Public-Private Partnerships: Goods and the Structure of Contracts

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Abstract

This paper presents a framework for analyzing the structure of contracts for public-private partnerships (PPP) that produce products and services that generally include mixtures of both public and private goods. A three-stage framework, sourced with the incomplete contracting and control rights literature, is advanced to evaluate the successes and failures of a variety of PPP in the natural resources. These case studies provide unique insights into the contract structures that are typically designed for the management and provision of impure public goods. We demonstrate the desired contract structure of a PPP depends on the type of good or service produced, and it is this pivotal point that generally results in shared authority in the extraction or production and consumptive distribution of natural resources.

1. INTRODUCTION

Public-private partnerships (PPPs) are pervasive. Governments have partnered with the private sector to solve problems ranging from social security to nuclear waste management. In the United Kingdom, between 1992–2003, the government invested more than £36 billion in nearly 600 PPPs and is expected to spend another £110 billion between 2004 and 2029 (Allen 2003; Hodges & Mellett 2003, 2004). These partnerships are estimated to have reduced costs more than 17% over the previous forms of public provision (Pina & Torres 2001). In the European Union, 7% of all services provided by local governments are provided by PPPs, and in small cities, PPPs account for 33% of service provision.

Developing countries have also reduced costs and improved quality by using PPPs to provide services and infrastructure (Boubakri & Cosset 1998; World Bank 2002, 2004). In the 1990s, more than 15% of investments in water and sanitation in developing countries came through private firms working with local governments. Overall, private firms contributed more than $580 billion to infrastructure in developing countries, accounting for nearly 20% of total annual investments. Recently, governments around the world have announced their intention to form PPPs in the financial sector to control systemic risks. Though there has been much discussion in both the popular press and academic community, no consensus has been reached on the optimal contract structure for these partnerships (Savas 1982, Donahue 1989, Shapiro & Willig 1990, Shaoul 2005).

PPPs have been especially prevalent in countries attempting to improve management and service provisions of natural resources. In this paper, we focus on PPPs that have been designed and implemented in natural resources. We define natural resources to include both market and nonmarket goods and services that arise from, inter alia, water, land use, mining, environmental remediation, forestry, fisheries, or public/private goods research. Partnerships in natural resources provide unique insights into the optimal PPP structure because they must address the management and provision of impure public goods.[1] The optimal structure of a PPP depends on the type of good or service produced, and it is this pivotal point that generally results in shared authority in the extraction or production and consumptive distribution of natural resources.

Contracts for PPPs in the natural resources, and their associated control and property rights, come in many forms, ranging from large, multiproject, multiyear alliances to small-scale projects. We present a three-stage operational framework to analyze these contracts. This structure is based on control rights that stem from contingencies in the partnership's production process and are embedded in the contract. In Stage 1, the public and private partners negotiate to determine the allocation of the front-end control rights and the back-end property rights.[2] The front-end control rights determine the nature and scope of the activities that the partnership will undertake as well as decision-making authority over those activities, whereas back-end property rights determine ownership and how any benefits generated by the partnership will be distributed. The partners also make relationship-specific investments according to the contract in Stage 1. In Stage 2, the partners bargain over management decisions with bargaining power determined by the contract

[1]Impure public goods are goods that are either nonrival or nonexcludable but not both (if both, then the good is a pure public good).

[2]There is no consistent definition of control rights and property rights in the literature. In this paper, we use control rights to refer to the authority to make decisions during the production process (the front end) and property rights to refer to ownership of either the partnership's assets or the goods produced by the partnership (the back end).

and investments made in Stage 1. The equilibrium outcome of this bargaining process is either a noncooperative decision (commonly referred to as a default outcome or a disagreement payoff) or a cooperative solution that maximizes the joint benefit. In Stage 3, there is an unanticipated shock that causes the partners or stakeholders to revisit their control and property rights. Depending on the nature of the shock, the partners may engage in renegotiation that reassigns control and property rights (and return to Stage 1) or they may conclude the partnership.

Our analysis and evaluation are organized as follows: In Section 2, we provide a survey of the relevant theory; in Section 3, we present the three-stage framework for evaluating PPP contracts; in Section 4, we apply this framework to a variety of PPPs in the natural resources; and in Section 5, we offer concluding remarks.

2. REVIEW OF PUBLIC-PRIVATE PARTNERSHIP THEORY

The core of any framework for evaluating PPPs is sourced with incomplete contracting literature (Hart & Moore 1988, Aghion & Bolton 1992, Aghion et al. 1994, Dewatripont & Maskin 1995, Hart 1995, Aghion & Tirole 1997, Hart et al. 1997, Hart & Moore, 1999, Tirole 1999).[3] Of particular relevance to PPP contracts is the determination of control rights. In this literature, a control right is the authority to make a decision with respect to both anticipated events and events that are not foreseen in the contract. The allocation of control rights can determine whether a partnership will operate efficiently (Schmidt 1996a,b; Helmut 2005).

In the case of a partnership that produces a pure private good, the partners have an incentive to underinvest because the benefits from their investment can be lost in ex-post renegotiation (Grossman & Hart 1986, Hart & Moore 1990). Grossman & Hart (1986) used a two-period model with two firms. In the first period, the firms create a contract that allocates control rights and each firm makes relationship-specific investments, (a_1, a_2). In the second period, each partner makes production decisions, (c_1, c_2), based on the control rights assigned in the contract, which determine the partnership value for partners 1 and 2, $B_1[a_1, c_1, c_2]$ and $B_2[a_2, c_1, c_2]$. Both the investments and the decisions are uncontractible in period 1, but once the decisions are made, each partner is presumed to have equivalent information about their values.

In the first period, the firms make the relationship-specific investments noncooperatively. After these investments are observed, the second period begins and the control rights, which were allocated by the first-period contract, are exercised. These decisions can be made noncooperatively or cooperatively, through costless renegotiation, because the choice of c becomes contractible in period 2. It is unlikely that the noncooperative equilibrium decisions, $(\hat{c}_1, \hat{c}_2)$, will maximize the partnership's value, so the firms can benefit from renegotiation in period 2, after observing the investment decisions from period 1, which are chosen in anticipation of the renegotiation, and create a contract specifying the optimal c_1 and c_2. Grossman & Hart (1986) and Hart & Moore (1990) assumed the firms divide the surplus from the joint venture symmetrically. This outcome will generally be inefficient as both firms underinvest and do not maximize ex-ante value of the partnership.

[3]A contract is incomplete in the sense that there is a set of events, that can influence the partnership, that have not been enumerated in the contract.

If one firm's first-period investment has a larger effect on the partnership's value than the other firm's, the contract should assign the firm with the more valuable investment full control over decision making in the second period. Under this circumstance, the allocation of control in the first period provides the firm with the most valuable investment an incentive to invest optimally. When the firm whose investment has a larger impact on the partnership's value invests optimally, the partnership's value is maximized. Thus, underinvestment can be mitigated, in a joint venture that produces a private good, if the contract assigns agents control rights to assets on which their production is dependent.

Hart (2003) used the incomplete contract theory to evaluate a PPP that creates infrastructure that must be constructed and operated. The government can "bundle" the construction and operation by forming a partnership with a private firm or "unbundle" the project using different firms, one to construct and another firm to operate the infrastructure. The advantage of bundling is the private firm internalizes the benefits of investments made during construction. A firm that manages a bundled project will be more willing to make investments in construction that lead to more efficient operation than a firm that is responsible for construction only. If the quality of the infrastructure cannot be specified in the contract, but the quality of the service can be specified, a PPP could provide the best incentives for the private firm to invest optimally in construction.

Besley & Ghatak (2001) extended the incomplete contracting framework to a partnership that produces a public good. In their model, two agents, n and g, make relationship-specific investments, a_n, a_g, that increase the nonrival and nonexcludable benefits generated by a project, $B(a_n, a_g)$. Each agent's valuation parameter, θ_i, determines his or her respective payoffs: g's payoff is $\theta_g B(a_n, a_g) - a_g$ and n's payoff is $\theta_n B(a_n, a_g) - a_n$. The first-best levels of investment, which maximize the joint payoff $(\theta_g + \theta_n)B(a_n, a_g) - a_g - a_n$, are generally not reached because the investments are not contractible and each agent will possess bargaining power once the investments are sunk. If the parties engage in ex-post Nash bargaining, with a symmetric split of the surplus, the ex-ante investment decisions will not be optimal because the partners will receive only a fraction of the social benefit generated by their investment.

Besley & Ghatak (2001) demonstrated that the project's joint surplus will be maximized by allocating all control rights to the partner that assigns the highest monetary value to the project. The partner with the highest valuation has the incentive to invest optimally and this assignment of authority allows that partner to do so. Thus, when a public good is produced by a partnership, the agent's valuation of the output generated, and not the relative value of their investment, should determine the allocation of control rights.

Most of the control rights literature has focused on the optimal allocation of control rights when producing either a private good or a public good, and though we can glean useful lessons, it does not provide a complete framework to evaluate PPPs in the natural resources that produce impure goods such as environmental remediation, water sanitation, or infrastructure. For such goods, Francesconi & Muthoo (2006) developed a framework for allocating control rights in PPPs. Initially, two agents, g and n, divide the control rights between themselves. The partner g holds a share $c \varepsilon [0, 1]$ of the control rights, and the remaining $(1 - c)$ of the control rights are held by the partner n. After the control rights are allocated, g and n invest $a_g, a_n \geq 0$, respectively, in the project. Once the investments are made, the partners can make decisions either unilaterally or jointly through cooperative bargaining. If the partners do not cooperate, the project's value will be $B(c, a_g, a_n)$; if they cooperate, the value will be $b(a_g, a_n)$, where $b(a_g, a_n) > B(c, a_g, a_n)$.

Table 1 Optimal assignment of control rights in a public-private partnership by type of good

	Control rights assigned to the firm(s) with the highest valuation of the project	Control rights assigned to the firm(s) with the most valuable investments
Private good (Grossman & Hart 1986, Hart & Moore 1990)		X
Public good (Besley & Ghatak 2001)	X	
Impure good (Francesconi & Muthoo 2006)	X[a]	X[a]

[a]Depending on the impunity of the good produced by the partnership

The noncooperative project value, $B(c, a_g, a_n)$, is assumed to be a linear function of control rights: $B(c, a_g, a_n) = cB^g(a_g, a_n) + (1 - c)B^n(a_g, a_n)$, where $B^i(a_g, a_n)$ is the project's value for partner i when i has sole decision-making authority.

The players bargain over whether the decisions are to be made cooperatively or noncooperatively and what, if any, transfers there will be from g to n or n to g. If g and n cooperate, their payoffs are $\theta_g b(a_g, a_n) + t$ and $\theta_n b(a_g, a_n) - t$, respectively, where the valuation parameters, θ_n and θ_g, determine each partner's valuation of the project, and t is a monetary transfer from n to g, which can be positive or negative. But if the partners choose to make decisions noncooperatively, the payoffs are $\theta_g[cB^g(a_g, a_n) + (1 - \alpha)(1 - c)B^n(a_g, a_n)]$ and $\theta_n[(1 - \alpha)cB^g(a_g, a_n) + (1 - c)B^n(a_g, a_n)]$, respectively, where the impurity of the good produced by the project is measured by the parameter $\alpha\varepsilon[0, 1]$. The α parameter allows this framework to be extended to PPPs that produce any good on the spectrum between pure private goods and pure public goods.

If the partnership produces a pure private good ($\alpha = 1$) or a pure public good ($\alpha = 0$), the model yields the results from Grossman & Hart (1986), Hart & Moore (1990), or Besley & Ghatak (2001). However, if the PPP produces an impure good, $\alpha\varepsilon(0, 1)$, and each partner's investment is equally important, the low-valuation partner should have sole authority. Intuitively, high-valuation partners already have an incentive to invest because they will enjoy some of the benefits of the impure good even without decision-making authority, and low-valuation partners will be more willing to invest if they gain a greater share of the control rights. For a summary of the model results for the three types of goods, see **Table 1**.

The broad themes developed in these papers yield useful results when applied to PPPs in specific industries. Bundling the construction and operation of a project reduces underinvestment when the quality of investment cannot be observed (Hart 2003) as well as when the quality of the investment can be observed (Bennett & Iossa 2006).[4] When there is an externality between the construction and management or operation of infrastructure, the two should be bundled only when the externality is positive, that is, when the externality resulting from increases in the quality of design in turn decreases operating costs (Martimort & Pouyet 2006).

[4]Investments with unobservable quality, like managerial effort, cannot be verified by other parties, whereas investments with observable quality, like construction equipment, can be verified (Kessler & Lülfesmann, 2000).

PPPs that conduct research related to natural resources can be structured so that private firms sponsor research that benefits public goods research (Spielman et al. 2007, Rausser et al. 2008). Public investment in research can stimulate private investment by creating new technologies that can be profitably exploited by the private sector (Wang 2007). In forming these relationships, PPPs cannot be justified solely as a fund-raising device where public funds are replaced with private funds, because the payout to the private firm can cause greater distortions than a tax levied by the public sector (Sadka 2006, Engel et al. 2007).[5]

3. OPERATIONAL FRAMEWORK

The theoretical papers on incomplete PPP contracts have been developed in terms of primitives and, as the authors acknowledge, ignore important details found in PPP contracts. For example, the papers typically assume symmetric bargaining power, though this is rarely the case. Using these frameworks as a guide, we develop a three-stage framework to evaluate PPP contracts. In Stage 1, the public and private partners negotiate an incomplete contract that assigns front-end control rights over decision making and back-end property rights over the partnership's assets and the goods produced by the PPP. Once these rights are assigned, the partners make investments. In the following stage, the partners make management decisions through bargaining. This bargaining will lead either to the noncooperative bargaining solution or to the cooperative bargaining solution that maximizes the joint benefit to both partners. In Stage 3, the partners respond to an unanticipated shock by either concluding their partnership or beginning this process again at Stage 1 by renegotiating the allocation of control rights and property rights. If the partners choose to renegotiate, the control rights will generally be distributed differently.

An operational conceptual lens is necessary to analyze PPP contracts in natural resources that includes the terms and conditions used to assign front-end control rights and back-end property rights. The following three-stage framework provides a lens that allows us to evaluate PPP contracts.

3.1. Stage 1: Setting the Bargaining Space and Negotiating the Contract

In Stage 1, the partners negotiate a contract and make investments. The PPP is based on a contractual commitment that involves more than public sector regulations being imposed on a private party. The public institution should begin this process with a self-assessment to identify their primary objectives in seeking out private partners, their strengths and assets, and the desired complementarities. This assessment is essential to form an efficient partnership.

Though the order in which partnership negotiations proceed is of little material consequence, it is vital for the public institution to be deliberate early in the process, when seemingly innocuous decisions ex-ante may severely limit its control or flexibility at crucial junctures ex-post. At each point in a relationship, it is important for the public

[5]Engel et al. (2007) make the standard assumption that raising \$1 in taxes costs society $\lambda > 1$ dollars. An additional dollar invested by a private firm saves society $\lambda - 1 > 0$ dollars in taxes. However, the firm must be compensated for its investment with at least an additional \$1 in present value. Because this future revenue could have been used by the government to reduce distortions created by taxes, the opportunity cost of losing the future \$1 in user fees is the shadow cost of public funds, λ.

institution to consider the long-term consequences of all relationship-related decisions. In finding and selecting a partner, firms often seek government contracts and make specific offers, leaving public institutions in a passive role of waiting to be approached. Alternatively, the public institution can take a proactive role. Given the results of the self-assessment, the public institution can seek out well-matched partners that complement their strengths. Although deliberately seeking out partners, rather than waiting to be approach with a proposal, requires more effort initially, it provides the public institution the greatest degree of control over the selection of partners, which implicitly defines the control the public institution has over the remainder of the structuring process. In addition, by actively approaching potential partners in the private sector, a public institution can form a consortium with a group of specialized partners if that better suits the public institution's objective. This active approach can substantially broaden the public institutions choice set. Likewise, a proactive approach on the part of a private firm can increase its control in the bargaining process.

Once a partner is selected, the public and private institutions engage in negotiations that result in a contract that allocates to each of the i partners, $i = 1, 2$, a share of the front-end control rights, c_i, and back-end property rights, r_i, where $0 \leq c_i \leq 1$, $0 \leq r_i \leq 1$ for all i and $\sum_{i=1}^{2} c_i = 1, \sum_{i=1}^{2} r_i = 1$. The front-end control rights enumerate the resources committed by both partners and give the partners decision-making power over the partnership's investment and production processes. The back-end property rights assign ownership of assets and specify the manner in which the partnership's assets will be distributed. The project's risks are implicitly assigned through this allocation of property and control rights. The contract also specifies each partner's investments, which are made during the first stage.

In the first stage, each partner works to minimize its share of input while making sure the combined resources will be sufficient for a successful joint effort. The commitment of resources in the front-end is fairly transparent; however, the implications of choosing particular governing structures for the partnership are less transparent. Given the diversity of assets, it is difficult for potential partners to balance their respective asset contributions. These assets can be tangible, as with financial assets or equipment, or intangible "knowledge" assets (Rausser et al. 2000). Unlike tangible assets, the value of intangible assets is not easily defined as it relies on many factors such as the nature of the assets and the degree of complementarity.

Identifying these aspects of the partner's assets is important to create complementarities among the different assets held by the public and private partners and when negotiating over the contributions each partner will make to the relationship. Private institutions are likely to have more access to funding, state-of-the-art scientific tools, commercialization expertise, and marketing resources. In return, public institutions can give the private partner rights in a natural monopoly, preferential access to natural resources, and assistance in navigating bureaucracies. The objective of the contract is to utilize each partner's assets in the most productive combinations (Leavitt & Morris 2004).

The governance structure of the partnership must be determined in the first stage. Fundamentally, it defines each partner's front-end control rights and back-end property rights. This assignment of control and ownership will determine how the partners will interact, make decisions, resolve conflicts, and terminate the agreement if necessary. An important consequence of the governance structure is that it determines how the project will be evaluated and under what conditions the scope will be changed (i.e., the agreement

extended or terminated). At the conclusion of the partnership, the options in the agreement determine how benefits are disseminated and the process for establishing ownership through property rights. Each of these issues is crucial in determining how both the pecuniary and nonpecuniary benefits of the project are shared by the partners and by the public.

3.2. Stage 2: Decision Making Through Bargaining

In Stage 2, the partners jointly manage the partnership by making decisions based on a two-person, two-phase bargaining game [see Rausser et al. (2009) for an extension of this analysis to an n-person bargaining game]. In the first phase, the public partner and the private partner decide what threats to invoke if no agreement is reached, where the threat strategies are chosen to maximize their payoff while minimizing effort and are based on the control rights and property rights assigned in Stage 1. These threat strategies, $(\tilde{c}_i, \tilde{r}_i)$, determine the disagreement payoffs, $[B_1(\tilde{c}_1, \tilde{r}_1), B_2(\tilde{c}_2, \tilde{r}_2)]$, where B_i is the i^{th} partner's objective function, and these strategies are taken as given in the second phase. These strategies need not actually be carried out and may not even be explicit; all that is required is the potential of threat.

From the endogenous determination of the noncooperative equilibrium, a Pareto move to a cooperative outcome can be easily determined. The latter outcome is found by choosing (c_1, r_1) and (c_2, r_2) to maximize the product, $[B_1(c_1, r_1) - B_1(\tilde{c}_1, \tilde{r}_1)][B_2(c_2, r_2) - B_2(\tilde{c}_2, \tilde{r}_2)]$, such that $B_i(c_i, r_i) - B_i(\tilde{c}_i, \tilde{r}_i) \geq 0,\ i = 1, 2$. In this stage, the partners will achieve an efficient outcome, in which the partners exercise their rights and share the payoff. The partner holding the relevant right is aware of the noncontrolling partner's influence and unilaterally selects an action that maximizes the controlling partner's objective function given the noncontrolling partner's active threats (penalties or rewards or its reactive pattern) (Rausser et al. 2008).

Beyond their choice of influence strategy, each partner may exercise control over the resources dedicated to the relationship depending on the results of Stage 1. For example, if a public institution is approached by a single firm and considers only their offer, it has a very limited choice set and is likely to have little leverage over that firm's resources. However, if a public institution considers multiple offers from partners with varied assets, its choice set is broader.

3.3. Stage 3: Is There a Shock?

In the final stage of the agreement (Stage 3), the partners respond to unanticipated shocks. For our purposes, a shock is an event that affects the partnership over which there is no explicit contingency. When there is a shock, the partners have two options: (*a*) They can conclude the partnership and exercise their back-end property rights over the assets and goods produced by the partnership, or (*b*) they can renegotiate the control rights and property rights assigned and begin again at Stage 1. If the partners choose to renegotiate, the allocation of bargaining power in renegotiation may be different from the allocation in the previous stages. By this stage, a partner may find itself in a more vulnerable position as a result of the nature of the shock or relationship-specific investments. This potential for changes in relative bargaining power could lead to a reassignment of control rights.

After Stage 3, the partners assess the outcome of their partnership and consider whether to renew the agreement. Public institutions, lacking until now a formal method for review of partnerships with private institutions, have developed a variety of evaluation policies. See the United Kingdom's *Value for Money Assessment Guidelines* (Treasury 2006) for one such leading example. These policies rely mainly on anecdotal feedback from involved personnel to measure the merits of specified projects and monitor unintended consequences. The informal reviews and vague impression of both partners are coupled with more tangible outcomes, such as the PPP's output value, in assessing the success of a partnership.

A key policy issue is developing concrete measures of PPP productivity. Much of the literature on PPPs focuses on developing proper incentives within the scope of an individual agreement, but little consideration is given to incentives that fall outside a specific agreement. Because many of these agreements are up for renewal once completed, there are incentives for the public institution to ensure that the private partner is satisfied with the outcome of the agreement, and under increasing financial pressure, this may affect behavior within a current agreement. In other words, these agreements are not necessarily one-shot games; instead, they may be a single round of a repeated game. As such, there are incentives for the public institution to develop a certain reputation so that the private partner will support a renewed relationship. This speaks to one of the primary concerns with PPP agreements—that public institutions will fail to look for funding from other sources and thus become dependent on renewing these agreements. As a result, the public institution may lose its ability to walk away from negotiations and, therefore, much of its bargaining power. If recognized, these issues may be addressed by choosing a partner with which there is strong incentive alignment as well as safeguards in the agreement.

4. CASE STUDIES

In this section, we apply our operational framework to PPPs in natural resources. These case studies allow us to examine the outcome of a variety of PPP contracts in environmental remediation, infrastructure, water and wastewater management, and public goods research. PPPs in the natural resources typically have long-term project horizons (10–20 years). Because our concern is with PPPs that have completed all three stages of our framework, recently established PPPs are omitted.

4.1. PPPs and Environmental Remediation

The public sector often lacks sufficient funding and clear definitions of roles and procedures to manage efficiently with environmental protection and remediation. Because environmental remediation is an impure public good, the private sector does not have incentives to invest the socially optimal amount on its own. By forming PPPs, the public sector, especially in developing countries, draws on the experience and technical expertise of the private sector to manage environmental investments. PPPs can be formed to work exclusively on environmental remediation, or environmental remediation can be included in the contract of a larger project involving the PPP. These PPPs can often construct facilities and provide ongoing services at a lower cost than can the public sector, resulting primarily from superior private sector scale efficiencies and technical expertise.

A leading example of PPPs in environmental remediation are those the U.S. Department of Energy (DOE) initiated in 1994 to reform management of the Department's legacy

nuclear waste. The DOE's management of nuclear waste was notoriously unreliable and inefficient, so the Department formed partnerships with the private sector to strengthen oversight capabilities and lower costs. Prior to 1994, the DOE hired private sector contractors to dispose of nuclear waste under cost-plus-fixed-fee contracts. In these contracts, contractors were repaid all of their expenses, plus some negotiated profit margin in the form of either a fixed percentage of total costs or a fixed dollar amount. In addition to these predetermined earnings, an incentive award was usually granted in recognition of the contractor's ability to meet general performance expectations. Though cost-plus contracts are thought to be effective where uncertainty is high or when the project has not been completely specified, these contracts were plagued by unanticipated cost increases and time extensions. These contracts were also inefficient because they dealt with the provision of an impure public good, and without joint decision making in Stage 2, the contractors would not provide the socially optimal level of investment. Under pressure to improve performance from the General Accountability Office and Congress, the DOE began forming PPPs to manage environmental remediation.

The DOE initiated performance-based incentive contracts in these new partnerships with the private sector. Though the structure of the contract varied by project, each contract comprised a system of rewards and penalties (working on the premise that contractors will tailor their work so as to earn the former while avoiding the latter) that were selected to dictate the level of financial risk sharing between parties. In 1995, the DOE formed a PPP to construct and operate a nuclear waste disposal facility at the nuclear production complex in Hanford, Washington. This partnership would replace the efforts of contractors, hired with cost-reimbursable contracts, that had unsuccessfully managed the site. In addition to lowering costs and speeding up production, the DOE planned on transferring some of the risks associated with nuclear waste disposal to the private partners.

The DOE began Stage 1 by actively seeking out partners in the private sector that would be willing to form a consortium capable of handling the complex disposal process to increase the set of potential partners. The Department, in an effort to determine whether interested firms had resources at their disposal to complete the project, used a two-phase process to form the partnership. During the first phase, the DOE established the requirements, both technical and financial, potential partners would be expected to meet. To foster competition, the Department selected two groups of firms for the first phase of the project and entered into short-term contracts with both groups. At the end of this phase, the firms presented a financing and development proposal based on their on-site waste tests and negotiations with financial institutions. The DOE created a final contract, expected to last 10–14 years, which included a plan for design, construction, operation, and financing, with a group of firms that included Betchel National, Inc., and British Nuclear Fuels. At the end of this contract, the second phase would begin, during which the DOE would create a new contract, based on lessons learned during phase 1, with any qualified firm to manage the disposal of the remaining waste.

The Department attempted to implement a performance-based contract in Stage 1 that allocated the control rights over the production process to the private partners to avoid cost overruns and construction delays, which could lead to further contamination of the area (Diprinzio 2000). Rather than share decision-making authority in Stage 2, as is optimal when producing an impure public good, the private firms would make all decisions regarding the nuclear waste processing process and receive payments from the DOE

at the agreed on fixed rate. The DOE included construction and processing benchmarks in the contract that specified the time the facility would be completed and the level of waste it would be expected to process. Though the DOE did not retain any decision-making authority over the production process, the Department did provide incentives for the private firms to use their control rights to meet the processing benchmarks through a three-tier payment system. The firms would receive a base payment to cover their operational costs and debt obligations for meeting specified output levels before the facility reached full capacity. Once output reached full capacity, the firms would receive a contract capacity payment for output that reached the DOE's minimum order threshold. If the firm's output exceeded the minimum output stipulated in the contract, a premium capacity payment would be made. The pricing structure was designed to provide incentives for the firms to exceed the production level. The DOE was responsible for providing an adequate level of waste for the firms to meet their benchmarks.

The incentive system, which used benchmarks and payments rather than joint decision making to reach production goals, proved ineffective as the partnership experienced an unexpected shock in Stage 3 that increased construction costs (Akintoye et al. 2003). The contract originally called for a small-scale waste disposal facility that would be used only in the short-term and that would be replaced by a permanent facility in the second phase. As the private firms began to design and construct the facility, it became clear that a temporary facility would cost as much as a permanent facility, because of strict federal regulations regarding nuclear waste disposal, which drastically increased the cost and complexity of the project. Rather than renegotiate the control rights and property rights to provide appropriate incentives for the firms to construct a permanent facility, the DOE made only minor changes that did not adequately adjust the contract in response to the shock. Because the DOE did not return to Stage 1 to carefully align incentives during the renegotiations that followed unanticipated shocks in Stage 3, the Department unintentionally decreased the partnership's probability of success.

In Stage 2, bargaining over the project's financing led to a shock that also required renegotiation and changes to the initial contract. The contract initially gave the private firms sole decision-making authority to arrange for the project's funding through debt and equity financing. Though this assignment of control rights limited the Department's financial risk and gave the firms an incentive to secure a loan with favorable terms, the government made postcontract efforts to be granted termination-for-convenience rights that would allow the Department to terminate the contract at any time and be responsible only for paying the private partner's termination costs. These rights are usually found in government contracts but are not typically part of industry contracts.

As termination-for-convenience rights were bargained over in Stage 2, it became clear that the Department's payment to its partners would not cover the outstanding principal and interest, which substantially increased the firm's financial exposure. The firms, anticipating nearly $4 billion in debt financing, in addition to their own equity, were unable to bear the risk associated with this clause. The government had little leverage in the bargaining and subsequent renegotiation because the contract allocated sole financial decision-making authority to the firms.

During renegotiation in Stage 3, the government agreed to accept most of the project's financial risk in exchange for right-to-termination rights, which skewed the private firm's incentives for securing efficient financing. Similar concessions that changed the private firm's incentives were made during renegotiation in response to bargaining over the

Department's effort to include other provisions typically used in government contracts, including adherence to Federal Cost Accounting Standards and submission to audits by the Defense Contractor Auditing Agency (Diprinzio 2000). Because the DOE did not address these unanticipated shocks by returning to Stage 1 to reassign decision-making authority and ownership optimally, the private partner's incentives to complete the project efficiently were gradually eroded. By May 2000, the project's expected costs increased to 120% of the original projection, and with the project over budget and unable to meet construction benchmarks, the project was terminated (U.S. Government Accountability Office 2004).

4.2. PPPs and Infrastructure Investment

Infrastructure development projects carry significant risk as they require large capital investments over a long time period to construct, operate, and maintain assets. Traditionally, infrastructure development was pursued only by the public sector because many of the projects (bridges, roads, telecommunications, railroads, energy, etc.) dealt with natural resources and produced impure public goods. But as infrastructure development has grown increasingly complex and expensive, governments have looked to improve efficiency by using private sector expertise and financing through PPPs (Engel et al. 1997; Ramamurti 1997; Estache et al. 2000, 2007). PPPs also allow the government to avoid levying distortionary taxes by tapping private sector funding, which can be repaid by user fees generated by the partnership. PPPs can also reduce the public sector's financial risk in both the cost of the project and the future revenue streams, and some public agencies argue that this risk transfer is the primary benefit flowing from the use of financing by PPPs.

When an infrastructure PPP is formed, the private firms usually manage the finance, planning, and construction of the asset base for the services to be generated. Upon completion of the project, the firm is allowed to manage and collect rents from the asset for a length of time, after which the asset reverts to the government. In developing countries, infrastructure financing by PPPs is particularly promising as it allows governments without sufficient funding, risk-bearing capability, or intellectual capital to build their country's infrastructure (Irwin et al. 1997, Alonso-Conde et al. 2007).

Infrastructure development projects are typically long lived, illiquid, capital intensive, and difficult to value, carrying with them significant risks (construction risk, operating risk, revenue risk due to volume shortfall, financial risk, force majeure risk, regulatory risk, and environmental risk). A major challenge in securing private sector involvement in the provision of public infrastructure has been to design contracts that result in appropriate risk sharing. Contracts for infrastructure PPPs can reduce these risks by carefully structuring the renegotiation process so as not to distort each partner's incentives (Gausch 2004).

A leading example occurred in Australia where the government has been successful in using PPPs to increase the provision of an impure public good (roads) by forming contracts that directly address the private sector's concerns about risk sharing (Brown 2005). The government has repeatedly created successful partnerships that have led private firms to invest over $9 billion in the country's roads. In Stage 1, the government learned that the private partners would enter into a contract only if it included price-setting mechanisms that correctly reflected the risks they assumed by financing and operating these projects. The Australian government addressed this concern by sharing price-setting control rights with the firms in the Stage 1 contract. The partners would jointly set prices in Stage 2 to

reflect the private firm's risks and allow for price flexibility in response to unanticipated shocks. By assigning the firms some control rights for setting prices in the face of unanticipated events and setting prices according to the firm's risks, these contracts aligned the partner's expectations for pricing, which reduced the private firm's risk and the need for renegotiation. This assignment of control rights has decreased unanticipated shocks (Stage 3) and allowed the Australian government to form successful contracts with the private sector to finance infrastructure.

Another leading example are the build-operate-transfer (BOT) partnerships the Mexican Government formed with private contractors during their National Highway Program (1989–1994). In a typical BOT partnership, the contractors construct, operate, and capture revenues in Stage 2 and, after a fixed period of time, transfer ownership to the government in Stage 3 (Ruster 1997, Rogozinski 1998). In Stage 1, the Mexican government created contracts for the partnerships that used the firm's construction cost and revenue projections to estimate the operation time. Since the government chose private partners based solely on their projected costs, the firms had an incentive to underbid the competition with unrealistic estimates. As a result, in Stage 3, when construction and management costs were much higher than anticipated (a shock the government did not anticipate), the partners would renegotiate with the government to extend the operation period, and the associated control rights, to recover their costs. Rather than terminate these contracts in Stage 3, the government renegotiated, but it did not share decision-making authority or provide incentives and benchmarks to encourage efficient use of control rights.

As the government's willingness to renegotiate became clear, contractors would also overcapitalize costs, because larger investments by the private partners invariably led to the government granting longer operation times. The government was unable to prevent overcapitalization because there was no shared decision-making authority in the Stage 1 contract over the construction and management process that took place in Stage 2. The Mexican BOT partnerships were not successful because the lack of shared decision-making authority led to Stage 3 renegotiations that distorted the private partner's incentives.

With the Mexican experience in mind, the Chilean government embarked on a similar BOT partnership to improve the country's roads (Lobo & Hinojosa 1999). To avoid renegotiations, the partners shared decision-making authority, which led to efficient outcomes because these infrastructure partnerships produced impure public goods. In Stage 1, the contracts allocated some price-setting control rights to the government in anticipation of attempts to renegotiate in response to low revenue. To establish a floor for the firm's expected earnings, all contracts fixed the duration of the operation period and gave the government decision-making authority over minimum toll levels. The contracts also set a ceiling on revenue during the operation period and required the private partner to give the government any revenue in excess of that ceiling. Finally, the government agreed to pay fixed subsidies if the revenue from operating a toll road did not cover costs. By using shared authority to establish a clear range for expected earnings and establish a framework for earnings outside of that range in the contract, the Chilean government avoided losing bargaining power in renegotiation due to unanticipated shocks in Stage 3.

4.3. PPPs in Water and Wastewater Management

PPPs are often the most efficient choice for governments looking to trim budgets and improve quality by transferring control of public utilities to the private sector (Seppala

et al. 2001, Lorena et al. 2002, Foster 2005, Chong et al. 2007, Auriol & Blanc 2007). Public utilities that use natural resources (water, power, etc.) provide impure public goods. If these public utilities are sold to and operated by the private sector, we would expect the firms to exercise market power by setting prices above the optimal level and producing quantity below the optimal level. By forming a PPP, the government retains some control over production and pricing decisions and can limit the private firm's use of market power (Limi 2008). Beyond limiting the use of market power, forming partnerships between public utilities and the private sector can improve quality and decrease operating costs.

Drinking water in the United States is an impure public good provided by regional governments. Local provision prevents local public sectors from realizing returns to scale in water purification technology and customer service. These smaller public providers can improve operation by finding partners in the private sector that complement the public sector's capabilities. Local governments have created successful partnerships by identifying partners in the private sector with complementary assets and by creating contracts that provide incentives for the private partner to efficiently use those resources.

A leading example of PPPs in this field was the five-year partnership formed in 1997 by the Buffalo Water Authority which delivers water to more than 77,000 people in Buffalo, New York, with American Water to repair and operate the city's water system. The size of the city's water services did not justify in-house development of the technology necessary to manage its services more efficiently. In Stage 1, the Buffalo Water Authority actively approached private sector firms and chose its partner on the basis of its experience and technological capacity in managing water services for more than 13 million people. Because water is an impure public good, the Stage 1 contract established shared authority by assigning the city and the private partner partial control rights to ensure socially optimal provision. During Stage 2, the partners decided to use American Water's collection management system to collect bills, the partnership's primary source of revenue, which led to an increase in payment rates from 80% to 97%. The partners also jointly managed water provision technology and customer service. Cost and services benchmarks were set by the partners, with compensation for meeting those benchmarks, to provide incentives for the firm to use their control rights efficiently. The firm exceeded the benchmarks, and net of compensation payments, Buffalo saved $21 million over the course of the partnership in operational costs and eliminated redundancies.

Following Buffalo's example, Indianapolis Water formed a partnership in 2002 to improve the quality of drinking water and decrease costs. Like the Buffalo Water Authority, Indianapolis Water began Stage 1 by actively seeking private partners that had the resources to improve the city's water provision. Indianapolis chose to partner with the multinational corporation Veolia Water, which gave the city access to water-purifying technology and expertise that would have otherwise been prohibitively expensive. The city created a shared authority contract that provided incentives for Veolia to invest the socially optimal amount in technology it otherwise would not, because water is an impure public good, by retaining the control rights over price setting.

Indianapolis used this decision-making authority to stipulate that the rates charged for water would be fixed for five years, which meant that any reductions in cost would increase the revenue Veolia shared with the city. This incentive structure led Veolia, which held control rights over the production processes, to lower costs consistently over the five-year period. The Stage 1 contract also provided incentives for the private partner to improve quality by including measurable quality standards and rewards, in addition to

the base fee, if those standards were met. Veolia exceeded these benchmarks and significantly improved the city's water quality. By choosing partners that could compensate for the public sector's deficiencies and providing proper incentives in Stage 1 through a contract with shared authority, these partnerships have been more successful than provision by either a public or private entity.

Wastewater management in the United States faces a similar challenge: Wastewater is an impure public good that is managed at the local level and systems implemented by smaller cities are not as efficient as those in larger cities because of the economies of scale. Some local governments have realized significant cost reductions by forming PPPs instead of hiring contractors to manage wastewater. The first long-term PPP in wastewater management in the United States was formed in 1992 by the city of Glen Cove, New York, and the British water company Severn Trent, a water supplier and wastewater treatment firm.

Glen Cove began looking for a private partner (Stage 1) in response to a requirement from the State of New York Department of Environmental Conservation to reduce the city's Water Pollution Control Plant effluent by 58.5% within 15 years. The city was awarded a $3.4-million-dollar grant to make the necessary improvements to the facility that served the city's 30,000 residents. The city, looking to decrease costs and limit liability, formed a 20-year partnership with Severn Trent.

Meeting New York's effluent-reduction benchmark would require large investments in the wastewater management facility that were not feasible for Glen Cove. In Stage 1, the city used the contract to provide incentives for its private partner to make the needed investments in this impure good by assigning the firm all liability for environmental damage. Because Severn Trent indemnified the city against any and all liability for damages, joint bargaining in Stage 2 led the firm to invest over $3 million in cost-lowering safety technology within the first two years of the partnership to decrease the likelihood of a wastewater accident, even though the firm was contractually obligated to invest only $900,000. These investments increased the plant's environmental compliance and saved Glen Cove $200,000 in operating costs per year.

During Stage 2, cooperative decision making also led the partners to improve the efficiency of the plant's workers. The private partner's investments gave the partnership an opportunity to lower costs by decreasing the plant's hours of manned operation from 24 to 16. Working with the city, Severn Trent restructured the facility's workforce and provided health and safety training, which led to a 100% reduction in lost-time accidents.

4.4. PPPs and Public Goods Research

As public funding of scientific research has declined, and knowledge inputs have played an increasingly important role in industrial processes, universities and other public research institutions have looked to private sources to increase their research budgets. Many lessons have been learned as public criticism and scrutiny of these research partnerships have evolved (Press & Washburn 2000). Issues such as conflict of academic and industry interests; ownership of, and access to, intellectual property (e.g., issues of hold-up and blocking patents); and publication delays have fueled the current debate and often present insurmountable obstacles to forming research partnerships (Lach & Schankerman 2004).

A host of external forces have shaped the current environment in which public researchers are seeking to engage actively with private researchers. Among these are

diminishing federal and state funds for public goods research and increased state funding for private-public research. In addition, legislation (e.g., the Bayh-Dole Act), the restructuring of many large life sciences firms, and an alignment of private and public research incentives have contributed to this trend (Rausser 1999). Moreover, the traditional research paradigm that presumes there is a one-way flow from basic science conducted in public institutions to applied research and commercialization undertaken by private industry has begun to be replaced by a chaotic research and development feedback-loop paradigm (Rausser 1999, Rausser et al. 2008). Increasingly, public universities and private companies are engaging in joint research, establishing relationships with exchange and collaboration in all stages of research (Henderson et al. 1998, Jensen & Thursby 2001).

The potential benefits from university-industry partnerships have been well articulated. Complementarities between scientific and practical knowledge have the capacity to generate rapid and far-reaching innovation. It follows that each partner is seeking attributes and assets in prospective partners that complement their own abilities and resources. Industry is interested in combining its knowledge of markets with information on new research and innovation to identify those developments that are likely to lead to commercial applications (Aghion & Tirole 1994, Aghion et al. 2005). This motivation may be obvious, but industry is also interested in more subtle assets such as access to academic expertise, networks, and first-hand information about up-and-coming scientists (current graduate students). Although universities are clearly interested in financial capital, they also seek intellectual capital, cutting-edge research technologies, proprietary research tools (e.g., databases), and, in many instances, enabling intellectual property (Heller & Eisenberg 1998, Blumenstyk 2001). Access to these research assets enhances a university's ability to provide a first-rate education to its graduate students.

Although the potential benefits of research partnerships are reasonably transparent, the potential risks to both parties are opaque. These risks pose serious obstacles to the successful formation of public-private research partnerships. In addition to the uncertainty inherent in any research process, the differences between university educational objectives and corporate goals are an important source of risk in these relationships (Slaughter & Leslie 1997, Graff et al. 2002). Recent data show that almost 70% of research in universities has been categorized by the National Science Foundation as basic, whereas the proportion is reversed in industry. In 2000, although universities accounted for only 14% of total research and development funding in the United States, they performed approximately 50% of the total basic research (Scotchmer 2004). With private financing comes concerns arise that the traditional orientation of the academic research agenda toward basic, public goods research will be directed toward more applied, appropriable research that serves the objectives of the private partner and that this, in turn, will result in a loss of academic integrity.

Not only research direction but research results from sponsored studies may be biased toward sponsors' interests. Bekelman et al. (2003), for instance, showed that in biomedical research there is a statistically significant association between industry sponsorship and proindustry conclusions. Industrial sponsors may also impose constraints on communication between grantees and other colleagues that, in turn, may hinder research progress and increase research costs (Scotchmer 2004). Planning horizons tend to differ; university researchers focus on long-term research, while companies often seek quick payoff projects. In addition, the cultures and values of research partners may simply clash, creating insurmountable blocks to a continuing relationship. Furthermore, the incentives to secure a

renewal or extension of an existing contractual agreement may adversely influence university scientists' behavior under a current collaboration.

Rights to intellectual property are especially contentious (Kenney 1986, Slaughter 1988, Brooks 1993). Hold-up and background rights are of primary concern to an industry partner interested in commercializing the products of a research partnership. Researchers at universities and other public institutions often use proprietary or enabling intellectual property research tools in their research without obtaining rights. They are sometimes blocked, however, from using these tools for commercial purposes. Generally, one researcher in a university institution may freely access another researcher's patented research tool for academic study. This opportunity does not typically extend to private researchers unless a formal agreement is forged. Thus a private company looking to partner with a particular researcher, for example, may experience hold-up at the commercialization stage because the public research partner did not obtain formal rights to all research inputs (i.e., background rights) from some other private company. Note also that if numerous university researchers and graduate students are involved in a research project, industry risks loss of privacy and protection for proprietary information.

The interests of parties outside a research agreement (i.e., third parties) are also at risk under public-private research agreements. If an agreement is not effectively structured with regard to patenting and licensing rights, a third-party interest in having reasonable access to research discoveries and innovations may not be adequately represented. In fact, blocking patents can and do arise (Heller & Eisenberg 1998).

In summary, the cooperation between universities and industry prompts a series of questions: Does the profit-driven sponsor shift the university's mission away from basic research? Does industry's desire to exploit intellectual property rights interfere with communication within and between universities to an extent harmful to open science (Scotchmer 2004)? These conflicts are an inevitable consequence of a fundamental clash between a public system that encourages openness in science and an industrial system that gives financial rewards based on secrecy. In the end, this all boils down to one question: Can a university-industry partnership be socially beneficial or, more precisely, Pareto improving?

Scotchmer (2004) argued that a public-private venture is justifiable for big science projects. On the one hand, for certain large projects, the public sector may face the problem of choosing the right investments (those with high probability of success) and making sure the funds are used as intended; on the other hand, the private sector has the expertise needed to screen likely successful projects but sometimes cannot reap unappropriable social benefits, thus is unable to recover the cost of research (Sheridan 2007). In this situation, a PPP can help solve the duality problem. If this asymmetric information problem does exist, however, then industry can strategically engage the public sector into subsidizing its privately profitable projects.

A leading example of university-private research partnerships was formed by the University of California (UC), Berkeley, and Novartis Agricultural Discovery Institute, Inc. (NADI), in 1998. The partnership's Stage 1 contract allowed UC Berkeley to retain control of an open research agenda. The research agenda is determined in Stage 2 when an open call is put out to participating faculty for research proposals—neither UC Berkeley nor NADI defines the type of project proposals to be considered. Furthermore, the committee that allocates funding to each project in Stage 2 (all proposed projects receive some amount of funding) is made up of three UC Berkeley faculty members and two members representing NADI. The criteria used for ranking projects include the

quality and intellectual merit of the proposed research, potential advancement of discovery, and the past and present productivity of the research—the interest of the project to NADI is not considered.

An alternative structure governs a biological research agreement in another leading example: the partnership between Washington University (WU), St. Louis, and the plant biotechnology company Monsanto. This partnership's Stage 1 contract assigned both partners control over the research agenda, which gave Monsanto control over research funding decisions that NADI did not have. In Stage 2, the agreement specifically directs an advisory committee to solicit proposals and identify and fund those projects that not only have exceptional academic merit, but also serve the research interests of Monsanto. In this case, the advisory committee is equally split with three WU members and three representatives from Monsanto. This joint assignment of control rights over the research agenda gives the interests of Monsanto more weight, both in defining the choice set of research proposals that will be considered by the committee and in selecting which of those proposals are funded, than NADI has in its agreement with UC Berkeley.

Depending on the mission of the university and its role in the community, both of these alternative contract structures, with the associated control rights, have merits. Because the research interests of the private partner carry more weight, the WU/Monsanto agreement may be more likely to generate innovations that result in commercial applications, meeting the objective of serving the community with successful technology transfers. On the other hand, the UC Berkeley/NADI agreement more adequately protects the academic freedom of participating faculty. What is important is that the public institutions make conscience decisions about where they are comfortable on this spectrum of control over the research agenda and that they are fully aware of the implicit tradeoffs contained in the related contract language.

The primary interest of universities is to share their research results with colleagues as rapidly as possible, through publications and presentations at conferences, with the hope that scientific knowledge and research will be advanced. This academic mission conflicts with the private partner's interest in appropriating innovation and technological advancements, which requires, for a certain amount of time, that research results be kept from competing interests until the private partner establishes rights to the innovation.

Including publication-delay provisions in Stage 1 research agreements usually comes under considerable scrutiny. In fact, guidelines issued by the National Institutes of Health (1994) recommend a delay of no more than 30–60 days. A more relevant question concerns control of the option for terminating the delay period rather than the specified maximum length of this period. In Stage 1, the UC Berkeley/NADI contract assigns both partners authority over publication delay. NADI was assigned the right to decide whether an innovation has the potential to be patented during an initial 30-day delay. If they decide that the parties should proceed with a patent application, publications can be delayed only up until the time the patent application is filed or 90 days—whichever is shorter. UC Berkeley was assigned the right to file the patent application at any time. The filing process can be expedited, with an initial application filed in a day or so. Therefore, under this agreement, although the maximum publication delay is 120 days, UC Berkeley has complete control to end the delay (past the initial 30-day period). In contrast, in the WU/Monsanto agreement, WU does not have control over the end of the delay. Monsanto has the right to review all research prior to publication and request a short delay to begin the process of filing for a patent. In both agreements, the private partner is responsible for

managing and paying for any patents they choose to file. WU can license the patent to others only if Monsanto does not elect to file for a patent.

A more subtle issue is whether a university is obligated to file for a patent if requested to do so by the industry partner, or whether it has some discretion. A university partner may wish to avoid expending the effort required to patent innovations if it does not foresee that the patent will be applied commercially. For example, under the UC Berkeley/NADI agreement, the partners share authority over the patent decision process, so UC Berkeley can elect not to file for a patent that NADI does not intend to commercialize. In other words, UC Berkeley can make sure that innovation, or know-how, that would not otherwise be commercialized remains freely available to the public and that limited administrative resources are not diverted to pursue meaningless patents.

Of vital importance for industry-university research agreements is the nature of the licensing options. Currently, it is common for the industry partner to be given a first-to-negotiate licensing option for some subset of the innovations generated under the research agreement. Generally, these options must be exercised within a specified time period, or else the option is extended to third parties. In response to public outcry concerning previous, poorly structured agreements, such as the Sandoz/Scripps agreement,[6] and concern about blocking patents, right-of-first-refusal options evolved into right-to-negotiate options. In theory, if the industry partner is granted the more limited option of right-to-negotiate, a university has greater control over licensing rights and can prevent blocking patents from being awarded.

Other aspects of licensing agreements receive less attention but are also critical. One such aspect is the percentage of the total innovation for which the industry partner holds an option to negotiate an exclusive license (i.e., access option). Under the UC Berkeley/NADI agreement, NADI can exercise this option for an "allowable percentage" of patents, equal to the percentage of the research funding that came from NADI. As a result, NADI had limited access options. Under other agreements, the industry partner holds this option for all patented discoveries generated by the agreement.

Third-party options are also a critical aspect of licensing options. These options are the rights that parties outside the agreement have to innovation generated by the agreement. In the UC Berkeley/NADI agreement, these options are managed jointly in Stage 2. UC Berkeley can give third parties open options on patents not included in the allowable percentage and on patented innovations either covered by nonexclusive license or for which the first-to-negotiate option has expired for NADI. NADI has no recourse once their licensing option has expired, and UC Berkeley is free to enter into licensing negotiations with third parties. In contrast, under the WU/Monsanto agreement, the contract grants Monsanto much more control in Stage 2, and third parties hold only a conditional option. Monsanto has right-of-first-refusal on any licensing arrangement between WU and third parties, even if Monsanto's original licensing option has expired. Thus, Monsanto is guaranteed an option of first refusal on any third party offers made to WU. This severely limits the options available to third parties.

[6]In 1993, the publicly funded Scripps Research Institute agreed to form a research partnership with Sandoz Pharmaceuticals. Sandoz would provide $300 million in funding for research over 10 years in return for a worldwide license of all discoveries made by researchers at Scripps. This controversial agreement, which would have given Sandoz licensing rights to nearly $1 billion worth of research funded by the federal government, was restructured after the government threatened to cut off funding to the institute.

5. CONCLUSION

As PPPs in the natural resources become more common, it is important to use a conceptual framework that takes into account the type of good the partnership produces to guide contract structure and evaluate performance. We turn to the incomplete contracts literature to create a three-stage framework that focuses on the allocation of front-end control rights and back-end property rights. In Stage 1, the partners form a contract that assigns control and property rights. Once these rights are assigned, the partners bargain in Stage 2 over whether management decisions will be made cooperatively or noncooperatively. In Stage 3, the partnership may experience an unanticipated shock. In response to this shock, the partners may return to Stage 1 by renegotiating the assignment of control and property rights or they may conclude the partnership.

We use this framework to evaluate various PPPs in the natural resources and find that the assignment of control and property rights can determine a PPP's success. Whether in environmental remediation, infrastructure development, water provision, or public/private research, either the assignment of these rights will provide the partners incentives to manage the partnership efficiently (e.g., the UC Berkeley/NADI partnership, the Buffalo/American Water partnership) or it will not (e.g., the DOE's Hanford partnership, the Mexican BOT highway partnerships).

Though partnerships have been efficiently applied in Europe and some developing countries, PPPs in the United States and Canada have not been as successful. For example, surveys of infrastructure PPPs have found governments were unable to reduce their budgets while the private partners have had trouble generating a profit (Swimmer 2001, Boardman et al. 2006). In these projects, as in our case studies, the partners generally failed because their incentives were misaligned as a result of the assignment of control and property rights. Using our operational framework to assign control and property rights that align incentives, PPPs in North America could become more successful.

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Errata

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