Credible Commitments: Using Options to Support Partnerships

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Abstract

Opportunism—either governmental hold-up by unfair regulation and expropriation, or private monopoly pricing and investment and quality curbing—is a powerful deterrent from successful-to-be public-private partnerships with large sunk investments and welfare externalities. The agents can overcome this double-sided moral hazard by exchanging an exit (put) option for the investor and a bail-out (call) option for the public agent on the investor's outlay. The exit/bail-out option mechanism increases the set of payoffs by offsetting deviation, and thus facilitates cooperation. The mechanism is applicable to other settings with partially aligned goals and informational asymmetries.

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> "When technical conditions make a monopoly the natural outcome of competitive market forces, there are only three alternatives that seem available: private monopoly, public monopoly, or public regulation. All three are bad so we must choose among evils" (Friedman 1962, 28).

Milton Friedman was only partially right. There is in fact a fourth alternative, arguably also bad, to organize natural monopolies in the utilities sector: public-private partnerships.

Public-private partnerships (PPPs) are getting momentum, both for governments seeking efficient solutions to public services and for investors as an asset class (Esty and Sesia 2010). The risk of opportunistic behavior[1] on either side—the investor by curbing investment and quality (Hart and Moore 2008); the government by capping margins and expropriation—can be, however, a deterrent to many potentially successful projects.

Due to substantial sunk assets, long-term payback, informational asymmetries, and unaligned goals, PPPs capture most of—if not all—the serious contractual difficulties described in the literature, namely, "credible commitments" (Williamson 1983); "curbing," "breaching," and "shading" (Hart 2003), "hold-up" (Holmström and Roberts 1998), "dynamic-costs" (Williamson 1976), and "short-termism" (Laffont and Tirole 1993).

I model public-private partnerships as a strategic game between public agents and investors. The model incorporates opportunism hazards to sustainable long-term contracting. In order to lessen *ex ante* risk aversion to opportunistic behavior, I introduce over-the-counter contracts analogous to put and call options on the investor's layout. The adoption of such options improves market contestability and welfare, operationalizes Williamson's (1983) hostages for credible commitments, solves double-sided moral hazard (Bhattacharyya and Lafontaine 1995; Arruñada, Garicano, and Vázques 2005; Opp 2012), and complements the Least-Present-Value-of-Revenue compensation for forced contract termination with the counter exit option (Engel, Fischer, and Galetovic 2001).

[1] As Williamson (1985, 47) explains, opportunism is not tantamount to simply pursuing one's interests: "By opportunism I mean self-interest with guile. This includes but is scarcely limited to more blatant forms, such as lying, stealing, and cheating. Opportunism often involves subtle forms of deceit. Both active and passive forms and both *ex ante* and *ex post* types are included."

1 Hindrances in Long-Term Public-Private Contracting

There are four theoretical combinations of occurrence of bounded rationality and opportunism in long-term agreements:

1. Unbounded rationality/non-opportunism—a condition of contractual utopia[2]
2. Unbounded rationality/opportunism—contract feasibility by recourse to contractual completeness, i.e., foresight of all possible opportunistic actions and their consequences for both parties[3]
3. Bounded rationality/non-opportunism—contract feasibility by recourse to a "general clause" against hazards of contractual incompleteness, i.e., the parties undertake to reveal all relevant information and cooperate throughout the execution and renegotiation of the agreement
4. Bounded rationality/opportunism—concurrence of all serious contractual difficulties

According to Williamson (1985), the fourth case corresponds with contractual reality in natural monopolies.[4] The propositions put forward to overcome these "serious contractual difficulties" are: (a) complete "once-and-for-all" contracts (Stigler 1968); (b) incomplete long-term contracts (Demsetz 1968); and (c) renewable short-term contracts (Posner 1972).

In complete "once-and-for-all" contracts, one-time auctions induce savings on transaction costs. Due to claims from unforeseen circumstances—a result of bounded rationality—these contracts are, however, unrealistic and their feasibility is questionable.

[2] Bounded rationality is considered a semi-strong form of rationality (Williamson 1985). It assumes economic agents are "intendedly rational, but only limitedly so" (Simon 1961, xxiv).

[3] Complete contracts are, however, inaccessible due to the bounded rationality and impossibility of predicting all possible circumstances.

[4] Although Williamson (1985) analyzes franchise agreements and focuses on CATV, the classification is appropriate for partial or total privatization of natural monopolies. In the public utilities sector, "serious contractual difficulties" have their source in bounded rationality (not so much in intentions as in scope, i.e., developments in technology and changes in the economic environment, etc.), in private and public opportunism, and in the specificity of the assets, since securing these assets triggers the process of contract termination.

Incomplete long-term contracts[5] enable renegotiation and soothe claims from unforeseen events. Nonetheless, a number of difficulties arise: hold-up and opportunistic renegotiations, i.e., successful bidders may want to renegotiate terms for their own benefit and thus jeopardize the execution of the contracts. Moreover, a (costly) regulatory agent is required to determine the level of quality, monitor the activities of the investor, and cap prices. Incomplete long-term contracts, as Williamson (1976) points out, differ from regulations only in depth, not in essence.[6]

Posner's (1972) mechanism of renewable short-term contracts is aimed at solving adaption of long-term agreements. The "problem-freeness" assumption of his rationale—i.e., low transaction cost and equal conditions for incumbent bidders and new bidders during contract renewals—is, however, questionable (Williamson 1985). The incumbent investor is further along the learning curve (tested technologies, trained staff) and is better informed (acquainted with the specificity of the product and the market), which gives her an advantage over potential competitors contending for the short-term contract.

2 Framing Public-Private Partnerships as a Strategic Game

In a simple, non-cooperative non-zero-sum game each player is solely concerned about her own payoffs which are (partly) opposed, players do not communicate with each other, and their agreements are not binding (Sulejewicz 1994).[7] In the Nash equilibrium achieved between actions and expectations, each player chooses such a strategy that she finds beneficial and is unwilling to change, irrespective of strategies implemented by other players (Mas-Colell, Whinston, and Green 1995). Previous studies have focused on the dichotomy "invest – not

[5] Contracts are always incomplete and, to a large extent, the degree of incompleteness is chosen by the parties (Spiller 2008). In the opinion of Viscusi, Vernon, and Harrington (2000), such contracts should be designed for the period of 15–20 years. Guislain and Kerf (1995) provide examples of long-term agreements spanning from 10 to 95 years.

[6] "At the risk of oversimplification, regulation may be described contractually as a highly incomplete form of long-term contracting in which (1) the regulatee is assured an overall fair rate of return, in exchange for which (2) adaptations to changing circumstances are successively introduced without the costly haggling that attends such changes when parties to the contract enjoy greater autonomy" (Williamson 1976, 91).

[7] Opposed interests occur in zero-sum or normalized to zero-sum games. Non-zero-sum games allow for cooperation and do not exclude agreement between players (Sulejewicz 1994). The description of natural monopolies in the public sector as a strategic game conforms to the latter case.

invest" given demand stochasticity (Newbery 2000). Less attention has been paid, however, to the public agent's strategies "regulate – not regulate – penalize."

To focus on opportunistic strategies, I assume demand is certain.[8] The investor's strategies are: "invest" or "not invest." If she invests and engages in a monopoly, the next set of strategies is "contract fulfillment" (providing contracted quality at agreed price) or deviation to "profit maximization" (by lowering quality or increasing price).[9] The public agent's set of strategies consists of: "lack of regulation," "regulation" (i.e., enforcement of contract specificity, quality standards, and marginal cost pricing), or "penalization" (transfer from the monopoly to the public agent, including full expropriation).[10] Due to informational asymmetries (the public agent is unaware of whether the monopoly fulfills the contract or maximizes its profit), all decisions are simultaneous and each player chooses her strategy independently of the other player's strategy.

The tariff system is (at least) two-part: fixed costs—including capital costs—are covered by the fixed part of the tariff, variable costs by the demand-dependable part of the tariff, and market clearance takes place when the variable part price equals marginal cost.

The public agent maximizes welfare (measured as consumer's utility) and does not care about private profit. If the investor does not invest, she gets welfare U_{pu}. If the investor fulfills the contract[11] and there are no regulation costs, welfare amounts to U^*. This would be a first-best equilibrium; in practice, an unattainable benchmark. The difference between U^* and U_{pu} stems from operational inefficiencies when the company is run by the public agent, which in turn reduces consumer surplus through higher price (or tax) and lower demand.

The public agent may choose to regulate a utility company incurring regulation cost. Consequently, price (or tax) increases and welfare drops to $U_{re} < U^*$. At marginal cost

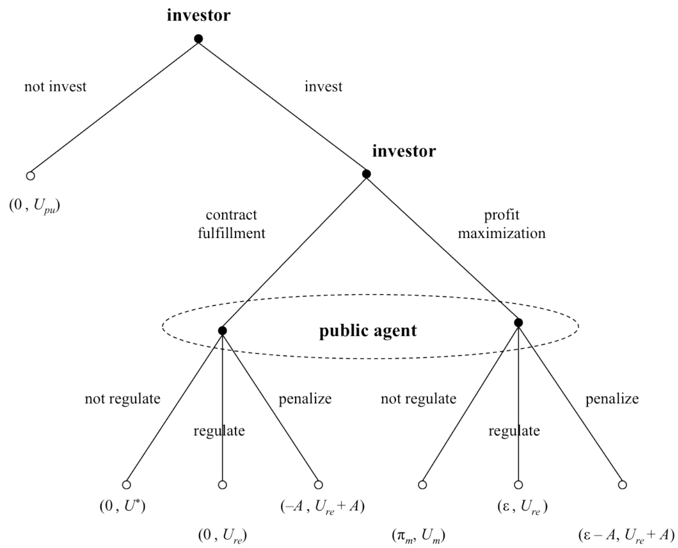
[8] Demand for infrastructure is inelastic and constant and, in a two-part tariff regime, consumers bear fixed fees irrespective of their level of demand.

[9] In this section, I present boundary strategies. There exists, however, a continuum between contract fulfillment and profit maximization.

[10] Pongsiri (2002) points to incremental expropriation and Spiller (2008) refers to "subtle works of administrative process" as possible penalties for preventing the investor from achieving a fair payoff for incurred costs and risk.

[11] The investor fulfills the contract when she invests in technology and infrastructure to provide contracted quality and operates efficiently without increasing price.

Figure 1: Investor and public agent in a regulation strategic game.



pricing regulation and contract fulfillment, the investor's profit amounts to zero.

The public agent can force "penalties," which increase the public agent's payoff by A at the expense of the investor's payoff.[12] Penalties A can be discretional or predetermined and amount to a substantial sum bigger than the welfare loss from regulating the monopoly (i.e., $A > U^* - U_{re}$).

If the investor opts for "profit maximization" and she is not regulated by the public agent—because she is either unable or unwilling to do so—she reaps monopoly profit π_m by limiting quality and increasing price and welfare drops to $U_m < U_{re}$. By regulation, the public agent can force monopoly profit to drop to ε, where $0 < \varepsilon << \pi_m$.[13]

Figure 1 presents the investor's and public agent's regulation strategic game and Table 1 presents the "invest" subgame as a payoff matrix.

To normalize payoffs I subtract the vector $(0, U_{re})$ from each term of the payoff matrix

[12] The "penalty" strategy may also be understood as a harsh form of regulation, e.g., by setting price below the equilibrium level, enforcing higher quality requirements, or introducing new regulations. It seems that this strategy is particularly alluring for public agents in pre-election periods; however, public choice theory and the political economy of public contracting are not the subject of this paper.

[13] As perfect regulation (no informational asymmetry) is hardly possible, I assume that profit exceeds zero. This profit may be, however, hidden (e.g., through cross transfers to related companies) and is different from reported accounting profit.

Table 1: Payoff matrix of the "invest" subgame.

		Public agent		
		Not regulate	Regulate	Penalize
Investor	Contract fulfillment	$(0, U^*)$	$(0, U_{re})$	$(-A, U_{re} + A)$
	Profit maximization	(π_m, U_m)	(ε, U_{re})	$(\varepsilon - A, U_{re} + A)$

(see Table 2).

Table 2: Normalized payoff matrix of the "invest" subgame by subtracting $(0, U_{re})$ from each payoff.

		Public agent		
		Not regulate	Regulate	Penalize
Investor	Contract fulfillment	$(0, U^* - U_{re})$	$(0, 0)$	$(-A, A)$
	Profit maximization	$(\pi_m, U_m - U_{re})$	$(\varepsilon, 0)$	$(\varepsilon - A, A)$

Since the investor's "profit maximization" strategy dominates the "contract fulfillment" strategy, the public agent's best response strategy is to "penalize."[14] "Penalize" will be a dominating strategy if $A > U^* - U_{re}$. The investor's best response strategy would then be "profit maximization." This game resembles the classic "prisoner's dilemma." "Profit maximization – penalization" is the equilibrium in this one-shot non-cooperative subgame, although with cooperation ("contract fulfillment – lack of regulation") the payoffs for the players would have been higher. The equilibrium of the whole game is "not invest," as it ensures that the investor will at least not incur loss $\varepsilon - A$. The public agent will incur, however, regulation cost $U^* - U_{re}$ and will not benefit from the know-how advantage of the private sector $U_{re} - U_{pu}$.

Build-Operate-Transfer (BOT) contracts have been presented as an example of the "prisoner's dilemma" (Axelrod 1984; Brandl and Brooks 1982; Kay 1993). The underpinning assumption is that both parties gain considerably more if they cooperate rather than maximize their profit irrespective of the other party. On one hand, regulation leads to smaller payoff

[14] I assume that welfare loss due to the monopoly exceeds regulation cost ($U_m - U_{re} < 0$). Otherwise, not regulating the monopoly would be a better strategy for the welfare maximizer public agent. E.g., the Chilean Ministry of Public Works seemed to prefer "development over regulation" (Engel, Fischer, and Galetovic 2003).

for the investor and higher payoff for the public agent. This point is of greatest importance in the case of natural monopolies, as their activity consists mainly of substantial investments in specific non-liquid assets. What follows is that any changes in the contract introduced after investment may induce hold-up problems and substantially decrease future profit. On the other hand, regulation is costly and the public agent may be able internalize part of the producer surplus in other ways. The comparative statics between regulation cost and internalized profit will set the equilibrium.

Even if the game is repeated a finite number of times (e.g., successive franchise contracts), "profit maximization – penalization" will still be—by backwars induction—the subgame equilibrium. Complex contracts with warranties obliging the public agent to regulation without deviation lead to "profit maximization – regulation." This is, however, an equilibrium only in mixed strategies, as the risk of governmental opportunism—i.e., penalization or expropriation counter to prior commitments (Spiller and Tommasi 2007; Opp 2012)—is always existent and higher the more unstable the political system is.[15]

3 Designing Public-Private Partnerships as an Internalized Repeated Game

Designing a natural monopoly as a PPP considerably changes the game's character. First, the public agent is now a shareholder in the utility company. The choice of a strategy is consequently a result of an internalized game (negotiations) between the investor and the public agent. The dichotomy in the company's strategy—"contract fulfillment" vs. "profit maximization"—is transformed into a continuum between "welfare maximization" and "profit maximization."[16] Second, information asymmetries decrease, i.e., the public agent knows better about both the marginal cost and quality of goods and services provided by the utility company than in the case of sole external regulation. Such a game becomes a quasi-non-

[15] This may be the reason why BOT investments are rarely employed in developing countries. The rule of law is one of the prerequisites of long-term contracting. In this paper, I concentrate on governmental opportunism. A theory of public contracts under third-party opportunism is presented in Spiller (2008) and Moszoro and Spiller (2013).

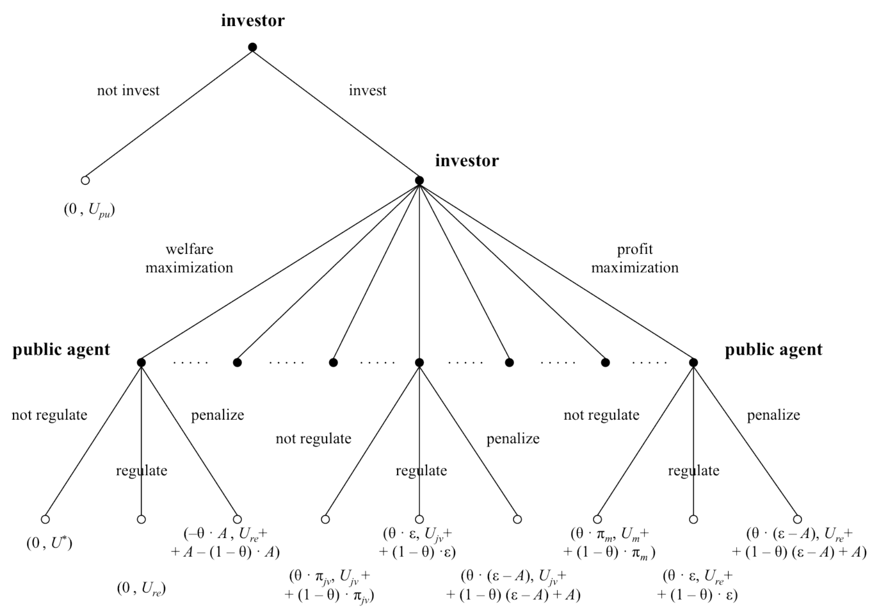
[16] This continuum is also present in the case of private monopolies, but with a strong tendency for polarization.

cooperative or quasi-cooperative game.[17]

3.1 Public-Private Partnerships as a One-Shot Game

In a PPP, joint venture's payoffs and penalties are split between the public agent and the investor proportionally to their share in the investments (see Figure 2). The players' goals—welfare maximization and profit maximization—are at least partially contradictory.[18]

Figure 2: Public-private partnership as a strategic joint venture game.



Definition 1 *A "mixed motive strategy" consists of an investor's strategy such that:*

[17] Mixed motive games were first introduced by Schelling (1960). Sulejewicz (1994) presents the games' scope in the following way:

		Communication		
		Lack	Partial	Perfect
Agreements	Binding			Classical cooperative games
	Conditionally binding		Quasi-cooperative games Quasi-non-cooperative games	
	Not binding	Classical non-cooperative games		

Binding agreements and effective communication occur, at least theoretically, between public agents and government-owned companies. Conditional or not binding agreements and weak communication are typical characteristics of the relations between public agents and private monopolies. This does not mean that they do not communicate or do not fulfill their agreements at all, but rather that some objective hindrances occur which justify the assumption of the existence of information asymmetries.

[18] The degree of opposition between welfare and profit maximization depends on the degree of internalization of private profit by the public agent.

(a) *PPP profit is positive and greater than the regulated monopoly profit, which is greater equal to the opportunity cost, i.e.,* $\pi_{jv} > \pi_{re} \geq r_{pr}I$

(b) *Welfare from PPP is bigger than welfare from public monopoly and regulated monopoly, i.e.,* $U_{jv} > U_{pu}, U_{re}$

Strategies will be the result of negotiations over investment and profit share θ for the investor and $1-\theta$ for the public agent, quality, and price.[19]

Definition 2 *Investment and profit share* $\theta \in [e, 1-h]$ *captures the outcome of negotiations on the "mixed motive strategy," where* e *is the minimum share required by the investor to transfer its know-how and increase efficiency and* h *is the minimum required by the public agent to exercise sufficient internal control within the company and save regulation costs to achieve* U_{jv} *and* π_{jv}*.*

Table 3 shows the payoff matrix for the "invest in a PPP" subgame.

Table 3: "Invest in a public-private partnership" subgame payoff matrix. π_m is monopoly profit, π_{re} is regulated monopoly profit, and π_{jv} is PPP profit.

		Public agent								
		Contract fulfillment and welfare maximization			Mixed motive strategy			Profit maximization		
		Not regulate	Regulate	Penalize	Not regulate	Regulate	Penalize	Not regulate	Regulate	Penalize
Investor	Contract fulfillment and welfare maximization	$(0, U^*)$	$(0, U_{re})$	$(-\theta A, U_{re} + A - (1-\theta)A)$	$(0, U^*)$	$(0, U_{re})$	$(-\theta A, U_{re} + A - (1-\theta)A)$	$(0, U^*)$	$(0, U_{re})$	$(-\theta A, U_{re} + A - (1-\theta)A)$
	Mixed motive strategy	$(\theta\pi_{jv}, U_{jv} + (1-\theta)\pi_{jv})$	$(\theta\varepsilon, U_{re} + (1-\theta)\varepsilon)$	$(\theta(\varepsilon - A), U_{re} + (1-\theta)(\varepsilon - A) + A)$	$(\theta\pi_{jv}, U_{jv} + (1-\theta)\pi_{jv})$	$(\theta\varepsilon, U_{re} + (1-\theta)\varepsilon)$	$(\theta(\varepsilon - A), U_{re} + (1-\theta)(\varepsilon - A) + A)$	$(\theta\pi_{jv}, U_{jv} + (1-\theta)\pi_{jv})$	$(\theta\varepsilon, U_{re} + (1-\theta)\varepsilon)$	$(\theta(\varepsilon - A), U_{re} + (1-\theta)(\varepsilon - A) + A)$
	Profit maximization	$(\theta\pi_m, U_m + (1-\theta)\pi_m)$	$(\theta\varepsilon, U_{re} + (1-\theta)\varepsilon)$	$(\theta(\varepsilon - A), U_{re} + (1-\theta)(\varepsilon - A) + A)$	$(\theta\pi_m, U_m + (1-\theta)\pi_m)$	$(\theta\varepsilon, U_{re} + (1-\theta)\varepsilon)$	$(\theta(\varepsilon - A), U_{re} + (1-\theta)(\varepsilon - A) + A)$	$(\theta\pi_m, U_m + (1-\theta)\pi_m)$	$(\theta\varepsilon, U_{re} + (1-\theta)\varepsilon)$	$(\theta(\varepsilon - A), U_{re} + (1-\theta)(\varepsilon - A) + A)$

To normalize payoffs, I assume that the welfare loss due to regulation cost equals $U^* - U_{re}$, welfare from a public-private joint venture utility company equals welfare from a regulated

[19] Investments I are assumed to be determined by the level of minimum quality and financed by the parties proportionally to their profit share.

monopoly (i.e., $U_{jv} = U_{re}$), profit from joint venture equals π_{jv}, and public and private share in the partnership $\theta = 1 - \theta = 0.5$, and then subtract the vector $(0, U_{re})$ from each term of the payoff matrix (see Table 4).

Table 4: Normalized "invest in a public-private partnership" subgame payoff matrix. I assume $U^* - U_{re} = U^* - U_{jv} = \pi_{jv}$, and $\theta = 1 - \theta = 0.5$, and then subtract $(0, U_{re})$ from each payoff term.

		Public agent								
		Welfare maximization			Mixed motive strategy			Profit maximization		
		Not regulate	Regulate	Penalize	Not regulate	Regulate	Penalize	Not regulate	Regulate	Penalize
Investor	Welfare maximization	$(0, \pi_{jv})$	$(0, 0)$	$(\frac{-A}{2}, \frac{A}{2})$	$(0, \pi_{jv})$	$(0, 0)$	$(\frac{-A}{2}, \frac{A}{2})$	$(0, \pi_{jv})$	$(0, 0)$	$(\frac{-A}{2}, \frac{A}{2})$
	Mixed motive strategy	$(\frac{\pi_{jv}}{2}, \frac{\pi_{jv}}{2})$	$(\frac{\varepsilon}{2}, \frac{\varepsilon}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$	$(\frac{\pi_{jv}}{2}, \frac{\pi_{jv}}{2})$	$(\frac{\varepsilon}{2}, \frac{\varepsilon}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$	$(\frac{\pi_{jv}}{2}, \frac{\pi_{jv}}{2})$	$(\frac{\varepsilon}{2}, \frac{\varepsilon}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$
	Profit maximization	$(\frac{\pi_m}{2}, U_m - U_{re} + \frac{\pi_m}{2})$	$(\frac{\varepsilon}{2}, \frac{\varepsilon}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$	$(\frac{\pi_m}{2}, U_m - U_{re} + \frac{\pi_m}{2})$	$(\frac{\varepsilon}{2}, \frac{\varepsilon}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$	$(\frac{\pi_m}{2}, U_m - U_{re} + \frac{\pi_m}{2})$	$(\frac{\varepsilon}{2}, \frac{\varepsilon}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$

In a one-shot PPP game, "profit maximization" is also a dominating strategy for the investor, and she knows that the public agent will identify deviation without delay. Through backward induction, the game is simplified to the choice of strategies made by the investor, in which payoffs correspond to the public agent's most effective protective strategies (see Table 5).

Table 5: Normalized "invest in a public-private partnership" subgame payoff matrix with backwards induction, public agent's most effective protective strategies, and different penalties levels. I assume that $U_m - U_{re} + \frac{\pi_m}{2} < \frac{\epsilon + A}{2}$.

		Profit π_{jv} compared to penalties A		
		$\pi_{jv} > \varepsilon + A$	$\frac{A}{2} < \pi_{jv} < \varepsilon + A$	$\pi_{jv} < \frac{A}{2}$
Investor	Welfare maximization	$(0, \pi_{jv})$	$(0, \pi_{jv})$	$(\frac{-A}{2}, \frac{A}{2})$
	Mixed motive strategy	$(\frac{\pi_{jv}}{2}, \frac{\pi_{jv}}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$
	Profit maximization	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$	$(\frac{\varepsilon-A}{2}, \frac{\varepsilon+A}{2})$

Proposition 1 *In a one-shot PPP game, the "mixed motive strategy" is a feasible strategy for the investor iff* $\pi_{jv} > I$.[20]

[20] Proofs are presented in Appendix B.

3.2 Repeated Games, Financial Standing of Utility Companies, and Public Agent's Opportunism

The public agent takes into account that, if the investor refrains from investing, she incurs welfare loss due to inefficient management of public infrastructure equal to $U_{jv} - U_{pu}$. Therefore, the public agent's best strategy is to "not regulate" the utility company. But how to convince the investor of the public agent's intention of neither regulating nor penalizing the utility company?

In a sequential game, deviation in one period may not be a profitable strategy when future losses are considered. Repeated games increase the set of payoffs achievable for the players, comparing to the public-private Nash stage game (Abreu 1988). In the analyzed model, the public agent would gain A for one period of time and then get welfare loss $U_{jv} - U_{pu}$.

Assumption 1 *When welfare loss due to inefficient management equals welfare loss due to costly regulation, a proxy for welfare change $U_{jv} - U_{pu}$ is the differential profit $\pi_{jv} - \pi_{pu}$.*

Definition 3 *For a given player, the likelihood of opportunism of the counter-party equals her beliefs on the counter-party's opportunistic behavior.*

Proposition 2 *The public agent's incentives for (and likelihood of) opportunistic behavior increases in investment I, public discount rate r_{pu}, and investor's share θ, and it decreases in differential profit $\pi_{jv} - \pi_{pu}$.*

The fact that public opportunism decreases in PPP profit is counter-intuitive to rent appropriation.[21] Paradoxically, on the one hand, public-private partnerships improve profitability; on the other hand, however, because utility companies' profitability is low before the private sector's engagement, public agents are believed to behave opportunistically. As the cost of capital decreases (e.g., emerging economies converging with developed countries), the conditions for public opportunism of inequality (3) become more difficult to satisfy, and thus investors' beliefs about public opportunism decrease and are more inclined to invest.

[21] This result is in line with Williams (1999), who shows that the conditional probability of franchise termination by the franchisor decreases as outlet performance increases, contrary to the prediction if franchisors were primarily opportunistic (Arruñada, Garicano, and Vázques 2005).

3.3 Case Example—Water Companies in Poland

In 2002, the city of Poznan was considering a partial privatization of Poznanskie Wodociagi i Kanalizacja Sp. z o.o. (Poznan Water and Wastewater Company, further referred as PWiK).[22]

The profitability of Polish utility companies classified by the Central Statistical Office (GUS) in the category "Production and distribution of electricity, gas and water" was relatively low during systemic transformation years (see Table 6).

Table 6: Profitability ratios of electricity, gas and water utility companies in years 1995–2001 (in %). Data is from GUS (2002).

Year	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Operating profit margin	6,4	4,3	4,1	1,8	1,3	0,4	1,0
Returns on Sales	3,5	2,0	2,3	0,7	0,2	-0,5	0,0

Although water companies reported higher profitability than the mean for the whole utilities category, they did not generate positive economic value added (see Table 7).

Among Polish traded municipal companies, only Bedzin SA achieved a high Return on Equity ($ROE = 13.9\%$ in 3Q2002–2Q2003), at low leverage (Debt to Assets ratio was 9.9%). Other companies achieved ROE well below their cost of capital: Aqua 5.7%, Kogeneracja 2.0%, MPEC 0.1%, Wodkan 2.4%, and ZOiGO MZO 0.0%;[23] ergo, they did not make economic profit. PWiK, whose operating profit margin was above average and whose cost of capital was relatively low (in 2001 the city of Poznan, the main shareholder in PWiK, issued five- and six-year bonds at 40 basis points above 52-week Treasury bond reference rate), did not achieve economic profit (see Table 8).

Taking into account that in 2002 the cost of borrowing for the city of Poznan was 6.65% and assuming after-money $\theta = .5$, the $NOPAT/I$ ratio should have been above 9.975% to deter the public agent from contract deviation. Thus low profitability (see Table 8) and high

[22] As of October 18, 2002, six municipalities were shareholders in PWiK: Poznan 3,749,184 shares, i.e., 81.50% at nominal value of PLN 187,459,200; Lubon 3.77%; Mosina 4.02%; Murowana Goslina 3.15%; Puszczykowo 2.55%; Swarzedz 5.01%. At the time, it was one of a few whose financial statements were publicly available (www.pwik.poznan.pl, accessed June 13, 2003). In July 2003 the company changed its name to Aquanet.

[23] Data from: "Raport spolek. Skonsolidowane wyniki finansowe spolek i wybrane wskazniki, I–II kwartal 2003," *Rzeczpospolita* nro. 192 (6572) of August 19, 2003, p. B7.

Table 7: Financial standing of water utility companies responsible in years 1997-2001 (in million PLN). Working Capital not disclosed; if assumed positive, then EVA would be even lower. Data is from GUS (2002).

Year	**1997**	**1998**	**1999**	**2000**	**2001**
Revenues from the business activity, including:	3,310.4	3,739.3	4,296.1	4,815.0	5,424.6
—Revenue from goods and services	2,959.6	3,431.5	3,952.4	4,380.1	4,983.2
—Revenue from items and materials	52.7	43.4	42.1	51.7	61.3
—Financial revenues	143.8	75.9	67.5	101.3	123.9
Tax deductible costs, including:	3,128,3	3,589,5	4,141,2	4,768,3	5,308,1
—Cost of goods sold	2,921.8	3,394.9	3,916.4	4,314.4	4,979.6
—Cost of items and materials sold	51.5	83.8	36.5	46.1	48.1
—Financial costs	91.5	26.6	65.9	264.1	117.8
Operating profit	182.1	149.8	154.9	46.7	116.5
Extraordinary profit	6.8	2.7	6	0.7	1.6
Extraordinary loss	21.1	10.7	12	3.5	3
Income before taxes	167.8	141.8	148.9	43.9	115.1
Gross profit	184.8	179.8	209.3	263.8	217.8
Gross loss	96.3	38	60.4	219.9	102.7
Taxes and fees	65.7	51.7	64.3	137.4	91.9
—Income tax	59.5	46.1	56.5	131.9	87.1
Income after taxes	102.1	90.1	84.6	-93.5	23.2
Net profit	119.7	128.4	145.6	130.6	126.5
Net loss	17.6	38.3	61	224.1	103.3
Operating profit margin	5.1%	3.8%	3.5%	0.9%	2.1%
Return on sales	3.1%	2.4%	2.0%	-1.9%	0.4%
NOPAT = operating profit + financial costs − taxes and fees	207.9	124.7	156.5	173.4	142.4
I = net value of fixed assets (a)			20,244.4	22,062.8	23,892.8
Weighted Average Cost of Capital $WACC = r_{pu}$			16.80%	18.06%	11.52%
$EVA = NOPAT - WACC \cdot I$			-3,244.6	-3,811.1	-2,610.1
$NOPAT/I$			0.8%	0.8%	0.6%

likelihood of public opportunism could have been a substantial deterrent for the investor in the privatization process.

4 Minimizing Opportunism Through Exit and Bail-out Options

One of the mechanisms of minimizing the risk of public opportunism is to specify contractual provisions for subsidies or compensations from the public agent when profit falls below the expected profit of the public-private joint venture π_{jv}. This mechanism, one the one hand, requires contract completeness and, on the other hand, might place the public agent in an ambiguous position and make it the judge in its own case. Even if there is a higher court to appeal to, the investor may deter from investing due to the time and costs necessary for the judiciary to execute court decisions.

Table 8: Economic value added for PWiK in years 2001–2002 (in PLN). Financial data from PWiK (www.pwik.poznan.pl, accessed June 13, 2003).

Year	**2001**	**2002**
Operating profit margin	8.%	1.0%
Return on Sales	6.0%	0.2%
$NOPAT$ = operating profit + financial costs – income tax	18,751,374	11,926,444
$WACC = r_{pu} = T52 + 0.4\%$	11.24%	6.21%
I = equity + long-term debt + credits and loans	535,601,241	909,610,975
$EVA = NOPAT - WACC \cdot I$	–41,450,205	–44,560,397
$NOPAT/I$	3.5%	1.3%

To reduce double-sided opportunism as a deterring factor of private investments in public-private joint-ventures, I propose the contractual creation of exit and bail-out options which allow the investor to opt out and the public agent to buy out the investor from a public-private investment[24] at a compensation equal to the annualized value of the investment.

These exit and bail-out option contracts present features of both financial and real options:

1. *Underlying asset:* similarly to financial options, stock in the utility company
2. *Pricing of the underlying asset:* discounted cash flow methods as with real options, because utility companies are seldomly traded in stock exchanges
3. *Form of the contract:* formally contractible like financial options, but characterized by quasi-idiosyncrasies like real options
4. *Accessibility:* over the counter
5. *Complexity:* more complex than standard financial options
6. *Risk:* systematic and specific, as with of both real and financial options
7. *Execution rights:* option holders
8. *Execution criteria:* multiple criteria (including political factors and externalities), as with real options

[24] See "abandonment option" in Copeland, Koller, and Murrin (1994) and "bail-out option" in Zerbe Jr. and Dively (1994).

9. *Incidence:* as with real options, exit and bail-out options form a sequence and signal the conditions for feasible future public-private investments

10. *Type:* executable at any time, like American-type options, without expiration[25]

11. *Valuation model:* as with real options, the binomial option pricing model (lattice model)

12. *Value:* as with real options, the parties can actively influence investment, cash flows, cost of capital, expiration date, and—as a result—the entire present value of the underlying asset

To streamline calculations, I assume, convergently with Posner (1972), replacement investments equal to assets' depreciation and profit paid to the shareholders as dividend, thus the share price equals their face value.

4.1 Deterring Public Opportunism With Exit (Put) Options

Using a binomial model (Cox, Ross, and Rubinstein 1979; Cox and Rubinstein 1985), the difference between the expected value of payoffs without the exit option and the expected value with the exit option amounts to the implied value of the exit option.

Let $\theta, \sigma \in (0, 1)$, and $A > 0$, i.e., let us assume a public-private joint venture subject to restrictive regulation and expropriation.

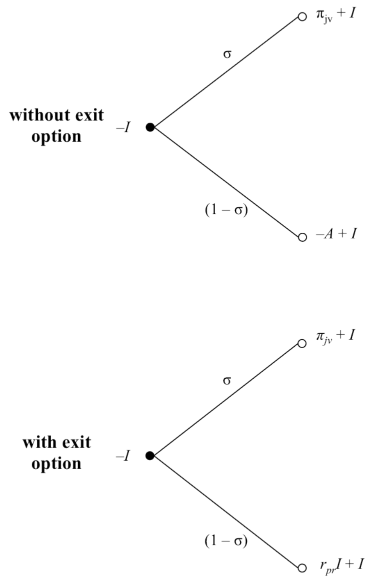
Proposition 3 *In a one-shot game an exit option in a public-private company is of positive value for every θ, σ and A.*

Decision analysis is more complex in the case of repeated and infinitely repeated games. Figure 4 presents a tree diagram assuming that payoff equals π_{jv} with probability σ and $-A$ with probability $1 - \sigma$ of public opportunism for each period. Let $\varphi \in [0, 1 - \sigma]$ be the probability of positive outlook belief by the investor when loss is reported (see Figure 5).

Definition 4 *An optimistic investor refrains from executing the exit option despite incurring*

[25] The postulate for perpetual options is aimed at avoiding reverse induction and ineffective equilibria. Sequential options renewed at the end of each period would yield the same result.

Figure 3: Expected payoffs for an investor with and without an exit option in a one-shot game.



one-round loss; a pessimistic investor executes the exit option whenever loss is incurred. $\varphi/(1-\sigma) \in [0,1]$ *is the investor's level of optimism.*

Proposition 4 *An investor with an exit option at a strike price equal to the annualized investment will end up with non-negative profit if the public agent believes she is pessimistic.*

Lemma 1 *The pessimistic investor's payoff of a contract with an exit option at a strike price equal to the annualized investment is non-negative and satisfies minimax conditions.*

Example (Cont. from Section 3.3) At PWiK, $I = 909.6$ million PLN and $NOPAT = 11.9$ million PLN in 2002 (see Table 8). Assuming $r_{pr} = 8.65\%$ (200 basis points premium over the prime rate for municipal bonds) and $\sigma = .8$, the exit option would be of value for the investor if she fears penalties $A > 33.3$ million PLN, i.e., 3.7% of investments.

Corollary 1 *An exit (put) option at a strike price equal to the annualized investment offsets the gains from public opportunism.*

By offsetting the gains from public opportunism, the exit option reduces public opportunism as a *ex ante* deterring factor for the investor. The investor will be better off if she is

Figure 4: Expected payoffs for an investor in a repeated game.

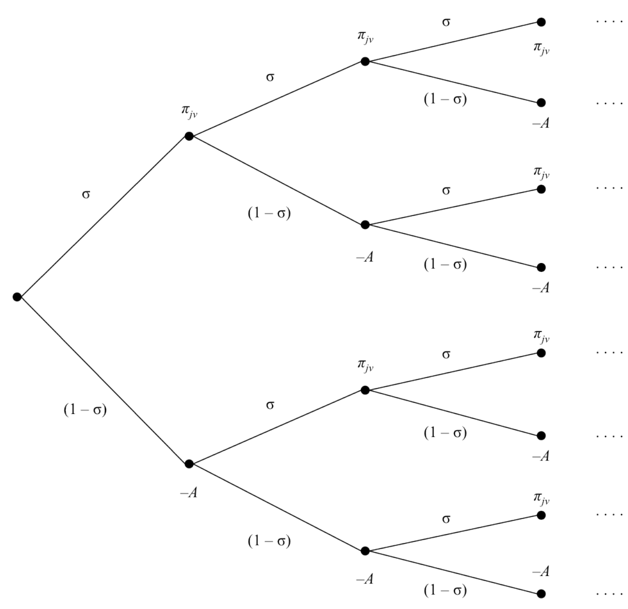
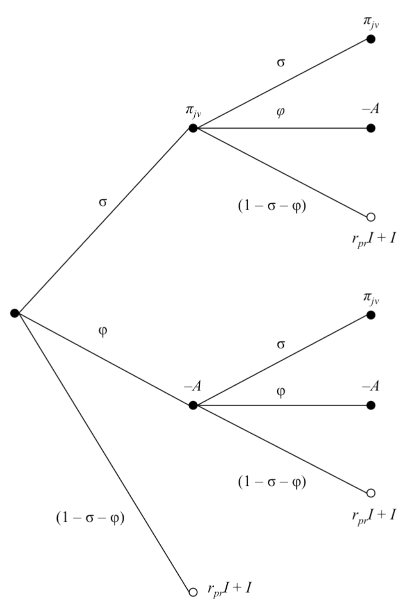


Figure 5: Expected payoffs for an investor with an exit option in a repeated game.



fully pessimistic, i.e., exercises the option when profit is below expected π_{jv}. For the public agent to restrain from opportunism it is sufficient that she believes that the investor is pessimistic (φ equal to zero).

4.2 Deterring Private Opportunism With Bail-Out (Call) Options

The opportunism strategy is profitable for the investor if the expected one-period excess profit $\pi_m - \pi_{jv}$ minus discounted penalties exceeds the present value of all future profit of the PPP.

Proposition 5 *The investor's incentives for (and likelihood of) opportunistic behavior increases in monopoly profit π_m and discount rate r_{pr}, and it decreases in investment I and PPP profit π_{jv}.*

Analogously to the investor, who can execute the exit option to secure her interests, the public agent can secure herself against the risk of opportunism of the investor by holding a bail-out (call) option. The bail-out option gives the public agent the right to purchase, at the end of each period, the investor's shares at the strike price $\theta(1 + r_{pr})I$, i.e., the annualized investment.

Definition 5 *An optimistic public agent refrains from executing the bail-out option despite one-round loss of welfare due to high price or low investment (quality); a pessimistic public agent executes the bail-out option whenever there is loss of welfare.*

Proposition 6 *A public agent with a bail-out option at a strike price equal to the annualized investment will end up with non-negative payoff if the investor believes she is pessimistic.*

Taking into account that the public agent executes the bail-out option with a view to renegotiating the terms of the contract or reselling the shares to another investor.[26] Bail-out options at a fair strike price solve the "dynamic costs" problem (Williamson 1976) of periodically repeated auctions, i.e., short-termism in the investment behavior of the incumbent firm (Laffont and Tirole 1993).

[26] Assigning the option to bail-out investors to public agents is not a novel idea. E.g., it was present in cable TV license contracts in Los Angeles (Williamson 1985). A multi-stage call option mechanism is described by Engel, Fischer, and Galetovic (2003) in a highway franchise in Chile, which involved performance callable bonds from the franchise bidder during the construction stage and the possibility of buying back the franchise with a fair compensation after the twelfth year of the franchise.

Lemma 2 *The pessimistic public agent's payoff of a contract with a bail-out option at a strike price equal to the annualized investment is non-negative and satisfies minimax conditions.*

The bail-out option might be executed by the public agent for the following reasons:

a) Lack of fulfillment of contract terms by the investor regarding investment

b) Appearance of a new technology which can notably improve the effectiveness of the utility company: if a new investor can reduce costs due to this new technology, it is beneficial for the public agent to repurchase shares in the PPP and enter a new partnership

c) Curbing production, lowering quality, or raising prices, by which the PPP would become closer to a private monopoly captured by the investor. The public agent might find it beneficial to regulate the monopoly, or repurchase shares from the investor and enter a new partnership, or create a public monopoly

Another advantage—quite significant, though harder to formalize quantitatively—of holding a bail-out option by the public agent is that it reduces concerns of the public at large (consumers, voters) about the possible lack of agreement between the public agent and the investor, or the capturing of the utility company by the investor in the future. The awareness of the existence of the bail-out option might prove an effective social "tranquilizer" and reduce third-party opportunism (Moszoro and Spiller 2013).

The value of the bail-out option is dependent on market contestability. Exit and bail-out options, similar to financial put and call options, provide both parties with notable advantages: the investor minimizes potential loss, while the public agent enhances the efficiency of utility companies and lowers potential hold-up and opportunistic renegotiations.

Corollary 2 *A bail-out (call) option at a strike price equal to the annualized investment offsets the gains from private opportunism.*

4.3 Secondary Markets

The proposed bail-out and exit options are not investment-class assets. They are over-the-counter no-cash barters (i.e., premiums are offset) and constitute a contractual opportunism deterrent mechanism. Therefore the existence of secondary markets ("aftermarkets") for these options is—*nomen omen*—of secondary importance.

Secondary markets are not necessary for bail-out (call) options. On the one hand, whereas the investor cares about profit, the public agent cares both about profit and welfare. Therefore the public agents valuation of a utility company is always higher than the investors valuation. At the margin, when a call option is in the money for the public agent, the investor will sell. On the other hand, the public agent is always liquid (or "more liquid" than the investor), thus can execute the call option.

The problem of secondary markets for exit (put) options is solvable. The contractual mechanism can contemplate put options convertible to liquid assets (e.g., Treasury bonds) held in an escrow account or long "calls on puts," i.e., the right to sell another stock at a set price.

5 Option Contracts As a Means to Sustainable Partnerships

The option mechanism for public-private partnerships combines the advantages of incomplete "once-and-for-all" contracts (Stigler 1968) and incomplete long-term contracts (Demsetz 1968) with those of short-term contracts (Posner 1972). Incentives for long-term investments are at the same time risk deterrents of opportunism. The flexibility of the option contracts enables a continuous process of enhancing cooperation between the investor and the public agent or termination of cooperation without loss for any of the parties. Under this regime, information asymmetries (e.g., on quality or accounting) are less likely to occur, since deviation is penalized in the subsequent period. Furthermore, the issue of problem-free transfer of assets mentioned by Posner (1972) de facto boils down to the purchase of assets at a set price: the strike price of the exit or bail-out option.

The exit/bail-out option mechanism reduces entry barriers by streamlining incomplete long-term contracts and avoiding contractual problems related to bounded rationality and opportunism. As a result, a natural monopoly becomes similar to a contestable market. The mechanism does not eliminate, however, the problem of human capital, transfer of experienced staff, and the advantage of the incumbent investor over potential competitors.

Alleged close cooperation makes room for higher payoffs from deviation. In the fear of opportunism, the consequence is weak cooperation. Exit and bail-out options set at the right strike price reduce the gains from opportunism of the agents (if minimax conditions are satisfied) and foster close cooperation, similarly to folk theorem reasoning (Abreu 1988). If higher punishments (lower gains) are allowed in the next rounds by means of exit and bail-out options, the counter-party will not deviate because, even though she can gain considerably in a single round, the other player will punish her by executing the option in the follow-up round. Thus, exit and bail-out options increase the payoffs of the players.

Interestingly, increasing the profitability of the joint venture improves its sustainability reducing the incentives for both public and private opportunism.

Corollary 3 *High operating profit of the PPP improves its sustainability vis-à-vis public and private opportunism.*

Concession contracts often include a kind of non-symmetrical termination option mechanism or *ad nutum* clause. The public agent can pay a predefined compensation and execute the termination.[27] The investor can execute the termination option on similar compensation terms only in case of misbehavior of the public agent. There are no contracts with non-conditional exit options for the investor. The question is, therefore, why the exit (put) option is subject to "bad behavior" of the public agent, while the bail-out (call) option can be deliberately executed by the public agent, and whether this contract design mitigates or favors public opportunism. The understanding of these issues is a domain for further research on public-private agreements.

6 Other Applications

The exit/bail-out option mechanism can be applied to foster long-term cooperation in joint ventures where the players have partially aligned interests and can act opportunistically (hold-

[27] Engel, Fischer, and Galetovic (2003) argue that if fair compensation is the expected present value of future profits under the original contracted terms, this amount cannot be deduced from accounting data, is highly subjective, and therefore may induce disputes. They suggest a novel flexible bail-out mechanism where the compensation (strike price) equals the Present Value of Revenues (PRV) bid by the franchise holder minus the value of realized revenues.

up, deviate from cooperation, or free-ride) for one period and information about deviation is revealed in subsequent periods, e.g.:

1. Mergers and acquisitions, including early stages of venture financing, where targeted companies can hide information to pump up their valuations

2. Corporate governance and compensation, where the managers have idiosyncratic assets (skills, insider information) that can affect the performance of the company[28]

3. Concessions for the exploitation of natural resources (oil, gas, minerals), where investments are subject to governmental expropriation (Opp 2012)

4. Franchises and dealerships, where franchisees and dealers have incentives to curb service quality and franchisors and manufactures may expropriate individuals by lowering margins, increasing the number of dealerships in the same local market, underperforming on their police role, and underinvesting in brand maintenance (Arruñada, Garicano, and Vázques 2001; Arruñada, Garicano, and Vázques 2005)

5. Cooperatives and export consortia, where members can cheat on their actual investment and quotas to free-ride on the remaining members

[28] It is a common practice—especially in start-ups and the financial sector—to compensate managers with call options as an incentive to enhance corporate value. No research has been conducted, however, on symmetrical penalty mechanisms with put options to punish managers' malpractices that destroy corporate value.

Appendix A Notation

Variable	Formula	Meaning
A	$\leq I$	Public agent's rents from penalties, restrictive regulation, and expropriation
I		Sunk investments in specific assets
r_{pr}		Investor's discount rate
r_{pu}	$\leq r_{pr}$	Public agent's discount rate
U_{jv}	$\in (U_m, U_{pu})$	Welfare from public-private partnership
U_m		Welfare from private monopoly
U_{pu}		Welfare from public monopoly
U_{re}		Welfare from regulated monopoly
U^*		First-best welfare output
V_{call}		Value of an bail-out (call) option
V_{put}		Value of an exit (put) option
ε		Residual profit over regulated (capped) profit
φ	$\in [0, 1-\sigma]$	Investor's belief on the probability of positive outlook when loss is reported; $\varphi/(1-\sigma)$ is the investor's optimism
π_{jv}	$\in (\max(\pi_{pu}, \pi_{re}), \pi_m)$	PPP profit
π_m		Private monopoly profit
π_{pu}		Public monopoly profit
π_{re}		Regulated monopoly profit
σ		Likelihood of profit π_{jv}
$1-\sigma$		Likelihood of loss $-A$
θ		Investor's share in investment and profit
$1-\theta$		Public agent's share in investment and profit

Abbreviation	Meaning
EVA	Economic Value Added®; allows to disentangle operating profit from the cost of capital. Its methodology was introduced by Stern Stewart and Co. (see www.eva.com)
GUS	Glowny Urzad Statystyczny (Polish Central Statistical Office)
NOPAT	Net Operating Profit After Tax
NPV	Net Present Value
PPP	Public-Private Partnership
WACC	Weighted Average Cost of Capital

Appendix B Proofs

Appendix B.1 Proof of Proposition 1 (Unfeasibility of mixed motive strategies in a one-shot PPP game)

As $A \leq I$, if $\pi_{jv} < \varepsilon + A \leq I$, the investor will not invest in a PPP. $\blacksquare$

Appendix B.2 Proof of Proposition 2 (Incentives for public opportunism)

Opportunism is a profitable strategy for a public agent if:

$$A - \sum_{t=1}^{\infty} \frac{U_{jv} - U_{pu}}{(1 + r_{pu})^t} > 0$$

$$A > \frac{U_{jv} - U_{pu}}{r_{pu}} \tag{1}$$

where r_{pu} is the public agent's discount rate.

Since $A \leq \theta I$, inequality (1) can be formulated as:

$$\theta I > \frac{U_{jv} - U_{pu}}{r_{pu}} \tag{2}$$

From Assumption 1:

$$\theta I > \frac{\pi_{jv} - \pi_{pu}}{r_{pu}} \quad \blacksquare \tag{3}$$

Appendix B.3 Proof of Proposition 3 (Value of an exit option in a one-shot PPP game)

Let the likelihood of profit π_{jv} be σ and the likelihood of loss $-A$ be $1 - \sigma$, and the NPV of the investment in a PPP for the investor be:

$$NPV_{pr} = \theta \left[-I + \sigma \frac{\pi_{jv} + r_{pr} I + I}{1 + r_{pr}} + (1 - \sigma) \frac{-A + r_{pr} I + I}{1 + r_{pr}} \right] \tag{4}$$

i.e., at the beginning of the period, the investor invests θI, and at the end of the period the investor receives a return on invested capital $\theta r_{pr} I$, payoff $\theta \pi_{jv}$ with probability σ or $-\theta A$ with probability $1 - \sigma$, and residual value θI.

Simplifying terms:

$$NPV_{pr} = \theta \left[\frac{\sigma \pi_{jv} - (1 - \sigma) A}{1 + r_{pr}} \right] \tag{5}$$

If the utility company incurs loss $-A$ and the investor sells her shares to the public agent, the investor's payoff with an exit option equals:

$$NPV_{pr_{put}} = \theta \frac{\sigma \pi_{jv}}{1 + r_{pr}} \tag{6}$$

The value of the exit (put) option equals:

$$V_{put} = NPV_{pr_{put}} - NPV_{pr}$$

$$V_{put} = \theta\frac{\sigma\pi_{jv}}{1+r_{pr}} - \theta\left[\frac{\sigma\pi_{jv}-(1-\sigma)A}{1+r_{pr}}\right]$$

$$V_{put} = \theta\frac{(1-\sigma)A}{1+r_{pr}} > 0 \quad \blacksquare \tag{7}$$

Appendix B.4 Proof of Proposition 4 (Sufficient condition for investor's non-negative payoff with an exit option)

The expected value of a repeated game for the investor without an exit option equals:

$$NPV_{pr} = \theta\left[\frac{\sigma\pi_{jv}-(1-\sigma)A}{1+r_{pr}} + \frac{\sigma^2\pi_{jv}-\sigma(1-\sigma)A+\sigma(1-\sigma)\pi_{jv}-(1-\sigma)^2A}{(1+r_{pr})^2} + \cdots\right]$$

$$NPV_{pr} = \theta\left[\frac{\sigma\pi_{jv}-(1-\sigma)A}{1+r_{pr}} + \frac{\sigma[\sigma\pi_{jv}-(1-\sigma)A]+(1-\sigma)[\sigma\pi_{jv}-(1-\sigma)A]}{(1+r_{pr})^2} + \cdots\right]$$

$$NPV_{pr} = \theta\left[\frac{\sigma\pi_{jv}-(1-\sigma)A}{1+r_{pr}} + \frac{\sigma\pi_{jv}-(1-\sigma)A}{(1+r_{pr})^2} + \cdots\right]$$

$$NPV_{pr} = \theta\frac{\sigma\pi_{jv}-(1-\sigma)A}{r_{pr}} \tag{8}$$

which can be positive or negative.

The expected value of the repeated game with an exit option equals:

$$NPV_{pr_{put}} = \theta\left[\frac{\sigma\pi_{jv}-\varphi A}{1+r_{pr}} + \frac{\sigma^2\pi_{jv}-\sigma\varphi A+\varphi\sigma\pi_{jv}-\varphi^2A}{(1+r_{pr})^2} + \cdots\right]$$

$$NPV_{pr_{put}} = \theta\left[\frac{\sigma\pi_{jv}-\varphi A}{1+r_{pr}} + \frac{\sigma(\sigma\pi_{jv}-\varphi A)+\varphi(\sigma\pi_{jv}-\varphi A]}{(1+r_{pr})^2} + \cdots\right]$$

$$NPV_{pr_{put}} = \theta\left[\frac{\sigma\pi_{jv}-\varphi A}{1+r_{pr}} + (\sigma+\varphi)\frac{\sigma\pi_{jv}-\varphi A}{(1+r_{pr})^2} + \cdots\right]$$

$$NPV_{pr_{put}} = \theta\frac{\sigma\pi_{jv}-\varphi A}{r_{pr}+1-\sigma-\varphi} \tag{9}$$

For $\varphi = 0, NPV_{pr_{put}} \geq 0 \quad \blacksquare$

Appendix B.5 Proof of Lemma 1 (Investor's payoff with an exit option)

The $NPV_{pr_{put}}$ for the pessimistic investor with an exit option equals:

$$NPV_{pr_{put}} = -\theta I + \sum_{t=1}^{T-1}\frac{\theta\pi_{jv}}{(1+r_{pr})^t} + \theta\frac{I(1+r_{pr})}{(1+r_{pr})^T}$$

$$NPV_{pr_{put}} = \theta\left[-I + \pi_{jv}\frac{1-(1+r_{pr})^{-(T-1)}}{r_{pr}} + \frac{I}{(1+r_{pr})^{T-1}}\right] \tag{10}$$

where T is the time of execution of the exit option.

(a) For all $t = 1, 2, ..., T-1$ when profit $\pi_{jv} \geq r_{pr} I$, the cost of capital is covered

(b) Upon execution of the option at $t = T$, the initial investment and last period's opportunity cost are recovered: $I/(1 + r_{pr})^{T-1}$ $\blacksquare$

Appendix B.6 Proof of Corollary 1 (Exit option offsets public opportunism)

The public agent's payoff from opportunism (inequality (2)) is strictly lower than the value of the investor's exit (put) option strike price:

$$\theta I - \frac{U_{jv} - U_{pu}}{r_{pu}} < \frac{\theta I(1 + r_{pr})}{1 + r_{pu}} \quad \blacksquare \tag{11}$$

Note: without welfare loss ($U_{jv} - U_{pu} = 0$), inequality (11) also holds.

Appendix B.7 Proof of Proposition 5 (Incentives for private opportunism)

The opportunism strategy is profitable for the investor if:

$$\theta(\pi_m - \pi_{jv}) - \sum_{t=1}^{T} \frac{\theta A}{(1 + r_{pr})^t} > \theta \frac{\pi_{jv}}{r_{pr}} \tag{12}$$

where r_{pr} is the investor's discount rate.

As the sum of discounted penalties cannot exceed invested capital ($\sum_{t=1}^{T} A/(1 + r_{pr})^t \leq I$), the outcome is the following condition for private opportunism:

$$\theta(\pi_m - \pi_{jv}) - \theta I > \theta \frac{\pi_{jv}}{r_{pr}}$$

$$\pi_m - \pi_{jv} > I \frac{\pi_{jv}}{r_{pr}} \quad \blacksquare \tag{13}$$

Appendix B.8 Proof of Proposition 6 (Sufficient condition for public agent's non-negative payoff with an exit option) and Lemma 2 (Public agent's payoff with an exit option)

Replace r_{pr} with r_{pu}, $\theta\pi_m$ with $U_m + (1 - \theta)\pi_m$ and $\theta\pi_{jv}$ with $U_{jv} + (1 - \theta)\pi_{jv}$ in proofs of Proposition 4 and Lemma 1. $\blacksquare$

Appendix B.9 Proof of Corollary 2 (Bail-out option offsets private opportunism)

When the public agent exercises the bail-out option, the investor is deprived from excess profit $\pi_m - \pi_{jv}$ and compensated at the annualized value of the investment $\theta r_{pr} I$. The present value of the bail-out option's strike price is lower than the present value of cooperating:

$$I < \frac{\pi_{jv}}{r_{pr}} \tag{14}$$

for $\pi_{jv} > r_{pr} I$ as per definition 1 of PPP profit. $\blacksquare$

Appendix B.10 Proof of Corollary 3 (Profitability strengthens sustainability of PPP)

From Propositions 2 and 5, high PPP profit π_{jv} decreases the incentives for both public and private opportunism. $\blacksquare$

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