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The Holdout Problem and Long-Term Contracting

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ECONOMIC ANALYSIS GROUP
DISCUSSION PAPER

The Holdout Problem and
Long-Term Contracting

by

Alexander Raskovich*
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Abstract

The holdup problem of under-investment in specific capital has been studied extensively. Less attention has been paid to the “holdout” problem of over-investment in outside options. A buyer’s gain from (unverifiably) developing an outside option exceeds the joint gain, given rent shifting when an inferior option binds in subsequent bargaining with the seller. Long-term contracts can solve holdout by increasing the buyer’s surplus from trade within the relationship. With a nonbinding contract, however, the seller’s participation constraint may require the buyer (who may be financially constrained) to pay a large signing bonus. This suggests a novel motive for vertical integration.

1. Introduction

As part of the broader study of transaction cost economics, the holdup problem has been explored extensively in the industrial organization literature.¹ The holdup problem involves the under-provision of noncontractible, relationship-specific investment, given that the investing party captures only a fraction of the increment to joint surplus in ex post bargaining. A large empirical literature has generally found that vertical integration is associated with asset specificity, consistent with the idea that the holdup problem can be more effectively addressed within the boundaries of a firm.²

This paper explores a significant coordination problem, “holdout,” that has garnered much less attention than holdup. The holdout problem, as the term is used here,³ involves over-investment in an outside option. Prior to bargaining over a spot sale, a buyer’s expected gain from developing an outside option typically exceeds the joint gain, given rent shifting when the realized option is inferior to the seller’s existing technology but the option binds in subsequent bargaining between the buyer and seller.

¹ Transaction cost economics and theories of the firm have their origin in Coase (1937), while the study of holdup in particular began with Klein et al. (1978) and Williamson (1975, 1985). The property rights approach of Grossman and Hart (1986) and Hart and Moore (1990) provides a formal theory of asset ownership as a response to holdup. Joskow (2005) offers a recent survey of the transaction cost economics literature.

² Klein (2005) surveys empirical studies of the make-or-buy decision.

³ “Holdout” has been used (e.g., Grossman and Hart, 1980; Menesez and Pitchford, 2004) to describe a problem facing a principal who must assemble separately owned complementary assets, such as contiguous land parcels (for a development project) or shares of stock (for a takeover). The present analysis abstracts from the issue of multiple agents and emphasizes investment costs of holding out.

While the holdout problem is distinct from the holdup problem, the backdrop for both is a relationship between a buyer and seller whose trade is more efficient than external trade. Holdup refers to the problem that the joint surplus from trade within a relationship is not maximized because agents' private incentives to undertake relationship-specific investment are too low. Holdout refers to the problem that joint surplus is not maximized because agents' private incentives to develop options for external trade are too high.

There has been growing appreciation that outside opportunities can adversely affect coordination within a business relationship. In the property rights approach to the theory of the firm, developed by Grossman and Hart (1986) and Hart and Moore (1990), choosing the right agent to hold (sole) ownership rights over a critical asset is a powerful coordination tool. De Meza and Lockwood (1998) show, however, that owning an asset will have no effect on an agent's incentive to undertake relationship-specific investment when the asset owner faces a fixed and binding outside option. Rajan and Zingales (1998) further find that ownership can diminish an agent's incentive to invest if, contrary to the standard assumption in the property rights approach, specializing an asset degrades the asset owner's outside option. When general and relationship-specific investments are substitutes, Cai (2003) shows that joint ownership of an asset can be optimal. The power each owner has to veto the other's exercise of an outside option can sharpen both owners' incentives to undertake relationship-specific investment. In a similar vein, de Meza and Selvaggi (forthcoming) find that exclusive dealing restrictions can foster relationship-specific investment.

A common thread in these studies is that outside opportunities may distract agents from optimally undertaking relationship-specific investment,⁴ exacerbating the holdup problem. The present paper focuses instead on the problem of holdout. The threat to develop an outside option bolsters an agent's bargaining position, yielding a shift in rents captured from trade within a relationship. If trade within the relationship is efficient, in that a project to develop an outside option would reduce expected joint surplus net of the project's cost, then undertaking the project would incur waste. With vertical separation, the decision on whether to proceed with the project may be subject to a coordination problem, holdout, that does not depend on whether specific investment is important to generating the joint surplus from trade within the relationship.

Holdout problems appear common throughout the economy. Some examples:

■ *Make-or-buy decisions.* In the literature on make-or-buy decisions,⁵ “make” is typically associated with vertical integration and “buy” with vertical separation. The make-or-buy decision is thus equated with a choice of organizational form. While this perspective has proven very fruitful, it fails to capture important cases involving project choice. Consider the following two scenarios. First, an independent buyer must decide

⁴ The adverse effects of outside opportunities have also been a central concern in the incentive approach to the theory of the firm, beginning with the seminal contributions of Alchian and Demsetz (1972) and Holmstrom (1982). This literature treats the moral hazard problem that arises when effort is difficult to observe, so that agents may avail themselves of outside opportunities to consume leisure or moonlight. Holmstrom and Milgrom (1991) find it optimal to provide high-powered incentives to an asset-owning agent, to deter an agent from underutilizing an asset so as to preserve its value in alternative employments. Holmstrom and Milgrom (1994) similarly find that, in contrast to an employee sales force, independent sales agents are optimally given more freedom to pursue outside business but are also paid higher commissions.

⁵ See Klein (2005) for a recent survey of this literature.

whether to purchase from a given seller who employs production technology S or develop production capability internally by undertaking project P . Second, a vertically integrated firm that has access to technology S faces the choice of whether to produce internally using S or develop a new technology for internal production by undertaking project P . The first scenario becomes the second upon the vertical merger of the buyer and seller. A key question is how organizational form may affect the decision to proceed with project P . In particular, can arms-length contracting always solve a holdout problem (where project P is profitable to the buyer but lowers joint surplus), or is vertical integration sometimes necessary?

■ **Dual sourcing.** Rather than the development of a production technology, project P may involve the costly development of a request for proposal and subsequent due diligence in vetting a second source of supply. The buyer's choice to qualify a second source may reflect a holdout problem, motivated in part by the private benefits of an improved bargaining position vis-à-vis the first supplier. A requirements contract or exclusive dealing restriction might solve the holdout problem, with the buyer and incumbent supplier sharing the joint gains from economizing on second-sourcing costs.

■ **Buyer search.** Similarly, consider a buyer and seller who have traded in the past and have a good sense of the joint surplus they could generate in a future trade. At some cost, the buyer could search for a better trading partner (project P). Again, search would tend to benefit the buyer in part by improving the buyer's outside option in bargaining with

the incumbent seller.⁶ One potential benefit of a long-term purchasing agreement is that it may deter the buyer from undertaking wasteful search, thus solving a holdout problem.⁷

■ **Best-price guarantees.** Consider the case of a buyer for whom it is privately profitable in expectation to delay purchasing a durable good from a given seller, in anticipation of receiving a possibly lower price offer from another seller (project P is delay). Delay would be costly because of the buyer's loss of current consumption benefits and the seller's inventory costs. The threat of delay reflects a holdout problem if concluding the sale immediately would maximize the buyer's and seller's expected joint surplus.⁸ A sales contract with a best-price guarantee may solve this holdout problem.

■ **Patent licenses.** Gallini (1984) shows that an incumbent firm has a strategic incentive to license its technology on favorable terms to a potential entrant, to deter the entrant from developing an alternative technology. One example (Gallini, 1984) is Standard Oil of New Jersey and Farben broadly licensing their technologies for (respectively) synthetic rubber and synthetic oil production. Another example (Telser, 1960) is General Electric licensing its suite of patents on incandescent light bulbs to research rival Westinghouse on favorable terms. In both examples, a potential entrant faces a make-or-buy decision: to develop an alternative technology or license the existing technology.

⁶ The buyer's incentive to search may be socially suboptimal, given that the buyer bears the cost of search but captures only part of any increase in joint surplus in bargaining with the new seller. See Diamond and Maskin (1979) and (on a related point) Raskovich (forthcoming).

⁷ This explanation for long-term contracting is similar in spirit to Kenney and Klein's (1983) theory of block booking.

⁸ The large literature on low-price guarantees has focused on price discrimination and on strategic motivations (e.g., facilitating collusion, deterring entry) for the practice.

Potential entry could be viewed as a type of holdout problem, which might be resolved through a licensing contract that shares monopoly profits with the potential entrant.

■ ***Shared facilities.*** Chen and Ross (2000) likewise show that an incumbent may deter entry by sharing production facilities with a potential entrant. Such sharing occurs in the airline industry, for example, where airlines commonly share terminal space, ground crews and other ground-based facilities.

■ ***Research alliances.*** Firms coordinating research efforts face the holdout problem that an alliance partner may undertake research that is excessive from the standpoint of joint profits. Biotech company Tanox withdrew a promising experimental peanut allergy treatment, TNX-901, upon the insistence of its corporate partners, Novartis and Genentech (Farrell, 2006). The partners had identified Xolair, an existing Genentech drug marketed for a different indication, as the most promising project for peanut allergy treatment. Tanox's initial development of TNX-901 (and threat to continue) plausibly improved the company's position in bargaining with its research partners over the division of expected profits from future sales of Xolair as a peanut allergy treatment.

■ ***Exhaustible resources.*** Lewis et al. (1986) show that the supplier of an exhaustible resource may extract it at a faster rate than optimal for a secure monopolist, to induce a consuming country to put off developing a substitute (project *P*). As one example, some analysts perceive Saudi Arabia to have acted to moderate crude oil prices in past years in an attempt to slow investments in fuel efficiency and alternative energy sources.

■ ***Store brands.*** Morton and Zettelmeyer (2000) find that retailers are more likely to carry a store brand (project *P*) the higher the market share of the leading national brand in a product category, but that this share does not affect the store brand's share. This is

consistent with a strategic bargaining motive for introducing store brands.⁹ That store brands are so common may reflect a failure to solve holdout through contracting.¹⁰

■ **Powerful employees.** Rajan and Zingales (2000) and Zingales (2000) discuss the decline of Saatchi & Saatchi, which had been the world's largest advertising agency. In 1994, Chairman Maurice Saatchi wished to be awarded a generous option package. The proposal met with opposition from a large block of shareholders, however. This led to Maurice Saatchi's departure from the firm, together with his brother Charles and several other key executives, to form the rival agency M&C Saatchi. The rival firm soon captured a number of Saatchi & Saatchi's key accounts. Apparently shareholders in Saatchi & Saatchi failed to perceive the strength of Maurice Saatchi's holdout threat.¹¹

As suggested by the foregoing examples, holdout problems can occur in a wide range of contexts; their study may thus yield insights of broad applicability. Two questions naturally arise. First, under what circumstances can contracting solve the holdout problem? In particular, can a long-term contract solve the holdout problem when the outside-option project is not verifiable? Second, does the presence of a holdout

⁹ See also Narasimhan and Wilcox (1998), who reach a similar conclusion based on survey data. Katz (1987) treats a case in which a discriminating monopoly manufacturer optimally offers lower prices to retailers that have an ability to integrate backward into production.

¹⁰ The holdout problem is likely "small" here. Store brands are unadvertised and so require little investment; their development thus entails little resource waste. As discussed in Section 4, such small holdout problems are especially "hard" to solve through nonbinding long-term contract.

¹¹ Maurice Saatchi could be viewed as facing a make-or-buy decision on how to maintain and grow advertising accounts: whether to continue "buying" support services from Saatchi & Saatchi or form a rival firm. As with the case of store brands (*supra* note 9), the holdout problem here appears to be small. Little investment was likely needed to form M&C Saatchi; most of the new firm's capital base was the human capital of executives who had defected from Saatchi & Saatchi.

problem affect the attractiveness of vertical integration as an alternative organizational form to long-term contracting? In addressing these questions, the analysis focuses on how organizational form affects the parties' expected joint surplus. As illustrated by some of the foregoing examples, however, solving holdout does not necessarily improve total surplus, inclusive of the surplus of third parties such as downstream consumers.

The remainder of the paper is organized as follows. Section 2 lays out the economic setting of a seller with an incumbent technology and a buyer who can undertake a costly, unverifiable project to develop an outside option. Section 3 finds the conditions under which a holdout problem arises in a regime of bargaining over spot sales—that is, when undertaking the project is privately profitable for the buyer but would lower expected joint surplus net of project costs. Section 4 analyzes long-term contracting solutions to the holdout problem. Section 5 discusses these results and considers possible implications for vertical integration. Section 6 concludes.

2. Economic Setting

A buyer and a seller play a game over five dates, depicted in the timeline in Figure 1. At date 0, one of three organizational forms is adopted: spot sales, long-term contracting or vertical integration. Rather than fully model the determination of organizational form at date 0, the analysis takes organizational form as given and focuses on the resulting subgame perfect Nash equilibrium (SPNE) of the continuation game. At date 1, the buyer (if unintegrated, or else the integrated firm) chooses whether to undertake a project to develop an alternative to the seller's existing technology. Without the project, the buyer's outside option is zero; undertaking the project yields an outside option of uncertain value realized at date 2, as discussed below. At date 3, the buyer and

seller (if unintegrated) may bargain over the division of surplus generated by their trade (if the regime is spot sales), or else renegotiate their long-term contract (if it is nonbinding). If the parties had entered a binding long-term contract at date 0, no renegotiation can take place at date 3. The buyer and seller execute their trade at date 4, or else the buyer takes the outside option.

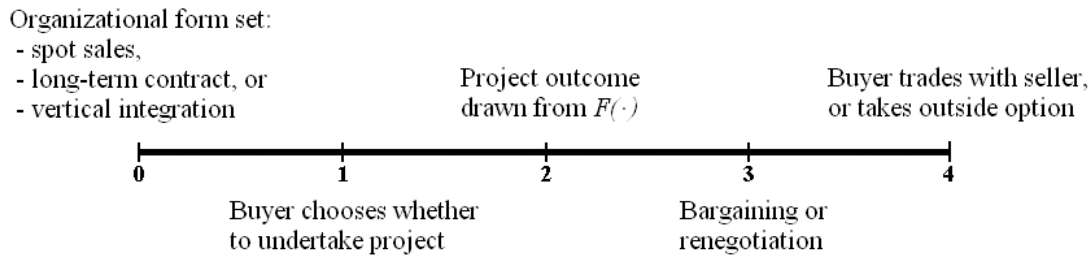


Figure 1: Timeline of the Game

The formal analysis addresses two questions. First, in a regime of spot sales, when would the buyer choose to undertake an inefficient¹² project in the resulting SPNE? Second, when such a holdout problem exists, can long-term contracting solve the problem, in that there exists a mutually acceptable and budget-balancing contract under which the buyer would forego the inefficient project in the resulting SPNE?

As usual, subgame perfect equilibrium can be found by backward induction. At date 4, the parties (both of whom are risk neutral) can generate a commonly known joint surplus, normalized to one, by employing the seller’s existing technology to transfer a good to the buyer. If the project has been undertaken and has yielded an outside option

¹² Inefficient in the sense that undertaking the project would lower the buyer’s and seller’s expected joint surplus. Some such projects might increase total surplus, however, when taking into account the surplus of third parties such as downstream consumers.

whose value exceeds one, the buyer (or integrated firm) will forego trade with the seller (or internal trade) in favor of taking the outside option.

Under either spot sales or nonbinding long-term contract, the buyer and seller can bargain at date 3 over division of the unit joint surplus from trade at date 4. If the parties entered a nonbinding contract at date 0, its terms set threat points for renegotiation at date 3. If the parties entered a binding contract at date 0, its terms govern trade and no renegotiation is possible.

Abstracting from the details of any particular bargaining game, suppose that the game at date 3 is one in which the outside option principle applies.¹³ Let $\beta \in [0,1)$ denote the surplus the buyer would capture in the bargaining outcome absent a binding outside option constraint, where β is common knowledge. According to the outside option principle, if the buyer obtains a binding outside option $v \in (\beta, 1]$, the buyer will obtain surplus of v in the date 3 bargaining outcome. Thus, under either spot sales or nonbinding long-term contract, the bargaining outcome at date 3 will depend on whether the buyer undertook the project at date 1 and on the project's outcome at date 2.

At date 1, the buyer (or integrated firm) has an opportunity to seek an alternative to the seller's incumbent technology. At cost y , $y \geq 0$, a project can be funded to develop an alternative procurement option.¹⁴ For example, the project could involve plans to develop internal production capability,¹⁵ invent around an existing patent, search

¹³ See, for example, the discussion of outside options in Osborne and Rubinstein (1990).

¹⁴ This cost is taken to be sunk once the project is undertaken.

¹⁵ The project involves only research and planning, but no development, and so yields an outside option. If the project were taken to include the actual development of production capability, it would instead yield an inside option. Plausibly the buyer, upon undertaking the project, will not

for an alternative trading partner, etc. The investment decision is discrete: either the project is undertaken, or it is not.¹⁶

It is common knowledge that the value of the procurement option realized by the project is v , where v is distributed according to the cumulative density function $F(\cdot)$. If the buyer undertakes the project at date 1, v is then drawn from $F(\cdot)$ at date 2 and this realization becomes common knowledge.

Let $F(\cdot)$ have support on $[\underline{v}, \bar{v}]$, where $\underline{v} \leq \beta < \bar{v}$. There are two cases to consider. First, if $\bar{v} \leq 1$, the project involves pure rent-shifting from the seller. The procurement option created by the project cannot yield higher joint surplus than trade with the seller, so the buyer never exercises this option in equilibrium. If the buyer were to undertake the project in this case, joint surplus would fall by the project's cost y . If unprofitable jointly, the project might still be privately profitable to the buyer because any project realization $v \in (\beta, \bar{v}]$ would yield the buyer higher surplus of v in subsequent bargaining with the seller.¹⁷ Second, if $\bar{v} > 1$, the project sometimes yields higher surplus than trade with the seller. In this case, undertaking the project may be jointly optimal.

sink any development costs prior to bargaining with the seller at date 3. The project outcome v represents the project's surplus net of development costs, which are assumed to be significant and known with certainty. The buyer incurs these development costs if $v > 1$, in which case the buyer prefers to take the outside option, or if negotiations with the seller break down in disagreement.

¹⁶ The discreteness of the investment decision captures the idea that the project has fixed costs. The project may also entail variable investments along a number of dimensions. These details can be suppressed for present purposes by assuming that, conditional on undertaking the project, variable investments are chosen to maximize the project's overall expected value.

¹⁷ Gross of the sunk project cost y . For project realizations $v < \beta + y$, green lighting the project is a mistake in retrospect; improvement in the buyer's bargaining position (if any) would not justify the project's cost.

However, the buyer's private incentive to undertake the project is still greater than the joint incentive because of the rent shifting the buyer obtains for project realizations $v \in (\beta, 1]$.

Finally, long-term contracting is assumed to be limited in the following ways. Trade is verifiable, in that a contract can specify what good the seller delivers and in what quantities, as well as what (possibly nonlinear) price the buyer pays. In accordance with the holdup literature, however, investment is assumed to be noncontractible. While the nature of the outside-option project (i.e., $F(\cdot)$) is common knowledge to the parties and the buyer's decision on whether to undertake the project and its realization are likewise observable, none of these is verifiable by a third-party contract enforcer such as a court or arbitrator. By assumption, then, a long-term contract cannot be made contingent on whether the project has been undertaken or on its outcome.

Given the structure of the game, an analysis of long-term contracting can be restricted to simple contracts without loss of generality. For the case of binding contracts, treated in Section 4.1, a long-term contract is assumed to stipulate trade of a given quantity at a given price.¹⁸ For nonbinding contracts, treated in Section 4.2, a long-term contract is assumed to take the form of a simple buyer-option contract.¹⁹ In restricting

¹⁸ Equivalently, in terms of incentive effects, such a contract can be taken as being renegotiable but conferring expectation damages to the seller in case the buyer breaches.

¹⁹ Equivalently, in terms of incentive effects, such a contract can be taken as conferring reliance damages to the seller. Reliance damages are zero here, given that the analysis abstracts from specific investment to highlight issues particular to the holdout problem.

attention to these contractual forms, note that there is no scope for improving upon simple contracts by using message-contingent mechanisms.²⁰

3. Spot Sales

A necessary condition for the project to be jointly optimal is $\bar{v} > 1$. In this case, any project realization $v \in (1, \bar{v}]$ would improve the gross joint surplus (gross of project cost y) by $v - 1$. From the perspective of maximizing the buyer-seller joint surplus, then, the project is worth undertaking only if

$$\int_1^{\bar{v}} (x - 1) f(x) dx - y \geq 0, \quad (\text{project jointly profitable}) \quad (1)$$

where $f(\cdot)$ is the first derivative of $F(\cdot)$.

From the buyer's perspective, however, undertaking the project is worthwhile in a regime of spot sales so long as

$$\int_{\beta}^{\bar{v}} (x - \beta) f(x) dx - y \geq 0, \quad (\text{project privately profitable}) \quad (2)$$

where again β is the surplus the buyer would obtain in date-3 bargaining absent a binding outside option. The integral on the left-hand side of condition (2), which is the buyer's gross gain from the project, can be explained as follows. For realizations $v \in (\beta, \min\{\bar{v}, 1\}]$, the outside option binds and the buyer obtains surplus of v in bargaining with the seller over trade, reaping a private gain of $v - \beta$ from the project. If

²⁰ If the project were verifiable, a message-contingent contract could implement the optimal project decision by a direct revelation mechanism. This mechanism cannot be employed in the present context because the act of undertaking the project is unverifiable. Another possible role for message-contingent mechanisms is to assure ex post efficiency of trade. However buyer-option contracts can also assure ex post efficiency.

$\bar{v} > 1$, then for project realizations $v > 1$ the buyer forgoes the seller's inferior technology in favor of taking the outside option, and so again gains $v - \beta$ from the project.

Condition (2) is a looser constraint than condition (1). Let y_J denote the critical project cost such that the project is jointly profitable for $y \leq y_J$:

$$y_J \equiv \begin{cases} \int_1^{\bar{v}} (x-1) f(x) dx & \text{if } \bar{v} > 1, \\ 0 & \text{otherwise.} \end{cases} \quad (3)$$

Define y_P similarly, such that the project is privately profitable to the buyer for $y \leq y_P$:

$$y_P \equiv \int_{\beta}^{\bar{v}} (x - \beta) f(x) dx. \quad (4)$$

Note that $0 \leq y_J < y_P$. This reflects the buyer's excessive willingness to develop the project. There are high project costs $y \in (y_J, y_P]$ for which undertaking the project is privately profitable to the buyer in expectation, but reduces expected joint surplus. For project costs in this range, the difference $y - y_J$ is the loss in expected joint surplus from undertaking the project. Hereafter, references to the holdout problem being "small" or "large" refer to the magnitude of $y - y_J$ for $y \in (y_J, y_P]$.

Proposition 1. *There is no holdout problem (i.e., the privately and jointly optimal project choices align under spot sales) when $y > y_P$ and also when $\bar{v} \geq 1$ and $y \leq y_J$. In either case, spot sales achieve the joint optimum in the resulting SPNE.*

Proof. Follows immediately from the foregoing development. \square

For $y > y_p$, the project is unprofitable both privately and jointly. For $\bar{v} \geq 1$ and $y \leq y_j$, the project is profitable both privately and jointly. In either case, the parties can rely on spot sales in stage three to attain the joint optimum.

The private and joint project choices diverge under spot sales, however, when $\bar{v} < 1$ and $y \leq y_p$, and also when $\bar{v} \geq 1$ and $y \in (y_j, y_p]$. In either case, the buyer could gain privately in expectation by undertaking the project, although doing so would lower expected joint surplus net of project costs. For $\bar{v} < 1$ and $y \leq y_p$, the buyer's private gain from the project would come purely from rent shifting. For $\bar{v} \geq 1$ and $y \in (y_j, y_p]$, undertaking the project would increase expected gross joint surplus, but not enough to justify the project's cost. To summarize:

Proposition 2. *There is a holdout problem when $\bar{v} < 1$ and $y \leq y_p$ as well as when $\bar{v} \geq 1$ and $y \in (y_j, y_p]$. In either case, under spot sales the buyer undertakes the project in the resulting SPNE, although doing so lowers expected joint surplus net of project costs.*

Proof. Follows immediately from the foregoing development. \square

The divergence between private and joint incentives to undertake the project is due to a bargaining externality. Under spot sales, project realizations $v \in (\beta, \min\{\bar{v}, 1\}]$ yield a purely private gain to the buyer by posing a binding outside option in subsequent bargaining with the seller. When there is a holdout problem, the bargaining externality may be internalized through long-term contracting or possibly vertical integration.

4. Long-term Contracting

The remainder of the paper focuses on the interesting case in which condition (2) holds but condition (1) does not, so that a holdout problem exists under spot sales.

Although the project is noncontractible, a long-term contract may deter the project by delivering to the buyer enough of the ex post surplus from trade within the relationship that the buyer no longer finds undertaking the outside-option project worthwhile. As shown below, the amount of surplus the contract must deliver to the buyer depends on whether the contract is binding or subject to renegotiation.

4.1 Binding Long-Term Contracts

Let $u_b(\beta)$ denote the expected surplus the buyer would receive in the bargaining outcome at date 3 under spot sales, if the buyer were to undertake the project:

$$u_b(\beta) \equiv \beta F(\beta) + \int_{\beta}^{\bar{v}} x f(x) dx - y. \quad (5)$$

With probability $F(\beta)$ the outside option created by the project does not bind, in which case the buyer receives β . For any project realization $v > \beta$, the buyer receives v .

Likewise let $u_s(\beta)$ be the expected surplus the seller would receive at date 3 under spot sales, if the buyer were to undertake the project:

$$u_s(\beta) \equiv (1 - \beta) F(\beta) + \int_{\beta}^{\min\{\bar{v}, 1\}} (1 - x) f(x) dx. \quad (6)$$

With probability $F(\beta)$ the buyer's outside option does not bind, in which case the seller receives $1 - \beta$ (given budget balance). For any project realization $v \in (\beta, \min\{\bar{v}, 1\}]$, the outside option binds and the seller receives $1 - v$. Finally, if $\bar{v} > 1$, for any project realization $v > 1$ the seller receives nothing as the buyer would pursue the outside option.

Now let z denote the surplus the buyer would receive at date 4 under a long-term contract that stipulates trade with the seller. The buyer is willing to sign a binding

contract z so long as the surplus the contract yields the buyer is at least as great as the buyer's expected surplus under spot sales:

$$z - u_b(\beta) \geq 0. \quad (\text{buyer participation constraint for binding } z) \quad (7)$$

Note also that the buyer, upon signing a binding contract z that satisfies condition (7), cannot thereafter gain by undertaking the project.

The seller would be willing to sign a contract²¹ z so long as

$$\sigma + 1 - z - u_s(\beta) \geq 0, \quad (8)$$

where σ is a signing bonus the seller receives upon entering the contract at date 0,²² $1 - z$ is the surplus the seller receives under the contract upon the execution of trade at date 4 (given that the contract deters the project), and $u_s(\beta)$ is the seller's expected surplus under spot sales (from equation (6)), given that the buyer undertakes the project under spot sales.

Lemma 1 is key to establishing that there are binding long-term contracts that solve the holdout problem.

Lemma 1. *If a holdout problem exists, (i) $u_b(\beta) \in [\beta, 1]$ and (ii) $u_s(\beta) + u_b(\beta) \leq 1$.*

Proof. See the Appendix.

Lemma 1 implies a range of binding long-term contracts characterized by $z \in [u_b(\beta), 1 - u_s(\beta)]$ that satisfy the buyer's participation constraint (7) as well as the seller's participation constraint (8) for $\sigma = 0$. That is, no signing bonus is necessary to

²¹ Note that condition (8) applies to a nonbinding as well as a binding contract; in the former case the condition applies so long as project deterrence is incentive compatible for the buyer, as discussed below.

²² For simplicity, condition (8) assumes no time discounting across dates, or else σ can be considered to be denominated in date-4 dollars.

induce the seller's participation in a binding long-term contract z that deters the inefficient project. This leads immediately to:

Proposition 3. *Suppose there is a holdout problem and contracts bind. Then there exist mutually acceptable, budget-balancing long-term contracts without signing bonus ($\sigma = 0$) that solve the holdout problem, i.e., deter the buyer from undertaking the inefficient project in the resulting SPNE.*

According to Proposition 3, when contracts bind there is always some split in surplus from trade that satisfies both the buyer's and seller's participation constraints.

4.2 Nonbinding Long-Term Contracts

Now suppose that long-term contracts do not bind: any contract signed at date 0 may be renegotiated at date 3, with the buyer facing zero damages for breach. In particular, if the buyer undertook the project at date 1 and realized an outside option of $v \in (z, 1]$ at date 2, where z is the surplus the buyer would obtain under the original contract, then at date 3 the buyer can renegotiate the contract to obtain the higher surplus v . Likewise, if the realized option is $v > 1$, the buyer can obtain surplus of v by foregoing trade with the seller and taking the outside option.

A nonbinding long-term contract that delivers trade-contingent²³ surplus of z to the buyer would deter the buyer from undertaking the project only if

$$z - u_b(z) \geq 0. \quad (\text{buyer's IC constraint, nonbinding } z) \quad (9)$$

Condition (9), the buyer's incentive compatibility constraint with a nonbinding contract, is harder to satisfy than condition (7), the buyer's participation constraint with a

²³ Here trade-contingent payoffs are gross of any date-0 signing bonus the buyer may have to pay the seller to satisfy the seller's participation constraint.

binding contract. Note that when long-term contracts bind (or are enforced using an expectation damages measure), the buyer's expected net gain from undertaking the project, $u_b(\beta) - z$, decreases dollar-for-dollar in the relevant range with the ex post surplus z the contract delivers to the buyer. When long-term contracts are subject to renegotiation (or are enforced using a reliance damages measure of zero), however, the buyer's expected net gain from undertaking the project, $u_b(z) - z$, decreases by *less* than dollar-for-dollar with z :

$$\frac{\partial}{\partial z}(u_b(z) - z) = -(1 - F(z)) > -1, \quad \text{for } z \in [\beta, \bar{v}].^{24} \quad (10)$$

Moreover, there are diminishing returns to this deterrent effect of nonbinding long-term contracts. Differentiating equation (10) yields

$$\frac{\partial^2}{\partial z^2}(u_b(z) - z) = f(z) > 0, \quad \text{for } z \in [\beta, \bar{z}]. \quad (11)$$

Let z_0 be implicitly defined by exact equality in condition (9):

$$z_0 - u_b(z_0) \equiv 0. \quad (12)$$

That is, project deterrence is incentive compatible for the buyer so long as $z \geq z_0$. Note also that $z_0 > u_b(\beta)$, so that it is individually rational for the buyer to sign any nonbinding long-term contract $z \geq z_0$.

²⁴ Note that the larger is $F(\beta)$ the more likely it is that undertaking the project would be unprofitable privately as well as jointly under short-term contracting. However, conditional on the project being privately profitable, long-term contracts are less effective at deterring the project the larger is $F(\beta)$. Intuitively, the only way the project could be privately profitable despite $F(\beta)$ being large is for the distribution to be stretched out beyond β to include some very high project outcomes. In this case, the marginal deterrent effect of raising z above β would typically be small, because much of the project's relevant probability weight would remain above z .

Lemma 2. *Suppose there is a holdout problem and contracts are nonbinding. To deter the inefficient project, a long-term contract must promise the buyer ex post surplus of at least $z_0 = \phi(y)$, where $\phi(y_J) = \min\{\bar{v}, 1\}$, $\phi(y_P) = \beta$, and $\phi' < 0$ for $y \in [y_J, y_P)$.*

Proof. See the Appendix.

The intuition for $\phi' < 0$ and $\phi(y_P) = \beta$ is straightforward. The higher are project costs y , the less surplus the long-term contract must promise to the buyer to deter the buyer from undertaking the inefficient project. In the extreme case of $y = y_P$, the buyer is indifferent to undertaking the project under spot sales, so a long-term contract can deter the project by delivering the same surplus β as the buyer would obtain under spot sales.

The more substantive and perhaps surprising result in Lemma 2 is $\phi(y_J) = \min\{\bar{v}, 1\}$. This implies that for low project costs, those above but close to y_J , long-term contracting can only deter the buyer from undertaking the project by delivering a very large surplus to the buyer.

Proposition 4. *Suppose there is a holdout problem and contracts are nonbinding. Then:*

- (i) *There exist mutually acceptable, budget-balancing long-term contracts that solve the holdout problem.*
- (ii) *Further, if the project cost y is such that $1 - \phi(y) - u_s(\beta) < 0$, then every long-term contract that solves the holdout problem involves the buyer paying the seller a strictly positive signing bonus $\sigma > 0$.*

Proof. Follows immediately from the foregoing development. \square

4.3 Breach Remedies

The dichotomy of binding versus nonbinding contracts studied thus far could be interpreted as reflecting alternative remedies for breach. Under an expectation damages

measure, the breaching party (the buyer, in taking the outside option) must leave the non-breaching party (the seller) as well off as if the contract had been executed. Thus a buyer's incentive to undertake the outside-option project would be the same under a contract subject to renegotiation together with expectation damages for breach as it would under a binding contract, holding other contract terms fixed.

Under a reliance damages measure, the breaching party need only compensate for any reliance investments the non-breaching party has undertaken. The present setting abstracts from reliance investments to highlight the problem of holdout by the buyer. Thus in the present setting the buyer would face zero damages for breach under a reliance standard, just as was assumed in the case of nonbinding contracts above.

As discussed in the next section, paying an up-front signing bonus to the seller may entail real resource costs for the buyer when the buyer is financially constrained. The foregoing analysis implies that under reliance damages (but not under expectation damages) a high signing bonus is sometimes required in any mutually acceptable, budget-balancing contract that solves the holdout problem. This suggests a novel reason for favoring expectation damages over reliance damages,²⁵ insofar as the function of contract law is to facilitate contracting parties' maximization of their joint surplus. As a remedy for breach, reliance damages may to some extent help protect investing parties against the holdup, but can offer no support for the contracting function of solving holdout.

A third type of breach remedy is stipulated (or liquidated) damages, in which damages are set by agreement of the contracting parties. Aghion and Bolton (1987) and Spier and Whinston (1995) show that the contracting parties can have an incentive to

²⁵ See Shavell's (1980) seminal analysis of damage measures for breach; also Leitzel (1989).

stipulate damages above expectation damages, in order to extract surplus from a second supplier who might appear and wish to trade with the buyer. This possibility has been set aside in the foregoing analysis. The practical relevance of contracting parties stipulating excessive damages is unclear, given that the “penalty doctrine” of U.S. contract law appears to preclude such penalties.²⁶ It would not undermine the qualitative results of Section 4, however, for contracting parties to have the ability to extract surplus from third parties through breach penalties. This ability would tend to expand the range of jointly profitable outside-option projects, but there still could be a holdout problem.

5. Discussion

Proposition 3 and Proposition 4(i) together establish that simple long-term contracts, binding or not, can always solve the holdout problem, assuming the buyer is not wealth-constrained. However, Proposition 4(ii) indicates that when contracts do not bind, solving holdout may require that the buyer pay the seller a positive signing bonus upon entering the long-term contract. If the buyer’s wealth (exclusive of future prospects from trade with the seller) falls short of the minimum signing bonus the seller must receive, a nonbinding long-term contract to solve holdout may not be feasible. The buyer may be financially constrained, unable to obtain external credit to finance the signing bonus due to asymmetric information about the buyer’s prospects from trade.

To illustrate Proposition 4(ii), consider the special case in which $1 - \bar{v} - u_s(\beta) < 0$. By Lemma 2, there is a range of project costs y above but close to y_j

²⁶ See Schwartz and Scott (2003), who cite the Uniform Commercial Code, Section 2-718(1): “Damages for breach by either party may be liquidated in the agreement but only at an amount which is reasonable in the light of anticipated or actual harm caused by the breach ... A term fixing unreasonably large liquidated damages is void as a penalty.”

such that $\phi(y)$ is below but close to $\phi(y_j) = \min\{\bar{v}, 1\}$, implying $1 - \phi(y) - u_s(\beta) < 0$. The lowest value of z that could satisfy the buyer's incentive compatibility constraint (condition (9)) is $\phi(y)$, but this exceeds the highest value of z that could satisfy the seller's participation constraint of $1 - z - u_s(\beta) \geq 0$ (condition (8)) given $\sigma = 0$. In this case, any nonbinding long-term contract z that satisfies the buyer's incentive compatibility constraint, $z \geq z_0 = \phi(y)$, requires that the seller be paid a signing bonus of $\sigma \geq u_s(\beta) - (1 - z) > 0$ to be willing to enter the contract at date 0.

Perversely, the smaller the holdout problem, the "harder" it is to solve through nonbinding long-term contract, in the sense that the minimum ex post surplus the buyer must be promised to secure incentive compatibility is higher,²⁷ and by the same token the minimum ex ante signing bonus the seller must receive to satisfy the seller's individual rationality constraint tends to be higher as well.

The minimum signing bonus can be large. Suppose $\bar{v} > 1$, in which case $\phi(y_j) = 1$ according to Lemma 2. To solve a vanishingly small holdout problem, where $y \approx y_j$, the contract must promise the buyer (for incentive compatibility) nearly the entire unit joint surplus from trade with the seller, $\phi(y) \approx 1$, and consequently the seller's signing bonus (for rational participation in the contract) must be nearly as high as the seller's expected surplus under spot contracting, $\sigma \approx u_s(\beta)$. Note that this extreme case is equivalent to a cash buyout of the seller's interests that gives the buyer residual claim to the joint surplus.

²⁷ Although it can never exceed the unit joint surplus from internal trade, by Lemma 2.

The buyer may not have sufficient cash on hand for such a buyout, or mustering the required funds may carry a high opportunity cost for a financially constrained buyer, who might have to divert resources from other internal projects that have positive net present value, or resort to issuing debt with potentially adverse consequences.²⁸ Alternatively, the seller could acquire the buyer's interests by paying the buyer at least $u_b(\beta)$. This route to integration might entail lower resource costs if the seller were less financially constrained than the buyer, or had poorer alternatives for internal investment. If $u_b(\beta) < u_s(\beta)$, then even if the buyer and seller face similar financial constraints and similar internal investment opportunities, a cash buyout of the buyer's interests would entail lower resource costs than would a cash buyout of the seller's interests (and vice versa).

The resource costs of a cash buyout (by either party) might be avoided by structuring the integration as a stock swap, in which the parties obtain shared ownership in the merged entity.²⁹ In the present context, this form of vertical integration is similar to a binding long-term contract that splits the joint surplus from trade in a particular way, the split being accomplished by equity shares rather than contract. Appealing to Proposition 3, then, there always exist mutually acceptable stock-swap mergers that solve the holdout problem. A stock-swap merger may be preferred by the parties over a cash buyout or a nonbinding long-term contract with a large signing bonus, because the

²⁸ See Hubbard (1998) for a survey of research on capital market imperfections.

²⁹ In the sample of mergers studied by Andrade et al. (2001), about 35% are all-cash while nearly 46% are all-stock transactions. For a recent empirical investigation of the determinants of the choice of payment method in mergers and acquisitions, see Faccio and Masulis (2005), who also provided a good review of earlier literature.

merger may entail lower resource costs than these alternatives given the parties' financial constraints. Likewise, vertical integration through a stock-swap may entail lower resource costs than a long-term contract with a high cash signing bonus.³⁰ This suggests a novel motivation for vertical merger.

6. Conclusion

This paper has explored holdout, a coordination problem that arises in a wide variety of contexts. With bargaining over spot sales, a buyer's expected gain from developing an outside option typically exceeds the joint gain, given rent shifting when the realized option is inferior to the seller's existing technology but the option binds in subsequent bargaining between the buyer and seller. Long-term contracting can always solve the holdout problem. If contracts are subject to renegotiation (and the breach remedy is limited to reliance damages), however, it may be that every long-term contract that solves a given holdout problem requires that the buyer receive a large share in the joint surplus from trade, so that the seller must then receive a large up-front bonus to be willing to sign the contract. Paying a large bonus can be costly for a financially constrained buyer; a vertical merger through a stock swap may entail lower resource costs than long-term contracting as a means of solving the holdout problem.

³⁰ The seller's signing bonus might also take the form of a partial equity stake in the buyer.

Appendix

Proof of Lemma 1:

Proof of part (i):

Note first that equation (5) can be written as

$$u_b(\beta) = \beta + \left(\int_{\beta}^{\bar{v}} (x - \beta) f(x) dx - y \right).$$

Given that the parenthetic expression on the right-hand side above is nonnegative by hypothesis that condition (2) holds, $u_b(\beta) \geq \beta$. The proof is complete once it is also shown that $u_b(\beta) \leq 1$. There are two cases to consider. First, if $\bar{v} \leq 1$ then clearly $u_b(\beta) \leq 1$. Second, if $\bar{v} > 1$ then equation (5) can be written as

$$u_b(\beta) = 1 + \int_{\beta}^1 (x - 1) f(x) dx + \left(\int_1^{\bar{v}} (x - 1) f(x) dx - y \right).$$

The first integral on the right-hand side above is negative, and the parenthetic expression is nonpositive by hypothesis that condition (1) does not hold.

Proof of part (ii):

Summing together equations (5) and (6) yields

$$u_s(\beta) + u_b(\beta) = F(\min\{\bar{v}, 1\}) + \int_{\min\{\bar{v}, 1\}}^{\bar{v}} x f(x) dx - y. \quad (\text{A1})$$

There are two cases to consider. For $\bar{v} \leq 1$, equation (A1) reduces to

$$u_s(\beta) + u_b(\beta) = 1 - y,$$

where $y \geq 0$. For $\bar{v} > 1$, equation (A1) can be written as

$$u_s(\beta) + u_b(\beta) = 1 + \left(\int_1^{\bar{v}} (x - 1) f(x) dx - y \right),$$

where the parenthetic expression on the right-hand-side above is nonpositive by hypothesis that condition (1) does not hold. \square

Proof of Lemma 2:

Replacing β with z in equation (5) yields

$$u_b(z) \equiv zF(z) + \int_z^{\bar{v}} x f(x) dx - y \quad (\text{A2})$$

as the buyer's expected surplus under long-term contract z . Equation (A2) may be rewritten as

$$z - u_b(z) = y - \int_z^{\bar{v}} (x - z) f(x) dx, \quad (\text{A3})$$

noting that $-z \int_z^{\bar{v}} f(x) dx = -z[1 - F(z)]$. Equation (A3) and $z_0 - u_b(z_0) \equiv 0$ together yield

$$y - \int_{z_0}^{\bar{v}} (x - z_0) f(x) dx = 0. \quad (\text{A4})$$

By the implicit function theorem, equation (A4) defines a function $z_0 = \phi(y)$. Totally differentiating (A4) with respect to y and z_0 yields $\phi'(y) = \frac{\partial z_0}{\partial y} = \frac{-1}{1 - F(z_0)} < 0$ in the

relevant range. Evaluating (A4) at $y = y_p$ by substituting equation (4) into (A4) yields

$$\int_{\beta}^{\bar{v}} (x - \beta) f(x) dx - \int_{z_0}^{\bar{v}} (x - z_0) f(x) dx = 0, \text{ which implies } \phi(y_p) = \beta. \text{ Finally, determining}$$

$\phi(y_j)$ requires that the two cases $\bar{v} > 1$ and $\bar{v} \leq 1$ in equation (3) be taken in turn. For

$$\bar{v} > 1, \text{ evaluating (A3) at } y = y_j \text{ yields } \int_1^{\bar{v}} (x - 1) f(x) dx - \int_{z_0}^{\bar{v}} (x - z_0) f(x) dx = 0, \text{ which}$$

implies $\phi(y_J) = 1$. For $\bar{v} \leq 1$, $y = y_J = 0$ yields $-\int_{z_0}^{\bar{v}} (x - z_0) f(x) dx = 0$, which implies $\phi(y_J) = \bar{v}$. Thus $\phi(y_J) = \min\{\bar{v}, 1\}$. \square

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