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THE VALUE OF CONTRACTING WITH THE SEQUENTIAL INVESTMENTS: THE ROLE OF OUTSIDE VALUES

KYOUNGWON RHEE*

This article addresses two issues in understanding whether contracting subject to renegotiation can provide the right incentives for investments: the degree of specificity of investments and the sequentiality of investments. The paper considers an environment in which the seller makes a specific investment and then the buyer undertakes an investment. Assuming the general investment, recent articles argue that option contracts can achieve the first best outcome. This article shows, however, that their result is not robust when the first investment is specific. In particular, option contracts cannot do better than no contract. Moreover, this paper proves that contracting replicates at best no contract. Our results imply that the value of contracting depends heavily on whether the first investment is general or specific in the sequential investment environment.

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I. INTRODUCTION

It is well known that in bilateral trade without contracts, holdups discourage trading parties' incentives for relationship specific investments,

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* I am grateful to Yeon-Koo Che and Larry Samuelson for their helpful comments. Department of Economics, Dongguk University, 3-26 Pil-dong, Joong-gu, Seoul, Korea, 100-715. E-mail: krhee@dongguk.edu

leading to underinvestments.[1] However, recent studies have argued that although renegotiation is not prohibited, appropriately designed contracts can solve the holdup problem, so that contracting parties are given the efficient incentives for investments (for example, see Chung (1991), Aghion, Dewatripont, and Rey (1994), Nöldeke and Schmidt (1995), and Edlin and Reichelstein (1996)). In contrast, Che and Hausch (1999) show that the first best outcomes may not be attainable through contracting with renegotiation. These opposite claims rely crucially on the nature of investments. That is, the former argument holds when selfish investments are concerned, whereas the latter proves true when cooperative investments are significantly involved. Selfish (rep. cooperative) investment is the one which gives the benefit directly to the investor (rep. trading partner).[2]

Those results are derived under the assumption that the parties undertake their investments simultaneously. Recently, Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000) analyze the holdup problem when one party (say, a seller) invests ahead of trading partner (say, a buyer).[3] [4] Renegotiation is assumed not to be prohibited. The buyer receives a direct benefit from their investments conditional on trade with the seller, which we shall refer to as *internal* trade. In addition, the seller has the value of the good in the event of no internal trade with the buyer in question. For example, the seller can capture some surplus from trading with other buyers, which we shall refer to as *external* trade.[5] They show that the sequentiality of investments plays an important role on parties' ability to achieve the first best outcome. Their argument depends

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[1] The holdup problem has been also known to be unavoidable both when contracting is incomplete and when the parties cannot commit not to renegotiate original contracts ex post. See Hart (1995).

[2] See Che and Hausch (1999) for more examples of cooperative investments.

[3] The model of Edlin and Hermalin (2000) restricts the timing of trade to only after the seller's investment before the buyer's, while the latter also allows trade to occur after the buyer's investment.

[4] Trade interpretation is our version of their models. In particular, Nöldeke and Schmidt (1998) adopt the ownership structure model. More precisely, the models are intended to answer a question of who, between the first investing party and the second one, should own the value of the project in order to achieve the first best.

[5] The seller also can consume the good and then receive some benefit. In what follows, however, we assume that the seller produces an intermediate good but is not a user of the good so that she cannot benefit directly from the good.

critically on the assumption that the buyer and the seller have the equal valuation for the good. That is, parties' investments can create outside value that is equal to inside one. Furthermore, this assumption includes that the marginal contribution of each party's investment to the value of internal trade is exactly the same as that to the value of external trade. Thus, the investments undertaken by the buyer and seller in Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000) are *general*.

We are interested in the case where the parties make investments that are *specific* to the value of trade between them. Put it differently, those investments can generate the greater surplus from internal trade than from external trade. Moreover, the marginal contribution of each party's investment is larger to internal trade than to external one. This follows the requirements of relationship specific investments suggested by Grossman and Hart (1986) and Hart (1995). Most of recent papers assume that parties gain nothing from no trade, which does not hurt the above characteristics of relationship specific investments. Indeed, general and specific investments each may generate the different values of trades, and further affect the value of contracting differently.

Consider, for instance, a relation between a producer of parts of an automobile and a car maker, where the former is the seller and the latter is the buyer of components. The car maker assembles those parts into cars and realizes his profit by selling the cars in a market. We also take into account an environment where they invest sequentially in that one party's investment precedes the other's, which is commonly observed. The producer of parts puts efforts for improving the quality of their parts. The parts producer's efforts are mostly made ahead of car maker's investments such as advertisement and repair services for enhancing the demand of cars, or introducing new assembly technology for cost reduction.

Investments made by the parties may not have the same characteristics. If the parts producer invests for developing the machine which lowers error rates or for new design, her investments are valuable not only to the internal trade with the car maker but also to the parts producer's external trade with other car suppliers, i.e., general investments. On the other hand, the parts producer can invest for developing the model of parts fitting into the car. Fisher Body – GM's classical example fits here. Such investments do not generate any value to the cars made by other car makers, and thus do not give any direct benefit to the parts producer in the event of external trade. In that sense, that kind of investment is characterized as specific to internal trade.

When relationship specific investments are considered, the result by Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000) does not shed lights on whether the parties can achieve the best. This is because relationship specific investments not only create less surplus from external trade, but also have less marginal impact on the gains from external trade than general investments. This paper explores the parties' ability to achieve the first best when the seller, an intermediate good supplier, makes specific investment before trade, and the buyer undertakes investment after trade. In order for a clear comparison, we choose the same model as in Nöldeke and Schmidt (1998) except that the investments are specific, in that both parties receive nothing when no internal trade takes place. That is, the buyer values the good higher than the seller in our model, while the parties have the equal valuation in the model of Nöldeke and Schmidt. Thus, the seller's external value is no longer available. Both parties' investments increase the buyer's value of the good. If the seller's investment is specific, then the seller's investment has a cooperative aspect and the buyer's a selfish one.

The parties can secure the efficiency when the seller makes general investment. The reason is as follows. Consider first what happens in a market, i.e., with no contracting. Since the parties value the intermediate good equally after the seller's investment but before the buyer's investment, the buyer is not valuable to the seller. If trade does not take place, then the buyer has no incentive to make an investment. However, the internal trade is efficient, because the buyer invests after acquiring the good. While bargaining for internal trade, the seller's valuation for the good plays a role of threat point. This implies that if the seller's and buyer's investments are substitutes, the seller has an excessive incentive to invest for fostering her threat point, because the seller captures some value from external trade without the buyer's contribution. However, they can design an *option contract* which dampens the seller's overinvestment incentive which would arise without contracting. Furthermore, such an option contract can give the seller the right incentive for investment. So, the first best is achieved.

Unlike Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000), we show that when the investment made by the seller, the first investor, is relationship specific, no option contract achieves the first best. To see this, consider first what happens in a market. When the seller's investment is specific, unlike the preceding case, the buyer is valuable to the seller at the trading stage. While the internal trade is efficient for the parties, the seller cannot use the value from external trade for her threat point in the bargaining. This means that the only holdup problem remains, leading to underinvestment. Hence, an option contract used to alleviate the investment incentive cannot provide the seller the right incentive for investment. Specifically, the paper contends that option contracts cannot do better than no contract. This means that option contracts at best replicate the no contract outcome. Moreover, we prove that contracting fails to induce the seller's investment incentive higher than no contract, thereby no value of contracting.

Our results imply that the value of contracting depends heavily on whether the first investment is general or specific. Our findings are related to those by Che and Hausch (1999). They show that the first best outcomes are not achievable in the following setup: investments are (i) specific, (ii) significantly cooperative, and (iii) simultaneously made by the trading parties. De Fraja (1999) notes the importance of the sequentiality of investments to solve the holdup problem even when the investments are cooperative. However, his argument holds only in a very special condition, and does not apply in more general environment, as shown by Che (2000) and Fares (2006).

Related to our discussion, there are another lines of arguments which cast doubt on the value of contracting. Smirnov and Wait (2004) contend that the sequentiality of investments may arise as a source of inefficiency due to the possibility that a party will profitably opt out of the relationship during the whole investment phase. Swinnen and Vercammen (2006) identify uncertainty as another source of inefficiency which can hardly be solved in the environment of weak contract enforcement.

The paper is organized as follows. Section Ⅱ illustrates the model. Section Ⅲ shows no contracting outcomes. Section Ⅳ discusses whether the optimal contracts can achieve the first best. Section Ⅴ concludes.

II. THE MODEL

Consider a relationship between two parties, a buyer (B) and a seller (S). S produces an intermediate good at 0 cost. B intends to use the good as an input in order to generate his own value.[6] B demands at most one unit of the good. We adopt a deterministic model. Suppose that B expends a level of investment, $b \in R_+$, and that S chooses a level of investment, $s \in R_+$. The investments made by both B and S directly affect B's value of the good, $v(s,b) \geq 0$ for all s and b. We assume that $v(s,b)$ is continuously differentiable, strictly increasing, and strictly concave in each argument. It is further assumed to satisfy $\lim_{s\to\infty} v_s(s,\cdot) = \lim_{b\to\infty} v_b(\cdot,b) = 0$ and $\lim_{s\to\infty} v_s(s,\cdot) = \lim_{b\to\infty} v_b(\cdot,b) = \infty$, where $v(s,b)$ denotes partial derivative with respect to investment $i = s,b$.

We consider an environment in which sequential investments are involved,[7] specifically, S invests s and then B puts forth b. Trade between B and S can take place after S's investment but before B's investment.[8] Before S invests, the parties may sign a contract governing their trade. We assume that the level of investment, s, is observable to the parties, but unverifiable to a third party (e.g. a court).[9]

[6] An interpretation of the relation between B and S is that in a vertical relation B is a retailer or a final good manufacturer, while S is an input supplier.

[7] Most existing papers have focused on the cases in which one of trading partners invests or both invest simultaneously. In Shavell (1980) and Rogerson (1984), only one party invests. Hart and Moore (1988), Chung (1991), Aghion, Dewatripont, and Rey (1994), Nöldeke and Schmidt (1995), Edlin and Reichelstein (1996), and Che and Hausch (1999) deal with the case where two parties make investments simultaneously.

[8] We may allow other possibility for timing of trade; after both parties' investments. One can easily show that when there is no contract, trading before B's investment is more efficient than that after both parties' investments. This is because of the classical holdup problem. That is, B does not invest efficiently when trade occurs after both parties' investments, while he invests efficiently when trade takes place before he invests.

[9] Those variables turn out to consist of the ex post state of nature. The literature on incomplete contracts (e.g. Grossman and Hart (1986) and Hart (1995)) proposes that the unverifiability relies heavily on the existence of "transaction costs": for example, the high cost of verification or the complexity of specifying the relevant events. Such transaction costs can affect contract forms, by which incomplete contracts are commonly observed in practice. Recently, Maskin and Tirole

Thus, a contract cannot be directly contingent upon the variable. Instead, a contract can describe the terms of trade so that a court can enforce those contract terms. We assume that the parties cannot commit not to renegotiate the contract. In addition, renegotiation may occur whenever the parties wish to improve upon an ex post inefficient decision.

If trade occurs between B and S, B makes an investment. Then, B's value $v(s,b)$ is realized. There may occur no trade between them. We assume that in that case, the relationship between B and S is no longer sustainable, and thus that B receives nothing, whereas S can capture some scrap value through dealing with another buyer from external relations. Let $zv(s,0)$ denote the scrap value that S can acquire. This means that B's value $v(s,b)$ is realized upon *internal trade*, i.e., trade between B and S, while $zv(s,0)$ accrues to S upon the failure of internal trade. Assume $z \in [0,1]$ so that a total value generated from their external relations cannot exceed that from internal trade, although there is no B's investment.[10] The sequence of events is summarized as follows.

- Date 1: B and S may write a contract.
- Date 2: S chooses s.
- Date 3: The initial contract may be enforced or renegotiated. $zv(s,0)$ is obtained if no trade takes place.
- Date 4: B expends b if Date 3 trade occurs.
- Date 5: $v(s,b)$ is realized if trade occurs at Date 3.

Note that z plays an important role for S's investment to affect her external value. Specifically, when $z=0$, S's investment has no effect on S's external value, but only on B's value from internal trade. This implies that when $z=0$, S's investment is *specific* to the relationship with B. Moreover, since it gives a direct benefit to B, S's investment is purely *cooperative*. On the other hand, when $z>0$, S's investment influences not only B's value from internal trade but also her scrap value

(1999) and Tirole (1999) argue that the existence of transaction costs itself cannot be a rigid foundation for incomplete contracts.

[10] This is the way to encompass the models by Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000) into ours.

from external trade. Moreover, when $z=1$, S's investment is *general*, because it gives rise to a value equally for both internal and external trades. Therefore, z can be interpreted as the degree of relationship specificity of S's investment. The difference of the gains to trade between internal and external relationships can be written as $(1-z)v$ $(s,\cdot)$. The smaller z, the more important to the internal trade S's investment than to the external trade. Furthermore, the marginal impact of S's investment on this difference is greater as z is smaller. In this paper, we consider two extreme cases, $z \in \{0,1\}$.

Bargaining is assumed to be efficient, implying that the parties agree to an efficient trade decision at Date 3. Whenever a bargaining phase begins, S makes a take-it-or-leave-it offer to B with the probability $\alpha \in [0,1]$, which is exogenously determined. Likewise, B proposes a sharing rule to S on a take-it-or-leave-it basis with the probability $1-\alpha$.[11] For simplicity, we assume that discount factor for the parties is 1. A solution concept adopted is subgame perfect equilibrium.

The First Best Outcome

For a benchmark, we establish the best outcome. Since $v(s,b) \geq zv(s,0)$ for all s, b, and z, internal trade is always efficient. We are required to identify the levels of investments which maximize the total gains to trade. Since internal trade generates the extra surplus by $v(s,b)-zv(s,0)$ compared to external trade, the ex ante payoffs of B and S from trade are respectively $(1-\alpha)[v(s,b)-zv(s,0)]-b$ and $zv(s,0)+\alpha[(s,b)-zv(s,0)]-s$. They are obtained by the bargaining game described above. Then, the ex ante total surplus from trade is given by

$$W(s,b) = v(s,b) - s - b\,.$$

[11] The bargaining game adopted here is explained more accurately as follows. One party is chosen randomly to offer a price of the good for trade. In this model, S is selected with a probability of α, while B with a probability of $1-\alpha$. Once a party offers a price to his trading partner, the latter makes a decision of whether she accepts the offer or not, and then the bargaining game ends. The equilibrium of this bargaining game is subgame perfect. The parties bargain over the extra surplus created by agreeing to an efficient decision whenever an initial decision incurs the inefficiency. In this paper, bargaining can occur at Date 3 or at Date 5.

The first best investments $(s^*, b^*) > (0, 0)$ are characterized by

$$v_s(s^*, b^*) = v_b(s^*, b^*) = 1. \tag{1}$$

Let $b^*(s)$ be B's efficient investment given s, obtained from the first order condition for B's investment decision, $v_b(s, b^*(s)) = 1$.[12]

III. NO CONTRACTING OUTCOME

This section builds another benchmark, no contracting outcome. Together with the first best, it will be compared to the results obtained when the parties are subject to contracting. Suppose that the parties do not sign any contract at Date 1. Using backward induction, begin with exploring B's investment incentive.

Suppose first that the parties reach an agreement for trade at Date 3. Then, a gross return, $v(s, b)$, accrues to B after he expends b. Thus, at Date 4, B solves (exclusive of the terms of trade)

$$\max_b v(s, b) - b .$$

It is easy to see that B can reap the full marginal return to his investment. Thus, given s, he chooses the efficient level of investment, $b^*(s)$. The corresponding first order condition is $v_b(s, b^*(s)) = 1$. The parties expect the gains from trade at Date 3, $v_b(s, b^*(s)) - b^*(s)$.

When the parties do not agree to trade at Date 3, B invests nothing, because he gains nothing in that event. By the way, since S receives $zv(s, 0)$ from external trade, the parties anticipate the joint payoff, $zv(s, 0)$, from no trade at Date 3.

Given s, it is clear that $v(s, b^*(s)) - b^*(s) \geq zv(s, 0)$. That is, the extra surplus created by internal trade is non-negative and denoted by

[12] The first best S's investment, $\hat{s}$, is such that $\hat{s} \in \arg\max_s \ v(s, b^*(s)) - s - b(s)$. $\hat{s}$ is characterized by the associated first order condition, $v(\hat{s}, b(\hat{s})) + [v_b(\hat{s}, b(\hat{s})) - 1]b'(\hat{s}) - 1 = 0$, where $b(s)$ is B's investment in the second period, taking S's investment as given. Note that $\hat{s} = s^*$ only when $b(s) = b^*(s)$ and that $b^* = b^*(s^*)$.

$$ES(s) = v(s, b^*(s)) - b^*(s) - zv(s, 0) .$$

The non-negative extra surplus generated by internal trade implies that the parties have the incentives to trade with each other. In order to determine the terms of trade, as discussed in section 2, S makes a take-it-or-leave-it offer to B with the probability α. Similarly, with the probability $(1-\alpha)$, B is chosen as the party to make a take-it-or-leave-it offer to his trading partner. It is important to see that the threat point for each party in this bargaining game is the payoff that each party would obtain from no trade at Date 3. That is, receives $zv(s, 0)$ from external trade, while B gains nothing. Then, the post-trade payoff for S and B are respectively,

$$\begin{aligned} U_S(s; z) &= zv(s, 0) + \alpha ES(s) - s \\ &= (1-\alpha)zv(s, 0) + \alpha[v(s, b^*(s)) - b^*(s)] - s \end{aligned} \tag{2}$$

$$U_B(s) = (1-\alpha)ES(s)$$

3.1 S's Incentive for General Investment

Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000) study S's ability to achieve the first best when she is involved in general investment, i.e., $z = 1$. In this case, S's expected payoff, (2), turns to be

$$U_S(s; z = 1) = (1-\alpha)v(s, 0) + \alpha[v(s, b^*(s)) - b^*(s)] - s \tag{3}$$

The marginal impact of S's investment on her payoff is then

$$U_S^{'}(s; z = 1) = (1-\alpha)v(s, 0) + \alpha v_s(s, b^*(s)) - 1 \tag{4}$$

The first term of the right hand side of (4) represents the effect of S's investment on the threat point for S. And the second term captures S's portion of the marginal joint return to S's investment through trade at

Date 3.[13] The latter indicates the *holdup effect* implying that S cannot obtain the full marginal contribution of her investment to the surplus created from the trade as long as $\alpha > 0$. Let s^{**} denote the interior solution such that $U_S^{'}(s^{**}; z=1) = 0$ That is, s^{**} is the investment level made by S with no contracting

Note that $v_s(s^*, b^*) = 1$. Then, using (4), we can characterize S's incentive to invest at the efficient level by

$$U_S^{'}(s^*; z=1) = (1-\alpha)[v_s(s^*, 0) - (s^*, b^*)]. \quad (5)$$

Since B invests nothing whenever trade does not occur, it is straightforward that the sign of $U_S^{'}(s^*; z=1)$ depends on substitutability or complementarity of the parties' investments.[14] When the parties' sequential investments are substitutes, the marginal impact of S's investment on her own disagreement payoff is maximal so as to overcome the holdup effect. That is, $U_S^{'}(s^*; z=1) > 0$ for all $\alpha < 1$. Thus, S has an incentive to overinvest $(s^{**} > s^*)$. On the contrary, when their investments are complements, it is minimal. To put it differently, $U_S^{'}(s^*; z=1) < 0$, for all $\alpha < 1$. In this case, she tends to underinvest $(s^{**} < s^*)$. Observe that when the investments are independent, invests efficiently $(s^{**} = s^*)$. The following lemma is our version of Proposition 4 of Nöldeke and Schmidt (1998).

Lemma 1. *Suppose that* S *and* B *invest sequentially, and further that* S *undertakes general investment. With no contract,* S *makes an overinvestment when the parties' investments are substitutable, an underinvestment when they are complementary, and an efficient investment when they are independent.*

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[13] The marginal impact of S's investment on $v(s, b^*(s)) - b^*(s)$ is $v_s(s, b^*(s))$ because B internalizes the changes in S's investment, which is the envelope theorem.

[14] If the cross partial derivative of the two investments, $v_{bs}(b, s)$, has a positive sign, then the two investments are referred to as substitutable. On the other hand, if it has a negative sign, they are defined as complementary.

3.2 S's Incentive for Specific Investments

Let us pursue what incentive for investment S has, when her investment is specific to the internal relationship. In this case, S's external value is no longer available, i.e., $z = 0$.

Unlike the case in which $z = 1$, in the event of no at Date 3, S cannot obtain her scrap value from external trade. More precisely, S's additional specific investment does not affect the surplus from external trade. Thus, each party's payoff is 0, when the parties do not reach an agreement for internal trade. Then, the extra surplus from internal trade is $v(s, b^*(s)) - b^*(s)$, since B will make an efficient investment after trade. The parties' expected payoffs from trade are

$$U_S(s; z = 0) = \alpha[v_s(s, b^*(s)) - b^*(s)] - s \quad \text{for} \quad S, \tag{6}$$

$$U_B(s) = (1-\alpha)[v(s, b^*(s)) - b^*(s)] \quad \text{for} \quad B.$$

In order to analyze S's incentive for investment, we examine the marginal impact of S's investment on $U_S(s; z = 0)$. It is characterized by

$$U_S^{'}(s; z = 0) = \alpha v_s(s, b^*(s)) - 1 \tag{7}$$

Compared to (4), the right hand side of (7) shows the holdup effect only. It is very important to note that when S's investment is specific, S's investment does not give rise to any effect on her threat point. In other words, unlike the case in which $z = 1$, there is no hope to cure the holdup problem, even when the parties' investments are substitutes. S cannot capture the full marginal return from trade to her investment. This leads to underinvestment. It is easy to see that at the efficient level of S's investment, its marginal impact of her own payoff is negative, i.e., $U_S^{'}(s^*; z = 0) = -(1-\alpha)v_s(s^*, b^*) < 0$. We can establish the following lemma immediately.

Lemma 2. *Suppose that* S*'s investment is relationship specific. Then,* *with no contracting,* S *underinvests for all* $\alpha < 1$.

The fact that S's incentive for investment is essentially related with the extent to which her investment is specific deserves to discuss. Interestingly, when S's investment is specific, S underinvests, regardless of substitutability of the parties' investments. This is in contrast to the result by Nöldeke and Schmidt (1998) that overinvests when the parties' investments are substitutes and when S's investment is general.

Once a general investment is made, S's incentive to trade with B is alleviated, compared to the case in which specific investment is undertaken. Moreover, with the opportunity for external trade enabled by general investment, S has the extra incentive for investment to improve her bargaining position. When the parties' investments are substitutes, S's incentive is reinforced, thereby overinvestment. On the contrary, when S's investment is specific, B is indispensable from S's standpoint in order to capture some of the gains from trade. This enables B to hold up some of the returns from S's investment. Since S's disagreement payoff is 0 in this case, her investment incentive is not affected by whether the parties' investments are substitutes or complements. Therefore, S underinvests.

IV. CONTRACTING WITH SPECIFIC INVESTMENT

We have observed that S tends to underinvest when S's investment is specific. Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000) present that an option contract can achieve the first best when S makes general investment. The question still remains whether contracting can correct S's incentive to underinvest when S is engaged in specific investment. In this section, we derive the optimal contracts on incentive to underinvest when S In this section, we derive the optimal contracts only when S's investment is relationship specific, equivalently, S has no external value, i.e., $z = 0$. And then, we investigate whether the optimal contracts encourage S to invest efficiently. For the purpose of comparison with the result by Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000), we first examine whether S's underinvestment incentive is boosted by option contracts which give B the right to exercise option at Date 3 with a fixed option price of p. The option is to purchase the good from S.

4.1. Option Contracts with p

Suppose that B performs his option. Given s, the value (net of the option price) accruing to B turns to be $v(s, b^*(s)) - b^*(s)$, since B will invest efficiently after obtaining the good.

Consider what happens if B does not exercise, given the option price p. We focus on the case that there is no contract for the second period trade. According to the analysis in section 3, B will invest nothing whatever level of B's investment. However, since B chooses $b^*(s)$ once trade occurs, the parties wish to renegotiate the initial contract so that trade takes place before B invests. The bargaining process for renegotiation is just like that for trade with no contracting discussed in section 3. Accordingly, B's post-renegotiation payoff from not exercising is given by $(1-\alpha)[v(s, b^*(s)) - b^*(s)]$.

Since B derives $v(s, b^*(s)) - b^*(s) - p$ from exercising his option, he wishes to perform his option at Date 3 whenever

$$p \le \alpha[v(s, b^*(s)) - b^*(s)]$$

S's payoff corresponding to such B's strategy is

$$U_S(s;\, p) = \min\{p, \alpha[v(s, b^*(s)) - b^*(s)]\} - s$$

Then, we can establish the following proposition.

Proposition 1. *Suppose that S's investment is relationship specific. Then, for all $\alpha < 1$, no option contract achieves the first best outcome.*

proof : It suffices to show that no option contract implements the first best level of S's investment. Suppose that, on the contrary, there is an option price p inducing S to invest efficiently. Then, it must be the one with which B does exercise his option given S's investment, because S underinvests whenever B does not exercise from Lemma 2. Since S is paid a fixed price p whenever option is exerted, she has no incentive to raise her investment above s^*. Check if S has no incentive to deviate below s^*. Suppose that S expends $s' < s^*$. Since the option contract requires B to execute his option, given p and s', S receives p but with the lower cost than s^*. Thus, S wishes to invest s' rather than s^*. It implies that S has an incentive to reduce investment from s^* under any option contract. Contradiction. Q.E.D.

Proposition 1 states that unlike Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000), option contracts are not useful to implement the first best. Suppose that B does not exercise his option. With no trade, B invests nothing. Lemma 2 applies to this case. That is, S tends to underinvest whenever she expects that B will not exercise his option. It is because the holdup effect arises. B's not exercise of his option is not an efficient decision, which leads to renegotiation for trade, implying that the parties share the extra surplus from the renegotiation. Hence, cannot receive the full marginal return to S's investment. This means that no option contract inducing B not to exercise can correct S's incentive to underinvest.

Now consider an option contract under which B wishes to exert his option. Note that the option price specified on this contract must be sufficiently low. Otherwise, B may extract a higher payoff from not exercising his option. Moreover, whenever B is expected to exercise his option, S tends to make no investment because she is given the fixed option price whatever level of investment she chooses. Since the role of option contract is to dampen the incentive for investment, it is difficult for B's exercise of his option to improve S's incentive for investment. This is what Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000) fail to capture with their models, where S's investment is general. They argue that since S will overinvest under no initial contract when the investments made by the parties are substitutes (see Lemma 1), an option contract can be used to achieve the first best by discouraging the overinvestment incentives. Figure 1 depicts the impossibility of option contracts to achieve the first best, for example, with the target price

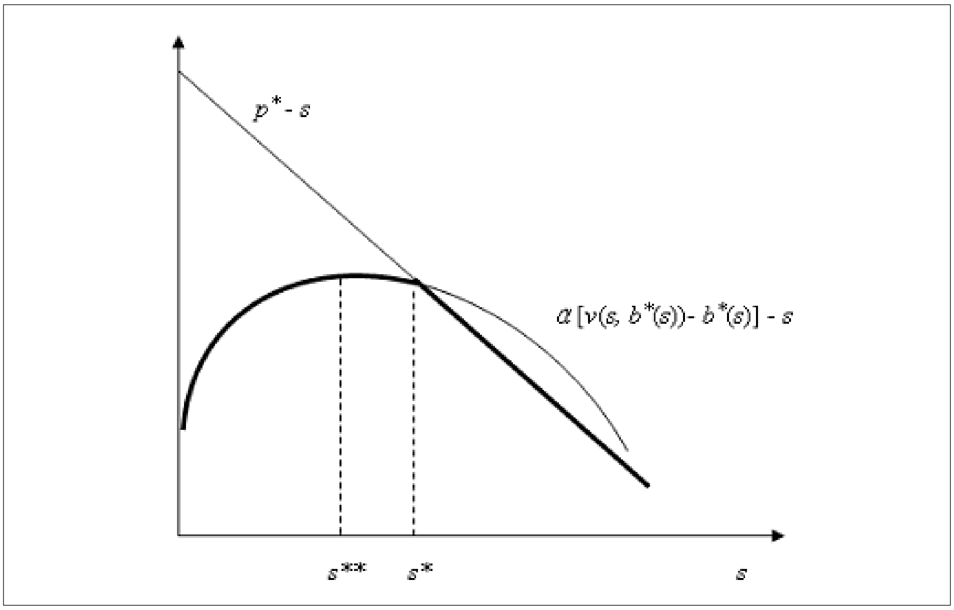
$p^* = \alpha[v(s^*, b^*) - b^*]$.

The following proposition is also obtained. Proposition 1 and 2 tell us that when S's investment is specific, option contracts not only fail to achieve the first best, but also cannot do better than no contract.

Proposition 2. *Suppose that S's investment is relationship specific. Then, for all $\alpha < 1$, option contracts have no value.*

proof : Let $\bar{p} = \alpha[\bar{s}, b^*(\bar{s})) - b^*(\bar{s})]$. This is the strike price which makes B indifferent between purchasing from S and no trade, when S makes an investment at the level of $\bar{s}$. Recall $U_S(s; p) = \min\{p, \alpha[v(s, b^*(s)) - b^*(s)]\}$. Then, S will not make any $s > \bar{s}$, because her payoff turns out to be $U_S(s; p) = \bar{p} - s$ with $s > \bar{s}$. On the other hand, $U_S(s; p) = \alpha[v(s, b^*(s)) - b^*(s)] - s$ for all $s < \bar{s}$. Since $\alpha v_s(s, b^*(s)) > 1$ for $s < s^{**}$ and $\alpha v_s(s, b^*(s)) < 1$ for $s > s^{**}$, S's payoff is maximized at $\bar{s}$ with $s^{**} \geq \bar{s}$, while at s^{**} with $s^{**} < \bar{s}$. Thus, an option contract $\bar{p}$ induces $\min\{\bar{s}, s^{**}\}$. Q.E.D.

[Figure 1] The Impossibility of Option Contract to Achieve the First Best



$p^* = \alpha[v(s^*, b^*) - b^*]$. The thick curve is S's payoff under the option contract.

4.2 General Contracts

One might wonder if there are more complicated contracts that may induce the first best, since option contracts are not effective to achieve the first best. We consider general contracts which are based on what both parties announce about states. The fact that S's investment is not verifiable does not prevent the parties from writing a contract contingent on the parties' verifiable messages.[15] In particular, we consider a general mechanism in which both parties make announcements observable to a third party about S's investment. Denote B's announcement by s_B and S's announcement by s_S. Define a contract space for trade, $q = \{0,1\}$, i.e., q is a trade decision variable. $q = 0$ denotes no trade, while $q = 1$ trade. t is a payment from B to S associated with trade. Both q and t must depend on the parties' reports. Thus, the contract is such that $< q, t >: s_B \times s_S \mapsto \{0,1\} \times R$.

Given a true state s, whenever $q = 1$ is enforced, $v(s, b^*(s)) - b^*(s)$ will be induced as a social surplus (net of S's investment). Suppose that an initial mechanism combined with the parties' announcements induces no trade. Since B does not invest after no trade, it is inefficient for the parties. Expecting B's no investment, the parties renegotiate the initial contract for reaching an agreement for trade. This leads to B's efficient level of investment, $b^*(s)$. The gains from trade is $v(s, b^*(s)) - b^*(s)$. S's post-renegotiation payoff (net of S' investment cost) under a contract $< q(s_B, s_S)$, $t(s_B, s_S) >$ is

$$\tilde{\pi}_S(s_B, s_S; s) = t(s_B, s_S) + \alpha(1 - q(s_B, s_S))[v(s, b^*(s)) - b^*(s)]. \qquad (8)$$

Investigating the impact of S's investment on (8), we can establish the following Proposition.

Proposition 3. *Suppose that S's investment is relationship specific. Then, for all $\alpha < 1$, contracting has no value.*

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[15] Maskin and Moore (1999) and Che and Hausch (1999) establish the formal setup of implementation with renegotiation under complete information. Segal and Whinston (1998) develop the first order approach to the same problem.

proof : Let $\pi_i(s) \equiv \tilde{\pi}_i(s, s; s)$, $i = B, S$. Then, by incentive compatible direct revelation mechanism and the fixed sum property of renegotiation game, the following must hold. For any pair of states (s', s) such that $s' > s$, when B announces s and S reports s' at a state,

$$\pi_S(s) \geq \tilde{\pi}_S(s, s'; s), \tag{9}$$

$$\pi_S(s') \leq \tilde{\pi}_S(s, s'; s'). \tag{10}$$

The first inequality states that the truthful reports by both parties give S a higher payoff. The second inequality depicts that when B's report is different from the true state, S's truthful report provides S with a higher payoff than when both parties report truthfully. These two inequality consist of incentive compatibility.

Then, combining (9) with (10), we obtain the effect of increasing S's investment on S's payoff as follows.

$$\begin{aligned}\pi_S(s') - \pi_S(s) \leq \tilde{\pi}_S(s, s'; s') - \tilde{\pi}_S(s, s'; s) \\ &= \alpha(1 - q(s, s'))[\{v(s', b^*(s')) - b^*(s')\} \\ &\quad - \{v(s, b^*(s)) - b^*(s)\}] - (s' - s) \\ &\leq \alpha[\{v(s', b^*(s')) - b^*(s')\} - \{v(s, b^*(s)) - b^*(s)\}] \\ &\quad - (s' - s).\end{aligned}$$

The last inequality is yielded by the fact that $q(s, s') \geq 0$. From this inequality, we obtain

$$\lim_{s \to s'} \frac{\pi_S(s') - \pi_S(s)}{s' - s} \leq \alpha v_s(s', b^*(s')) - 1 \tag{11}$$

Suppose that $s' > s^{**}$. Then, since $\alpha v_s(s^{**}, b^*(s^{**})) = 1$ for all $\alpha < 1$, the right hand side of (11) is negative. This means that S has no incentive to invest more than s^{**}, which is S's investment level with no contracting. That is, general mechanism can induce at most s^{**}. **Q.E.D.**

Proposition 3 has a novel feature of this paper. It shows that the parties have no ability to do better than no contract by writing any contract when S 's investment is relationship specific and cooperative. When S 's investment is relationship specific, the only hope to give S the incentive to invest is to make the parties not trade whenever their reports are not the same so that they renegotiate the initial contract. However, if the marginal contribution of a target level of investment is less than its marginal cost, then a contract cannot implement that level. In other words, when S tends to underinvest under no initial contract, the maximal level of investment that a contract can implement is the level of investment induced without contracting.

Proposition 1 and 3 are in contrast to Nöldeke and Schmidt (1998) and Edlin and Hermalin (2000), where the first best is easily achieved through contracting with genenral investments. We argue that the degree of relationship specificity of investment is important to determine whether contracting gives the parties the right incentives for investments. Our result is close to Che and Hausch (1999) who prove that when specific investments are highly cooperative, contracting has no value, implying that contracting just replicates at best the no contract outcome. However, they only consider the environment in which the parties invest simultaneously and do not discuss how the degree of relationship specificity affects the value of contracting.

V. CONCLUDING REMARKS

We have studied how the degree of relationship specificity and the sequentiality of investments affect the incentives for investments. With the sequence of cooperative - selfish investments, this paper shows that the trading parties have difficulty in achieving the first best with the fully specific investment, which is incongruent to the previous result with the model of the fully general investments. Furthermore, this paper demonstrates that although the trading parties may want to do better with contracting, they fail to induce higher investment than no contract.

Our results imply that the value of contracting depends heavily on whether the first investment is general or specific in the sequential investment setting. They provide some view on why the degree of specificity of investment should be taken into account for examining the value of contracting.

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