The Holdout Investment Problem and Long-Term Contracting

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Abstract. When traders can undertake outside option projects before bargaining, the private incentive to do so tends to be excessive, given that such a project shifts rents from trade when it yields a binding outside option. With strong contractual commitment, long-term contracting can always solve this “holdout investment” problem, deterring a bilaterally inefficient project. With weak commitment, contracting fails to solve the problem when the project developer faces financial constraints or can invest before bargaining over contractual terms. The analysis suggests that legal restrictions on contractual commitment may favor vertical integration over long-term contracting when traders face a holdout investment problem.

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1. Introduction

Buyers and sellers commonly have opportunities to invest in outside options before bargaining over their trade. For example, an intermediate buyer can develop internal production capacity as a potential alternative to purchasing an input—or perform R&D to invent around a patent as a potential alternative to licensing—before coming to the table to bargain over purchasing or licensing terms. The outcome of such projects is typically uncertain; the resulting alternative may or may not be superior to trade. When traders engage in outside option bargaining, a trader’s incentive to undertake an outside option project tends to be excessive. This is because an inferior project outcome (i.e., one that offers lower bilateral surplus than does trade) enables the project developer to capture rents in subsequent bargaining over trade when it yields a binding outside option, although the option is not exercised in equilibrium.

Divergence between the private and bilateral incentives to undertake an outside option project can be called a problem of *holdout investment*.¹ That is, a trader’s motivation to invest comes partly from the prospect of improving the threat to hold out in subsequent bargaining over trade. The holdout investment problem appears to be common throughout the economy, as suggested by the context of many make-or-buy decisions, the operation of vertical joint ventures, and employment relations within firms.

The goal of this paper is to explore the implications of the holdout investment problem for the choice of organizational form and governance relations between

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¹ “Holdout” has been used (e.g., Grossman and Hart, 1980; Menesez and Pitchford, 2004) to describe the problem of a principal who must assemble separately owned complementary assets, such as contiguous land parcels (for a building project) or shares of stock (for a takeover). The present analysis abstracts from multiple agents and emphasizes investment costs of holding out.
vertically related parties. Hereafter (and without loss of generality), the discussion is couched in terms of a buyer’s decision to undertake an outside option project. The analysis applies equally well, however, to the case of a seller with an opportunity to undertake holdout investment, such as a manufacturer developing an alternative distribution channel before bargaining with a major retailer.² The central question addressed here is whether long-term contracting can solve the holdout investment problem. The goal is to gain insight into circumstances under which contracting fails to solve the problem, leaving vertical integration as potentially the only viable alternative.

In particular, under what circumstances can contracting solve the holdout investment problem when investment in the outside option project is not verifiable by a third-party contract enforcer, such as a court or arbitrator? In this setting, solving the holdout investment problem through contracting requires that the contract be structured so that it is not incentive compatible for the buyer to undertake an inefficient project. The analysis herein shows that the effectiveness of contractual solutions to the holdout investment problem depends on two key features of the contracting environment. First, how strong are feasible contracts as commitments, given the constraints set by contract law? Second, does the buyer have an opportunity to (strategically) sink some investment into the project before coming to the contract bargaining table?

With respect to the strength of contractual commitment, two cases are considered here. At one extreme, contracts have a take-or-pay form that obligates the buyer to pay the contracted price regardless of whether the buyer takes delivery of the seller’s good. At the other extreme, contracts have a buyer-option form that allows the buyer to take an

² The analysis is limited, however, to one-sided holdout investment problems.
outside option with no penalty other than the opportunity cost of foregoing trade with the seller at the contracted price. In both cases, a long-term contract can solve the holdout investment problem in principle, deterring the buyer from undertaking an inefficient outside-option project by guaranteeing the buyer a sufficiently large share of the joint surplus from trade with the seller. However, when commitment is weak (e.g., buyer option contracting), the share in joint surplus the contract must deliver to the buyer is so high that the buyer may have to make a side payment to the seller to induce the seller to sign the contract. In the face of significant wealth and financing constraints, the buyer may be unable to muster the capital for the requisite side payment. This suggests a rationale for vertical integration when feasible contracts offer only weak commitment.

With respect to the timing of investment opportunities, again two cases are considered here. In the basic setting, the parties bargain over terms of the long-term contract before the buyer has any opportunity to invest in the outside option project. Thus in the basic setting all outside option investment is implicitly “on the bargaining table.”

In a second setting treated here, the buyer has an opportunity to invest some or all project development costs prior to coming to the contract bargaining table. Given this opportunity, could a buyer gain strategically by sinking some investment beforehand? The answer is always “no” when contractual commitment is strong (take-or-pay contracting), but can be “yes” when commitment is weak (buyer-option contracting). Sinking partial investment into the project strengthens the buyer’s holdout threat at the bargaining table, allowing the buyer to capture more of the surplus from trade. When commitment is weak, the surplus that the (buyer-option) contract must deliver to the buyer to deter the buyer from completing the project (incentive compatibility constraint)
rises by more than a dollar for each dollar sunk into the project. Thus when commitment is weak, long-term contracting cannot completely solve the holdout problem of inefficient investment. This suggests another rationale for vertical integration when feasible contracts offer only weak commitment.

The remainder of the paper is organized as follows. Section 2 lays out the basic economic setting of a seller with an incumbent technology and a buyer who can undertake a costly, unverifiable project to develop an outside procurement option. Section 3 develops the conditions under which a holdout problem arises in a regime of outside-option bargaining over spot sales. Section 4 analyzes long-term contracting solutions to the holdout problem when contracting precedes all investment. Section 5 modifies the basic setting so that the buyer has an opportunity to sink investment into the project prior to bargaining over contract terms. Section 6 discusses the results in the light of related literature. Section 7 concludes.

2. Basic Setting

A buyer and a seller play a game over five dates, as depicted in the timeline in Figure 1.

At date 1, the parties adopt one of three organizational forms: long-term contracting (C), vertical integration (I) or spot trade (S). The parties bargain over their organizational form in two steps at date 1. In the first step, each party i = b, s makes an organizational choice $\omega_i \in \{C, I, S\}$. If $\Omega = (\omega_b, \omega_s) = (C, C)$, the parties agree to bargain over contract terms in step two of date 1. If $\Omega = (I, I)$, the parties agree to bargain over terms of their integration. Any other $\Omega$ results in the default organizational outcome of spot trade (S). If the parties tentatively agree on organizational form C or I in
step one at date 1, they then engage in outside-option bargaining over the terms of the contract or merger in step two. The buyer’s outside option at date 1 is to revert to the spot trading regime.

At date 2, the buyer (or else the integrated firm) chooses whether to undertake a project to develop an alternative to the seller’s technology. Once developed at date 2, the project yields (at date 3) an outside option to procure the good, e.g. through internal production. The project’s realized value at date 3 is uncertain, as discussed below.

The action at date 4 depends on the organizational outcome at date 1. Nothing occurs at date 4 under vertical integration, but if a long-term contract was entered at date 1, its terms can be renegotiated at date 4. If the default of spot sales was the date 1 outcome, then at date 4 the buyer and seller bargain de novo over the division of surplus to be generated by their spot trade at date 5.

![Figure 1. Timeline in the Basic Setting](chart.png)

Subgame perfect Nash equilibrium (SPNE) is the equilibrium concept employed here. The analysis addresses two types of question. First, in a regime of spot sales, when
would the buyer choose to undertake an inefficient\textsuperscript{3} 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 chooses to forego the inefficient project in the resulting SPNE?

As usual, subgame perfect equilibrium can be found by backward induction. At date 5, 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 trade a good. If the project has been undertaken and has yielded an outside procurement option whose value exceeds one, the buyer (or integrated firm) foregoes trade with the seller (or internal trade) in favor of taking the outside option. Otherwise the parties trade, with payoffs determined by the reigning agreement, given the outcome of date 4 bargaining.

If the parties had entered a long-term contract at date 1, its terms set the seller’s outside option for renegotiation at date 4. That is, the seller has the option to withdraw from renegotiations at date 4 and insist that the terms of the reigning contract be enforced at date 5 as originally agreed upon at date 1.\textsuperscript{4} The buyer likewise has the outside option at date 4 to insist upon execution of the reigning contract.

The buyer may also have an outside procurement option at date 4, but only if the buyer undertook the project at date 2. Whether this option binds depends on the project’s realization (at date 3) and on the terms of the long-term contract, if one is in place.

\textsuperscript{3} Inefficient in the sense that undertaking the project would lower the buyer’s and seller’s expected joint surplus. To the extent that third parties (e.g., final consumers) may also benefit from the project, the project might increase expected total surplus.

\textsuperscript{4} The value of the seller’s outside option depends on how strongly the contract binds the buyer, e.g., whether the contract is take-or-pay or buyer-option.
If the parties had not entered a long-term contract at date 1, they bargain *de novo* at date 4 over the terms of their spot trade at date 5. Abstracting from the details of any particular bargaining game, suppose that the game at date 4 is one in which the outside option principle applies. Let $\beta \in [0,1)$ denote the surplus the buyer would capture in the bargaining outcome at date 4 absent a binding outside option constraint, where $\beta$ is common knowledge. According to the outside option principle, if the buyer realizes a binding outside option $\nu \in (\beta, 1]$ at date 3, the buyer will obtain surplus of $\nu$ in the bargaining outcome at date 4. (And if $\nu > 1$, the buyer foregoes trade with the seller and takes the outside option.)

At date 2, 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. For example, the project could involve plans to develop internal production capability or invent around an existing patent. The investment decision is discrete: either the project is undertaken, or it is not.

It is common knowledge that the value of the procurement option realized by the project will be $\nu$, where $\nu$ is distributed according to the cumulative density function $F(\cdot)$. If the buyer undertakes the project at date 2, $\nu$ is then drawn from $F(\cdot)$ at date 3.

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5 See, for example, the discussion of outside options in Osborne and Rubinstein (1990).
6 This cost is taken to be sunk once the project is undertaken.
7 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.
and this realization becomes common knowledge prior to the bargaining or renegotiation at date 4. Let \( F(\cdot) \) have support on \([v, \bar{v}]\), where \( v \leq \beta < \bar{v} \).

Finally, the feasibility of long-term contracting at date 1 is assumed to be limited in the following way. Trade is verifiable, in that both delivery of the good by the seller and payment by the buyer can be verified by a third-party contract enforcer, such as a court or arbitrator. Investment is noncontractible, however. 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 assumption, then, a long-term contract cannot be made contingent on whether the project has been undertaken or on its outcome.

3. Spot Trade

Suppose for the moment that the outcome of the date 1 bargaining over organizational form is that the parties remain independent and reach no long-term contract; they may subsequently trade on a spot basis. If the buyer undertakes the project at date 2, project realizations at date 3 fall into three cases (depicted in Figure 1 below). First, if \( v < \beta \) the outside option is not binding and so has no effect on the bargaining outcome at date 4. Second, if \( v \in (\beta, 1] \) the project involves pure rent-shifting from the seller. In this case the outside option would yield lower joint surplus than trade with the seller, so the buyer does not exercise the option at date 5 in SPNE. However the outside option binds, increasing the surplus the buyer captures in the bargaining outcome at date 4, from \( \beta \) to \( v \). Third, if \( v > 1 \) the buyer foregoes trade with the seller and takes the outside option at date 5 in SPNE.
A necessary condition for the project to be jointly optimal is $\overline{v} > 1$. In this case, any project realization $v \in (1, \overline{v}]$ would improve the gross joint surplus (gross of project cost $y$) by $v - 1$. From the perspective of buyer-seller joint surplus, then, the project is worth undertaking only if

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

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

From the buyer’s perspective, however, the project is worth undertaking in a regime of spot trade so long as

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

where again $\beta$ is the surplus the buyer would obtain in date 4 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, reaping a private gain of $v - \beta$ from the project. If $\bar{v} > 1$, then 
for project realizations $v > 1$ the buyer forgoes trade with the seller 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 $y \leq y_J$:

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

(3)

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

$$
y_P \equiv \int_\beta^\infty (x-\beta)f(x)\,dx.
$$

(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 the project is privately 
profitable to the buyer in expectation, but reduces expected joint surplus. For project 
costs in this range, the difference $y - y_J$ represents 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 $y \in (y_J, y_P]$.

**Definition 1.** There is a holdout investment problem if condition (2) holds but condition 
(1) does not.
**Proposition 1.** There is a holdout investment problem if and only if the outside option project’s cost $y$ is such that $y_J < y \leq y_P$. 

**Proof.** Follows immediately from the foregoing development. □

The private and joint project choices would diverge under spot trade if $y_J < y \leq y_P$. In this case, the buyer could gain privately in expectation by undertaking the project, although doing so would lower expected joint surplus net of project costs. Conversely, the private and joint project choices align for $y > y_P$ or $y \leq y_J$. For $y > y_P$, the project is unprofitable both privately and jointly. For $y \leq y_J$, the project is profitable both privately and jointly. In either case, note that the parties can rely on spot trade to attain the joint optimum. If $y > y_P$ and spot trade is the organizational outcome at date 1, the buyer will not undertake the project at date two. If $y \leq y_J$, the project will be undertaken whatever the organizational outcome at date 1. In particular, neither contracting nor vertical integration pareto dominate spot trade in this case. This leads immediately to:

**Proposition 2.** If there is no holdout investment problem, there is a SPNE in which the buyer and seller spot trade.

The divergence between private and joint incentives to undertake the project is due to a bargaining externality. Under spot trade, 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 vertical integration or possibly through long-term contracting.
4. Long-term Contracting

The remainder of the paper focuses on the interesting case in which a holdout problem exists (i.e., condition (2) holds but condition (1) does not), so that the buyer would undertake the project in a regime of spot trade, but doing so would lower joint surplus.

In this case the parties could gain by deterring the buyer from undertaking the project. They might do so, for example, by vertically integrating at date 1. By assumption, the buyer’s investment in the project is observable to the seller and plausibly would also be observable to the headquarters of the merged firm. Headquarters might then simply direct the purchasing division not to undertake the project, or deny the division access to the necessary resources.\(^8\) In his classic study of the transfer pricing practices of firms, Eccles (1985) finds that firms often mandate internal trade, denying the purchasing division recourse to an outside procurement option.

The principal question addressed here is whether long-term contracting can deter an inefficient project. The consolidation of firms—merging workforces, assets and management teams—involves substantial costs that do not attend contracting. If the holdout investment problem could be solved easily through contracting, it seems plausible that contracting would be preferred over integration.

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\(^8\) The firm can deny a division access to physical capital the firm owns and controls. The firm can also effectively deny financial capital, if division managers would have difficulty raising capital externally upon leaving the firm. However, vertical integration may fail to solve the holdout problem if the resources critical to the project are primarily human capital. See in particular the discussion of Maurice Saatchi’s departure from Saatchi & Saatchi in Section 5.
**Definition 2.** In the basic setting, a contract solves the holdout investment problem if the contract budget balances ex ante (inclusive of any side payment) and the side payment is within the payer’s financial means, the contract satisfies both parties’ participation constraints, and the buyer foregoes the outside option project in the resulting SPNE.

Although the project is noncontractible, a long-term contract may deter the inefficient investment in the post-contract SPNE by delivering to the buyer enough of the surplus from trade with the seller that the buyer does not find it profitable to undertake the outside-option project.

**Proposition 3.** If there is a holdout investment problem and a feasible contract that solves the problem, then:

(i) there is a SPNE in which the parties sign the contract, and

(ii) there is no SPNE in which the parties spot trade.

**Proof.** The proof follows immediately from the efficiency of bargaining at date 1 and by hypothesis that the contract pareto dominates spot trade by solving holdout. □

Hereafter, the discussion focuses on whether there is a feasible contract that solves the holdout problem. If there is, then by Proposition 3 there is a SPNE in which the parties sign the contract and there is no SPNE in which the parties spot trade.

As shown below, the amount of surplus a contract must deliver to the buyer for incentive compatibility depends on the strength of the contractual commitment (e.g., whether the contract is take or pay, or buyer option). The contracted price must be low enough that the buyer cannot gain in expectation by undertaking the project, given the
prospect of renegotiating an even lower price at date 4 if a sufficiently favorable project outcome is realized at date 3.

For the organizational outcome of spot trading at date 1, let \( u_b(\beta; y) \) denote the buyer’s expected surplus the if the buyer undertakes the project at date 2:

\[
u_b(\beta; y) = \beta F(\beta) + \int_\beta^\tau x f(x) dx - y .
\]

(5)

With probability \( F(\beta) \) the outside option realized at date 3 does not bind, in which case the buyer receives \( \beta \) in the bargaining outcome at date 4. For any project realization \( v > \beta \), the buyer receives \( v \) in the bargaining outcome or by taking the outside option.

Likewise let \( u_s \) denote the seller’s expected surplus if the buyer undertakes the project:

\[
u_s = (1 - \beta) F(\beta) + \int_\beta^{\min\{\tau, 1\}} (1 - x) f(x) dx .
\]

(6)

With probability \( F(\beta) \) the buyer’s outside option does not bind, in which case the seller receives \( 1 - \beta \) in the bargaining outcome at date 4. 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 forgoes trade with the seller and takes the outside option.

The values of \( u_b(\beta; y) \) and \( u_s \) set outer bounds to what organizational deal can be struck at date 1. The buyer must obtain at least \( u_b(\beta; y) \) from the terms of a merger or contract deal; otherwise the buyer would prefer spot trade. Likewise the seller must obtain at least \( u_s \).
4.1 Take or Pay Contracts

Let \( z \) denote the surplus the buyer would receive from trade at date 5 given that a particular take or pay contract has been signed at date 1. The take or pay contract obliges the buyer to pay the contracted purchase price of \( 1 - z \) regardless of whether the buyer accepts delivery of the good. The buyer is willing to sign a take or pay contract \( z \) so long as the surplus the contract yields the buyer is at least as great as the buyer’s expected surplus from spot trade:

\[
z - u_b(\beta; y) \geq 0. \quad (\text{buyer participation constraint; take-or-pay}) \quad (7)
\]

Importantly the buyer, upon signing a take or pay contract \( z \) that satisfies condition (7), cannot thereafter gain in expectation by undertaking the project, despite the prospect of renegotiating the contract at date 4 in case of a favorable project outcome realized at date 3. This is because a take or pay contract \( z \) guarantees the seller surplus of \( 1 - z \). In any renegotiation of the contract at date 4, the seller is assumed to have the outside option of requiring enforcement at date 5 of the contractual provision that the buyer pay the seller \( 1 - z \) regardless of whether the buyer takes delivery. In Watson’s (2007) mechanism design terminology, this contract enforcement is private rather than public. That is, the seller retains the right to compel the buyer to adhere to the original contract’s terms at date 5. Thus a take or pay contract \( z \) that satisfies condition (7) is incentive compatible with project deterrence.

The seller is willing to sign a contract\(^9\) \( z \) so long as

\[
\sigma + 1 - z - u_s \geq 0, \quad (\text{seller participation constraint}) \quad (8)
\]

\(^9\) Note that condition (8) applies to both take or pay and buyer option contracts, so long as the contracts are incentive compatible and renegotiation proof.
where $\sigma$ is a side payment the seller receives from the buyer upon signing the contract at date 1, $1 - z$ is the surplus the seller receives under the contract upon trade execution at date 5 (given that the contract deters the project), and $u_s$ is the seller’s foregone expected surplus under spot trade (from equation (6)), given that the buyer would undertake the project under spot trade.

Lemma 1 is key to establishing that there are take-or-pay contracts that solve the holdout problem.

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

**Proof.** See the Appendix.

Lemma 1 implies that there is a range of take or pay contracts $z \in [u_b(\beta; y), 1 - u_s]$ that satisfy the buyer’s participation constraint (7) as well as the seller’s participation constraint (8) for $\sigma = 0$. That is, no side payment is necessary to induce the seller’s participation in take or pay contract $z$ that deters the project. This leads immediately to:

**Proposition 4.** For any holdout investment problem, there is a take or pay contract that solves the problem without requiring the buyer to make any side payment to the seller ($\sigma = 0$).

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$^{10}$ For simplicity, condition (8) assumes no time discounting across dates, or else $\sigma$ and all other magnitudes can be considered to all be denominated in date 5 dollars.
4.2 Buyer Option Contracts

Now suppose that take or pay contracts are not feasible. Rather, contracts must take a buyer option form, in which the buyer can take an outside procurement option without incurring any liability for breach. The strength of contractual commitment is now much weaker than in the take or pay case. The buyer’s commitment to trade with the seller upon signing a buyer option contract is limited to the opportunity cost the buyer faces: in taking the outside option the buyer would sacrifice the opportunity to trade at the contracted price.

Suppose the parties sign a buyer option contract \( z \) at date 1, i.e. a contract that delivers trade-contingent\(^{11}\) surplus of \( z \) to the buyer. If the buyer were thereafter to undertake the project at date 2 and realize an outside option of \( v \in (z,1] \) at date 3, then at date 4 the buyer could renegotiate the contract to obtain the higher surplus \( v \) from trade with the seller. Likewise, if the realized option were \( v > 1 \), the buyer could obtain surplus of \( v \) by foregoing trade with the seller and taking the outside option.

A buyer option contract deters the buyer from undertaking the project only if

\[
z - u_b(z;y) \geq 0, \quad \text{(buyer IC constraint; nonbinding } z) \tag{9}\]

where \( u_b(z;y) \) is given by equation (5) upon the replacement of \( \beta \) with \( z \).

Condition (9), the buyer’s incentive compatibility constraint with a buyer option contract, is harder to satisfy than condition (7), the buyer’s participation constraint with a take-or-pay contract. Note that, for a take-or-pay contract, the buyer’s expected net gain from undertaking the project, \( u_b(\beta;y) - z \), decreases dollar-for-dollar in the relevant

\(^{11}\) The trade-contingent payoff is gross of any date 1 side payment the buyer may have had to pay the seller to satisfy the seller’s participation constraint.
range with the trade-contingent surplus $z$ the contract delivers to the buyer. For a buyer-option contract, however, the buyer’s expected net gain from undertaking the project, $u_b(z; y) - z$, decreases by less than dollar-for-dollar with $z$:

$$\frac{\partial}{\partial z}(u_b(z; y) - z) = -(1 - F(z)) < -1, \quad \text{for } z \in \beta, \bar{z}. \quad (10)$$

There are also diminishing returns to this investment deterrent effect of buyer-option contracts. Differentiating equation (10) yields

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

Let $z(y)$ be implicitly defined by exact equality in condition (9):

$$z(y) - u_b(z; y) \equiv 0. \quad (12)$$

That is, project deterrence is incentive compatible for the buyer so long as $z \geq z(y)$. Note also that $z(y) > u_b(\beta; y)$, so that it is individually rational for the buyer to sign a buyer-option contract $z \geq z(y)$. Finally, note that $z(y)$ is a differentiable function in the relevant range of $y \in [y_j, y_p]$.

**Lemma 2.** If there is a holdout investment problem, then for a buyer option contract to deter the project (incentive compatibility) it must promise the buyer surplus at trade execution of at least $z(y)$, where $z(y_j) = \min\{\bar{v}, 1\}$, $z(y_p) = \beta$, and $z'(y) < -1$ for $y \in [y_j, y_p]$.

**Proof.** See the Appendix.

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

By Lemma 2, not only is $z' < 0$ but $z' < -1$. This means that the surplus a buyer-
option contract must deliver to the buyer to deter the project increases by more than
dollar-for-dollar with decreases in the project’s cost. This observation is critical to the
later discussion of the buyer’s incentive to sink some investment into the project prior to
coming to the contract bargaining table.

Perhaps a surprising result in Lemma 2 is $z(y_J) = \min \{\nu, 1\}$. 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 5.** If there is a holdout investment problem and only buyer option contracts
are feasible, then:

(i) if project cost $y$ is such that $1 - z(y) - u_s \geq 0$, there is a contract that solves
the holdout investment problem with no side payment ($\sigma = 0$).

(ii) If instead $1 - z(y) - u_s < 0$, a contract that satisfies incentive compatibility
involves a strictly positive side payment of $\sigma \geq u_s - (1 - z(y)) > 0$ to satisfy
the seller’s participation constraint. In this case, there is a contract that
solves the holdout investment problem only if the buyer’s wealth or access to
external financing exceeds $u_s - (1 - z(y))$.

**Proof.** Follows from equation (8) and Lemma 2. □
To illustrate Proposition 5(ii), consider the case in which $1 - \bar{v} - u_s < 0$. By Lemma 2, there is a range of project costs $y$ above but close to $y_J$ such that $z(y)$ is below but close to $z(y_J) = \min\{\bar{v}, 1\}$, which implies $1 - z(y) - u_s < 0$. The lowest value of $z$ that could satisfy the buyer’s incentive compatibility constraint (9) is $z(y)$, but this exceeds the highest value of $z$ that could satisfy condition (8), the seller’s participation constraint of $1 - z - u_s \geq 0$, given $\sigma = 0$. In this case, any buyer-option contract $z$ that satisfies the buyer’s incentive compatibility constraint, $z \geq z(y)$, requires that the seller be paid a signing bonus of $\sigma \geq u_s - (1 - z(y)) > 0$ to be willing to sign the contract.

Perversely, the smaller the holdout problem, the “harder” it is to solve through a buyer-option contract, in the sense that the minimum ex post surplus the buyer must be promised to secure incentive compatibility is higher,\(^{12}\) and by the same token the minimum ex ante side payment the seller must receive to satisfy the seller’s individual rationality constraint tends to be higher as well.

The side payment required to induce the seller to sign a buyer-option contract that solves the holdout problem can be large. Suppose $\bar{v} > 1$, so that $z(y_J) = 1$ by 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, $z(y) \approx 1$, 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, $\sigma \approx u_s$. Note that this extreme case is equivalent to a cash buyout of the seller’s interests that leaves the buyer residual claimant to the joint surplus.

\(^{12}\) Although it can never exceed the unit joint surplus from internal trade, by Lemma 2.
4.3 Financial Constraints

Proposition 5 indicates that when contractual commitment is weak (only buyer-option contracts feasible), incentive compatibility may require that the contract promise the buyer the lion’s share of joint surplus at trade execution, in which case the seller may be unwilling to sign the contract without receiving a large up-front side payment from the buyer. Wealth or financial constraints may make it impossible or prohibitively costly for the buyer to muster capital for the requisite side payment.\(^ {13} \)

This suggests that when contractual commitment is weak, vertical integration may sometimes be a superior alternative to long-term contracting as a solution to the holdout problem. Vertical integration is, in effect, a means for the buyer to strongly commit to not undertaking the project, by ceding control of the investment decision to headquarters of the merged firm. For the buyer to be willing to merge, however, the merger deal must give the buyer at least the surplus the buyer would obtain in expectation by undertaking the project and engaging in spot trade. That is, the seller must “buy out” the buyer’s holdout interest. When contractual commitment is weak, as in a buyer-option contract, and the buyer faces financial constraints, contracting may be a very costly means to deter the inefficient project, because the buyer must to some extent “buy out” the seller’s interest through a side payment.\(^ {14} \) If the seller’s pockets are deeper than the buyer’s, or the seller’s access to financial markets is superior, it may be more efficient for the seller

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\(^ {13} \) See Hubbard (1998) for a recent survey of research on capital market imperfections.

\(^ {14} \) Note that in the limit as the holdout problem \( y - y_f \) becomes vanishingly small, incentive compatibility requires a buyer-option contract to deliver to the buyer the entire joint surplus at trade execution. In this case the buyer option contract is similar to a merger in which the buyer acquires the seller’s entire interest to become residual claimant to the joint surplus from trade.
to buy out the buyer’s interest through a merger than for the buyer to buy out the seller’s interest through a side payment to enter a long-term contract.

5. Investment Before Contracting

In the basic setting of Section 4, the game timeline has the buyer and seller bargaining over contract terms (at date 1) before the buyer has any opportunity to invest in the outside-option project (at date 2). Now consider that two additional dates, date \( -1 \) and date 0, are appended to the left of the timeline depicted in Figure 1. Date \( -1 \) is a clone of date 1: the parties can bargain over their organizational form (vertical integration, long-term contract, or spot trade). Likewise date 0 is a clone of date 2: the buyer has an opportunity to invest some or all of the cost \( y \) of the outside-option project.

Extending the game in this way allows the buyer an opportunity to sink some investment (at date 0) before reaching a contract deal (at date 1). Can the buyer gain strategically by doing so? The answer is always “no” for take-or-pay contracts but may be “yes” for buyer-option contracts. (See Figure 3 below.)

Recall that, for a take-or-pay contract \( z \), the buyer’s expected net gain from undertaking the project, \( u_b(\beta; y) - z \), decreases dollar-for-dollar in the relevant range with the trade-contingent surplus \( z \) the contract delivers to the buyer. This is reflected in Figure 3 in the 45 degree line that represents the (minimum) buyer surplus a take-or-pay contract must deliver at trade execution to assure incentive compatibility. Now suppose the buyer were to refuse to sign a contract at date \( -1 \) and subsequently were to sink an investment of \( \delta \in (0, y - y_J) \) into the project at date 0. Doing so would strengthen the buyer’s holdout threat in contract negotiations at date 1, because the (nonsunk) cost of completing the project would fall to \( y - \delta \). This enables the buyer to negotiate a more
favorable contract. However the buyer’s surplus from the resulting contract negotiated at date 1 (gross of the sunk cost $\delta$) would increase only by $\delta$, relative to the buyer’s surplus from the contract that otherwise would have been reached at date $-1$. Thus the buyer could not gain from such a maneuver; it is a SPNE for the buyer and seller to sign a contract at date $-1$ that solves the holdout problem.

![Diagram of Project Cost vs. Surplus](image)

**Figure 3. Incentive Compatibility Constraints in Contracting**

In contrast recall (from equation (10)) that, for buyer-option contracts, the buyer’s expected net gain from undertaking the project, $u_b(z) - z$, decreases by less than dollar-for-dollar with $z$. This implies that the buyer could gain, relative to signing a contract at date $-1$, by refusing to sign a contract at this date, sinking a partial investment into the project at date 0, and negotiating better contract terms at date 1. In particular, if vertical integration were barred then the buyer would do best, in the situation depicted in Figure 3, to refuse to engage in contract negotiations at date $-1$, invest $\delta = y - y^*$ in the project at date 0 and negotiate a contract at date 1 that solves the remaining holdout problem of $y^* - y_j$. By vertically integrating at date $-1$, the parties could jointly gain $\delta$
by deterring this wasteful investment that would arise in the best contractual alternative. Therefore the only SPNE in this case is vertical integration at date \(-1\).

This suggests another rationale for vertical integration. When contractual commitment is weak, the buyer has an incentive to strategically sink some investment in the outside-option project before coming to the contract bargaining table. Only vertical integration can then potentially solve the holdout problem.

The points in the foregoing discussion are summarized in Proposition 6:

\textbf{Proposition 6.} Suppose there is a holdout investment problem in the extended game.

(i) If take or pay contracts are feasible, there is a SPNE in the parties sign a contract at date \(1\) that specifies trade at the price \(1 - u_b(\beta; y)\), which solves the problem.

(ii) Let \(y^* \equiv 1 - u_s\). With buyer option contracts:

a. if \(y \in (y_f, y^*)\) and the buyer faces no binding financial constraint, in the unique SPNE the parties sign a contract at date \(1\) that specifies trade at price \(1 - u_b(\beta; y)\) and the buyer makes a side payment to the seller of \(\sigma = u_b(\beta; y) - (1 - u_s)\).

b. if \(y \in (y^*, y_r]\), in the unique SPNE the buyer invests \(y - y^*\) at date \(0\) and the parties to sign a contract at date \(1\) that specifies trade at the price \(1 - z(y^*)\).
6. Discussion

Holdout investment problems appear to be common throughout the economy, as suggested by the following examples.

■ Make-or-buy decisions. Consider the following two scenarios. First, an independent buyer must decide 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. Project decisions of this type are ubiquitous throughout the economy. The foregoing analysis shows that vertical integration may be the preferred solution to a holdout problem that an independent buyer has excessive interest in proceeding with project $P$.

■ 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. Potential entry could be viewed as a type of holdout investment 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.

- **Joint operating agreements (JOAs).** A newspaper JOA is a long-term contract between two newspapers (typically a strong morning paper and a struggling afternoon paper in a given area) that consolidates pricing decisions on advertising and subscription rates but preserves separation in editorial content. Although incentives for the weaker newspaper to invest in editorial content (e.g., by maintaining a staff of local beat reporters) are attenuated by the profit sharing structure of JOAs, Romeo et al. (2003) nonetheless find indirect evidence for significant editorial competition within JOAs. Romeo et al. (2003) attribute this to “end-game competition.” At a JOA’s termination date, the weaker newspaper may simply fold or it may remain a viable competitor. In the latter case, the stronger newspaper has an incentive to acquire its erstwhile JOA partner. Ongoing investments in editorial content during the operation of the JOA tend to bolster the weaker newspaper’s acquisition value at the termination date. The U.S. legislation enabling JOAs precludes the parties from solving this holdout investment problem by requiring that editorial decisions be kept separate.

- **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.\(^{15}\) That store brands are so common may reflect a failure to solve holdout through contracting.\(^{16}\)

- **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

\(^{15}\) 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.

\(^{16}\) 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.
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.\(^\text{17}\)

8. Conclusion

This paper has explored holdout investment, a coordination problem that arises in a wide variety of contexts. If the buyer and seller will bargain over spot trade, the buyer’s expected gain from developing an outside option prior to bargaining typically exceeds the joint gain, given rent shifting when the realized option is inferior to the seller’s existing technology but the outside option binds in subsequent bargaining. Long-term contracting can solve the holdout problem in many cases. If contractual commitment is weak, however, vertical integration may be superior to contracting as a solution to the holdout investment problem. In particular, only vertical integration can potentially solve the holdout investment problem when the buyer has an opportunity to strategically sink some investment into the outside option project before coming to the contract bargaining table. Solving a holdout investment problem improves welfare in the absence of externalities. However holdout investment can benefit third parties, such as final consumers.

\(^{17}\) 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 (\textit{supra} note 16), the holdout investment 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.
Appendix

Proof of Lemma 1: Proof of part (i):

Note first that equation (5) can be written as

\[ u_b(\beta; y) = \beta + \left( \int_{\beta}^{\bar{\nu}} (x - \beta) f(x) \, dx - y \right). \]

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

\[ u_b(\beta; y) = 1 + \int_{\beta}^{1} (x - 1) f(x) \, dx + \left( \int_{1}^{\bar{\nu}} (x - 1) f(x) \, dx - y \right). \]

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

\[ u_s + u_b(\beta; y) = F(\min\{\bar{\nu}, 1\}) + \int_{\min\{\bar{\nu}, 1\}}^{\bar{\nu}} x f(x) \, dx - y. \quad (A1) \]

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

\[ u_s + u_b(\beta; y) = 1 - y, \]

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

\[ u_s + u_b(\beta; y) = 1 + \left( \int_{1}^{\bar{\nu}} (x - 1) f(x) \, dx - y \right), \]

where the parenthetic expression on the right-hand-side above is nonpositive by hypothesis that condition (1) does not hold..
Proof of Lemma 2: Replacing $\beta$ with $z$ in equation (5) yields

$$ u_h(z; y) \equiv z F(z) + \int_z^\infty x f(x) \, dx - y \tag{A2} $$

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

$$ z - u_h(z; y) = y - \int_z^\infty (x - z) f(x) \, dx, \tag{A3} $$

noting that $-z \int_z^\infty f(x) \, dx = -z [1 - F(z)]$. Define $z_0$ implicitly by $z_0 - u_h(z; y) \equiv 0$. This together with equation (A3) yields

$$ y - \int_x^{z_0} (x - z_0) f(x) \, dx = 0. \tag{A4} $$

By the implicit function theorem, equation (A4) defines a function $z(y)$. Totally differentiating (A4) with respect to $y$ and $z_0$ yields $z'(y) = \frac{\partial z_0}{\partial y} = \frac{-1}{1 - F(z_0)} < -1$ in the relevant range. Evaluating (A4) at $y = y_+$ by substituting equation (4) into (A4) yields

$$ \int_\beta^\infty (x - \beta) f(x) \, dx - \int_x^{z_0} (x - z_0) f(x) \, dx = 0, $$

which implies $z(y_+) = \beta$. Finally, determining $z(y_-)$ requires that the two cases $\overline{v} > 1$ and $\overline{v} \leq 1$ in equation (3) be taken in turn. For $\overline{v} > 1$, evaluating (A3) at $y = y_-$ yields

$$ \int_1^{\overline{v} - 1} (x - 1) f(x) \, dx - \int_x^{z_0} (x - z_0) f(x) \, dx = 0, $$

which implies $z(y_-) = 1$. For $\overline{v} \leq 1$, $y = y_- = 0$ yields

$$ -\int_x^{z_0} (x - z_0) f(x) \, dx = 0, $$

which implies $z(y_-) = \overline{v}$. Thus $z(y_-) = \min\{\overline{v}, 1\}$. \qed
References


