.32 (4.39)***			0.07 (0.47)
Firm size	G1	–	–	–	–	–
	G2	0.01 (0.07)	0.13 (0.57)	-0.12 (-0.69)	-0.15 (-0.64)	-0.13 (-0.56)
	G3	-0.42 (-0.51)	-0.34 (-1.19)*	0.16 (0.51)	0.07 (0.24)	0.10 (0.32)
Firm nature	X1	–	–	–	–	–
	X2	0.16 (0.60)	-0.03 (-0.11)	0.62 (2.55)**	0.59 (2.45)**	0.56 (2.32)**
	X3	-0.42 (-0.96)	-0.70 (-0.98)	0.30 (0.82)	0.28 (0.75)	0.25 (0.95)
	X4	0.64 (2.39)**	0.38 (1.55)*	0.57 (1.77)*	0.56 (1.73)*	0.54 (1.68)*
Firm age	T1	–	–	–	–	–
	T2	-0.32 (-0.48)	-0.21 (-0.90)	−0.45 (-1.78)*	-0.40 (-1.60)*	-0.40 (-1.59)*
	T3	-0.01 (-0.02)	0.06 (0.18)	-0.17 (-0.51)	-0.13 (-0.38)	-0.15 (-0.45)
	T4	-0.08 (-0.28)	-0.03 (-0.12)	-0.40 (-1.25)	-0.34 (-1.14)	-0.34 (-1.16)
Value for project		–	–	control	control	control
Objects		140	140	89	89	89
Adjust-R^2		0.15	0.20	0.15	0.16	0.38
Omitted variable		0.55	0.31	0.12	0.16	0.22
Heteroskedasticity		0.04*modify	0.96	0.07	0.05	0.07
Multicollinearity		2.05	2.17	2.06	1.98	1.92

Note:

(1) The number above the bracketed numbers is the regression coefficient; the number in the brackets is the *t*-test value in the OLS model; *, **, and *** indicate significance at the 0.05, 0.01 and 0.001 levels, respectively.

(2) The allocation of control rights in the mathematical model is defined as the control rights share that the

nonprofit organization holds, so at first we transfer the enterprise's control rights to the nonprofit organization's control rights.

(3) Square of allocation of control rights after centering.

(4) Valuation by enterprise control of the joint project: this control variable is over the median of 4, and thus represents the enterprise valuation when this is higher than the partner valuation.