NBER WORKING PAPER SERIES

IMPLICIT CONTRACTS AND THE THEORY OF THE FIRM

George Baker
Robert Gibbons
Kevin J. Murphy

Working Paper 6177
http://www.nber.org/papers/w6177

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 1997

We are grateful for research support from the Division of Research at Harvard Business School (Baker), the Center for Advanced Study in the Behavioral Sciences (through a Fellowship funded in part by NSF grant SBR-9022192) and Cornell's Johnson School (Gibbons), and USC's Marshall School (Murphy). We thank Alexander Dyck, Oliver Hart, Bengt Holmstrom, Benjamin Klein, Edward Lazear, Patrick Legros, Bentley MacLeod, John Matsusaka, Kevin Murdoch, Canice Prendergast, Julio Rotemberg, Mike Waldman, and Mike Whinston for helpful comments. This paper is part of NBER's research programs in Corporate Finance and Industrial Organization. Any opinions expressed are those of the authors and not those of the National Bureau of Economic Research.

Implicit Contracts and the Theory of the Firm
George Baker, Robert Gibbons and Kevin J. Murphy
NBER Working Paper No. 6177
September 1997
Corporate Finance and Industrial Organization

ABSTRACT

We analyze the role of "implicit contracts" (that is, informal agreements supported by reputation rather than law) both within firms, for example in employment relationships, and between them, for example as hand-in-glove supplier relationships. We find that the optimal organizational form is determined largely by what implicit contracts it facilitates. Among other things, we also show that vertical integration is an efficient response to widely varying supply prices. Finally, our model suggests why "management" (that is, the development and implementation of unwritten rules and codes of conduct) is essential in organizations.

George Baker
Harvard Business School
Soldiers Field Road
Boston, MA 02163

Robert Gibbons
Sloan School of Management
Massachusetts Institute of Technology
E52-590
Cambridge, MA 02142
and NBER
rgibbons@mit.edu

Kevin J. Murphy
Marshall School of Business
University of Southern California
Los Angeles, CA 90089

Implicit Contracts and the Theory of the Firm

by

George Baker, Robert Gibbons, and Kevin J. Murphy

I. Introduction

Firms are riddled with implicit contracts: informal agreements, unwritten codes of conduct, and norms that powerfully affect the behaviors of individuals in firms. Virtually every collegial and hierarchical relationship in organizations involves important implicit contracts, including informal *quid pro quos* between co-workers and unwritten understandings between bosses and subordinates about task-assignment, promotion, and termination decisions. Many observers have emphasized the importance of these and other informal agreements in organizations.[1] Even ostensibly formal processes such as compensation, transfer pricing, internal auditing, and capital budgeting often cannot be understood without consideration of their associated informal agreements.[2]

Business relationships are also riddled with implicit contracts. Many transactions do not occur in a pure spot market between buyers and sellers who pass (goods) in the night. Instead, supply chains often involve long-run, hand-in-glove supplier relationships through which the parties reach accommodations when unforeseen or uncontracted-for events occur.[3] Similar

---

[1] See Barnard (1938) and Simon (1947), as well as the case studies by Blau (1955), Gouldner (1954), and Selznick (1949) that inspired American sociology's departure from Weber's emphasis on formal organizational structures and processes. Granovetter (1985: 502) offers a more recent assessment: "The distinction between the 'formal' and the 'informal' organization of the firm is one of the oldest in the literature, and it hardly needs repeating that observers who assume firms to be structured in fact by the official organization chart are sociological babes in the woods."

[2] See Lawler (1990) on compensation, Eccles (1985) on transfer pricing, Dalton (1959) on internal auditing, and Bower (1970) on capital budgeting. See also Blumenstein and Stern (1996) on how the 1700-page contract between General Motors and the United Auto Workers has important gaps that are covered by informal agreements.

[3] Macaulay (1963) emphasized the importance of such "non-contractual relations" in various businesses. Kogut, Shan, and Walker (1992) suggest the prominence of such relationships through their title: "The Make-or-Cooperate Decision." Eccles (1981) describes "quasifirms" in the construction industry—long-run relationships between general contractors and independent, specialized subcontractors. Kollock (1994) and Bester (forthcoming) describe long-standing supplier relationships in the rubber industry in Thailand and the

relationships also exist horizontally, as in the networks of firms in the fashion industry or the diamond trade.[4] Whether vertical or horizontal, these implicit contracts influence the behaviors of parties across firm boundaries.

In this paper we develop repeated-game models of implicit contracts both within and between organizations. In both settings, implicit contracts help circumvent difficulties in explicit contracting. For example, while an explicit contract must be specified *ex ante* in terms that can be verified *ex post* by a third party (such as a court), an implicit contract can be based on outcomes that cannot be verified *ex post*, and also on outcomes that are prohibitively costly to specify *ex ante*. An implicit contract thus allows the parties to utilize their detailed knowledge of their specific situation and to adapt to new information as it becomes available. For the same reasons, however, these implicit contracts cannot be enforced by a third party. Instead, implicit contracts must be designed to be self-enforcing: each party's reputation must be sufficiently valuable that neither party wishes to renege.

Our models allow us to re-examine Coase's (1937) analysis of markets versus firms, taking into account the ubiquity of implicit contracts in both domains. Formally, we combine Simon's (1951) and Williamson's (1975) emphasis on implicit contracts (which they see as the comparative advantage of firms over spot markets) with Grossman and Hart's (1986) definition of integration as asset ownership. We therefore consider not only spot markets and implicit contracts between integrated parties ("firms"), but also implicit contracts between non-integrated parties ("relational contracts") and even spot transactions between integrated parties ("spot employment"). We show that implicit contracts between integrated parties can be importantly different from those between non-integrated parties.[5] And we derive predictions about what kinds of transactions will occur in spot markets, firms, relational contracts, or spot employment.

---

tuna industry in Japan, respectively, where quality is an experience good and quality assurance is achieved through reputation.

[4] In "Neither Market Nor Hierarchy: Network Forms of Organization," Powell (1990) describes a variety of other examples and emphasizes their differences from spot markets and firms.

[5] We follow Grossman and Hart in assuming that bringing a transaction inside a firm does not create any additional information, or render formerly non-contractible outcomes contractible, or change the preferences of any actor. Nonetheless, we depart from the spirit of their assertion that "the benefits of integration must surely be more than the ability to choose a new payment method" (p.694). We show that the best implicit contract feasible in a firm can be much better or much worse than the best feasible implicit contract between non-integrated parties. In this sense, one important benefit of integration is precisely the ability to choose a new payment method (*i.e.*, a different implicit contract).

We interpret our model as shedding new light on the role of *management*: the development and maintenance of the nexus of implicit contracts that defines a firm or a relational contract. While many economic models fail to find (or even allow) any role for management, in our model it is essential. To implement an implicit contract, a manager uses subjective assessments and informal adaptations to events. Such management is the source of a firm's (or a relational contract's) advantage over a spot transaction.

Our analysis produces four main results. First, we show that implicit contracts (whether inside or outside firms) cannot exist if spot governance offers an inferior but sufficiently palatable alternative. Thus, like Coase, we predict that a firm arises only if a spot market would perform sufficiently poorly, but our reasoning is new. Rather than simply posit that superior firms will inevitably supplant inferior spot markets, we explain why superior firms cannot arise unless the spot-market alternative is sufficiently inferior.

Our second result is that vertical integration can be an efficient response to widely varying supply prices, even when all parties are risk neutral. This result helps explain a puzzle noted by Carlton (1979) and others: why would (risk-neutral) companies pursue vertical mergers to achieve certainty of supply? We show that under non-integrated ownership, an extreme realization of the supply price creates a large temptation to renege on an implicit contract. This reneging temptation limits the power of the implicit contract that can be implemented under non-integrated ownership. Under integrated ownership, however, the reneging temptation is independent of the supply price, making integration the more efficient governance structure when the supply price can vary widely.

Our third result supports Williamson's (1985: 76) claim that incentives in non-integrated supplier relationships are "higher-powered" than incentives in firms. In our model, incentives in firms are provided through bonuses based on subjective performance assessments. Because the firm owns the assets, an employee has no recourse if the firm asserts that performance was poor and refuses to pay the promised bonus. In relational contracts, in contrast, incentives are again based on subjectively determined bonuses, but now the "employee" is an independent contractor—someone who owns the assets and can dictate their use. If an independent contractor is not paid a promised bonus, she can still extract some payment through bargaining over the use of her assets. Reneging on the bonus owed to an independent contractor thus saves only the amount of the bonus over and above the payment that will be determined by such bargaining. The temptation not to pay the bonus is therefore smaller in the relational contract than in the firm. This reduced temptation makes it credible to promise a larger bonus to an independent contractor than to an employee, consistent with Williamson's claim.

Our fourth result squares with Eccles's (1985) observation that transfer prices are rarely used to allocate resources inside firms. Rather, Eccles finds that the rights to allocate resources are held centrally, with the transfer pricing scheme serving as part of the performance-measurement and incentive system for the divisions. The firms in our model correspond to those observed by Eccles: in our firms, resources are allocated centrally by fiat, rather than as a decentralized response to transfer prices. Yet transfer prices exist and play a crucial role in our model: consistent with Eccles's observations, they serve as part of the long-run incentive system in the firm, influencing divisions' incentives through their role in implicit contracts.

The paper concludes with several applications: situations in which subjective assessments and informal adaptations are integral parts of organizational processes. In the same spirit, we also provide a novel interpretation of the role of the board of directors in mediating the relationship between managers and investors. In all of these examples, firms are not governed solely by a set of formal, explicit contracts. Quite the reverse: the informal aspects of management that we explore are crucial to understanding the true nature of the firm.

II. Spot Markets, Spot Employment, Firms, and Relational Contracts

We consider an economic environment consisting of an upstream party, a downstream party, and an asset. Both parties and the asset live forever (or die together at a random date, as per the usual interpretation of "infinitely" repeated games). Both parties are risk-neutral and share the interest rate r per period. Initially, the downstream party owns the asset.

In each period, the upstream party may use the asset to produce a good. The downstream party values the good, but the good also has an alternative use. The good's value to the downstream party always exceeds its value in the alternative use. (For example, there might be other similar downstream parties but the asset might be tailored to this downstream party's needs. Alternatively, the upstream party might be able to set up shop as a downstream party, but lack the expertise to do so efficiently.) Regardless of how the good is used, its value falls to zero at the end of the period in which it was produced.

Ownership of the asset conveys ownership of the good produced using the asset.[6] Thus, if the downstream party owns the asset then the downstream party could simply take the good, refusing to pay the upstream party anything. Similarly, if the upstream party owns the asset then the upstream party could consign the good to its alternative use, paying no heed to objections from the downstream party. Of course, the latter scenario will not occur: because the value of the good to the downstream party exceeds its value in its alternative use, the efficient outcome when the upstream party owns the asset is for the parties to trade, exchanging money for the good.

In each period, the upstream party makes a choice of a vector of n actions, $a=(a_1,a_2,...,a_n)$ at a cost $c(a)$. The actions affect both the downstream value (Q) and alternative-use value (P) of the good in that period.[7] In particular, the downstream value is either high or low, Q_H or Q_L, and the alternative-use value is either high or low, P_H or P_L, where $P_L < P_H < Q_L < Q_H$. (We write $\Delta Q \equiv Q_H - Q_L$ and $\Delta P \equiv P_H - P_L$.) The upstream party's actions affect the probabilities that high values will be realized:

$$Q = \begin{cases} Q_H & \text{with probability} \quad q(a) \\ Q_L & \text{with probability} \quad 1-q(a) \end{cases}$$

$$P = \begin{cases} P_H & \text{with probability} \quad p(a) \\ P_L & \text{with probability} \quad 1-p(a) \end{cases}.$$

Given the upstream party's actions, the downstream and alternative-use values are conditionally independent. We assume that $c(0)=0$, $q(0)=0$, and $p(0)=0$, so that when the upstream party fails to take any actions, she bears no costs but also has no chance of realizing the high-valued outcomes Q_H or P_H.

The first-best actions, a^*, maximize the expected value of the good in its efficient use minus the cost of actions, $Q_L + q(a)\Delta Q - c(a)$, and so produce total surplus

---

[6] If fact, the asset in this model does nothing more than convey present and future ownership of the good to the owner the asset. When we speak of "selling the asset," we could as well speak of selling the rights to the stream of future goods, with no reference to any physical asset at all. We elaborate on and reinterpret this notion of ownership below.

[7] The production technology has no linkages across periods: there is no effect of one period's actions in subsequent periods; also, there is no learning by doing.

Figure 1

Combinations of ownership and contracting regimes that define four organizational forms: Spot Markets, Spot Employment, Relational Contracts, and Firms

	Ownership Environment	
Contracting Environment	Upstream Owns Asset	Downstream Owns Asset
Spot Governance	Spot Market	Spot Employment
Implicit Contracts	Relational Contract	Firm

(1) $$S^* \equiv Q_L + q(a^*)\Delta Q - c(a^*).$$

The actions are unobservable to anyone but the upstream party, so contracts contingent on actions cannot be enforced. Achieving the first-best would still be possible if contracts dependent on Q could be enforced. We assume, however, that neither Q nor P is contractible: a contract that depends on the realized value of Q or P cannot be enforced by a third party. On the other hand, both Q and P can be observed by the upstream and downstream parties. There are therefore two potential ways to influence the upstream party's choice of actions: asset ownership and implicit contracts. That is, if the upstream party owns the asset, she can negotiate with the downstream over a sales price for the good. Alternatively, independent of who owns the asset, the realized values of Q and P can form the basis of an implicit contract enforced through the parties' concerns about their reputations.

Figure 1 summarizes the combinations of asset ownership (upstream or downstream) and contracting regimes (spot governance or implicit contract) that are feasible in this environment. The four resulting governance structures in our analysis are "Spot Markets" (where the upstream party owns the asset but there is no implicit contract), "Spot Employment" (where the downstream party owns the asset but there is no implicit contract), "Firms" (where the downstream party owns the asset and there is an implicit contract), and "Relational Contracts" (where the upstream party owns the asset and there is an implicit contract).[8]

[8] Halonen (1994) also explores the effect of asset ownership on implicit contracting, akin to our models of firms and relational contracts. In her dynamic analysis, Halonen assumes that ownership is fixed forever, even after reneging on the implicit contract, whereas we assume that ownership after reneging reverts to the efficient ownership at that point (with an appropriate transfer payment between parties). There are also

Spot Markets

We first consider the spot market. Note that, contrary to common usage, our spot market has only two parties—upstream and downstream (although, as noted above, there may be other unmodeled downstream parties who generate the alternative use for the good).

Once the actions are taken and the good produced, the upstream party either sells the good to the downstream party or uses the good in its alternative capacity. Although upstream and downstream cannot contract directly on the realized values of Q and P, they can negotiate over the price of the good. We use the Nash bargaining solution (with equal bargaining powers) to arrive at this price: downstream will pay upstream the alternative-use value, P_j, plus half of the surplus from use by the downstream party, $Q_i - P_j$, so the price is $\frac{1}{2}(Q_i + P_j)$, where i=H,L and j=H,L.

The upstream party's payoff in such a spot market is the price $\frac{1}{2}(Q_i + P_j)$ less the cost of actions c(a). Upstream therefore chooses actions a^M to solve

$$\max_a \tfrac{1}{2}[Q_L+q(a)\Delta Q]+\tfrac{1}{2}[P_L+p(a)\Delta P] - c(a) \equiv U^M. \tag{2}$$

The spot-market actions are thus likely to differ from the first-best actions. Roughly speaking, the market can be "overheated" if ΔP is very large relative to ΔQ, or "underheated" in the opposite case. Consider the extreme case when $\Delta Q=0$, for example: the downstream party cannot benefit from effort, so the first-best level of effort is zero, but the upstream party will expend effort because P_j influences the price of the good under Nash bargaining.[9]

After Q_i and P_j are realized and trade occurs, the downstream party's total payoff is $Q_i - \frac{1}{2}(Q_i + P_j) = \frac{1}{2}(Q_i - P_j)$. Define $D^M \equiv \frac{1}{2} E[Q_i - P_j \mid a=a^M]$ as downstream's expected payoff in the spot market, conditional on upstream's optimal action choices. The total surplus from the spot market is therefore

$$S^M \equiv D^M + U^M = Q_L + q(a^M)\Delta Q - c(a^M). \tag{3}$$

---

important differences in our static analyses: we allow for multi-dimensional actions and various departures from first-best, whereas she focuses on unidimensional effort and the possibility of underinvestment. Our richer static model generates a correspondingly richer collection of outcomes in our dynamic analysis.

[9] Such overheated spot markets play only a small role in our analysis, but they clarify an important point in the larger literature concerning underinvestment in specific assets: asset specificity is measured in terms of the levels of asset values (for example, $Q_L - P_H > 0$ might be used as a measure of asset specificity in our model), whereas investment decisions are determined by marginal returns (here ΔP and ΔQ). Hence, assets can be very specific ($Q_L >> P_H$) and yet induce overinvestment (if $\Delta P >> \Delta Q$). This point is obscured in models that tie asset levels to marginal returns in such a way that asset specificity necessarily produces underinvestment.

Spot Employment

When the downstream party owns the asset but there is no implicit contract, the downstream party can simply take the output without paying the upstream party. In anticipation of this outcome, the upstream party will refuse to take any costly actions, so the downstream value of the output will be Q_L with certainty. Thus, the total surplus from spot employment is $S^E = Q_L$. Although we defer our main discussion of the comparative efficiency of spot markets and spot employment until Section III, we note that spot employment dominates spot markets only when the net benefit from upstream actions under spot-market governance is negative, $q(a^M)\Delta Q - c(a^M) < 0$. This could occur, for example, when the actions that affect the alternative-use value, P, are unproductive or even counter-productive to the downstream value Q, yet under spot-market governance these actions are undertaken by the upstream party to improve her bargaining position.

Our model of spot employment may seem trivial and unrealistic: the upstream party refuses to take any actions whatsoever. But this is in part because we have left unmodeled any possibility that explicit contracting (available in all four organizational forms) could provide imperfect incentives for upstream effort.[10] If such explicit contracts were available, our model of spot employment would resemble the simplest form of piece-work employment, such as day-labor agriculture, with no implicit contractual relationship beyond the agreement to pay the promised price per piece. We describe such employment as "spot employment," distinguishing it from a "firm" by its lack of the informal agreements and norms emphasized in the Introduction.

Firms

In firms, as in spot employment, the downstream party owns the asset. But in our firms (like Simon's (1951) employment relationships) there must also be an implicit contract based on the observable but noncontractible realizations Q and P. Our terminology reflects what we believe to be a crucial part of what makes firms firms. We follow Bull (1987) and Kreps (1990) in constructing a repeated-game model of such an implicit contract. Unlike the spot-employment case, the implicit contracts in the firm may provide upstream incentives, even though the downstream party owns the asset, provided that the parties value their reputations

[10] Holmstrom and Milgrom (1991) and Baker (1992) provide models of such imperfect incentives created by explicit contracts, in the absence of implicit contracts.

sufficiently. The core of the analysis is therefore checking whether reputation concerns in fact outweigh the temptation to renege on a given implicit contract.

An important part of this calculation is the payoff after reneging. We focus on trigger-strategy equilibria, in which the party who did not renege refuses to enter into any new implicit contract with the party who reneged. Because there are only two parties (one downstream and one upstream), this trigger-strategy assumption implies that the parties live under spot governance forever after one reneges. To determine whether such spot governance takes the form of a spot market or spot employment, we allow the parties to negotiate over asset ownership after reneging. Thus, the downstream party will retain ownership when $S^E > S^M$, but will sell the asset to the upstream party (at a price determined by Nash bargaining) when $S^M > S^E$.

Consider the implicit compensation contract $(s,b_H,b_L,\beta_H,\beta_L)$, where salary s is paid by downstream to upstream at the beginning of each period, b_H or b_L is supposed to be paid when $Q=Q_H$ or $Q=Q_L$, respectively, and β_H or β_L is supposed to be paid when $P=P_H$ or $P=P_L$, respectively. For the moment, suppose that the upstream party is confident that the downstream party will indeed pay b_i and β_j (for i,j=H,L) as promised (and that the upstream party will make any promised payments if $b_i < 0$ or $\beta_j < 0$). If the upstream party accepts the contract, she will choose a vector of actions a^F to solve

$$(4) \qquad \max_a \; s + b_L + \Delta b q(a) + \beta_L + \Delta\beta p(a) - c(a) \equiv U^F$$

(where $\Delta b \equiv b_H - b_L$ and $\Delta\beta \equiv \beta_H - \beta_L$). The expected downstream payoff is then

$$E[Q_i - s - b_i - \beta_j \mid a = a^F] = Q_L + \Delta Q\, q(a^F) - [s + b_L + \beta_L + \Delta b q(a^F) + \Delta\beta p(a^F)] \equiv D^F,$$

so the total surplus generated by a firm with an implicit contract generating actions a^F is

$$(5) \qquad S^F \equiv U^F + D^F = Q_L + q(a^F)\Delta Q - c(a^F).$$

The implicit contract $(s,b_H,b_L,\beta_H,\beta_L)$ is self-enforcing if both parties choose to honor the contract for all possible realizations of Q_i and P_j. The downstream party reneges if he refuses to pay the promised bonus $b_i + \beta_j$ to the upstream party, instead simply taking the good and paying nothing. After reneging, the downstream party will either retain ownership and earn the spot employment surplus of $S^E = Q_L$ in perpetuity (when $S^E > S^M$) or sell the asset upstream

and earn D^M in perpetuity (when $S^M > S^E$). Assuming Nash bargaining (with equal bargaining power), the sale price for the asset in the latter case (paid at the end of the period in which reneging occurred) will be $(U^M - D^M + S^E)/2r$.[11] Thus, the present value of selling the asset upstream for the Nash bargaining price and earning D^M in perpetuity is $(S^M + S^E)/2r$. To cover the two cases of $S^M > S^E$ and $S^M < S^E$, we write the present value of the downstream party's "fallback" payoffs after reneging as $\frac{1}{r}\max[\frac{1}{2}(S^M + S^E), S^E]$.

The downstream party will honor the implicit contract as long as the present value of honoring the contract exceeds the present value of reneging. Since the present value of honoring the contract is $-b_i - \beta_j + \frac{1}{r}D^F$, the downstream owner will honor rather than renege on the implicit contract when

$$-b_i - \beta_j + \frac{1}{r}D^F \geq \frac{1}{r}\max[\tfrac{1}{2}(S^M + S^E), S^E], \text{ or}$$

$$b_i + \beta_j \leq \frac{1}{r}(D^F - \max[\tfrac{1}{2}(S^M + S^E), S^E]). \tag{6}$$

The upstream party reneges on the implicit contract by refusing to accept a promised payment $(b_i + \beta_j)$ when it was offered (or by refusing to make a promised payment if $b_i + \beta_j < 0$), earning zero rents thereafter when $S^M < S^E$ (and the downstream party retains ownership) or buying the asset for price $(U^M - D^M + S^E)/2r$ and earning U^M in perpetuity when $S^M > S^E$, yielding a present value of $(S^M - S^E)/2r$. Thus, the upstream party will honor rather than renege on the implicit contract when

$$b_i + \beta_j + \frac{1}{r}U^F \geq \frac{1}{r}\max[\tfrac{1}{2}(S^M - S^E), 0]. \tag{7}$$

If (6) holds for all i and j then it must hold for the largest $b_i + \beta_j$, while if (7) holds for all i and j it must hold for the smallest $b_i + \beta_j$. Combining these two extreme versions of (6) and (7) yields a necessary condition for the implicit contract $(s, b_H, b_L, \beta_H, \beta_L)$ to be self-enforcing:

$$|\Delta b| + |\Delta \beta| \leq \frac{1}{r}(S^F - \max[S^M, S^E]). \tag{8}$$

---

[11] To derive the Nash bargaining price, define X as the asset price and note that the net surplus to the downstream party from selling the asset upstream rather than retaining ownership is $X + (1/r)(D^M - S^E)$, while the net surplus to the upstream party from buying the asset (rather than earning zero) is $(1/r)U^M - X$. The Nash bargaining price maximizes the product of these net surpluses.

In fact, (8) is sufficient as well as necessary, because for any Δb and $\Delta\beta$ satisfying (8), a fixed payment, s, can always be chosen that satisfies (6) and (7).

The left-hand side of (8), $|\Delta b| + |\Delta\beta|$, characterizes the total temptation to renege on the implicit contract (the upstream party's temptation plus the downstream's). The right-hand side equals the present value of the total surplus from continuing the relationship, S^F, less the best fallback if either party should renege, $\max[S^M, S^E]$. The absolute value signs around Δb and $\Delta\beta$ allow for possibility that $b_L > b_H$ and/or $\beta_L > \beta_H$ (although Δb and $\Delta\beta$ will be non-negative in equilibrium). The efficient implicit contract maximizes the total surplus S^F in (5), subject to the feasibility constraint (8). The resulting surplus can then be divided in any desired fashion through the salary payment, s, which has no effect on (8).

Given functional forms for q(a) and p(a) and values for the parameters ΔQ, ΔP, and r, we could now determine whether (i) a firm can achieve first-best upstream actions, (ii) a firm can survive (*i.e.*, an implicit contract can exist) but cannot achieve the first-best, or (iii) a firm cannot survive (*i.e.*, there are no values of Δb and $\Delta\beta$ satisfying (8)). We do not pause here to explore these three possibilities because for many functional-form assumptions and parameter values some other organizational form (*i.e.*, spot market, spot employment, or a relational contract) will be more efficient; see below.

Relational Contracts

We now consider relational contracts—implicit contracts where the upstream party owns the asset. Such implicit contracts between non-integrated parties have been analyzed by Klein, Crawford, and Alchian (1978), Klein and Leffler (1981), and Telser (1981), among others. In our model, implicit contracts between non-integrated parties differ from those between integrated parties in the ways they tempt each party to renege.

If the promised payment $b_i + \beta_j$ exceeds the price that would be negotiated under spot-market governance, $\frac{1}{2}(Q_i + P_j)$, the downstream purchaser would be better off this period if he reneged on the implicit contract. Similarly, if the promised payment $b_i + \beta_j$ is less than $\frac{1}{2}(Q_i + P_j)$ then the upstream producer would be better off this period if she reneged. Thus, a key difference between relational contracts and firms is that the good's value in its alternative use, P_j, affects the reneging decision in a relational contract but not in a firm. This difference drives Proposition 2 below.

A second difference concerns asset ownership after reneging: the efficient ownership structure after reneging is again determined by a comparison of the total surpluses in the two

static cases, spot markets and spot employment, so the conditions under which the asset changes hands after reneging on a relational contract are the reverse of those for reneging on an implicit contract in a firm. That is, if $S^M > S^E$ then it is efficient for the upstream party to retain ownership: the upstream party will earn U^M in perpetuity, the downstream D^M. If $S^M < S^E$ the upstream party will sell the asset to the downstream party at a Nash bargaining price of $(S^E + U^M - D^M)/2r$; thereafter, the upstream party will earn zero and the downstream party S^E in perpetuity.

If the upstream party is confident that the downstream party will honor the contract, the upstream party will choose a vector of actions a^R to solve

$$\max_a \; s + b_L + \Delta b q(a) + \beta_L + \Delta\beta p(a) - c(a) \equiv U^R.$$

The expected total surplus in the relational contract is then

$$S^R \equiv U^R + D^R = Q_L + q(a^R)\Delta Q - c(a^R), \tag{9}$$

where D^R is the expected payoff to the downstream party under a relational contract.

Once the good has been produced and Q_i and P_j have been realized, the downstream party is supposed to receive the net payoff $Q_i - b_i - \beta_j$. If he reneges on the implicit contract, he negotiates to buy the good for the spot-market price of $\frac{1}{2}(Q_i + P_j)$ instead of for $b_i + \beta_j$, realizing a current payoff of $Q_i - \frac{1}{2}(Q_i + P_j)$. Depending on which spot-governance mechanism is efficient, the downstream party may also need to buy the asset. If $S^M > S^E$ then the upstream party retains ownership of the asset, so the downstream party's discounted future payoff under spot-market governance is $\frac{1}{r}D^M$. If $S^M < S^E$ then the downstream party buys the asset from the upstream party and receives a discounted future payoff (after accounting for the purchase price) of $(S^E - U^M + D^M)/2r$. The downstream party therefore will honor rather than renege on the implicit contract when

$$Q_i - b_i - \beta_j + \frac{1}{r}D^R \;\geq\; \tfrac{1}{2}(Q_i - P_j) + \frac{1}{r}\max[D^M,\, \tfrac{1}{2}(S^E - U^M + D^M)], \text{ or}$$

$$b_i + \beta_j - \tfrac{1}{2}(Q_i + P_j) \;\leq\; \frac{1}{r}(D^R - \max[D^M,\, \tfrac{1}{2}(S^E - U^M + D^M)]). \tag{10}$$

Once Q_i and P_j have been realized, the upstream owner is supposed to the sell the good for the price $b_i + \beta_j$. If she reneges, she negotiates to sell the good for the spot-market price of $\frac{1}{2}(Q_i + P_j)$. If it is efficient for the upstream party to retain ownership of the asset then she receives a discounted future payoff of $\frac{1}{r}U^M$. If it is efficient to sell the asset then she receives

$(S^E + U^M - D^M)/2r$, after accounting for the sales price. The upstream party therefore will honor rather than renege on the implicit contract when

$$(11) \qquad b_i + \beta_j - \tfrac{1}{2}(Q_i + P_j) \geq \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R).$$

Equations (10) and (11) define eight constraints that must be satisfied to ensure that both downstream and upstream parties will honor the implicit contract for i,j=H,L. However, all eight constraints will not be binding simultaneously. In particular, as shown in Appendix 1, the constraints can be combined into a single necessary and sufficient condition for the implicit relational contract $(s,b_H,b_L,\beta_H,\beta_L)$ to be self-enforcing:

$$(12) \qquad |\Delta b - \tfrac{1}{2}\Delta Q| + |\Delta\beta - \tfrac{1}{2}\Delta P| \leq \frac{1}{r}(S^R - \max[S^M, S^E]).$$

Parallel to (8), the left-hand side of (12), $|\Delta b - \frac{1}{2}\Delta Q| + |\Delta\beta - \frac{1}{2}\Delta P|$, characterizes the total temptation to renege on the implicit relational contract (again, the sum of the upstream party's temptation and the downstream's), while the right-hand side equals the present value of the total surplus from continuing the relationship, S^R, less the best fallback if either party should renege, $\max[S^M,S^E]$. The efficient relational contract maximizes the total surplus S^R in (9), subject to the feasibility constraint (12). The resulting surplus can then be divided in any desired fashion through the salary payment, s, which has no effect on (12).

Given functional forms for q(a) and p(a) and values for the parameters ΔQ, ΔP, and r, we could again determine whether (i) a relational contract can achieve first-best upstream actions, (ii) a relational contract can survive (*i.e.*, an implicit contract can exist) but cannot achieve the first-best, or (iii) a relational contract cannot survive (*i.e.*, there are no values of Δb and $\Delta\beta$ satisfying (12)). We again defer our exploration of these possibilities.

Reinterpretations

Following Grossman and Hart, we have distinguished between a firm and a market through the ownership of a physical asset. In our model this asset is used to produce a physical good each period. Indeed, the sole function of the asset is to convey ownership of the good. Thus, we could instead assume that the good is produced from scratch each period (*i.e.*, without the use of a physical asset), but that there is a legal asset that conveys ownership of the good. Such a legal asset (or "title") could be bought and sold, just as we envisioned above for the physical asset after reneging.

In other potential reinterpretations of our model, what we call firms and relational contracts could *both* be employment relationships. For example, a "firm" might be an

employment relationship with a non-compete clause (so that the worker has no recourse if stiffed by the firm), in which case a "relational contract" would be an employment relationship without such a clause. As a second example, a "relational contract" might be an employment relationship with an arbitration clause, in which case a "firm" would be an employment relationship without such a clause. In such examples, the key issue is whether the employee has any useful response to malfeasance by the firm. In our model, the variable P reflects the payoff from such a response.

Williamson's (1991) discussion of "forbearance" suggests a final reinterpretation of our model (but one at odds with Grossman and Hart's presumption that integration does not change the feasible set of explicit contracts). Williamson argues that "courts routinely grant standing to firms should there be disputes over prices, the damages to be ascribed to delays, failures of quality, and the like, [but] refuse to hear disputes between one internal division and another over identical technical issues;" that is, "the implicit contract law of internal organization is that of forbearance" (1991: 274). In this spirit, our model of a "firm" corresponds to the case where the courts refuse to intervene, whereas our "relational contract" corresponds to the case where disputes have standing in court. Again, the key feature of our model is that an independent contractor has more recourse in a relational contract than does an employee in a firm.

III. A Comparative Analysis of Organizational Forms

The preceding section characterized upstream action decisions and total surplus under four alternative governance structures. The total surplus under governance structure k is

$$S^k = Q_L + q(a^k)\Delta Q - c(a^k),$$

where k = E, M, F, or R for spot employment, spot market, firm, or relational contract, respectively. In a given environment, the efficient organizational form maximizes this joint surplus. For some parameter values, firms will be the dominant organizational form; for others, relational contracts will dominate; for still other parameters, neither firms nor relational contracts will be feasible and spot markets or spot employment will dominate.

In this section we first derive the four results promised in the introduction: (1) implicit contracts (whether inside or outside firms) cannot exist if spot governance offers an inferior but sufficiently palatable alternative; (2) vertical integration is an efficient response to widely varying supply prices; (3) incentives are "higher-powered" in relational contracts than in firms;

and (4) transfer payments are part of the firm's performance-measurement and incentive system, not a device for allocating resources. We then solve two examples for which we compute and display the efficient organizational form as a function of parameters such as r, ΔQ, and ΔP.

To prove these four results, we impose additional assumptions on the model in Section II. We assume henceforth that the vector of actions has two components, $a=(a_1, a_2)$, and that the production functions $q(a)$ and $p(a)$ and the cost function $c(a)$ are:

$$q(a) = q_1a_1 + q_2a_2,$$

$$p(a) = p_1a_1 + p_2a_2, \qquad \text{and}$$

$$c(a) = \tfrac{1}{2}\, a_1^2 + \tfrac{1}{2}\, a_2^2,$$

where $q_1, q_2, p_1, p_2 \geq 0$. This model nests the two examples we solve at the end of this section: (1) one-dimensional effort ($q_2 = p_2 = 0$), where attempts to increase the probability of realizing the high alternative-use value (P_H) also increase the probability of the high downstream value (Q_H), and (2) unproductive multi-tasking ($q_2 = p_1 = 0$), where attempts to influence P are costly but have no effect on Q, and so strictly reduce social surplus. Other values of q_1, q_2, p_1, and p_2 capture cases such as academics, where research contributes to internal and external productivity ($q_1, p_1 > 0$) but administration contributes only to internal value ($q_2 > p_2 = 0$).

As noted above, the first-best actions maximize $Q_L + q(a)\Delta Q - c(a)$, so we can now derive that

$$a_1^* = q_1\Delta Q \quad \text{and} \quad a_2^* = q_2\Delta Q.$$

In a spot market, however, the upstream party maximizes $\tfrac{1}{2}(Q_L+P_L) + \tfrac{1}{2}q(a)\Delta Q + \tfrac{1}{2}p(a)\Delta P - c(a)$, so we have

$$a_1^M = \tfrac{1}{2}q_1\Delta Q + \tfrac{1}{2}p_1\Delta P \qquad \text{and}$$

$$a_2^M = \tfrac{1}{2}q_2\Delta Q + \tfrac{1}{2}p_2\Delta P.$$

Under spot employment the upstream party has no incentive to take costly actions and so chooses $a_1^E = a_2^E = 0$. Finally, in an implicit contract where $\Delta b \equiv b_H - b_L$ and $\Delta\beta \equiv \beta_H - \beta_L$, the upstream party maximizes $(s + b_L + \beta_L) + q(a)\Delta b + p(a)\Delta\beta - c(a)$, so we have

$$a_1^I = q_1\Delta b + p_1\Delta\beta \qquad \text{and}$$

$$a_2^I = q_2\Delta b + p_2\Delta\beta,$$

where "I" connotes implicit contract (and will be replaced by either "R" for relational contract or "F" for firm below).

We can now state formal versions of our four results. After stating each result we give an informal discussion; all proofs are presented in Appendix 2.

Proposition 1: Implicit contracts (whether inside or outside firms) cannot exist if spot governance offers an inferior but sufficiently palatable alternative. Formally, given q_1, q_2, p_1, p_2, ΔQ, and ΔP, there exists r^* such that if $r > r^*$ then no values of Δb and $\Delta\beta$ satisfy either the reneging constraint (8) for "firm" governance or the reneging constraint (12) for "relational contract" governance.

We give the intuition for the most interesting case of this result: an inefficient spot market can prevent the existence of a more efficient firm. Suppose that the spot market is superior to spot employment, $S^M > S^E$. Write the surplus from an implicit contract in a firm as $S^R(\Delta b, \Delta\beta)$. Large values of Δb and $\Delta\beta$ yield a large value of $S^R(\Delta b, \Delta\beta)$, approaching the first-best surplus S^*. But these large values of Δb and $\Delta\beta$ also produce a large temptation to renege. At a sufficiently high value of r, this large (current) temptation to renege outweighs the large (future) surplus.

So far, the argument is standard: in the vast majority of repeated-game models, a sufficiently high value of r prevents the existence of a first-best implicit contract. But the Proposition says that no implicit contract is feasible, whether close to first-best or only slightly more efficient than spot governance. The latter occurs because S^M is strictly positive, so the values of Δb and $\Delta\beta$ that yield $S^R(\Delta b, \Delta\beta)$ slightly larger than S^M are strictly positive. These positive values of Δb and $\Delta\beta$ create a positive temptation to renege, even though the surplus from the implicit contract is only slightly larger than the surplus from the spot market.[12]

---

[12] In Baker, Gibbons, and Murphy (1994) we established a similar result involving explicit and implicit compensation contracts: the latter are feasible only if the former are sufficiently inferior. MacLeod and Malcolmson (1989) anticipated part of this result, by showing that surplus is necessary for an implicit contract to exist. Relative to their result, there are two innovations in our two papers. First, we endogenize the performance of the spot-governance alternative to an implicit contract. That is, rather than taking the payoffs from spot governance to be exogenous, we derive these payoffs in the same economic environment in which we analyze implicit contracts. Second, we show that in our models surplus is necessary but not sufficient.

When implicit contracts are not feasible, there cannot be firms (by our definition). This can occur when an implicit contract would be more efficient than the spot market, but r is sufficiently high that the implicit contract cannot be supported as an equilibrium. It is in this sense that we say that an inefficient spot market can prevent the existence of a more efficient firm. We discuss this possibility in more detail in Example 1.

Proposition 2: Vertical integration is an efficient response to widely varying supply prices. Formally, given q_1, q_2, p_1, p_2, ΔQ, and r there exists ΔP^* such that if $\Delta P > \Delta P^*$ then the downstream party owns the asset in the efficient governance structure.

In our model of a relational contract, the upstream party could consign the good to its alternative use, so current market conditions (that is, realizations of P_L or P_H) play an important role in determining whether the parties will honor the implicit contract. In a firm, however, current market conditions do not affect the reneging decision because the downstream owner can simply take the good, without any restitution to the upstream party whatsoever. This distinction is clear from the reneging constraints: ΔP appears in the constraint for a relational contract, (12), but not in the constraint for a firm, (8).

This difference between firms and relational contracts offers an explanation for Carlton's (1979: 189) observation that companies vertically integrate to reduce uncertainty of supply.

> It has always been somewhat of a mystery why businessmen, as well as researchers, so often conclude that the significant force explaining . . . vertical integration . . . has been the desire to obtain a more certain supply of inputs.

Our model offers a novel answer to this puzzle: it is not the *ex ante* uncertainty associated with a volatile market price that is avoided by vertical integration, but rather the *ex post* temptation to renege on an implicit contract.[13] When the market price is highly variable, the upstream producer faces a large temptation to renege when the price is high, and the downstream consumer faces the symmetric temptation when the price is low. This makes it difficult to sustain an implicit contract. By vertically integrating (having the downstream party buy the

---

[13] In our model, a high ΔP represents a large variability in the value of the good in its next best use, assuming that this alternative value is still less than the internal value. We interpret a high ΔP as meaning that the "outside market price" of the good is highly variable.

asset, and thus the residual rights to the output), the market price no longer serves as a temptation to either party.

Klein (1996) and Klein and Murphy (1997) note that the recent wave of large vertical mergers in the pharmaceuticals and entertainment industries has followed major shifts in the market environments. They argue that this vertical integration is a response to "hold up" problems that occur when changing market conditions "place the relationship outside the self-enforcing range." Our formal model is consistent with their intuition: vertical integration dominates relational contracting when market conditions (ΔP) become highly variable.

Proposition 3: Incentives in relational contracts are "higher-powered" than incentives in firms. Formally, given q_1, q_2, p_1, p_2, ΔQ, ΔP, and r, if the most efficient firm yields $a_1^F < a_1^*$ and $a_2^F < a_2^*$ then either the most efficient relational contract yields $a_1^R > a_1^F$ and $a_2^R > a_2^F$ or no relational contract exists.

Recall that in a firm, the employee has no recourse if the firm asserts that performance was poor and refuses to pay the promised bonus, whereas in a relational contract an independent contractor owns the asset and can dictate its use. This improved fall-back position for the upstream party means that she can extract a positive payment after the downstream party reneges. Thus, the temptation for the downstream party to renege is not the full amount of the payment, but only the difference between this promised payment and the bargaining outcome. This reduced temptation means that the downstream party in a relational contract can promise a larger bonus than can a firm.

More formally, in our model of an implicit contract, the upstream party's actions are determined by Δb and $\Delta\beta$—these are the "bonuses" paid for achieving high realizations of Q and P, respectively. Therefore, holding Δb and $\Delta\beta$ fixed, the total surplus from an implicit contract does not depend on who owns the asset. But the temptation to renege, shown on the left-hand sides of (8) and (12), does depend on asset ownership. In particular, if strong incentives are desirable (*i.e.*, $\Delta b > \frac{1}{2}\Delta Q$ and $\Delta\beta > \frac{1}{2}\Delta P$) then the total reneging temptation is smaller in a relational contract than in a firm (namely, $|\Delta b - \frac{1}{2}\Delta Q| + |\Delta\beta - \frac{1}{2}\Delta P|$ rather than $|\Delta b| + |\Delta\beta|$). Thus, when strong incentives are desirable, a firm is an inefficient governance mechanism compared to a relational contract.

Proposition 3 corresponds to a thought experiment: fix the environment, measure the incentives in the optimal organizational form, and consider what incentives would emerge if the organizational form were changed. But an empirical test along these lines would require that

non-optimal organizational forms exist in the given environment. Fortunately, a related proposition also holds: choose a dataset with a narrow range of environments in which both firms and relational contracts exist; in this narrow range of environments, relational contracts will have higher-powered incentives than firms.

Proposition 4: In a spot market or a relational contract, prices determine the allocation of resources, but in a firm transfer payments serve only as part of the firm's performance-measurement and incentive system.

Transfer pricing has been a subject of extensive inquiry by economists. Early research (*e.g.*, Hirshleifer (1956) and Gould (1964)) treated the problem as one of trying to use the transfer pricing system to give incentives to decentralized agents to achieve the efficient allocation of resources within the firm—essentially trying to duplicate the market inside the firm. But Holmstrom and Tirole (1991) note that "a major deficiency of (this) approach is that it overlooks the reasons why trade is internal in the first place."

In our model, in the spot market or a relational contract, the upstream party can choose to reject the offered price and retain title to the good. In a firm, however, the good is already owned by the downstream party, who retains it no matter what. Thus, in our firm, any *ex post* payments from downstream to upstream cannot play any role in allocating resources; such payments can only be part of an implicit contract designed to provide *ex ante* incentives.

Eccles (1985) found that transfer prices are rarely used in organizations to allocate resources. Instead, the rights to allocate resources are held centrally, with the transfer pricing scheme serving as part of the performance-measurement and incentive system for the divisions. Our model assumes that the first part of Eccles's finding is correct: in the firms in our model, resources are allocated centrally by fiat, rather than as a decentralized response to transfer prices. Our result therefore concerns the second part of Eccles's finding: transfer payments exist, but only as the outcomes of the implicit contracts governing performance measurement and incentives for divisions.

Example 1: One-dimensional Effort

Suppose that $q_2 = p_2 = 0$: the upstream party takes a single action, a; the probability of realizing $Q = Q_H$ is $q(a) = qa$; the probability of realizing $P = P_H$ is $p(a) = pa$; disutility of effort is $c(a) = \frac{1}{2} a^2$. In Figure 2 we plot the efficient organizational form for this example, as a function of r and ΔP.

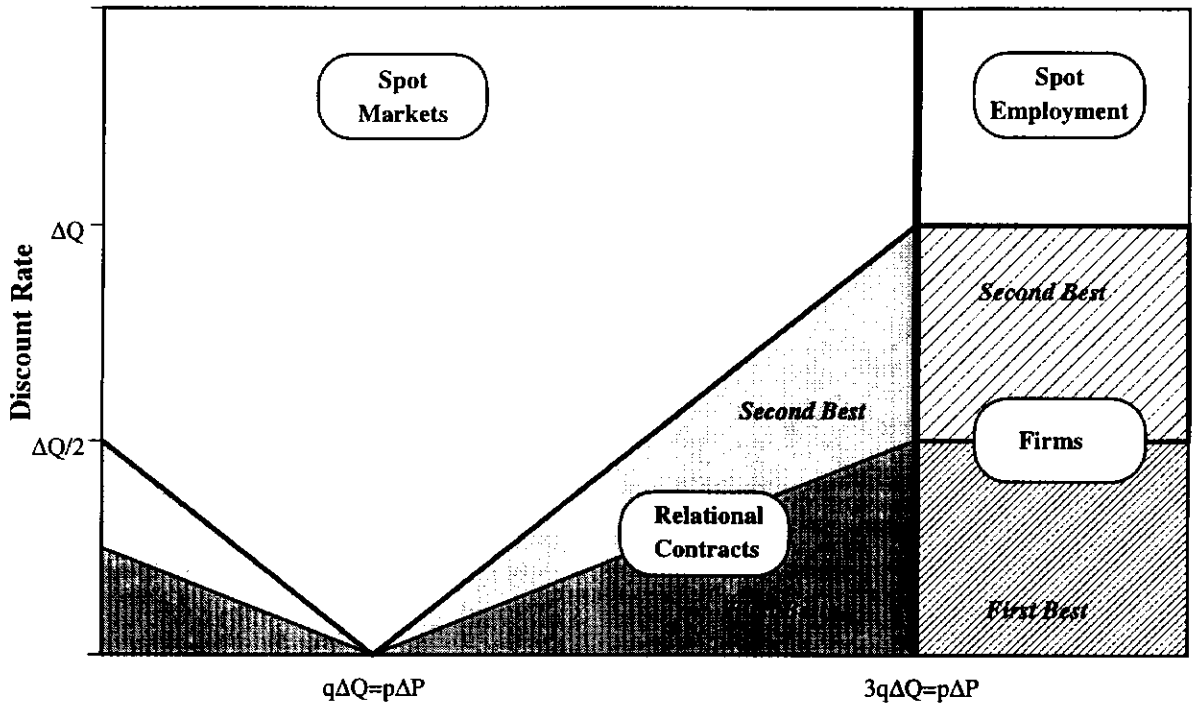

Figure 2: Efficient Organization Form as a Function of r and ΔP (Example 1: q(a)=qa, p(a)=pa, and c(a) = ½a²)

The figure shows how the efficient organizational form varies with the discount rate (r) and the difference between the high and low market valuations (ΔP), assuming that p=q=1. Given r, no implicit contract is feasible if the spot market is sufficiently close to first-best. At sufficiently low r, firms and relational contracts can achieve the first-best. As r increases, firms degenerate into spot employment and relational contracts into spot markets. Firms dominate relational contracts if and only if spot employment dominates the spot market.

SPOT MARKETS AND SPOT EMPLOYMENT: The upstream party's action in a spot market, $a^M = \frac{1}{2}q\Delta Q + \frac{1}{2}p\Delta P$, is first-best when $q\Delta Q = p\Delta P$ (shown towards the left of the figure). At this point, of course, no implicit contract can provide additional surplus beyond that delivered by the spot market, and so implicit contracts are not feasible at any discount rate. To the left of this point, when $p\Delta P < q\Delta Q$, the spot market provides inefficiently low incentives. This means that, at sufficiently low discount rates, relational contracts provide enough added surplus to be self-enforcing. When discount rates are very low, first-best relational contracts are feasible; when they are somewhat higher, second-best relational contracts are feasible. To the right of this point, when $p\Delta P > q\Delta Q$, the spot market provides inefficiently *high* incentives, which again allows relational contracts to be feasible. To the left of $p\Delta P=3q\Delta Q$, the surplus in the spot market ($S^M = Q_L + \frac{1}{8}(q\Delta Q + p\Delta P)(3q\Delta Q - p\Delta P)$), exceeds the surplus under spot employment ($S^E = Q_L$). Thus unless the spot market provides excessive incentives, ($p\Delta P > 3q\Delta Q$, shown towards the right of the figure), the spot market outperforms spot employment.

RELATIONAL CONTRACTS AND FIRMS: As in any repeated-game model, lower discount rates make implicit contracts more likely, for any value of ΔP. Similarly (and consistent with Proposition 1), spot governance always beats implicit contracting at sufficiently high discount rates. An interesting feature of this example is that the value of ΔP for which relational contracts outperform firms is the same as the value under which spot markets outperform spot employment. (That is, there is a vertical line at $p\Delta P = 3q\Delta Q$ separating upstream asset ownership from downstream ownership.) This result is somewhat surprising because when firms and relational contracts attain the same (second-best) level of surplus, they do so very differently: firms entail upstream *underinvestment* in effort, while (for $p\Delta P > q\Delta Q$) relational contracts achieve the same level of surplus with upstream *overinvestment* in effort (reminiscent of Proposition 3). Consistent with Proposition 2, when ΔP is large, spot employment provides more surplus than spot markets and firms provide more surplus than relational contracts: the downstream party owns the asset when ΔP is large. Finally, the boundary between spot employment and firms is independent of ΔP. In both of these organizational forms, the downstream party owns the asset, so the upstream party cannot threaten to sell the good in its alternative use. Thus, the outside price (P_H or P_L) is irrelevant to the determination of the optimal organizational form.

Example 2: Unproductive Multitasking

Suppose that $q_2 = p_1 = 0$: the upstream party takes a pair of actions, $a=(a_1,a_2)$; the probability of realizing $Q = Q_H$ is $q(a) = qa_1$; the probability of realizing $P = P_H$ is $p(a) = pa_2$; disutility of effort is $c(a) = \frac{1}{2} a_1^2 + \frac{1}{2} a_2^2$. In Figure 3 we plot the efficient organizational form for this example, again as a function of r and ΔP.

SPOT MARKETS AND SPOT EMPLOYMENT: In this example, the upstream party's action in a spot market is never first-best, because the spot market always provides too little incentive for a_1 and too much incentive (except when $\Delta P=0$) for a_2. Thus, unlike in Example 1, it is always possible (with sufficiently low r) to devise a self-enforcing implicit contract. However, the comparison between the spot market and spot employment is similar to Example 1 (and consistent with Proposition 2): spot employment dominates if ΔP is sufficiently large ($p\Delta P > \sqrt{3}q\Delta Q$ in the figure).

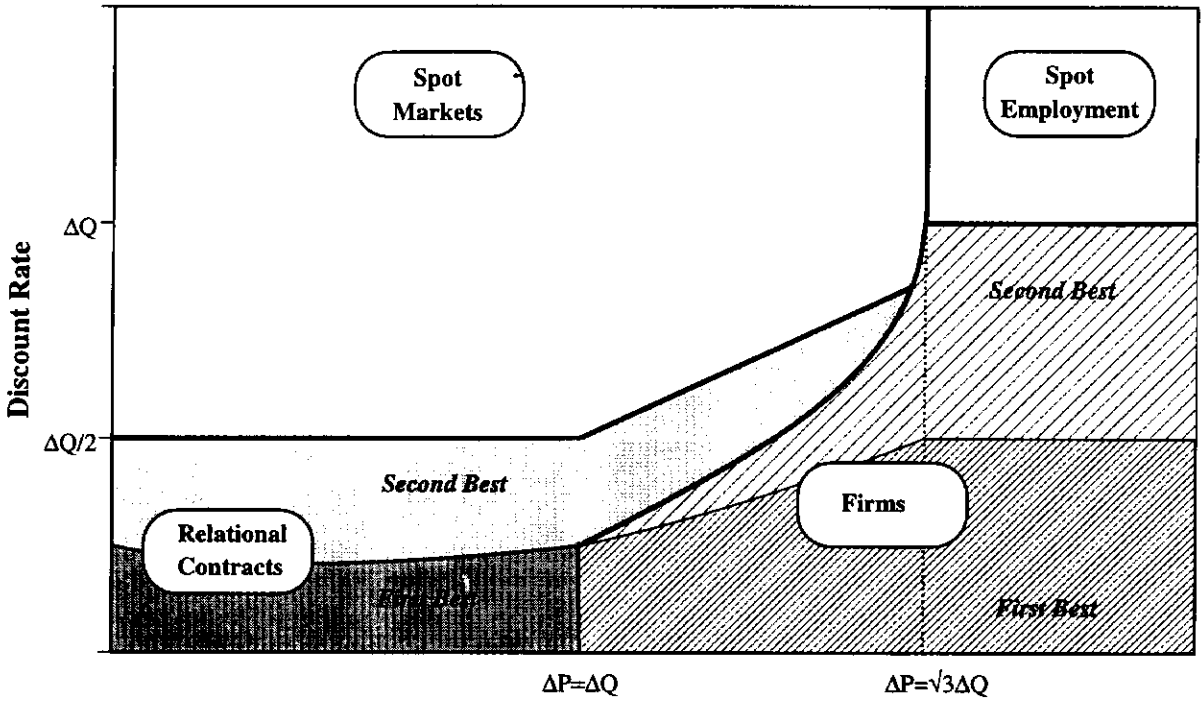

Figure 3: Efficient Organization Form as a Function of r and ΔP
(Example 2: $q(a)=qa_1$, $p(a)=pa_2$, and $c(a) = \frac{1}{2}a_1^2 + \frac{1}{2}a_2^2$)

The figure shows how the efficient organizational form varies with the discount rate (r) and the difference between the high and low market valuations (ΔP), assuming that p=q=1.

RELATIONAL CONTRACTS AND FIRMS: In contrast to Example 1, the conditions under which relational contracts out-perform firms in this example are not identical to those under which spot markets out-perform spot employment. Instead, the choice between a firm and a relational contract may now depend on r. (Although Proposition 2, that firms out-perform relational contracts at sufficiently high ΔP, continues to hold). At low values of r, the boundary between first-best firms and first-best relational contracts is at $\Delta P = \Delta Q$, as shown in the figure; at high values of r, the boundary is at $p\Delta P = \sqrt{3}q\Delta Q$, as noted above. The most interesting case is for intermediate values of r, such as where the boundary between second-best firms and second-best relational contracts is not vertical (ΔP just greater than ΔQ in the figure). On this boundary, an increase in r changes efficient governance from a firm to a relational contract. The intuition for this result is related to Proposition 3, which says that incentives in relational contracts are "higher-powered" than incentives in firms. In this region of the figure, total incentives are too high (*i.e.*, above first-best). Because Proposition 3 states that a firm provides lower (and thus more efficient) total incentives than a relational contract, a relational contract will not be observed unless it delivers a lower reneging temptation than would a firm.

Raising r, which changes neither the surplus from the contracts nor the (one-period) payoff from reneging, causes the implicit contract with the greater reneging temptation to become infeasible sooner, hence the transition from firms to relational contracts in the figure as r increases. Of course, consistent with Proposition 1, additional increases in r make all implicit contracts infeasible.

IV. Interpretation and Extensions

This paper sheds new light on what distinguishes firms from spot markets, and on how both these organizational forms differ from the long-term non-integrated relationships we call relational contracts. We emphasize the role of "management" in firms and relational contracts—the articulation of unwritten rules and codes of conduct, the development and maintenance of a reputation for abiding by these rules, and the use of subjective assessments and informal adaptation to events in the implementation of these rules.[14] Our description of management thus elaborates on Kreps's (1990) description of corporate culture, and shows that culture and management are just as important in non-integrated supplier relationships as in firms.

Management

In the introduction to the third edition of his book *Administrative Behavior*, Herbert Simon (1947; 1976) states:

> To many persons, an organization is something that is drawn on charts or recorded in elaborate manuals of job descriptions. . . . In this book, the term *organization* refers to the complex pattern of communication and relationships in a group of human beings. This pattern provides to each member of the group a . . . set of stable and comprehensible expectations as to what the other members of the group are doing and how they will react to what he says and does.

Determining what these patterns of expectations should be, and establishing them, is a complex task. Even once the expectations are set, maintaining the implicit contracts in an organization requires (i) that managers accurately assess the observable but non-contractible outcomes (the P's and Q's in our model), (ii) that they know the payoffs that are supposed to result from

---

[14] Bernheim and Whinston (1997) share our emphasis on management: in our terminology, they show that an optimal explicit contract may be incomplete in order to create a role for management of an implicit contract.

these outcomes (the b's and β's and when to pay them), and (iii) that they exercise discretion in deciding whether to honor the implicit contract (*i.e.*, properly evaluate the reneging constraints). In our model these three tasks are trivial; in reality each requires judgment and knowledge of the specifics of complex situations.

The implicit contracts in an organization are essential but difficult to observe. They provide a set of rules that may be clear to those who are inside the organization, but may be invisible to outsiders. Indeed, we believe that one of the reasons that organizational behavior has been such a mystery to economists is that those inside organizations appear to be dancing to music that outside analysts can't hear: this music is the set of implicit contracts that direct and motivate individuals to achieve coordinated action when they have few apparent incentives. Chester Barnard (1976) referred to these implicit contracts as "specific organization practice:"

> By this I mean the lines of organization, the governing policies, the rules and regulations, the patterns of behavior of a specific organization. Though much of this is recorded in writing in any organization and can be studied, much is "unwritten law" and can chiefly be learned by intimate observation and experience. . . . An effective working knowledge of a specific organization can only be acquired by working in it.

Given the prevalence of these unwritten rules, it is not surprising that models that do not account for them cannot completely explain the existence and performance of organizations. Blau and Scott (1962:6) make a stronger assertion in this spirit:

> It is *impossible* to understand the nature of a formal organization without investigating the networks of informal relations and the unofficial norms as well as the formal hierarchy of authority and the official body of rules, since the formally instituted and the informal emerging patterns are inextricably intertwined (emphasis added).

Haggling and Conflict

One legitimate criticism of our model is that it makes the process of management too neat. In our model, the implicit contracts provide the music to which the members of an organization dance, but saying that this music is inaudible to outsiders does not explain why organizations often look more like a disorganized rumble than our well-choreographed waltz. In future work we intend to address this issue by defining management more broadly than simply the maintenance of implicit contracts, to include also their creation and renegotiation. We expect this extension of our model to address the discord, confusion, and conflict that often seem to plague organizational life.

Just as the creation of *explicit* contracts involves the (generally unmodeled) process of gathering information about tastes and technology, hiring lawyers, and agreeing on enforcement mechanisms, so the creation of *implicit* contracts is a messy and conflict-laden process. And it is made even more difficult because the terms and conditions of implicit contracts often are not formally articulated. Rather, they are built up by precedent and experience. To cite Simon (1947; 1976) again:

> Much of what an executive does has its principal short-run effect on day-to-day operations. He makes a decision about a product price, a contract for materials, the location of a plant, an employee's grievance. Each of these has an immediate effect in settling the question before him. But the most important cumulative effect of this stream of decisions . . . is upon the patterns of actions in the organization.

It would be surprising if a system that relied on such implicit contracts ran perfectly smoothly.

A different way to add haggling to the model would be to depart from our assumption that the value of output (Q) is common knowledge, much as Green and Porter (1984) depart from the assumption that firms' quantity choices are common knowledge in the context of colluding oligopolists. This approach would produce inefficient punishments in equilibrium. In our model such punishments might take the form of the firm refusing to pay an employee some promised payment in the event of an unlucky bad outcome, because such a bad outcome could be generated by shirking—even though, in equilibrium, such shirking will never occur. Such an episode would then be followed by an inefficient period of low effort from the employee before the implicit contract was re-established.

Subjective Assessments and Uncertainty

In the model presented above, problems stemming from asset specificity are mitigated through what we have called management—the development and implementation of an implicit contract. Similarly, in our earlier paper (Baker, Gibbons, and Murphy, 1994) we showed how implicit contracts based on subjective performance evaluations could mitigate problems stemming from distortionary objective measures of performance. In both of these models, the benefits of implicit contracting arise because such contracts can use evaluations of outcomes that are either not verifiable *ex post* or not specifiable *ex ante*. In the case of asset specificity, the value of a specific asset (or, in our case, its current output) can be used in the implicit contract, while in the case of distortionary objective performance measures, a subjective performance evaluation can be used.

There is at least one other situation in which implicit contracts based on subjectively evaluated outcomes may be useful: situations in which contractible measures of outcomes are so noisy that explicit contracts will impose excessive risk on the contracting parties.[15] In this situation, subjective assessments of performance will be much more successful in providing incentives to an agent without imposing excessive risk. For example, stock prices are contractible measures of performance for executives (or any other employee in the firm), but they include a great deal of noise along with the signal that they provide about managerial performance. A subjective assessment of the executive's performance can potentially disentangle the effects of her actions from the uncontrollable effects of the environment.

An extension of our two models (in this paper and the earlier one), in the spirit of Holmstrom-Milgrom (1994) but with the addition of repeated games to their analysis, would provide a more general description and explanation of how organizations solve contracting problems. This model would allow for the simultaneous use of various instruments—including explicit contracts, implicit contracts, and asset ownership—to solve problems that arise from asset specificity, performance measurement problems, and uncertainty.

V. Applications and Conclusions

Recognizing the role of implicit contracts in organizations, and labeling the development and implementation of these implicit contracts "management," helps to explain several observations about informal processes inside of firms. We provide three examples: compensation, transfer pricing, and corporate governance.

Compensation

Most economic models of compensation and incentives suggest that compensation contracts should be fairly simple documents that specify performance measures and the weights that will be attached to these measures. In practice, however, compensation determination in most organizations is an administratively-intensive process that may involve

---

[15] Holmstrom and Milgrom (1994) suggest these three economic problems—asset specificity, difficulty with performance measurement, and uncertainty—as the exogenous parameters that determine the endogenously-chosen set of instruments that define a firm.

some use of formulas but almost always involves a great deal of subjective assessment and judgment on the part of higher-level management. As Edward Lawler (1990:90) argues:

> In most cases, there are simply no hard, objective measures available that would allow the [performance] appraisal to be based on objective data. Thus, a judgment call is necessarily involved.

Lawler goes on to describe the process by which subjective assessments of performance are made in organizations, and stresses that this process is extremely time-consuming for managers.

Eccles and Crane (1988) provide a similar description of the bonus-setting process in investment banks. Again, the process is management-intensive and highly subjective:

> Senior managers use subjective judgment in determining how funds from aggregate bonus pools should be allocated to individuals. Furthermore, they take into consideration a great deal of quantitative and qualitative information . . . from other systems and from conversations with people throughout the firm. . . . Armed with these and other data, top management then decides on individual bonuses. This is a complex and time-consuming process, which was described by many senior managers as one of the most important things they did.

These descriptions of the process of compensation determination are consistent with our model of implicit contracts, and with our interpretation of these contracts as involving a significant amount of managerial judgment in their implementation.

Transfer Pricing

Eccles (1985) argues that the role of "administrative process" is essential to understanding how transfer pricing systems are implemented in the organizations that he studied. He defines the elements of this process as how transfer prices are set, who sets them and when, what information is used, and how conflict over transfer prices is resolved. He describes this process as being highly administratively intensive, and as one that "needs constant management attention" (p. 116).

Eccles argues that understanding how transfer pricing systems work requires understanding the sources and functions of these administrative processes.

> Here, the term [administrative] process will be used . . . to refer to patterns of behavior that emerge from the activities and interactions of people in the company. . . . Structure and systems are the foundations on which processes are built, but processes are also affected by company culture (norms, values, beliefs, attitudes, rituals, and myths). (p. 269-270)

In our model, these administrative processes appear as part of the implicit contracts.

The Role of the Board

One of the original motivations for agency theory was to model the relationship between managers and investors. Beginning with Jensen and Meckling (1976) and Holmstrom (1979), the now-enormous literature on incentive contracting models this problem as the design of a contract that splits the output of the relationship between a risk-averse manager and investors. These models typically assume the existence of a contractible measure of output and solve for a second-best (explicit) contract that uses this measure to induce non-contractible effort on the part of the manager. But when we look for examples of principal-agent situations that conform to this contracting model, we find them in a somewhat unexpected place: the legal entity known as a Limited Partnership (LP). In an LP, the general partner (the agent) agrees to a formula with the limited partners (the principals) describing the distribution of proceeds from whatever projects the LP takes on. This sharing rule is part of a legally enforceable explicit contract between the general and limited partners that serves as the main basis for their agency relationship.[16] One of the important distinctions between this governance form and the corporate form is that there is almost never a board of directors in a Limited Partnership, and there is no need for one: the distribution of proceeds is done by explicit contract.

A typical Corporation differs greatly from a Limited Partnership in terms of the contracting process governing the distribution of value between the principals (the shareholders) and the agents (management). Whereas an explicit contract is the sole instrument in an LP, an executive compensation contract in a corporation almost always gives significant discretion to the board of directors in determining both the size and timing of payouts (see Kole, 1997). Similarly, the authority for the distribution of corporate proceeds through dividends rests with the board of directors.

But what does the board do? We argue that the role of the board is to serve as a designer and implementor of an implicit contract between management and the shareholders. Board members must establish this implicit contract, and must then evaluate outcomes and decide on payoffs. Using a variety of objective and subjective measures of performance, the board

---

[16] For a description and analysis of Limited Partnership governance see Wolfson 1985, Sahlman 1990, and Gompers and Lerner 1995.

attempts to disentangle the effects of management's actions from those of luck, and to eliminate distortions induced by accounting-based (and other objective) measures of performance. This description is consistent with both Lorsch and McIver (1994), who characterize the role of boards, and Dechow, Huson, and Sloan (1994), who present evidence that compensation committees implicitly adjust accounting-based bonuses for the negative consequences of restructuring charges.

Management and the Nature of the Firm

The model developed in Sections II and III, and the definition and interpretation of "management" given in Section IV, provide an answer to the question: Why are there firms? Like Kreps (1990), we argue that firms serve as reputation carriers in order to sustain implicit contracts. But we also recognize that reputations are important outside of firms: in our analysis they appear in relational contracts. We thus predict that management will be as important in relational contracts (to design and implement implicit contracts between non-integrated parties) as it is in firms. To distinguish between these two management-intensive organizational forms, we borrow Grossman and Hart's focus on asset ownership. The fact that the set of feasible implicit contracts depends on asset ownership creates a richer explanation for the existence of firms: firms exist not only to sustain implicit contracts but also to sustain different implicit contracts than could be sustained when assets are owned separately.

Our answer to "Why are there firms?" is consistent with Coase's analysis of the nature of the firm, but we add a new twist to his argument that firms arise where markets would perform poorly. In our model, firms (and relational contracts) can arise only where markets perform sufficiently poorly that an implicit contract can create enough surplus to be self-enforcing. Our emphasis on the implicit contracts inside firms also suggests an answer to a second question: what do managers do? Our answer is that managers develop and implement implicit contracts. Thus, whereas Jensen and Meckling (1976) define a firm as "a nexus of explicit and implicit contracts," we argue that it is the implicit contracts that are the key to understanding the nature of the firm.

Our model also enriches Grossman and Hart's description of the firm. We adopt their definition of a firm as a collection of non-contractible rights of control, but we argue that unless all such rights are held by a single individual, the firm must have some mechanism to coordinate the exercise of these rights. Since these rights are not contractible, their exercise cannot be controlled by explicit contracts. Instead, the exercise of non-contractible rights is coordinated by implicit contracts. We argue that the non-contractible rights of control that

Grossman and Hart study in their analysis of asset ownership are the very rights that firms manage through their administrative processes. Most organizations do not (and, realistically, cannot) allocate all of these rights to a single individual, but rather decentralize and control these rights through implicit contracts. We intend to formalize these arguments in future work.

The examples that we give in this section—of compensation systems, transfer pricing, and the role of boards—all demonstrate that systems and processes in organizations that have often been modeled as objective and explicit are generally subjective and implicit. Indeed, most descriptions of organizations suggest an enormous role for the activities we have described as management. While it is easy to see why economists often model organizations as collections of explicit contracts (and why managers would prefer a system that avoids the judgment and subjectivity that we have emphasized), our theory predicts that such systems will not survive. If an objective and explicit compensation plan or transfer pricing system worked well, the very basis for the existence of the firm should be questioned, since a spot-market relationship could perform just as well. Discretion and judgment, and the development and implementation of implicit contracts that rely on these qualities, are the essence of the managerial task.

References

Baker, George. 1992. "Incentive Contracts and Performance Measurement." *Journal of Political Economy* 100:598-614.

_____, Robert Gibbons and Kevin J. Murphy. 1994. "Subjective Performance Measures in Optimal Incentive Contracts." *Quarterly Journal of Economics* 109: 1125-56.

Barnard, Chester. 1938. *The Functions of the Executive.* Cambridge, MA: Harvard University Press.

_____. 1976. Forward to *Administrative Behavior* by Herbert Simon. New York: The Free Press.

Bernheim, Douglas and Michael Whinston. 1997. "Incomplete Contracts and Strategic Ambiguity." Forthcoming, *American Economic Review.*

Bestor, Theodore. Forthcoming. *Tokyo's Marketplace: Culture and Trade in the Tsukiji Wholesale Market.* Stanford, CA: Stanford University Press.

Blau, Peter. 1955. *The Dynamics of Bureaucracy.* Chicago: University of Chicago Press.

_____ and Richard Scott. 1962. *Formal Organizations: A Comparative Approach.* San Francisco: Chandler Publishing.

Blumenstein, Rebecca and Gabriella Stern. 1996. "UAW, Auto Makers Find Some Things Better Left Unsaid." *Wall Street Journal,* November 25, A1.

Bower, Joseph. 1970. *Managing the Resource Allocation Process.* Boston: Harvard Business School Press.

Bull, Clive. 1987. "The Existence of Self-Enforcing Implicit Contracts," *Quarterly Journal of Economics* 102: 147-59.

Carlton, Dennis. 1979. "Vertical Integration in Competitive Markets Under Uncertainty," *Journal of Industrial Economics* XXXVII: 189-209.

Coase, Ronald. 1937. "The Nature of the Firm." *Economica* 4: 386-405.

Dalton, Melville. 1959. *Men Who Manage.* New York: Wiley.

Dechow, Patricia, Mark Huson and Richard Sloan. 1994. "The Effect of Restructuring Charges on Executives' Cash Compensation." *Accounting Review* 69:138-56.

Eccles, Robert. 1981. "The Quasifirm in the Construction Industry." *Journal of Economic Behavior and Organization* 2: 335-57.

_____. 1985. *The Transfer Pricing Problem.* D. C. Heath: Lexington, MA.

_____ and Dwight Crane. 1988. *Doing Deals: Investment Banks at Work.* Boston: Harvard Business School Press.

Gompers, Paul and Josh Lerner. 1995. "The Use of Covenants: An Empirical Analysis of Venture Partnership Agreements." Working Paper, April. Harvard Business School.

Gould, J.R. 1964. "Transfer Pricing in Firms When There Are Costs of Using an Outside Market," *Journal of Business* 37: 61-67.

Gouldner, Alvin. 1954. *Patterns of Industrial Bureaucracy*. New York: The Free Press.

Granovetter, Mark. 1985. "Economic Action and Social Structure: The Problem of Embeddedness." *American Journal of Sociology* 91: 481-510.

Green, Edward and Robert Porter. 1984. "Noncooperative Collusion Under Imperfect Price Information." *Econometrica* 52:87-100.

Grossman, Sanford and Oliver Hart. 1986. "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Ownership." *Journal of Political Economy,* 94: 691-719.

Halonen, Maija. 1994. "Reputation and Allocation of Ownership." Working Paper, Helsinki School of Economics.

Hirshleifer, Jack. 1956. "On the Economics of Effective Intracompany Pricing." *Journal of Business* 29: 172-84.

Holmstrom, Bengt. 1979. "Moral Hazard and Observability." *Bell Journal of Economics* 10: 74-91.

_____ and Paul Milgrom. 1991. "Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design." *Journal of Law, Economics, and Organization* 7: 24-52.

_____ and _____. 1994. "The Firm as an Incentive System." *American Economic Review* 84: 972-91.

_____ and Jean Tirole. 1991. "Transfer Pricing and Organizational Form." *Journal of Law, Economics, and Organization* 7: 201-28.

Jensen, Michael and William Meckling. 1976. "Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure." *Journal of Financial Economics* 3: 305-60.

Klein, Benjamin. 1996. "Why Hold-ups Occur: The Self-Enforcing Range of Contractual Relationships." *Economic Inquiry* 34: 444-63.

_____, Robert Crawford, and Armen Alchian. 1978. "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process." *Journal of Law and Economics* 21: 297-326.

_____ and Keith Leffler. 1981. "The Role of Market Forces in Assuring Contractual Performance." *Journal of Political Economy.* 89:615-641.

_____ and Kevin M. Murphy. 1997. "Vertical Integration as a Self-Enforcing Contractual Arrangement." *American Economic Review*, forthcoming.

Kogut, Bruce, Weigian Shan, and Gordon Walker. 1992. "The Make-or-Cooperate Decision in the Context of an Industry Network." In N. Nohria and R. Eccles (eds.), *Networks and Organizations: Structure, Form, and Action.* Boston: Harvard Business School Press.

Kole, Stacey. 1997. "The Complexity of Compensation Contracts." *Journal of Financial Economics* 43: 79-104.

Kollock, Peter. 1994. "The Emergence of Exchange Structures: An Experimental Study of Uncertainty, Commitment, and Trust." *American Journal of Sociology* 100: 313-45.

Kreps, David. 1990. "Corporate Culture and Economic Theory." In J. Alt and K. Shepsle, eds. *Perspectives on Positive Political Economy.* Cambridge University Press.

Lawler, Edward. 1990. *Strategic Pay.* Jossey-Bass: San Francisco.

Lorsch, Jay and Elizabeth McIver. 1994. *Pawn and Potentates: The Reality of America's Corporate Boards.* Harvard Business School Press: Boston.

Macaulay, Stewart. 1963. "Non Contractual Relations in Business: A Preliminary Study." *American Sociological Review* 28: 55-67.

MacLeod, Bentley and James Malcolmson. 1989. "Implicit Contracts, Incentive Compatibility, and Involuntary Unemployment." *Econometrica* 57: 447-80.

Powell, Walter. 1990. "Neither Market nor Hierarchy: Network Forms of Organization." *Research in Organizational Behavior.* 12: 295-336.

Sahlman, William. 1990. "The Structure and Governance of Venture Capital Organizations." *Journal of Financial Economics*, 27: 473-524.

Selznick, Philip. 1949. *TVA and the Grass Roots.* Berkeley: University of California Press.

Simon, Herbert. 1951. "A Formal Theory Model of the Employment Relationship." *Econometrica* 19: 293-305.

_____. 1947 (1976). *Administrative Behavior.* New York: The Free Press.

Telser, Lester. 1981. "A Theory of Self-Enforcing Agreements." *Journal of Business* 53: 27-44.

Williamson, Oliver. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications.* Free Press: New York.

_____. 1985. *The Economic Institutions of Capitalism.* Free Press: New York.

_____. 1991. "Comparative Economic Organization: The Analysis of Discrete Structural Alternatives." *Administrative Science Quarterly* 36: 269-96.

Wolfson, Mark. 1985. "Empirical Evidence of Incentive Problems and Their Mitigation in Oil and Gas Tax Shelter Programs." In Pratt, John and Richard Zeckhauser, eds., *Principals and Agents: The Structure of Business.* Harvard Business School Press: Boston.

Appendicies

APPENDIX 1. NECESSARY AND SUFFICIENT CONDITIONS FOR HONORING RELATIONAL CONTRACTS

Equation (11) defines the following four constraints that must be satisfied to ensure that the downstream party will honor the implicit contract for i,j=H,L.

$$b_H + \beta_H - \tfrac{1}{2}(Q_H + P_H) \le \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

$$b_H + \beta_L - \tfrac{1}{2}(Q_H + P_L) \le \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

$$b_L + \beta_H - \tfrac{1}{2}(Q_L + P_H) \le \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

$$b_L + \beta_L - \tfrac{1}{2}(Q_L + P_L) \le \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]).$$

After substituting $b_H \equiv b_L + \Delta b$, $\beta_H \equiv \beta_L + \Delta\beta$, $Q_H \equiv Q_L + \Delta Q$, and $P_H \equiv P_L + \Delta P$, and defining $Z \equiv (b_L - \tfrac{1}{2}Q_L) + (\beta_L - \tfrac{1}{2}P_L)$, the four constraints can be rewritten as:

(A1.1a) $$Z + (\Delta b - \tfrac{1}{2}\Delta Q) + (\Delta\beta - \tfrac{1}{2}\Delta P) \le \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

(A1.1b) $$Z + (\Delta b - \tfrac{1}{2}\Delta Q) \le \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

(A1.1c) $$Z + (\Delta\beta - \tfrac{1}{2}\Delta P) \le \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

(A1.1d) $$Z \le \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]).$$

Similarly, equation (12) defines the following four constraints that must be satisfied to ensure that the upstream party will honor the implicit contract for i,j=H,L.

$$b_H + \beta_H - \tfrac{1}{2}(Q_H + P_H) \ge \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R),$$

$$b_H + \beta_L - \tfrac{1}{2}(Q_H + P_L) \ge \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R),$$

$$b_L + \beta_H - \tfrac{1}{2}(Q_L + P_H) \ge \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R),$$

$$b_L + \beta_L - \tfrac{1}{2}(Q_L + P_L) \ge \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R).$$

After similar substitution, these four constraints can be rewritten as:

(A1.2a) $$Z + (\Delta b - \tfrac{1}{2}\Delta Q) + (\Delta\beta - \tfrac{1}{2}\Delta P) \ge \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R),$$

(A1.2b) $$Z + (\Delta b - \tfrac{1}{2}\Delta Q) \geq \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R),$$

(A1.2c) $$Z + (\Delta \beta - \tfrac{1}{2}\Delta P) \geq \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R),$$

(A1.2d) $$Z \geq \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R).$$

All eight constraints will not be binding simultaneously; in fact at most two constraints will be binding. For example, suppose that $\Delta b > \tfrac{1}{2}\Delta Q$ and $\Delta\beta > \tfrac{1}{2}\Delta P$. Then, if (A1.1a) is satisfied, the other downstream constraints (A1.1b), (A1.1c), and (A1.1d) will also be satisfied. Similarly, if (A1.2d) is satisfied then (A1.2a), (A1.2b), and (A1.2c) will also be satisfied. Thus, when $\Delta b > \tfrac{1}{2}\Delta Q$ and $\Delta\beta > \tfrac{1}{2}\Delta P$, the relevant constraints are (A1.1a) and (A1.2d); if these two are satisfied then the other constraints are satisfied as well. Applying similar logic yields the following pairs of "relevant" constraints:

When $\Delta b > \tfrac{1}{2}\Delta Q$ and $\Delta\beta > \tfrac{1}{2}\Delta P$, the relevant constraints are:

(A1.1a) $$Z + (\Delta b - \tfrac{1}{2}\Delta Q) + (\Delta \beta - \tfrac{1}{2}\Delta P) \leq \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

(A1.2d) $$Z \geq \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R).$$

When $\Delta b > \tfrac{1}{2}\Delta Q$ and $\Delta\beta < \tfrac{1}{2}\Delta P$, the relevant constraints are:

(A1.1b) $$Z + (\Delta b - \tfrac{1}{2}\Delta Q) \leq \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

(A1.2c) $$Z + (\Delta \beta - \tfrac{1}{2}\Delta P) \geq \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R).$$

When $\Delta b < \tfrac{1}{2}\Delta Q$ and $\Delta\beta > \tfrac{1}{2}\Delta P$, the relevant constraints are:

(A1.1c) $$Z + (\Delta \beta - \tfrac{1}{2}\Delta P) \leq \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

(A1.2b) $$Z + (\Delta b - \tfrac{1}{2}\Delta Q) \geq \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R).$$

When $\Delta b < \tfrac{1}{2}\Delta Q$ and $\Delta\beta < \tfrac{1}{2}\Delta P$, the relevant constraints are:

(A1.1d) $$Z \leq \frac{1}{r}(D^R - \max[D^M, \tfrac{1}{2}(S^E - U^M + D^M)]),$$

(A1.2a) $$Z + (\Delta b - \tfrac{1}{2}\Delta Q) + (\Delta \beta - \tfrac{1}{2}\Delta P) \geq \frac{1}{r}(\max[U^M, \tfrac{1}{2}(S^E + U^M - D^M)] - U^R).$$

Multiplying the upstream constraint by minus one and adding the downstream constraint yields an identical necessary condition for each pair of constraints:

(12) $$|\Delta b - \tfrac{1}{2}\Delta Q| + |\Delta\beta - \tfrac{1}{2}\Delta P| \leq \frac{1}{r}(S^R - \max[S^M, S^E]).$$

Finally, note that (12) is sufficient as well an necessary, since for any Δb and $\Delta\beta$ satisfying (12), a fixed payment, s, can always be chosen that satisfies the relevant pairs of constraints.

APPENDIX 2. PROOFS OF PROPOSITIONS 1 THROUGH 3.

Lemma 1: For sufficiently large ΔP, spot employment dominates the spot market. That is, given q_1, q_2, p_1, p_2, and ΔQ there exists $\Delta P'$ such that if $\Delta P > \Delta P'$ then $S^E > S^M$.

Proof: $2(S^M - S^E) = (3/4)(q_1^2 + q_2^2)\Delta Q^2 + (1/2)(p_1q_1 + p_2q_2)\Delta Q\Delta P - (1/4)(p_1^2 + p_2^2)\Delta P^2$, so choose $\Delta P'$ to be the larger root of the quadratic.

Lemma 2: Too strong an incentive based on the alternative-use value makes a relational contract inferior to spot employment. That is, given q_1, q_2, p_1, p_2, and ΔQ there exists $\Delta\beta'$ such that, for any Δb, if $\Delta\beta > \Delta\beta'$ then $S^R - S^E < 0$.

Proof: $2(S^R - S^E) = (q_1^2 + q_2^2)\Delta b(2\Delta Q - \Delta b) + 2(p_1q_1 + p_2q_2)(\Delta Q - \Delta b)\Delta\beta - (p_1^2 + p_2^2)\Delta\beta^2$. Maximize the first term with respect to $\Delta b \geq 0$ (at $\Delta b = \Delta Q$); maximize the second term with respect to $\Delta b \geq 0$ (at $\Delta b = 0$). Now choose $\Delta\beta'$ to be the larger root of the resulting quadratic, with the maximized versions of the first and second terms replacing the originals.

Lemma 3: Too large a variation in the alternative-use value makes a relational contract infeasible. That is, given q_1, q_2, p_1, p_2, ΔQ, and r there exists $\Delta P''$ such that if $\Delta P > \Delta P''$ then the reneging constraint (12) for a relational contract fails.

Proof: Choose $\Delta P''$ such that $\frac{1}{2}\Delta P'' > \Delta\beta' + (S^* - S^E)/r$, where S^* is the first-best surplus. Then $\Delta\beta > \Delta\beta'$ implies that $S^R - S^E < 0$, by Lemma 2, so $S^R - \max\{S^M, S^E\} < 0$, so (12) fails. But $\Delta\beta \leq \Delta\beta'$ implies $\frac{1}{2}\Delta P'' > \Delta\beta$, so the second term on the lefthand side of (12) is at least $\frac{1}{2}\Delta P'' - \Delta\beta \geq \frac{1}{2}\Delta P'' - \Delta\beta' > (S^* - S^E)/r \geq (S^R - S^E)/r \geq (S^R - \max\{S^M, S^E\})/r$, so (12) fails.

Proposition 2: Vertical integration is an efficient response to widely varying supply prices. Formally, given q_1, q_2, p_1, p_2, ΔQ, and r there exists ΔP^* such that if $\Delta P > \Delta P^*$ then the downstream party owns the asset in the efficient governance structure.

Proof: Given Lemmas 1 and 3, Proposition 2 follows by setting $\Delta P^* = \max\{\Delta P', \Delta P''\}$: because $\Delta P > \Delta P'$, the spot market is not efficient; because $\Delta P > \Delta P''$, a relational contract is not feasible.

Lemma 4: For sufficiently high r, the only possible firm is the trivial case of $\Delta b = \Delta\beta = 0$ (*i.e.*, replication of spot employment). That is, given q_1, q_2, p_1, p_2, ΔQ and ΔP there exists r_D^* such that if $r > r_D^*$ then no values of Δb and $\Delta\beta$ satisfy the reneging constraint (8) except $\Delta b = \Delta\beta = 0$.

Proof: The reneging constraint (8) holds only if $|\Delta b| + |\Delta\beta| \leq (S^F - S^E)/r$. But this inequality can be written as

$$(A2.1) \qquad 2r(\Delta b + \Delta\beta) + (a_1^F - q_1\Delta Q)^2 + (a_2^F - q_2\Delta Q)^2 \leq (q_1^2 + q_2^2)\Delta Q^2,$$

where $a_i^F = q_i\Delta b + p_i\Delta\beta$. Note that at $\Delta b = \Delta\beta = 0$ we have $a_1^F = a_2^F = 0$, so (A2.1) holds with equality. We will show that for sufficiently high values of r, values of Δb and/or $\Delta\beta$ other than zero increase the lefthand side of (A2.1), but the righthand side is constant, so the reneging constraint (8) fails unless $\Delta b = \Delta\beta = 0$.

Let $L_D(\Delta b, \Delta\beta)$ denoted the lefthand side of (A2.1). Then $\partial L_D/\partial\Delta b = 2r + 2(a_1^F - q_1\Delta Q)q_1 + 2(a_2^F - q_2\Delta Q)q_2$. Because a_1^F and $a_2^F \geq 0$, we have that if $r > (q_1^2 + q_2^2)\Delta Q$ then $\partial L_D/\partial\Delta b > 0$. Similarly, $\partial L_D/\partial\Delta\beta = 2r + 2(a_1^F - q_1\Delta Q)p_1 + 2(a_2^F - q_2\Delta Q)p_2$, so if $r > (p_1q_1 + p_2q_2)\Delta Q$ then $\partial L_D/\partial\Delta\beta > 0$. Let $r_D^* = \max\{(q_1^2 + q_2^2)\Delta Q, (p_1q_1 + p_2q_2)\Delta Q\}$. Then for $r > r_D^*$ we have that (A2.1) fails and hence that (8) fails, except perhaps at $\Delta b = \Delta\beta = 0$.

Lemma 5: For sufficiently high r, the only possible relational contract is the trivial case of $\Delta b = \frac{1}{2}\Delta Q$ and $\Delta\beta = \frac{1}{2}\Delta P$ (*i.e.*, replication of a spot market). That is, given q_1, q_2, p_1, p_2, ΔQ and ΔP there exists r_U^* such that if $r > r_U^*$ then no values of Δb and $\Delta\beta$ satisfy the reneging constraint (12) except $\Delta b = \frac{1}{2}\Delta Q$ and $\Delta\beta = \frac{1}{2}\Delta P$.

Proof: The reneging constraint (12) holds only if $|\Delta b - \frac{1}{2}\Delta Q| + |\Delta\beta - \frac{1}{2}\Delta P| \leq (S^R - S^M)/r$. But this inequality can be written as

$$(A2.2) \qquad 2r\,|\Delta b - \tfrac{1}{2}\Delta Q| + 2r\,|\Delta\beta - \tfrac{1}{2}\Delta P| + (a_1^R - q_1\Delta Q)^2 + (a_2^R - q_2\Delta Q)^2$$

$$\leq (a_1^M - q_1\Delta Q)^2 + (a_2^M - q_2\Delta Q)^2$$

where $a_i^R = q_i\Delta b + p_i\,\Delta\beta$ and $a_i^M = = \frac{1}{2}q_i\Delta Q + \frac{1}{2}p_i\Delta P$. Note that at $\Delta b = \frac{1}{2}\Delta Q$ and $\Delta\beta = \frac{1}{2}\Delta P$ we have $a_i^R = a_i^M$, so (A2.2) holds with equality. We will show that for sufficiently high values of r, values of Δb and/or $\Delta\beta$ other than $\frac{1}{2}\Delta Q$ and $\frac{1}{2}\Delta P$ increase the lefthand side of (A2.2), but the righthand side is constant, so the reneging constraint (12) fails except at $\Delta b = \frac{1}{2}\Delta Q$ and $\Delta\beta = \frac{1}{2}\Delta P$.

Let $L_U(\Delta b, \Delta\beta)$ denoted the lefthand side of (A2.2). For $\Delta b > \frac{1}{2}\Delta Q$ we have $\partial L_U/\partial\Delta b = 2r + 2(a_1^R - q_1\Delta Q)q_1 + 2(a_2^R - q_2\Delta Q)q_2$. Because a_1^R and $a_2^R \geq 0$, we have that if $r > (q_1^2 + q_2^2)\Delta Q$ then $\partial L_U/\partial\Delta b > 0$ for $\Delta b > \frac{1}{2}\Delta Q$. For $\Delta b < \frac{1}{2}\Delta Q$ we have $\partial L_U/\partial\Delta b = -2r + 2(a_1^R - q_1\Delta Q)q_1 + 2(a_2^R - q_2\Delta Q)q_2$. We wish to show that if r is sufficiently high then $\partial L_U/\partial\Delta b < 0$ for $\Delta b < \frac{1}{2}\Delta Q$. It therefore suffices to establish an upper bound on $q_1a_1^R + q_2a_2^R$. Because $a_i^R = q_i\Delta b + p_i\,\Delta\beta$ and $\Delta b < \frac{1}{2}\Delta Q$, it suffices to establish an upper bound on $\Delta\beta$. This is done in Lemma 6.

Similarly, for $\Delta\beta > \frac{1}{2}\Delta P$ we have $\partial L_U/\partial\Delta\beta = 2r + 2(a_1^R - q_1\Delta Q)p_1 + 2(a_2^R - q_2\Delta Q)p_2$. Because a_1^R and $a_2^R \geq 0$, we have that if $r > (p_1q_1 + p_2q_2)\Delta Q$ then $\partial L_U/\partial\Delta\beta > 0$ for $\Delta\beta > \frac{1}{2}\Delta P$. For $\Delta\beta < \frac{1}{2}\Delta P$ we have $\partial L_U/\partial\Delta\beta = -2r + 2(a_1^R - q_1\Delta Q)p_1 + 2(a_2^R - q_2\Delta Q)p_2$. We wish to show that if r is sufficiently high then $\partial L_U/\partial\Delta\beta < 0$ for $\Delta\beta < \frac{1}{2}\Delta Q$. It therefore suffices to establish an upper bound on $p_1a_1^R + p_2a_2^R$. Because $a_i^R = q_i\Delta b + p_i\,\Delta\beta$ and $\Delta\beta < \frac{1}{2}\Delta P$, it suffices to establish an upper bound on Δb. This is done in Lemma 7.

Let r_U^* be the maximum of $(q_1^2 + q_2^2)\Delta Q$, $(p_1q_1 + p_2q_2)\Delta Q$, and the two other values of r determined above. Then for $r > r_U^*$ we have that (A2.2) fails and hence that (12) fails, except perhaps at $\Delta b = \frac{1}{2}\Delta Q$ and $\Delta\beta = \frac{1}{2}\Delta P$.

Lemma 6: Too strong an incentive based on the alternative-use value makes a relational contract inferior to a spot market. That is, given q_1, q_2, p_1, p_2, and ΔQ there exists $\Delta\beta''$ such that, for any Δb, if $\Delta\beta > \Delta\beta''$ then $S^R - S^M < 0$.

Proof: $2(S^R - S^M) = K(\Delta b) + 2(p_1q_1 + p_2q_2)(\Delta Q - \Delta b)\Delta\beta - (p_1^2 + p_2^2)\,\Delta\beta^2$. As in the proof of Lemma 2, maximize $K(\Delta b)$ with respect to $\Delta b \geq 0$, and maximize the second term with respect to $\Delta b \geq 0$ (at $\Delta b = 0$). Now choose $\Delta\beta''$ to be the larger root of the resulting quadratic, with the maximized versions of the first and second terms replacing the originals.

Lemma 7: Too strong an incentive based on the downstream value makes a relational contract inferior to a spot market. That is, given q_1, q_2, p_1, p_2, and ΔQ there exists $\Delta b''$ such that, for any $\Delta\beta$, if $\Delta b > \Delta b''$ then $S^R - S^M < 0$.

Proof: $2(S^R - S^M) = M(\Delta\beta) + 2\{(q_1^2 + q_2^2)\,\Delta Q - (p_1q_1 + p_2q_2)\Delta\beta\}\Delta b - (q_1^2 + q_2^2)\,\Delta b^2$. As in the proof of Lemma 2, maximize $M(\Delta\beta)$ with respect to $\Delta\beta \geq 0$, and maximize the second term with respect to $\Delta\beta \geq 0$ (at $\Delta\beta = 0$). Now choose $\Delta b''$ to be the larger root of the resulting quadratic, with the maximized versions of the first and second terms replacing the originals.

Proposition 1: Implicit contracts (whether inside or outside firms) cannot exist if spot governance offers an inferior but sufficiently palatable alternative. Formally, given q_1, q_2, p_1, p_2, ΔQ, and ΔP, there exists r^* such that if $r > r^*$ then no values of Δb and $\Delta\beta$ satisfy either the reneging constraint (8) for "firm" governance or the reneging constraint (12) for "relational contract" governance.

Proof: Given Lemmas 4 and 5, Proposition 1 follows by setting $r^* = \max\{ r_D^*, r_U^* \}$.

Proposition 3: Incentives in relational contracts are "higher-powered" than incentives in firms. Formally, given q_1, q_2, p_1, p_2, ΔQ, ΔP, and r, if the most efficient firm yields $a_1^F < a_1^*$ and $a_2^F < a_2^*$ then either the most efficient relational contract yields $a_1^R > a_1^F$ and $a_2^R > a_2^F$ or no relational contract exists.

Proof: Because the firm yields actions below the first-best, the reneging constraint (8) must bind. Consider implementing the same incentives, Δb and $\Delta\beta$, through a relational contract instead of a firm. Given the same incentives, the same actions would result, but the reneging constraint (12) would differ. If $\Delta b \geq \frac{1}{2}\Delta Q$ and $\Delta\beta \geq \frac{1}{2}\Delta P$ then the lefthand side of (12) is smaller than the lefthand side of (8), but the righthand sides are identical, so (12) is slack, so the actions in the efficient relational contract can be increased from those in the efficient firm. Alternatively, if $\Delta b < \frac{1}{2}\Delta Q$ and/or $\Delta\beta < \frac{1}{2}\Delta P$ then it may be that no relational contract is feasible. But if a relational contract is feasible then a small increase in Δb (if it is less than $\frac{1}{2}\Delta Q$) and/or $\Delta\beta$ (if it is less than $\frac{1}{2}\Delta P$) increases the actions while reducing the lefthand side of (12). Hence, it will not be efficient for the incentives in the relational contract to be as weak as those in the firm.