hold-up problem

Hold-up arises when part of the return on an agent's relationship-specific investments is *ex post* expropriable by his trading partner. The hold-up problem has played an important role as a foundation of modern contract and organization theory, as the associated inefficiencies have justified many prominent organizational and contractual practices. We formally describe the main inefficiency hypothesis and sketch out the remedies suggested, as well as the more recent re-examination of the relevance of these theories.

Investments are often geared towards a particular trading relationship, in which case the returns on them within the relationship exceed those outside it. Once such an investment is sunk, the investor has to share the *gross* returns with her trading partner. This problem, known as hold-up, is inherent in many bilateral exchanges. For instance, workers and firms often invest in firm-specific assets prior to negotiating for wages. Manufacturers and suppliers often customize their equipment and production processes to the special needs of their partners, knowing well that future (re)negotiation will confer part of the benefit from customization to their partners. Clearly, the risk of the investor being held up discourages him or her from making socially desirable investments.

We first describe a simple model of hold-up and illustrate the main *underinvestment* hypothesis (see Grout, 1984, and Tirole, 1986, for the first formal proof). A buyer and a seller, denoted B and S, can trade quantity $q \in [0, \overline{q}]$, where $\overline{q} > 0$. The transaction can benefit from the seller's (irreversible) investment. The investment decision is binary, $I \in \{0,1\}$, with $I = 1$ meaning 'invest' and $I = 0$ meaning 'not invest'. The investment I costs the seller $k \cdot I$, where $k > 0$. Given investment I, the buyer's gross surplus from consuming q is $v_I(q)$ and the seller's cost of delivering q is $c_I(q)$, where both v_I and c_I are strictly increasing with $v_I(0) = c_I(0) = 0$. Let $\phi_I = \max_{q \in Q}[v_I(q) - c_I(q)]$ denote the efficient social surplus given S's investment, and let q_I^* be the associated socially efficient level of trade. The net social surplus is then $W(I) := \phi_I - kI$. Suppose that

$$\phi_1 - k > \phi_0, \tag{1}$$

so it is socially desirable for S to invest.

A crucial assumption is that S's investment decision, although observable to the parties, is not verifiable, and therefore it cannot be contracted upon. For the moment, assume as well that the nature of trade is sufficiently 'inchoate' so that the parties can contract on q only after S's investment decision has been made. We model the negotiation of this contract *à la* Nash, yielding an efficient trading decision q_I and splitting the gross surplus ϕ_I equally between the parties. The seller thus appropriates only a fraction (a half, in this case) of her investment return, while she bears the entire cost of investment, k, so her net payoff will be $U_S(I) := \frac{1}{2}\phi_I - kI$, following her investment. Suppose

$$\frac{1}{2}\phi_1 - k < \frac{1}{2}\phi_0. \tag{2}$$

Then, even though the investment is socially desirable, S will not invest. Hence underinvestment arises.

Organizational remedies

One interpretation of the inefficiency is the failure of the Coase Theorem. The parties cannot achieve the efficient outcome since the non-contractibility of S's investment decision prevents them from meaningfully negotiating over that decision *ex ante*. From this perspective, the hold-up problem entails a transaction cost of market/bargaining mechanisms, and, as Coase (1937) suggested, the transaction cost may be avoided or reduced via other organizational structures. Indeed, Klein, Crawford and Alchian (1978) and Williamson (1979) suggested *vertical integration* as an organizational response.

Just how the hold-up problem disappears or at least diminishes through integration is not clear, however, and requires a theory of how a particular ownership structure affects the parties' exposure to hold up. This is precisely what Grossman and Hart (1986) and Hart and Moore (1990) accomplish (see also Hart, 1995, for an excellent synopsis). According to them, the ownership of an asset gives the owner the right to determine the use of the asset that is contractually not specifiable. The parties will still negotiate the terms of trade (presumably to achieve an efficient outcome), but this *residual right* – and thus ownership – matters, since it determines the status quo payoffs of the parties in the negotiation.

To illustrate how the status quo payoffs may affect the incentives, consider our model above and suppose that either B or S can own all assets necessary for the vertical operations. The former type of integration is called B-*integration* and the latter type is called S-*integration*. Fix i-integration and fix S's investment decision $I \in \{0,1\}$. If they fail to agree on the trade decision, party i can unilaterally realize the (status quo) payoff of $\psi_i^i(I)$ and party $j \neq i$ can realize the payoff of $\psi_j^i(I)$. It is reasonable to assume that

Assumption GHM: (i) $\psi_i^i(I) + \psi_j^i(I) \leq \phi_I$, $I \in \{0,1\}$; (ii) $\psi_S^i(1) - \psi_S^i(0) < \phi_1 - \phi_0$; (iii) $\psi_i^i(1) > \psi_i^i(0)$ and $\psi_j^i(1) = \psi_j^i(0)$, for $I \neq j$.

Assumption GHM-(i) means that the status quo is welfare dominated by efficient trade; (ii) means that S's investment is specific to the relationship; and (iii) means that the investment improves the owner's status quo payoff but not the non-owner's.

Given the assumption again that the parties split the surplus over and above the status quo payoffs, S's payoff will be

$$U_S^i(I) = \psi_S^i(I) + \frac{1}{2}(\phi_I - \psi_B^i(I) - \psi_S^i(I)) - kI = \frac{1}{2}\phi_I + \frac{1}{2}(\psi_S^i(I) - \psi_B^i(I)) - kI.$$

Hence, S's gain from investing under i-integration is

$$U_S^i(1) - U_S^i(0) = \frac{1}{2}(\phi_1 - \phi_0) + \frac{1}{2}\Delta^i - k, \tag{3}$$

where

$$\Delta^i := \psi_S^i(1) - \psi_S^i(0) - [\psi_B^i(1) - \psi_B^i(0)].$$

Given Assumption GHM-(ii) and -(iii), $\phi_1 - \phi_0 \geq \Delta^S > 0 > \Delta^B$. Hence,

$$W(1) - W(0) \geq U_S^S(1) - U_S^S(0) > U_S(1) - U_S(0) > U_S^B(1) - U_S^B(0).$$

This shows that the S-*integration* is the optimal ownership structure, dominating symmetric (non-integrated) structure, which in turn dominates B-*integration* structure. In particular, if $U_S^S(1) - U_S^S(0) > 0 > U_S(1) - U_S(0)$, then the investment is sustainable if and only if the seller has the asset ownership. This result reveals the main tenet of GHM that asset ownership can serve to reduce the owner's exposure to hold-up.

Remark 1. *The effects of alternative ownership structures may depend on the particular bargaining solution assumed. For example, the outside option bargaining or a Bertrand bidding solution may change the relative rankings of the alternative structures and may eliminate inefficiencies altogether. If the buyer's outside option is binding either from the buyer's owning more assets (that is, B-integration) or from the seller being subject to competition from another seller, then the seller is forced to make the buyer indifferent to that option, which causes the seller to internalize the social return of her investment. For this reason, B-integration may perform better than S-integration (Chiu, 1998; De Meza and Lockwood, 1998), or competition/non-integration may solve the hold-up problem (Bolton and Whinston, 1993; Che and Hausch, 1996; Cole, Mailath and Postlewaite, 2001; Felli and Roberts, 2001; MacLeod and Malcomson, 1993).*

Contractual solutions

In the above model, the trade decision is contractible only after the investment decision has been made. While this assumption resonates with many real business situations, it is difficult to reconcile with the fact that the parties can accurately calculate the payoff consequences of their behaviour (Maskin and Tirole, 1999). It is also crucial: if the parties *can* contract on q prior to the investment decision, the underinvestment problem may be solved, without requiring the organizational remedies discussed above.

To illustrate, suppose the parties sign a contract requiring them to trade $\hat{q}$ for the total price of $\hat{t}$. Unless renegotiated, this contract will give S a payoff of $\hat{t} - c_I(\hat{q}) - kI$ if she chooses $I \in \{0,1\}$. If $\hat{q} \neq q_I^*$, though, both parties will be better off by renegotiating to implement q_I^*. Given the assumption again that this renegotiation splits the surplus equally, S's *ex ante* payoff will be

$$\hat{U}_S(I;\hat{q}) := \hat{t} - c_I(\hat{q}) + \frac{1}{2}[\phi_I - (v_I(\hat{q}) - c_I(\hat{q}))] - kI.$$

Hence, her net benefit from investing under this contract is

$$\hat{U}_S(1;\hat{q}) - \hat{U}_S(0;\hat{q}) = \frac{1}{2}(\phi_1 - \phi_0) - \frac{1}{2}(v_1(\hat{q}) - v_0(\hat{q})) - \frac{1}{2}(c_1(\hat{q}) - c_0(\hat{q})) - k. \tag{4}$$

Whether a contract like this can create a sufficient incentive for S to invest depends on the nature of the investment made. Suppose first that the investment is

selfish, so that it only decreases S's cost but does not affect B's valuation (that is, $v_1(\cdot) = v_0(\cdot)$). In this case, the trade contract can indeed protect S's incentive for investment. Observe that

$$c_0(q_1^*) - c_1(q_1^*) = v_1(q_1^*) - c_1(q_1^*) - [v_0(q_1^*) - c_0(q_1^*)] > \phi_1 - \phi_0.$$

By the same logic, $c_0(q_0^*) - c_1(q_0^*) < \phi_1 - \phi_0$. Since $c_I(\cdot)$ is continuous, there exists $\hat{q}^*$ between q_0^* and q_1^* such that $c_0(\hat{q}^*) - c_1(\hat{q}^*) = \phi_1 - \phi_0$. Consequently,

$\hat{U}_S(1;\hat{q}^*) - \hat{U}_S(0;\hat{q}^*) = W(1) - W(0)$, so S will indeed invest whenever it is efficient to do so. Edlin and Reichelstein (1996) show that a fixed-price contract can provide efficient incentives for a selfish investment by either side and, with an additional condition, for selfish investments by both, in a more general environment with continuous investment. This result implies that, as long as the investments are selfish, the organizational remedies mentioned above will not be necessary.

Remark 2. *Aghion, Dewatripont and Rey (1994) and Chung (1991) have noted that efficiency can be achieved for investments by both sides via a contract that manipulates the status quo payoff of one party in the same way as above and gives the full bargaining power to the other party at the renegotiation stage, thus making that party a residual claimant of the social surplus in the marginal sense. The idea of contractual manipulation of bargaining powers also appears in Hart and Moore (1988) and Nöldeke and Schmidt (1995).*

Contract failure

Contracts may not restore efficiency if the investments are not selfish. Suppose the investment is *cooperative*: $c_1(\cdot) = c_0(\cdot)$. So, S's investment increases B's valuation only, worsening the former's bargaining position. Such a cooperative nature of investments underlies many instances of the hold up problem (for example, quality-enhancing R & D investment by a supplier and customization efforts by partners). In this case, any commitment to trade exacerbates rather than alleviates the investor's vulnerability to hold-up. Formally, given $c_1(\cdot) = c_0(\cdot)$, S's *ex ante* payoff will be

$$\hat{U}_S(1;\hat{q}) - \hat{U}_S(0;\hat{q}) = \frac{1}{2}(\phi_1 - \phi_0) - \frac{1}{2}(v_1(\hat{q}) - v_0(\hat{q})) - k \le \frac{1}{2}(\phi_1 - \phi_0) - k = U_S(1) - U_S(0) < 0.$$

for any $\hat{q}$. In other words, no such trade contract creates more incentives for S than the null contract. In fact, Che and Hausch (1999) demonstrated that all feasible contracts are worthless if investments are cooperative.

A similar result can be obtained if the investment is selfish, but it is difficult to predict the 'type' of trade that will benefit from the investment (Hart and Moore, 1999; Segal, 1999). Specifically, suppose that there are n potential goods the parties may wish to trade but that only one of them becomes a 'special' type and *only* the special type will benefit from an investment. Assume that each of the n goods has an equal chance of becoming that special type *ex post*, so the parties can predict the special type only with probability $1/n$. Adapted in our model, the surplus from trading the special type is ϕ_I given investment $I \in \{0,1\}$, and the surplus from trading a 'generic' type is ϕ_0, regardless of the investment decision. Assume for simplicity that $q_I^* = 1$, for $I = 0,1$. As the contract is renegotiable, under a contract requiring the parties to trade any good, S's *ex ante* payoff from choosing $I \in \{0,1\}$, becomes

$$\tilde{U}_S(I) := \frac{1}{n}(\hat{t} - c_I(1)) + \frac{n-1}{n}(\hat{t} - c_0(1)) + \frac{1}{2}\left[\phi_I - \frac{1}{n}\phi_I - \frac{n-1}{n}\phi_0\right] - kI.$$

In other words, S's investment influences her status quo payoff only when the good they contracted to trade turns out to be the special type, an event that arises with probability $1/n$. This feature weakens the ability of a contract to provide incentives, as can be seen from S's gain from investing:

$$\tilde{U}_S(1) - \tilde{U}_S(0) = \frac{1}{n}(c_0(1) - c_1(1)) + \frac{1}{2}\left[\phi_1 - \phi_0 - \frac{1}{n}(\phi_1 - \phi_0)\right] - k = \frac{1}{2}\left(1 + \frac{1}{n}\right)(\phi_1 - \phi_0) - k.$$

Further, as the environment becomes 'complex' in the sense that $n \to \infty$, S's incentive reduces to that under the null contract, thus rendering contracts virtually worthless.

Several implications can be drawn from these two results. First, the contract failure result implies that the true challenge of the hold-up problem may lie with the nature of specific investments – either the 'cooperative' nature or the 'unpredictability of investment benefit'. Second, the general failure of contracting to protect against hold-up lends credence and relevance to the GHM analysis of the ownership structures or organizational theory in general based on the hold-up problem as a source of inefficiency. Third, for the above results it is crucial for the parties to be

unable to commit not to renegotiate their contract. Were such commitment available, they could devise a contract that would induce them to reveal truthfully S's investment decision, say, by having both parties report simultaneously about the decision and penalizing both of them for any inconsistency via zero trade and zero transfer. Then, S can easily be induced to invest by a sufficient amount of bonus given to her conditional only on both parties reporting 'S has invested'. If a contract is renegotiable, such a costless revelation of information is impossible to achieve: Inconsistent reports do not reveal the identity of the liar, and both parties cannot be simultaneously punished, since they will renegotiate back to the Pareto frontier.

Remark 3. *Several elements are crucial for the contract failure result. First, it requires the existence of an opportunity to renegotiate following any contract-specified action. If there is some non-renegotiable action, then an efficient outcome may be achievable. Rogerson (1984) shows that liquidated damages achieve the efficient outcome if a contract can be breached non-renegotiably. Likewise, if in the last period of renegotiation the buyer can irrevocably determine the terms of trade, then buyer-option contracts can overcome the hold-up problem (see Lyon and Rasmusen, 2004). Contract failure re-emerges, however, in the case of cooperative investment if the parties discount delayed exercise of the option (Wickelgren, 2007). Second, risk neutrality is important for contract failure. If the parties were risk averse, then a lottery could be used to punish both parties even in the presence of renegotiation, and could achieve the first-best (Maskin and Tirole, 1999). Third, it is important for the contract to be bilateral. If a third party can be involved, efficiency can be achieved even when the contract is subject to renegotiation or collusion (Baliga and Sjostrom, 2005).*

Dynamics

The basic hold-up model assumes that there is a single opportunity to invest, followed by the distribution of the surplus. Not too surprisingly, if the interaction is repeated inefficiencies can be greatly reduced, in accordance with the Folk Theorem for repeated games (see, for example, Klein and Leffler, 1981). More surprisingly, allowing for dynamic investment patterns can have a dramatic effect even in a one-shot interaction, as shown by Che and Sákovics (2004a). When the agents can continue to invest even after the negotiation of the terms of trade has started, the

anticipated investment dynamics can influence the way the parties negotiate and improve the incentives for investment.

To see how this works, modify our running example by allowing S to invest in the following period if she has not invested in the past and no agreement has been reached yet. If the parties discount their future very little, S's 'invest' can be sustained in a subgame-perfect equilibrium. In this equilibrium, hold-up still arises on the equilibrium path in that S receives only the fraction of the gross surplus commensurate with his bargaining power. Yet this does not stop S from investing. Suppose S does not invest today but is expected to invest tomorrow in case no agreement is reached today. Then, there will be more surplus to divide tomorrow than there is today. Since the cost of tomorrow's investment will be borne solely by the investor, the prospect of the investor raising his investment tomorrow causes his partner to demand more to settle today. The investment dynamics thus results in a worse bargaining position for the party upon not investing, and creates a stronger incentive for investing than would be possible if such investment dynamics – that is, the option to invest in the future – were not allowed. As a result, investment can be supported in equilibrium.

In sum, dynamics in the trading relationship and/or investment technology lessens either the risk of hold-up or the degree of inefficiencies caused by it. This questions the relevance of the hold-up problem as a rationale for organization and/or contractual remedies. At the same time, the presence of dynamics alters the nature of the incentive problems and calls for different types of contractual or organizational prescriptions against hold-up than those proposed based on the static models, as seen by Baker, Gibbons, and Murphy (2002), Che and Sákovics (2004b) and Halonen (2002).

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See also Coase Theorem; contract theory; contract law, economics and; incomplete contracts; procurement.

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