Economic Analysis of Public-Private Partnerships in Japan: Theoretical and Empirical Analyses Focusing on Adverse Selection and Synergy Effect*

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Abstract

In Japan, the national and local governments' fiscal deficits are increasing, while public infrastructure systems remain old. To overcome these problems, the role of public-private partnerships (PPP), including the private finance initiative (PFI), is attracting increased attention. In the literature, emphasis has been placed only on improving fiscal efficiency, such as value for money (VFM). However, if differences in quality among private companies and the importance of incentive rewards are not considered, PPPs can end up creating inefficiencies in terms of social welfare. From this viewpoint, using theoretical and empirical analyses, our research' examines the circumstances under which PFI projects work effectively.

In the theoretical analysis, we consider PFI projects as a principal-agent relationship in which the public sector (principal) entrusts business operations to the private sector (agent) under an incomplete contract. Then, we conduct a comparison of projects under two types of contracts, namely build-operate-transfer (BOT) contract (the constructed facilities continue to be owned by the private sector until the expiry of the project) and the build-transfer-operate (BTO) contract (the ownership of constructed facilities is transferred to the public sector after construction). Through this comparison, we clarify the respective advantages and disadvantages of the two contract types due to the difference in the timing of ownership transfer. Moreover, regarding the quality of private companies, we point out the importance of setting the contractor's reward at a sufficient level to avoid the adverse selection problem.

In the empirical analysis, we estimate how the differences in the type of contract (BOT or BTO) and the level of VFM (which is negatively correlated with the contractor's fixed compensation) at the planning stage affect the contractor quality and the efficiency improvement in the project. We use data on PFI projects implemented in Japan from fiscal year 1999 to 2018. We proxy the quality of contractors by the number of companies that applied for the project, the share capital of the selected core company, and whether the company is listed or unlisted. We also proxy the efficiency improvement of the project by the degree of improvement of VFM at the time of contracting, relative to the level at the planning stage.

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We find that even when changes in the macroeconomic situation and the circumstances surrounding the PFI during the analysis period are considered, BOT-type projects attract more applicant companies than BTO-type projects. Furthermore, the degree of improvement of VFM was larger for BOT-type projects. This implies that in practice, the BOT type is superior on average, as it is likely to generate a greater synergy effect between construction and operation. We also find that the higher the level of VFM at the planning stage (the lower the fixed contractor's compensation), the lower the quality of the selected core company and the smaller the degree of improvement of VFM. These results indicate the importance of devising a suitable incentive mechanism to secure high-quality candidate companies and ensure appropriate behavior of the selected contractor.

Keywords: public-private partnership, PFI, BTO, BOT, VFM, incomplete contract, adverse selection, synergy effect
JEL Classification: H40, H43, H72, H83

I. Introduction

In Japan, governments (central and local) face extremely serious financial difficulties, with debt exceeding 200% of the nominal GDP. The recovery of fiscal soundness is an urgent policy issue. With the declining birthrate and aging population, social security expenditures are increasing dramatically, making it difficult to maintain the current level of administrative services with limited budget constraints. Meanwhile, a large number of public infrastructures constructed during the period of rapid economic growth are aging. It is expected that the percentage of facilities constructed more than 50 years ago will increase substantially in the next 20 years (Table 1). Thus, the maintenance, management, and renewal of road bridges, tunnels, rivers, sewage systems, ports, and harbors are urgent issues that need to be addressed.

Budget constraints are more serious for local governments. Although the number of local governments in Japan has greatly decreased because of the "great municipal mergers in Heisei," the total number of prefectures and municipalities still exceeds 1700. Furthermore, the economic inequalities among them remains large. The financial situation of many local governments is critical, as their revenue bases are weak and their debts are increasing. Meanwhile, the local governments need to provide a variety of administrative services essential to the daily lives of citizens, such as school education, welfare, and sanitation, police, and fire services.

Increases in local government expenditures have been restrained by administrative reforms, such as the reduction of salary-related and investment expenses (Fig. 1). However, considering the need to appropriately respond to the increase in administrative demand, there is a limit to the reduction of civil servants' salary-related expenses. Public infrastruc-

Table 1. Percentage of social infrastructures that are more than 50 years old

	Mar-18	Mar-23	Mar-33
Road bridges (approximately 730,000 bridges with a bridge length of 2m or more)	Approximately 25%	Approximately 39%	Approximately 63%
Tunnels (approximately 11,000)	Approximately 20%	Approximately 27%	Approximately 42%
River management facilities (water gate, etc., approximately 10,000)	Approximately 32%	Approximately 42%	Approximately 62%
Sewage systems (total length: approximately 470,000km)	Approximately 4%	Approximately 8%	Approximately 21%
Harbor quay (approximately 5,000 installations, water depth -4.5m or deeper)	Approximately 17%	Approximately 32%	Approximately 58%

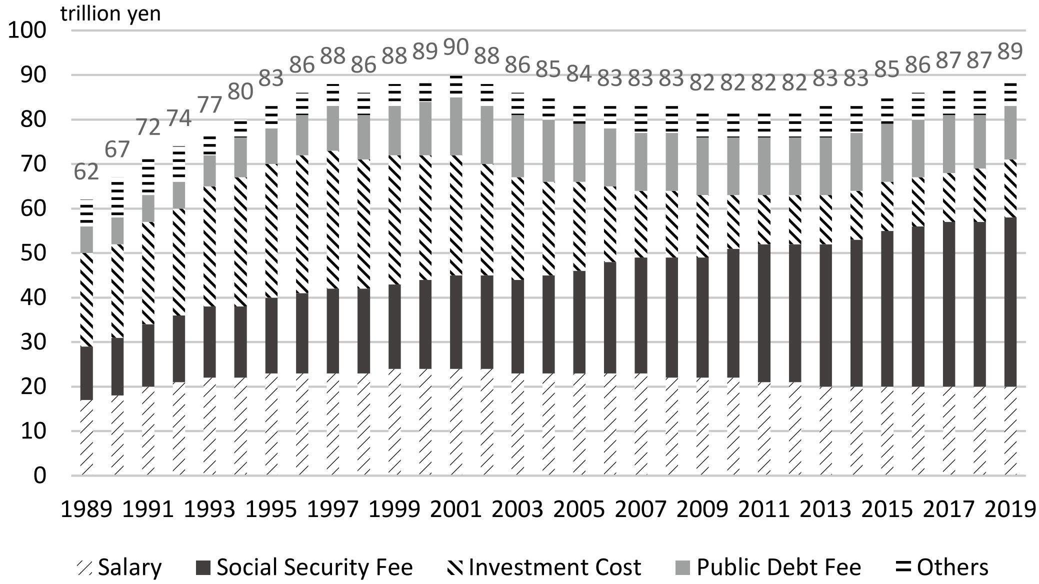
Source: Ministry of Land, Infrastructure, Transport and Tourism, Portal site for information on measures for the aging of social infrastructures: Infrastructure maintenance information.

ture is aging, and future fiscal demands for investments in their reorganization, maintenance, repair, and renovation are expected to increase. The problem of aging infrastructure and maintaining administrative services within a limited budget is an urgent policy issue to be debated.

Under these circumstances, the private finance initiative (PFI), or more broadly, public private partnership (PPP), has attracted attention as a new method of public management. The method differs from “privatization” and the “third sector organizations,” which were actively discussed in the past. The PFI is a form of PPP in which the public sector (local governments, central governments, public institutions, etc.) and the private sector (private companies, non-profit organizations (NPOs), etc.) share roles (goal setting, construction, ownership, operation, finance, etc.) while implementing projects with some policy objectives[1]. This is an attempt to provide better public services with a lower tax burden. However, unlike privatization, the PFI is not a business that can be run purely by for-profit private companies. Meanwhile, unlike the third sector, it is not a business that requires the public sector to shoulder most of the risks. Considering increasing fiscal constraints, there is a growing trend towards PFIs for the construction and management of infrastructures and public utilities such as airports and water supply services.

1 For an overview of PFI and PPP, see Hodge and Greve (2017).

Figure 1. Changes in expenditures regarding the local fiscal plan (trillion yen)



Source: Ministry of Internal Affairs and Communications, "Local government finance-related materials."

However, from an economic perspective, PFI does not always improve efficiency. Many PFI failures have been reported in countries such as the UK and France[2]. For PFIs to improve efficiency, we need an implicit assumption that private companies will always take socially optimal actions. However, this assumption is not necessarily satisfied without considering the incentives of private companies. As is well known, "corporate governance" that provides appropriate incentives is important for efficient business execution by private companies. Hoppe (2013) points out that such governance mechanisms are equally important in government organizations. Similarly, in the case of PPPs, it is essential to provide appropriate incentives for private companies to perform their work efficiently as a contractor. PPP projects without appropriate incentives are likely to be more inefficient than conventional public projects.

Unfortunately, promotion of PPP/PFI in Japan has tended to focus only on "reducing the financial burden." For example, the "Guidelines for Value for Money (VFM)" released in July 2001 by the PFI Promotion Committee of the Cabinet Office state that "it is fundamental to evaluate VFM" as a standard for implementing PFI projects. VFM refers to the concept of providing the most valuable service (value) for a specific payment amount (money). It indicates the percentage of total project costs that can be reduced by PFIs compared to that of conventional public projects. However, as a result of placing too much emphasis on

[2] For previous overseas studies, see Hodge and Greve (2007). Several related case studies in the UK include Froud and Shaoul (2001), Hood and McGarve (2002), Hood, Fraser, and McGarve (2006), Kakabadse, Kakabadse, and Summers (2007), Coulson (2008), Hellowell and Pollock (2010), Demirag and Khadaroo (2011), Shaoul, Stafford, and Stapleton (2011), and Lethbridge (2014).

VFM, the evaluation of PFI projects has mainly focused on how much public expenditure will be reduced. Therefore, discussions on social benefits, including incentives for private companies conducting PFI projects, have been insufficient.

In this study, departing from the previous view that put too much emphasis on the reduction of fiscal burden, we first theoretically discuss the conditions under which PPP/PFI functions well. Then, we examine the empirical characteristics of PFI projects that have been conducted in Japan and discuss their implications considering this theory. Specifically, we consider PFI to be a principal-agent relationship under incomplete contracts. It is necessary to attract candidate companies with sufficient capabilities and incentivize the selected contractor, who is a profit-maximizing agent, to consider the public interest. To achieve this goal, it is important to establish a type of PPP/PFI scheme that can be attractive for private companies by setting appropriate levels of compensation.

Principal-agent relationships can be found in every aspect of economic transactions, including shareholder-management relationships in listed companies. Behind such relationships is the "principle of expertise," which entrusts everything to experts because it is inefficient for individuals to do everything themselves. In other words, the principal-agent relationship is a mechanism to realize the benefits of expertise in economic activities and social life. PPP can also be interpreted as the creation of a principal-agent relationship in which public officials achieve their objectives by entrusting services to private companies with expertise. However, the principal-agent relationship does not always produce the results that the client expects. In particular, because of information asymmetry, clients cannot accurately grasp and monitor the quality and behavior of agents. Because of incomplete contracts, they cannot accurately predict, describe, and verify the events that may occur after a contract is concluded. Therefore, various inefficiencies (agency costs) can arise when there is a problem of asymmetric information or contract incompleteness.

Several studies on PPP/PFI have focused on governance structures. However, most are case studies on PFIs in the UK, which is the birthplace of PFIs. In addition, most of these studies belong to the field of "public administration studies" and not economics. Studies on PPP/PFI based on economics are very limited, except for the pioneering theoretical studies by Hart, Shleifer, and Vishny (1997), Hart (2003), and Iossa and Martimort (2015).

In Japan, public institutions, such as the PPP/PFI Promotion Office, the Japan Private Finance Initiative, and the PPP Association, actively explain the current situation and present case studies. In addition, there are several studies based on economics but from the "public perspective," such as reducing the fiscal burden. Among them, Shimono and Maeno (2010), and Yodo, Mizobata, and Hayashida (2017) are noteworthy studies that conducted an empirical analysis on the determinants of VFM in Japanese PFI projects. However, with few exceptions, such as Fukuda (2019), insufficient attention has been given to PPPs focusing on "incentives for private companies" in Japan.

To further disseminate the PPP/PFI concept in Japan, it is necessary for PPP/PFI to make maximum use of private funds and expertise to maximize social welfare. To realize the benefits of such expertise, it is important to select a highly efficient private company with appropriate compensation, and to select a suitable project scheme in which the private company takes socially desirable actions. However, to the best of our knowledge, only a few empirical studies consider PPP/PFI as a principal-agent relationship and examine compensation systems that provide appropriate incentives to the private companies.

The remainder of this study is organized as follows. Section II introduces the Hart (2003) model as a framework for analyzing private incentives in PPP/PFI projects to compare them with those of conventional public works projects. Section III extends the Hart model to consider the problem of adverse selection and analyzes the relationship between the level of fixed compensation and the quality of the applicants. Section IV empirically tests the hypotheses based on theoretical considerations in Sections II and III. Section V reports the estimated results of the impact on the number of companies that applied for the projects and the quality of the selected companies. Section VI reports the estimated results of the impact on the VFM improvement (the improvement in the contract VFM over the planned VFM). Section VII provides a summary of the study.

II. Unbundling and bundling contracts

II-1. The Hart (2003) model and implications for PFI projects

In the literature, incomplete contract theory has been used to analyze the incentives in agency problems. This theory is based on the assumption that a perfect state-contingent contract is not feasible in advance because the possible events are too many and too complicated. Therefore, even if a moral hazard occurs and an agent makes an undesired investment, it cannot be completely prevented by the contract. This is one of the sources of agency costs incurred under the incomplete contracts.

Hart, Shleifer, and Vishny (1997) applied the incomplete contract theory to analyze how private companies manage public facilities. In terms of the ownership of public facilities, incentives for private companies to invest differ depending on whether they are owned by traditional governments or private companies. To the extent that contracts are incomplete, it is not always desirable for the government to entrust its work to a private company, even if it has a high level of expertise. This is because private companies have an incentive to invest in increasing their own revenue by eliminating necessary services and costs.

Within the framework of the incomplete contract theory, Hart (2003) applied Hart, Shleifer, and Vishny's (1997) work to analyze which of the two project types (public or PFI) would be more efficient when the construction and subsequent operations of the facilities are entrusted to a private company. The following is an overview of Hart's (2003) model: In the conventional public project, "unbundling" was common, in which the project construction and operation contracts were awarded to different private companies. However, in PFI projects, a "bundling" system has been introduced, whereby both the construction and operation contracts are awarded to a group of private companies (usually a special purpose company, SPC, formed by a consortium of multiple companies). Hart (2003) drew attention to these differences and examined the circumstances under which the PFI scheme (bundling) would be preferable to the conventional public scheme (unbundling).

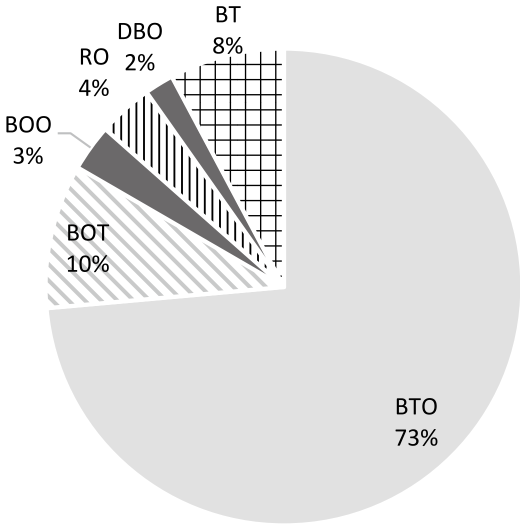
In the case of bundling, a group of private companies (an SPC consisting of construction companies and operating companies) are supposed to have the capability to construct public facilities with attractive designs and functions, provide high-quality public services, and reduce operating costs using their expertise that the government lacks. Therefore, when all the business revenue and expenditure from construction to operation are integrated into the same group of companies, the synergistic effect of the expertise of both the construction and the operation companies is clearly exerted. In contrast, under the unbundling of contracts whereby construction and operation are carried out by different private companies, the construction company does not have an incentive to invest in improving operational efficiency because the operation will be carried out by a different company. However, note that in the case of bundling, another agency cost is incurred if the contract is incomplete. In other words, a private company that seeks to maximize its own profits does not necessarily use its expertise to maximize social welfare. Rather, in some cases, it may cut down necessary public services to gain private benefits. Considering both these factors, Hart (2003) argued that both bundling (PFI) and unbundling (traditional public works) projects have their own advantages and disadvantages.

The Hart (2003) model discussed PFI based on experiences in the UK, where bundling-type contracts prevailed for PFI projects. Thus, it imposed an implicit assumption that the PFI is a build-operate-transfer (BOT) arrangement, in which the construction and the operation are consistently entrusted to a private company group, and ownership is transferred to the public after the expiration of the contract period. However, in PFI projects in Japan, although many projects initially adopted the BOT model, build-transfer-operate (BTO) projects increased rapidly afterwards; over 70% of all projects in FY1999 to FY2018 were conducted as BTO projects (Figure 2).

The BTO-type PFI project is characterized by Hart's (2003) unbundling contract type, with construction and operation being carried out by different companies. As Akai (2006) pointed out, the BTO model tends to be used to compensate for the short-term shortage of construction funds. This is because the ownership of the public facilities is transferred to the government after construction, and maintenance and repair costs are also covered by the government[3]. Therefore, incentives for operators are considered to be more like unbundling. In contrast, BOT projects are more similar to the bundling contract type of the Hart (2003) model because a private company group owns the public facilities and internalizes the lifetime costs, including operating, maintenance, and repair costs. As Hart (2003) admits, the mathematical model described below is simple, but it is useful for understanding the differences between BTO and BOT incentive structures.

[3] Maeno (2005) pointed out the influence of the subsidy system as the reason for the large number of BTO projects in Japan.

Figure 2. Percentage of PFI projects by type of facility ownership (FY1999 to FY2018)



Note: Besides BTO and BOT, there are BOO (Build-Own-Operate), RO (Rehabilitate-Operate), DBO (Design-Build-Operate), and BT (Build-Transfer) types.
Source: Japan PFI-PPP Association, "PFI Yearbook 2019."

II-2. Mathematical analysis of the model

We consider Hart's (2003) argument, outlined in Section II-1, using mathematical equations. In the Hart (2003) model, public facility projects are carried out through construction and operation. The benefits and operating costs derived from the operation of a public facility are determined by the investment of the construction company. We assume that the construction company makes two kinds of investments: socially desirable investment, i, and undesirable investment e. Both investments reduce the social cost (operating cost) C by $\gamma(i)$ and $c(e)$, respectively. However, investment i increases social benefit B by $b(i)$, whereas investment e decreases social benefit B by $d(e)$. In other words, it holds that:

$$B = B_0 + b(i) - d(e), \tag{1a}$$

$$C = C_0 - \gamma(i) - c(e). \tag{1b}$$

Where, $b>0$, $b'>0$, $b''<0$, $d>0$, $d'>0$, $d''>0$, $\gamma>0$, $\gamma'>0$, $\gamma''<0$, $c>0$, $c'>0$, and $c''<0$. Furthermore, $\gamma'(0)>1$, $c'(0)>1$, $\lim_{i\to\infty}\gamma'=0$, and $\lim_{e\to\infty}c'=0$.
The construction company makes each investment, paying one cost per unit.

$$\max_{i,e}\{B_0 + b(i) - d(e)\} - \{C_0 + \gamma(i) - c(e)\} - i - e. \tag{2}$$

We assume that when the undesirable investment e is made, the benefit loss $d(e)$ is sufficiently large such that $-d'(e)+c'(e)<1$ for all $e\geq 0$. In this case, the first-order condition of the social welfare maximization problem is as follows:

$$b'(i^*) + \gamma'(i^*) = 1, \ when \ e^* = 0. \tag{3}$$

Here, i^* and e^* denote the level of investments i and e, respectively, that maximize social welfare.

Increasing investment i is desirable in terms of social benefits when $0 < i \leq i^*$. That is, a positive value i^* that satisfies the above equation leads to the maximization of social welfare. In contrast, socially undesirable investment e needs to be zero when maximizing social welfare (i.e. $e^* = 0$)

However, even if the participation conditions in public works projects are always satisfied for private companies, a moral hazard problem will arise. Thus, it is not always possible to achieve a socially optimal combination of investment levels. Next, to show the mathematical grounds of this argument, we generalize Hart's (2003) model to include the unbundling and bundling models as special cases.

In the case of full unbundling, construction companies receive no return from investments. However, in the case of bundling, a reduction in operating costs increases private profit, depending on the degree of bundling. Thus, a portion of social welfare is internalized, except in the case of full unbundling, where construction and operation are carried out by separate companies. Mathematically, the profit maximization problem of the private companies can be written as follows, depending on the parameter λ ($0 \leq \lambda \leq 1$), which varies according to the degree of bundling.

$$\max_{i,e} \ Q_0 + \lambda\{-C_0 + \gamma(i) - c(e)\} - i - e. \tag{4}$$

Here, Q_0 denotes the fixed compensation to be paid by the government to private companies. Hart (2003) discusses only polar cases where $\lambda = 0$ (fully unbundling) and $\lambda = 1$ (fully bundling). However, in the case of PFI projects, various λ can be selected in the interval $0 < \lambda < 1$ by choosing the type and more detailed items of the contract, such as the timing of the ownership transfer of the facilities. Next, the profit-maximizing level of investments i and e by solving equation (4) are expressed as (i^{ub}, e^{ub}) when $\lambda = 0$, (i^b, e^b) when $\lambda = 1$, and (i^{pfi} and e^{pfi}) when $0 < \lambda < 1$, respectively.

First, in the case of λ=0 (fully unbundling), the private construction companies will see all the results realized from the investment as external effects, and not just their own benefits. Therefore, their profit maximization problem maximizes $Q_0 - i - e$. It is the optimum when $i^{ub} = 0$ and $e^{ub} = 0$, that is, no investment is made. Thus, social welfare is not maximized because no socially desirable investment is made.

Then, in the case of $\lambda = 1$ (fully bundling), $\gamma'(0) > 1$, $c'(0) > 1$, $\lim_{i \to \infty} \gamma' = 0$, and $\lim_{e \to \infty} c' = 0$ ensures an interior solution. Therefore, the optimum level of investments i and e selected by the private company are $\gamma'(i^b) = 1$, $c'(e^b) = 1$. That is, in the bundling case, both investments i and e are executed, unlike in the unbundling case. However, socially inefficient results are also generated in this case for a different reason. This is because only cost reduction effects $\gamma(i)$ and $c(e)$ are internalized into the private company, not benefits $b(i)$ and

$-d(e)$. Thus, socially desirable investment i, which has a positive effect on the benefit, becomes insufficient, while socially undesirable investment e, which has a negative effect on the benefit, is also implemented.

As a more general case corresponding to actual PFI projects, by solving equation (4) under $0 \leq \lambda \leq 1$, the profit-maximizing levels of investments i and e selected by the private company are determined as follows:

$$\gamma'(i^{pfi}) \leq \frac{1}{\lambda}, \; c'(e^{pfi}) \leq \frac{1}{\lambda}. \tag{5}$$

Equation (5), in the case of an interior solution, holds in equality. In this case, since $\gamma''(i^{pfi}) < 0$ and $c''(e^{pfi}) < 0$, $\frac{\partial i^{pfi}}{\partial \lambda} > 0$ and $\frac{\partial e^{pfi}}{\partial \lambda} > 0$ are obtained. Thus, i^{pfi} and e^{pfi} are both increasing functions of λ. However, if λ is close to zero, that is, if the degree of bundling is sufficiently small, equation (5) represents the corner solution. Then, $i^{pfi} = i^{ub} = 0$, $e^{pfi} = e^{ub} = 0$. Therefore, the relationship between the level of investments i and e selected by the private company is as follows:

$$0 = i^{ub} \leq i^{pfi} < i^{b} < i^{*}, \; 0 = e^{*} = e^{ub} \leq e^{pfi} < e^{b}. \tag{6}$$

In other words, from an incentive perspective, when the PFI projects are close to unbundling ($\lambda = 0$), such as typical BTO projects, neither investment i nor investment e will be implemented. In contrast, in the case of PFI projects in which λ is greater than 0 by more than a certain extent, such as BOT projects, not only the desirable investment i but also the undesirable investment e is made. The investment level increases as the degree of bundling λ increases and almost coincides with the investment level of the fully bundling case when λ is close to one. Thus, as Hart (2003) argued, both unbundling and bundling cases have advantages and disadvantages.

III. Relationship between adverse selection and fixed compensation

III-1. Reasons for inefficiency

In the previous section, we considered PFI projects as a principal-agent relationship in which the government (client) entrusts the work to a private company group (agent) and considered how public policy can maximize social welfare under this relationship. From the perspective of agency costs, it is essential not only to prevent a “moral hazard” for the private company but also to avoid the problem of “adverse selection,” in which inefficient companies are selected. This section shows that it is important to set an appropriate fixed compensation to avoid adverse selection under incomplete contracts. A key point in considering the problem of adverse selection is the “participation condition” of private companies. When a private company participates in PFI projects, it incurs an “opportunity cost” of not being able to carry out other projects due to limited resources. Therefore, the private company will participate in the PFI project only when the private profits obtained by participating in the PFI project exceeds the profits (= “reservation profits”) that would have been obtained by conducting another project. However, reservation profits are usually not the same among private companies. Good (efficient) companies with many business opportunities have high reservation profits, while bad (inefficient) companies with few business opportunities have low reservation profits. Thus, if the profits of the private company in a PFI are set too low, the participation conditions of good companies will not be met and the possibility of undesirable situations in which only inefficient companies will participate in the projects will be more likely.

For the government, the lower the compensation paid to the private company, the better it is in terms of reducing government spending. However, the lower the compensation paid to the private company, the lower the quality of the contractor, and consequentially, the outcome of the PFI project. In other words, in the evaluation of PFI projects, it is not enough to only consider how much government spending will be reduced; rather, it is also necessary to analyze social benefits by considering the incentives of private companies. Next, we show that it is useful to set an appropriate fixed compensation to prevent adverse selection by further extending the Hart (2003) model described in the previous section.

III-2. Theoretical model

III-2-1. Fixed compensation and participation conditions

In the following discussion, the project is considered to be a bundling type, although the conclusion remains the same even if it is an unbundling type. Denoting the fixed compensation as Q_0, the profit V of the private company regarding the bundled business is as follows:

$$V=Q_0-C_0+\gamma(\bar{\imath})+c(\bar{e})-\bar{\imath}-\bar{e}. \tag{7}$$

Here, $\bar{\imath}$ and $\bar{e}$ are the investment levels i and e chosen by private companies, respectively. In the previous section, we implicitly assumed that the fixed compensation Q_0 was set appropriately to satisfy the participation conditions of good private companies. However, if the fixed compensation Q_0 is too low, the participation conditions of good private companies will not be satisfied.

To demonstrate this, let V_0 be the reservation profits (the profits that a private company can make if it uses the same resources to do other projects). Then, the participation conditions of the private company in the bundling case are $V \geq V_0$. That is:

$$Q_0-C_0+\gamma(\bar{\imath})+c(\bar{e})-\bar{\imath}-\bar{e} \geq V_0. \tag{8}$$

This inequality does not hold with a sufficiently low level of a fixed compensation Q_0 even if investment levels $\bar{\imath}$ and $\bar{e}$ are socially desirable. Consequently, to maximize social welfare, it is necessary to set a fixed compensation Q_0 that satisfies the following inequality:

$$Q_0 \geq Q_0^* \equiv V_0+C_0-\gamma(\bar{\imath})-c(\bar{e})+\bar{\imath}+\bar{e} \tag{9}$$

Understandably, it is also not desirable for the government to pay a fixed compensation Q_0 that is too high for private companies. The government's aim is not only to increase social welfare by drawing on the expertise of private companies, but also to reduce the fiscal burden of public projects. Altogether, the government should spend less (Q_0) if it can achieve the same social welfare. Therefore, it is most desirable for the government to set a fixed compensation Q_0 to satisfy the participation condition (equation (9)) of the private company in equality.

III-2-2. Heterogeneity among private companies and adverse selection

In the previous section, we assumed that all the private companies were homogeneous. However, private companies are not homogeneous. Good companies with high investment efficiency $\{\gamma(i)+c(e)-i-e\}$ are considered to have many other project opportunities and high reservation profits V_0. Therefore, when the value of the fixed compensation Q_0 is low, only companies with low reservation profits and low investment efficiency may apply.

To show this, we consider a parameter $\alpha_j\,(>0)$ that reflects the degree of investment efficiency and reservation profits. We consider that the larger α_j is, the better the company's quality in terms of investment efficiency, and the higher its reservation profits. Then, the reservation profits of each private company j ($j=1,2,\ldots, N$) and its profits from the PFI project can be written as $\alpha_j V_0$ and $Q_0-C_0+\alpha_j\{\gamma(i)+c(e)-i-e\}$, respectively.

It is easy to see that the investment levels that maximize the profits of private companies are decided as $\bar{\imath}$ and $\bar{e}$, which are common to all private companies. In contrast, because the reservation profits are different, the participation condition of each private company j is different. That is, for the participation condition of company j to be satisfied, the fixed compensation Q_0 needs to satisfy the following inequality:

$$Q_0 \geq Q_{0,j} \equiv C_0+\alpha_j\{V_0-\gamma(\bar{\imath})-c(\bar{e})+\bar{\imath}+\bar{e}\} \tag{10}$$

Because $Q_{0,j}$ depends on α_j, the above inequality is different for each private company. Therefore, some private companies do not apply for the project because of the difference in α_j, even if they receive the same fixed compensation. Then, the following proposition holds:

<u>Proposition</u>: Suppose that $\alpha_1<\alpha_2<\cdots<\alpha_k<\alpha_{k+1}<\cdots<\alpha_N$ and $V_0>\gamma(\bar{\imath})+c(\bar{e})-\bar{\imath}-\bar{e}$. Then, to maximize the expected social welfare, the fixed compensation Q_0 must be equal to or greater than $Q_{0,N}\equiv C_0+\alpha_N\{V_0-\gamma(\bar{\imath})-c(\bar{e})+\bar{\imath}+\bar{e}\}$.

<u>Proof</u>: Since $V_0>\gamma(\bar{\imath})+c(\bar{e})-\bar{\imath}-\bar{e}>0$ and $\alpha_1<\alpha_2<\cdots<\alpha_k<\alpha_{k+1}<\cdots<\alpha_N$, it holds that $Q_{0,1}<Q_{0,2}<\cdots<Q_{0,k}<Q_{0,k+1}<\cdots<Q_{0,N}$.

Thus, when the government sets the fixed compensation Q_0 within the range of $Q_{0,k}<Q_0<Q_{0,k+1}$, the participation condition (10) indicates that private companies of Type h_1 ($h_1\leq k$) have an incentive to apply for PFI projects, but those with Type h_2 ($h_2\geq k+1$) have no incentive to apply. Meanwhile, the government needs to select a private company with α_N to maximize social welfare. This is because when private company j conducts PFI projects, so-

cial welfare is $W_j = B - C_0 + \alpha_j\{\gamma(\bar{\imath}) + c(\bar{e}) - \bar{\imath} - \bar{e}\}$, and it is maximized when $\alpha_j = \alpha_N$ from $\gamma(\bar{\imath}) + c(\bar{e}) - \bar{\imath} - \bar{e} > 0$. Therefore, to maximize social welfare, it is necessary to set a fixed compensation at $Q_0 \geq Q_{0,N}$. [Q.E.D].

The above proposition indicates that even the government that wants to minimize the fiscal burden must set a fixed compensation at least at $Q_{0,N}$. A fixed compensation that is too low is undesirable because it creates the problem of adverse selection by not meeting the participation conditions of the private company that is maximizing social welfare.

After Hart, Shleifer, and Vishny (1997) and Hart (2003), Iossa and Martimort (2015) reconsidered PPP/PFI from the perspective of incomplete contracts by introducing uncertainty into the previous model. However, all these studies assumed that private companies were homogeneous; therefore, there was no concern about adverse selection when the government selected the private company. In this section, using the incomplete contract model that considers the heterogeneity of private companies, we shed new light on the literature by showing that fixed compensation that is too low can lead to adverse selection.

IV. Framework of the empirical analysis

IV-1. Hypothesis

In Sections II and III, expanding on Hart’s (2003) model, we theoretically examined the conditions for realizing socially desirable public projects from two perspectives: “unbundling” or “bundling” projects. The former refers to when both construction and operation contracts are awarded to different companies, whereas the latter refers to when both contracts are awarded to the same company group. We showed that neither the unbundling nor bundling type is always desirable under an incomplete contract. When this model is applied to the PFI, both BOT and BTO projects can seemingly be classified as bundling type. However, in the BTO model, ownership is transferred to the government after construction, and the operation is similar to a fixed-price outsourcing service under the ownership of the government. Therefore, it can be interpreted that the BTO model is inherently more similar to the unbundling type than the BOT model. We also showed that to increase the incentive of the private company group in the PFI, the appropriate setting of the contracted amount (fixed compensation) plays an important role. Our analysis shows that if the government keeps the fixed compensation low, adverse selection may occur and lead to socially undesirable results.

However, it is difficult to determine whether unbundling or bundling is desirable, or whether adverse selection has occurred because the fixed compensation is too low in Japan’s PFI. In the following section, using panel data from PFI projects in Japan, we examine whether the following two hypotheses are valid:

Hypothesis 1: The BTO-type PFI has an incentive structure similar to that of an unbundling project because the government holds ownership of public facilities after construction. In contrast, the BOT-type PFI has an incentive structure similar to that of a bundling project because the private company holds ownership of public facilities. Under incomplete contracts, both BTO and BOT models have advantages and disadvantages.

Hypothesis 2: If the government underestimates the fixed compensation at the time of planning, there will be a negative correlation between fixed compensation and planned VFM. Therefore, a highly planned VFM may degrade the quality of the private company group if adverse selection is caused by very low fixed compensation.

VFM indicates the percentage of total project costs that can be reduced by PFI compared with conventional public projects. There are two types of VFM: "planned VFM (VFM at the time of selection of a specific project)," which is calculated by the government when the project is announced, and "actual VFM (VFM after the bidding results)," which is calculated by the private company after the operator is selected. If the government underestimates the fixed compensation at the time of planning, the planned VFM tends to be high; therefore, a negative correlation exists between the fixed compensation and planned VFM. For this reason, if the low fixed compensation set by the government at the time of planning causes adverse selection, the quality of PFI projects will deteriorate as the planned VFM increases. Hypothesis 2 is based on this consideration.

In Japan, very few empirical studies have evaluated the effectiveness of PFI projects, such as Shimono and Maeno (2010), and Yodo, Mizobata, and Hayashida (2015). These studies implicitly assumed that the government had set the fixed compensation appropriately and conducted an analysis on the premise that it would be desirable to increase VFM, which indicates the reduction ratio of the fiscal burden. However, under the perception that achieving higher VFM is a policy goal, it is likely that the government overestimates VFM when setting the basic policy of PFI projects. Planned VFM is an advanced evaluation of the percentage of the total project costs that can be reduced compared to conventional public projects. Therefore, when the fixed compensation paid from the public sector to the private company group is low, the planned VFM tends to be large, even if it is at a level that causes undesirable ex-post results. From this point, the efficiency of PFI projects can no longer be said to be better with a higher planned VFM.

IV-2. Estimation formula and data

In general, PFI projects take a long time to complete. Therefore, it is not easy to evaluate their performance empirically. In addition, the available data is quite limited, so the choice of variables consistent with the theory is insufficient. However, it is possible to analyze whether the design of institutional arrangements was desirable by comparing the situation at the time when the government planned the project to that when the private company group was selected. In this section, we first examine how the planned VFM and the choice of the type of contract (BOT, BTO, etc.,) affected the number of applicants and the quality of selected companies. Although the number of applicants and the quality of selected company groups do not directly reflect the performance of PFI, attracting many companies and selecting good companies is at least a positive factor of performance.

Specifically, the following equation was estimated: The dependent variable y_j is “the number of applicants of private company groups,” which is a proxy variable related to the quality of the selected private company group.

$$y_j = constant + a_1 * Planned\ VFM_j + b_{1,1} * BOT_j + b_{1,2} * BTO_j + c_1 * Project\ Length_j + u_{i,j}. \quad (11)$$

Here, $Planned\ VFM_j$ = planned VFM for project j, BOT_j and BTO_j are dummy variables that take the value one when the contract type for project j is BOT and BTO, respectively, and zero otherwise. The dummy variables BOT_j and BTO_j correspond to Hypotheses 1, and the variable $Planned\ VFM_j$ to Hypothesis 2. In addition, we added $Project\ Length_j$= length of project j as a control variable.

If the institutional design at the time of planning by the government is attractive to the private company group, the number of applicants for the project will increase. In addition, if the institutional design at the time of planning is attractive, private company groups with large reservation profits are likely to apply. Thus, private company groups with better quality are likely to be selected. Thus, if any of the explanatory variables in the above equation have a positive impact, it means that it has had a favorable impact on the performance of the PFI project.

The data was obtained from *the PFI Yearbook 2019* published by the Japan PFI-PPP Association. However, abandoned projects after the implementation of policy announcements were not included. Projects for which the variables were not available were also excluded from the estimation. The variables used in the following estimates are BOT dummy, BTO

Table 2. Descriptive statistics of variables

	average	S.D.	maximum	minimum	# of obs.
BOT dummy	0.095	0.293	1	0	717
BTO dummy	0.732	0.443	1	0	717
planned VFM (%)	9.04	7.41	80	0	641
actual VFM (%)	17.98	12.10	63	0.9	432
the project length (year)	15.23	7.35	65	0	742
# of applicants	2.90	2.06	16	1	687
non-competition dummy	0.290	0.454	1	0	687
predicted contract amounts (million yen)	11698	31234	426000	0	679
predicted initial costs (million yen)	4745	8205	72000	0	633
# of companies comprising the SPC	4.74	2.79	32	1	713
share capital (million yen)	40952	101295	1400900	3	700
listing status	0.494	0.500	1	0	700

dummy, planned VFM, actual VFM, project length, number of company groups applying, non-competition dummy (dummy variable that takes the value one when the number of applicants is one, and zero otherwise), estimated contracted amount, estimated initial cost, number of selected private companies (SPC), share capital, and listing status (Listed=0, Unlisted=1).

Table 2 summarizes the basic statistics. The average planned VFM of PFI projects was 9%. In addition, the standard deviation of all variables, including the VFM, was sufficiently large to ensure that we may obtain appropriate estimation results.

V. Estimates of the impact on the number of applicants and quality of selected companies

V-1. The effect on the number of applicants

Regarding the PFI data in Japan, the PFI Promotion Office of the Cabinet Office, and the Japan PFI and PPP Association collect information and publish it on their website and in *the PFI Yearbook*. According to Harada (2014), companies participate in bids when published information reveals that the project is attractive in terms of business scale, expected profits, and so on. Thus, it is likely that the number of bidding company groups will increase if the PFI project provides enough incentives to private company groups to utilize their expertise.

Equation (11) is estimated using the logged number of applicants in project j as the dependent variable y_j. Since there is a possibility that the larger the scale of the project, the larger the number of company groups that may apply, we included the estimated contracted amount of the successful bidder (estimated by the Japan PFI/PPP Association) as the explanatory variable. In this case, equation (11) is estimated using the instrumental variable method[4].

Table 3 summarizes the estimation results of equation (11). First, although the planned VFM and project length were positive, they were not statistically significant. This indicates that VFM had no particular effect on the number of applicants during the planning period, suggesting that Hypothesis 2 does not hold true for the number of applicants. When the estimated contracted amount was included as an explanatory variable, it was not significant.

In contrast, both the BOT and BTO dummies have a significantly positive impact on the number of applicants. In particular, it is noteworthy that the coefficient of BOT type greatly exceeded that of the BTO type. This shows that while both BOT- and BTO-type PFI projects tend to increase the number of applicants compared to the other minor types, the number of applicants increases more significantly with BOT-type PFI projects compared to the BTO type. As Hypothesis 1 suggests, there are both advantages and disadvantages theoretically in terms of whether the BTO- or BOT-type is desirable. However, in the PFI project in Japan,

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[4] The instrumental variable method is used because the estimated contracted amount has an endogeneity that is affected by the number of applicants. The instrument variables are the constant term, planned VFM, project length, BOT dummy, BTO dummy, the dummy that takes the value one when the project type is self-supporting, and the dummy that takes the value one when the selection method is general competitive bidding.

Table 3. Estimation results of equation (11) with number of applicants as the dependent variable

constant term	0.600 (7.551)***	0.689 (0.796)
BOT	0.488 (4.081)***	0.445 (3.004)***
BTO	0.189 (2.305)**	0.202 (2.389)***
planned VFM	0.004 (1.026)	0.007 (1.048)
the project length	0.003 (0.590)	0.003 (0.367)
log(contracted amounts)		−0.013 (−0.125)
year dummy	no	no
# of observations	594	575
adj. R-squared	0.032	0.032

Note: t-values are in parentheses. *** = 1% significance level, ** = 5% significance level, and * = 10% significance level.

we find that the BOT type is more attractive in terms of the number of applicants. Here, the BOT type is equivalent to the bundling-type project as described by Hart (2003) in that the private company group can continue to own and operate public facilities after construction.

V-2. The effects on the size of the selected contractor

In the previous section, we analyzed the effects of planned VFM and the type of contract, using “the number of applicants for the project” as a proxy variable for the attractiveness of the project. In general, however, the quality of applicants varies, and the large number of applicants does not necessarily mean that many good company groups apply. In this section, we analyze the impact of planned VFM and the type of contract on the quality of the core company of the SPC. In the PFI project in Japan, since many selected SPCs’ core companies are not listed companies, the information available to measure quality is limited. In such a situation, the size of the share capital is a useful quality-related information in that it is available as far as the core company is a stock company. In general, the larger the share capital, the larger the company. In addition, an SPC with a large core company is more likely to be a good company with substantial expertise. Thus, we use the size of share capital as a variable that can capture the quality of a core company. The share capital and listing status of the core company were obtained from the company’s securities reports and websites.

Equation (11) is estimated by $log(capital_{i,j})$, the logged share capital of an SPC’s core company, as a proxy variable of the scale of a private company for project j and as the dependent variable y_j. Similar to private company capital investment, the public offering of

PFI projects is affected by macroeconomic conditions, such as business cycles and monetary policy. Moreover, some practitioners point out that in the 20 years since the enactment of the Act on Promotion of Private Finance Initiative in 1999, there have been changes in various aspects due to the accumulation of expertise. To control for possible differences in the timing of implementation of these projects, year dummies (dummy variable of one in the year the contractor is selected and zero in other years) are added to the estimation[5].

Table 4 reports the estimation results of equation (11). First, BOT and BTO dummies are not statistically significant, regardless of whether year dummies are included. This suggests that the size of the selected core company is not affected by whether the type of the contract is bundling or unbundling.

Table 4. Estimation results of equation (11) with the core company's share capital (logged value) as the explanatory variable.

	estimation I	estimation II
constant term	8.370 (22.206)***	6.765 (4.061)***
BOT	0.720 (1.291)	−0.483 (−0.888)
BTO	−0.291 (−0.762)	−0.319 (−0.873)
planned VFM	−0.088 (−5.089)***	−0.094 (−5.798)***
the project length	0.046 (2.118)**	0.015 (0.694)
year dummy	no	yes
# of observations	608	608
adj. R-squared	0.049	0.183

Note: t-values are in parentheses. *** = 1% significance level, ** = 5% significance level, and * = 10% significance level.

In contrast, the coefficient of the planned VFM has a statistically significant negative value, regardless of whether year dummies are included. This result shows that the size of the selected core company tends to be small when the government sets a high-planned VFM. This result suggests that, as Hypothesis 2 implies, a high-planned VFM may lower the quality of the SPC's core company, given that larger companies mean better companies. The size of the planned VFM does not significantly affect the number of applicants, as shown in Table 3, but does affect the quality of applicants (Table 4).

When each company decides to participate in the PFI project, the planned VFM evaluated by the government provides important information for the bid. If the government overestimates the planned VFM by setting low fixed compensation, it is a bad signal for large

[5] To control the size of the project, we used an instrumental variable method that included the estimated contracted amount of the successful bidder. However, the estimation was not statistically significant and the estimates of other variables were essentially the same.

companies with high reservation profits. In this case, only small companies with low reservation profits have an incentive to participate in the bidding process. These results are consistent with the phenomenon of adverse selection (Hypothesis 2).

The coefficient of project length is significantly positive when year dummies are not included. This suggests that the longer the PFI project length, the larger the size of the SPC's core company. However, the PFI project length is not statistically significant when the year dummies are included.

V-3. The effect on the listing status of selected companies

In the previous section, we used the core company's share capital as a proxy variable for the quality of the company, and examined the impact of planned VFM and the type of contract on the quality of the selected core company. In this section, we use the listing status of the core company as a proxy variable for the quality of the selected company to see the effects of planned VFM and the type of contract. Unlisted companies tend to be small in size. In addition, note that unlisted companies' accounting information is less transparent than that of a listed company, which may aggravate informational asymmetry in the screening process.

Unlike the dependent variable used so far, the listing status is a binary variable that takes the value zero if the core company is listed, and one otherwise. Therefore, we estimated a probit model assuming that the latent variable $y^*_{i,j}$ of the listing status of core company i for project j can be written as follows:

$$y^*_{i,j} = constant + a_2 * Planned\ VFM_j + b_{2,1} * BOT_j + b_{2,2} * BTO_j + c_2 * Project\ Length_j + u_{i,j}. \quad (12)$$

In this model, when $y^*_{i,j} > 0$, the "listing status" equals one, and zero otherwise.

Table 5 summarizes the estimation results of equation (12). The estimation, including year dummies, is also carried out to control for year-specific effects.

The most noteworthy result in the table is that regardless of the inclusion of the year dummy, the BOT and BTO dummies are not statistically significant. Meanwhile, the planned VFM is significantly positive. In other words, although the type of contract does not affect the listing status of selected core companies, the higher the planned VFM, the higher the probability that the core company is an unlisted company.

This result is consistent with Hypothesis 2, which asserts that the higher the planned VFM, the higher the incidence of adverse selection. If the planned VFM is high (i.e., the fixed compensation is low), listed companies with high reservation profits are reluctant to submit bids. Therefore, the possibility of unlisted companies being selected increases. Of course, there are some good companies among the unlisted companies. However, the transparency of accounting for unlisted companies is low, on average. Therefore, in the sense that companies with low capability are more likely to be selected due to information asymmetry, this result supports Hypothesis 2.

Project length is significantly negative when year dummies are not included. This means

Table 5. Estimation results for equation (12)

	estimation I	estimation II
constant term	−0.079 (−0.496)	0.562 (2.209)**
BOT	−0.259 (−1.115)	0.167 (0.649)
BTO	0.006 (0.037)	0.000 (0.001)
planned VFM	0.028 (3.314)***	0.038 (3.940)***
the project length	−0.015 (−1.655)*	−0.001 (−0.115)
year dummy	no	yes
# of observations	598	598
McFadden R-squared	0.021	0.131

Note: t-values are in parentheses. ***=1% significance level, **=5% significance level, and *=10% significance level.

that PFI projects with short lengths tend to attract unlisted companies. However, the estimation using year dummies is not statistically significant.

VI. Estimation results of the impact on VFM improvement.

VI-1. The effect on VFM improvement

The analysis in the previous section revealed that the higher the planned VFM proposed by the government, the smaller the share capital of the core company of the selected SPC and the less likely that it is listed. This means that PFI projects with high planned VFM tend to attract smaller and less transparent companies to the bidding process, rather than large companies with high accounting transparency.

However, it is too simplistic to conclude that this trend has had a negative impact on the performance of PFI projects. There are a number of good, small, and unlisted companies. These companies may be able to make better proposals than what the government assumed at the time of planning. Therefore, in this section, we use the degree to which the actual VFM has improved from the planned VFM as a performance indicator for PFI projects, and examine how the type of contract, the number of companies that applied, and the quality of the core company affect the degree of VFM improvement.

The planned VFM, which is announced at the time of the public offering of participating companies, does not reflect the proposals of the selected private company group. After the government selects the company group as a contractor, the actual VFM reflecting the proposal of the selected private company group is publicized. Therefore, the larger the difference between the actual and planned VFM (hereafter, the “degree of VFM improvement”), the more attractive the selected group's proposal is to the government. The degree of improvement in VFM will be a proxy variable to measure the efficiency of the PFI project in terms of how much the private company has contributed to what was initially planned by the government.

Specifically, using the same dataset as in the previous section, we estimate how much the actual VFM has improved from the planned level, depending on the type of contract, the number of companies that applied, and the size and listing status of the selected companies. One possible concern about this estimation is that the number of companies applying for the project will be affected by the type of contract, and that the company's size and listing status of the core company may be endogenous in the selection of the company group. To avoid endogeneity biases, we used a two-step estimation method. First, we estimate baseline equations (11) and (12). Using the estimated coefficients, we calculate the predicted number of companies that apply and predict the logged share capital or listing status. Second, we regress the degree of VFM improvement estimates on these predicted values with several control variables. Specifically, we estimate the following equation:

$$\begin{aligned} VFM\ Difference_j &= constant + a_3 * \widehat{Share\ Capital}_{i,j} \\ &+ b_3 * \widehat{Share\ Capital}_{i,j} * Non\text{-}competition\ Dummy_j \\ &+ c_3 * \{log(Number\ of\ applicants_j) - log(\widehat{Number\ of\ applicants_j})\} \\ &+ d_{3,1} * BOT_j + d_{3,2} * BTO_j + \textstyle\sum_{h=1}^{H} e_{1,h} X_{i,j}^{\ h}, \end{aligned} \tag{13a}$$

$$\begin{aligned} VFM\ Difference_j &= constant + a_4 * \widehat{Listing\ Status}_{i,j} \\ &+ b_4 * \widehat{Listing\ Status} * Non\text{-}competition\ Dummy_j \\ &+ c_4 * \{log(Number\ of\ applicants_j) - log(\widehat{Number\ of\ applicants_j})\} \\ &+ d_{4,1} * BOT_j + d_{4,2} * BTO_j + \textstyle\sum_{h=1}^{H} e_{2,h} X_{i,j}^{\ h}. \end{aligned} \tag{13b}$$

where $VFM\ Difference_j$ is the difference between the actual and planned VFM estimates for project j; $\widehat{Share\ capital}_{i,j}$ = predicted logged share capital of the selected core company i for project j obtained from equation (11), $\widehat{Listing\ Status}_{i,j}$ = predicted listing status of the selected core company i for project j obtained from equation (12), $Non\text{-}competition\ Dummy_j$ = dummy variable, which takes the value one when the selected company is the only applicant in the bidding, and zero otherwise; log ($\widehat{Number\ of\ applicants_j}$) = predicted logged the number of applicants for project j obtained from equation (11); and $X_{i,j}^{\ h}$ = control variable h (h=1, . . ., H).

We include $log\ (Number\ of\ applicants_j) - log\ (\widehat{Number\ of\ applicants_j})$ as an explanatory variable to estimate the effect of the number of applicants after removing the effect of the type of contract (BOT or BTO) on the number of applicants. In both equations (13a) and (13b), we also include predicted values of capital and listing status as well as cross terms of non-competition dummies ($\widehat{Share\ Capital}_{i,j}) * Non\text{-}competition\ Dummy_j$ and $\widehat{Listing\ Status} * Non\text{-}competition\ Dummy_j$) in the explanatory variables. This is because if the selected company group is the only bidder for the project, the principle of competition will not work and the project proposal is likely to be unattractive. In addition, we add "estimated contract amount," "estimated initial cost," and "number of companies comprising the group" as control variables.

VI-2. Results

Table 6 shows estimation results of equation (13a). Regarding the effect of the type of the contract on the degree of VFM improvement, BOT type is always significantly positive and much higher than that of BTO type. In general, BOT type is considered to have more flexibility in project planning because the private company group is supposed to continue to own and operate the public facility after its construction. The results suggest that this feature of BOT type increases the incentives to improve the actual VFM. The number of applicants for the project is significantly positive, indicating that the quality of the project proposals

Table 6. Estimation results for equation (13a)

	estimation I	estimation II
constant term	17.173 (7.907)***	17.090 (7.903)***
# of applicants	7.356 (9.386)***	6.265 (6.722)***
BOT	8.326 (3.465)***	5.992 (2.279)**
BTO	3.453 (2.047)**	2.094 (1.166)
# of companies comprising the SPC	−0.362 (−1.723)**	−0.377 (−1.799)**
contracted amounts	−0.000 (−3.727)***	−0.000 (−3.898)***
initial costs	0.000 (3.247)***	0.000 (3.313)***
predicted logged share capital	0.000 (4.814)***	0.000 (5.279)***
predicted logged share capital *non-competition dummy		−0.000 (−2.139)**
# of observations	395	395
adj. R-squared	0.316	0.323

Note: t-values are in parentheses. *** = 1% significance level, ** = 5% significance level, and * = 10% significance level.

improves as the number of applicants for the project increases. Furthermore, for the control variables, the estimated contracted amount and the number of companies comprising the group are significantly negative, while the estimated initial cost is significantly positive. These results indicate that projects with larger estimated contracted amounts, or projects of the group consisting of more companies, do not show any improvement in VFM, while projects with larger initial costs show more improvement in VFM.

The noteworthy result in the table is that the predicted logged share capital is always significantly positive, regardless of the choice of control variables. This indicates that the larger the size of the core company, the greater the likelihood of the actual VFM being revised upward based on the private company's proposal. In the previous section, we showed that the higher the planned VFM, the smaller the predicted value of the logged share capital. This result suggests further that because of selecting more small-scale companies, the proposals of the selected private companies tend to be unattractive to the government. In addition, the cross term between the predicted value of share capital and the non-competition dummy is negative and significant. This is because the lack of competition during the bidding process reduces the attractiveness of the proposals, even when the core company is large.

Table 7 shows alternative estimation results of equation (13b). The abovementioned re-

Table 7. Estimation results for equation (13b)

	estimation I	estimation II
constant term	25.078 (11.647)***	25.154 (11.321)***
# of applicants	7.372 (9.512)***	7.476 (6.955)***
BOT	8.736 (3.699)***	8.844 (3.556)***
BTO	3.082 (1.830)*	3.116 (1.829)*
# of companies comprising the SPC	−0.299 (−1.414)	−0.296 (−1.397)
contracted amounts	0.000 (−3.340)***	0.000 (−3.337)***
predicted initial costs	0.000 (2.805)***	0.000 (2.804)***
predicted listing status	−13.803 (−5.077)***	−13.850 (−5.050)***
predicted listing status *non-competition dummy		0.428 (0.140)
# of observations	395	395
adj. R-squared	0.321	0.319

Note: t-values are in parentheses. ***=1% significance level, **=5% significance level, and *=10% significance level.

sults of equation (13a) also mostly holds when the predicted value of the listing status of the core company is used instead of the predicted value of the logged core company's share capital. In the estimation of equation (13b), the effect of the number of companies comprising the SPC and the cross terms between the predicted value of listing status and the non-competition dummy are no longer significant. However, other findings are almost the same, including the fact that BOT type is always significantly positive and that its estimated value is much higher than that of BTO type.

The noteworthy result in the table is that the predicted value of listing status is always significantly negative, regardless of the choice of control variables. This indicates that the actual VFM based on the private company's proposal tends to be significantly revised upward when the core company is listed on the stock market. In the previous section, the probability that the core company is an unlisted company increases as the planned VFM increases. Therefore, if the planned VFM is large, the proposal of the selected private company group is likely to be unattractive to the government.

PFI is expected to be an efficient method of providing services needed by society in the sense that it provides better VFM than conventional public projects. However, if the government concentrates on reducing the fiscal burden, it will overestimate the planned VFM. Thus, this may cause adverse selection, whereby a private company with poor quality project proposals is selected. These empirical results support this hypothesis.

VII. Concluding remarks

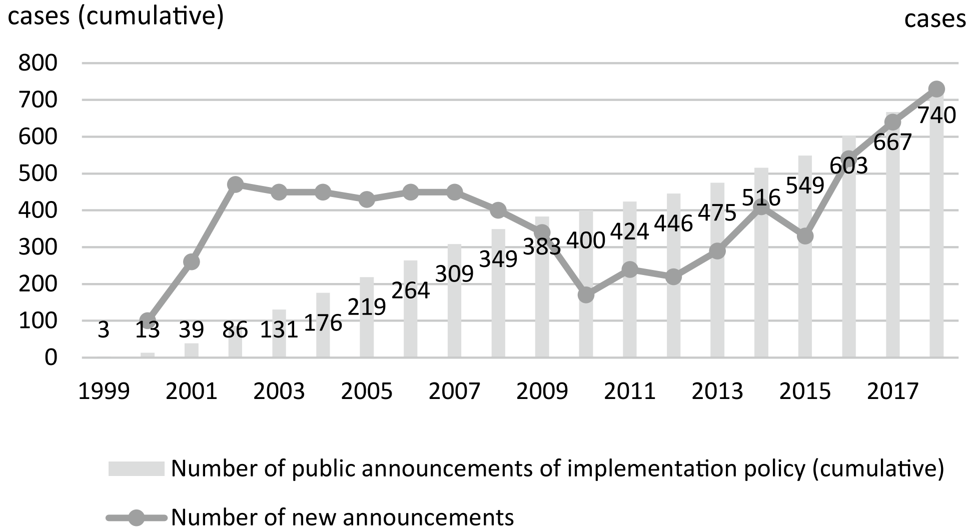
The introduction and promotion of PPP/PFI in Japan was accelerated by the enactment of the Act on Promotion of Private Finance Initiative (PFI Law) in 1999. However, in a PFI project, which comprises a principal-agent relationship established under an incomplete contract, a private company with superior expertise is not always selected. Moreover, the selected company does not always act in the way the public sector wishes. To conclude a contract between the public and private sectors that will realize socially desirable results, it is essential for the government to select an appropriate type of contract and design an appropriate compensation system.

In this study, we examined the conditions under which PFI becomes efficient from both theoretical and empirical perspectives, considering PFI as a principal-agent relationship between the public and private sectors. Our empirical analyses, based on data from Japan's PFI projects from FY1999 to FY2018, showed that when the fixed compensation is set lower than necessary (i.e. when the planned VFM is set higher than necessary), inefficiency due to adverse selection may occur. In addition, BOT projects, in which the private company continues to own the facilities after construction, outperformed BTO projects in terms of the attractiveness of the project and the quality of the selected contractor. This means that the advantages of synergy effects outweigh the disadvantages of inefficiency due to the pursuit of private profits.

Looking back over the 20 years since the PFI Law went into effect, the number of projects and project costs both grew rapidly in the first four years of the law's implementation, and then remained stable until around nine years (Figure 3). However, from around the tenth year, a sluggish trend became apparent. Although external factors such as the economic downturn caused by the global financial crisis and other factors contributed to the sluggish growth at that time, the more significant factor was the structural problems inherent in the PFI project scheme, which remain to date. PPP/PFI requires the active involvement of both the public and private sectors.

To overcome this situation, the government has focused on the development of infrastructure and public facilities through PPP/PFI in its growth strategy (see, for example, Cabinet Office (2013) and Ministry of Land, Infrastructure, Transport and Tourism (2014)). In particular, in June 2010, the "New Growth Strategy" included the introduction of a "public facility management concession system (concession method)," which led to the amendment of the PFI law in June 2011 to make this possible. Furthermore, the "Strategy for the Revitalization of Japan" in June 2013 and the "Action Plan for the Fundamental Reform of PPP/PFI" also set forth the idea of using private company funds and knowledge to develop, operate, and renew social infrastructure through PPP/PFI. The "Action Plan for Fundamental Reform of PPP/PFI" focuses on the following types of projects: (1) PFI using the Public Facility Management Authority System, (2) PFI that recover costs through project income, such as the establishment and use of profit-making facilities, and (3) PPP projects that utilize private company proposals, such as the effective use of public real estate. In October of the same year, following the second revision of the law, the Private Finance Initiative Corporation was established to provide financial and project formation support for infrastructure PFI projects. In addition, the promotion of PPP/PFI was listed as a growth strategy in the "Japan Revitalization Strategy Revised 2015" in June 2015.

Figure 3. Number of PFI projects



Source: Cabinet Office, Government of Japan, Implementation status of PFI projects.

As mentioned above, in recent years, the stage has been set for the operation and development of the next generation of infrastructure projects. In reality, however, there is still a substantial perception gap between the "public" and "private" sectors in PPP/PFI projects. In particular, from the perspective of the private sector, the problem is that a position of equality between the public and private sectors has not been established yet.

One of the arguments in favor of PPP/PFI in Japan is that if public projects are outsourced to private companies through PFI, the private company will be able to improve the management efficiency of the project and reduce fiscal expenditures. However, to further expand PPP/PFI projects in the future, it is necessary to make full use of the funds, wisdom, and expertise of private companies.

This study is the first to consider PPP/PFI as a principal-agent relationship, and to examine the type of contract and the design of compensation that provide appropriate incentives to private companies. However, there are many other factors that must be considered, such as differences in the characteristics of each project field. In addition, accounting information on private companies is limited, especially in the case of unlisted companies. Therefore, the results of this analysis should be interpreted carefully. To attract vibrant and quality private companies in the future, it is important to design a mechanism that makes it easy for highly efficient private companies to apply for PFI projects and to take socially desirable actions. We hope that further research will be conducted for this purpose.

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