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Supplier Relations and the Market Context: A Theory of Handshakes.*

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Abstract. This paper provides an economic theory of the degree of formality in industrial procurement. The argument is based on a tension between two procurement goals: imposing cost discipline on the supplier, and creating the conditions for cooperative innovation. In this model, a contract can solve the cost discipline problem, but only by discouraging cooperation; a less formal arrangement provides cooperation but poor discipline. The attractiveness of contracts is smaller, the less vertically integrated the industry, because a thick market for inputs provides its own discipline incentives even without a contract.

Thus, in highly integrated industries, contracts are used, while in less integrated industries business is done on handshakes. This theory of the role of market context roughly fits some stylized facts and international comparisons, and may be a useful complement to some sociological approaches.

JEL Codes: L14; L22.
Keywords: Japan-US comparisons, Subcontracting, Cooperative innovation.

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The tremendous diversity in relationships between industrial suppliers and their customers has long been noted by business analysts. For example, it is often observed that typically American and European supplier relations are litigious, with fixed-price contracts and little cooperation between supplier and purchaser,[1] while their Japanese counterparts exhibit relative informality, cost sharing, and cooperation.[2]

This paper argues that such differences may be partly explained by differences in the degree of vertical integration in the industries concerned. The argument is based on a tension between two goals a buyer may have in its outsourcing strategy: imposing cost discipline on the supplier, and creating the conditions for cooperative innovation. The argument will be made in a model in which purchasers choose between a completely enforceable contract and none at all.[3] Very briefly, it will be argued that a contract tends to solve the cost discipline problem but eliminate cooperation; non-contractual procurement, on the other hand, provides

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[1]Of course, this is a coarse generalization, and is meant to be taken as a relative statement. Counterexamples can certainly be found, and as Macaulay (1963) pointed out, even the relatively legalistic supplier relations in the US are rarely as formal as the text of the contract suggests. Nor are these patterns frozen in time, as suggested by Helper (1991), Cusumano and Takeishi (1991), Dyer (1996), Johnston and Lawrence (1988) and others who document movements by US manufacturers in the direction of the Japanese model, a topic that will be discussed in the concluding section of this paper.

[2]The literature on these comparisons is enourmous. For examples, see Clark (1989), Nishiguchi (1994), Dyer (1996), Cusumano and Takeishi (1991), and Liker et al. (1996). The contemporary textile industry of central Italy is also often discussed in terms that come closer to the Japanese model than to the rest of Europe; see, for example, Johnston and Lawrence (1988).

[3]This stark choice is imposed for simplicity. In practice, of course, most industrial supply uses some form of contract, and the question is how much structure it imposes on the relationship.

cooperation but only weak incentives for cost discipline. However, the more non-integrated firms there are in the industry, the better cost discipline incentives without a contract are, because of the way bargaining power effects affect incentives. Thus, with a highly non-integrated industry, a non-contractual arrangement effectively solves both problems at once. The result is that in highly integrated markets, contracts are used, while in less integrated industries business is done on handshakes. This is consistent with the observation that it is in relatively vertically integrated economies (such as the North American and European) that procurement is at its most litigious, and *vice versa* for relatively non-integrated economies (such as Japan, and portions of central Italy).

To elaborate, it may be useful to identify three generalizations emerging from the empirical literature and case studies. First, Western supplier arrangements tend to be much more formal in the sense of relying on detailed written contracts and specifications than Japanese ones, which use far less detailed contracts and often leave the final transactions price to be worked out later.[4] Second, Japanese supplier relations are much more likely than Western ones to make use of cost-sharing at the margin.[5,6] Western industrial buyers are more

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[4]See Dyer (1996), for example. Generally outsourcing in either country does involve a written contract specifying a price and other terms, but the standard Japanese outsourcing contract also contains a *schedule* for frequent renegotiation of that price (Asanuma, 1985a,b). This, combined with the frequent absence of a blueprint as part of the agreement ('black-box' arrangements; see Nishiguchi, 1994, pp. 129-30; Cusumano and Takeishi, 1991, pp. 572-3) means that the Japanese contract can be seen as largely a framework for ongoing discussions.

[5]This is sometimes described as the sharing of *reductions* in cost at the margin or the sharing of additional *profit* from cost savings at the margin. These are, of course, three ways of saying the same thing.

[6]See Liker et al. (1996, p. 77). Asanuma (1985a, b) discusses in some detail Japanese procedures for allocating the burden of cost shocks between buyer and seller. Cost-sharing is

likely to try to impose cost discipline on the suppliers by resisting any sharing of supplier cost overruns.[7] Third, Japanese suppliers typically make considerably more relationship-specific investment, including both more acquisition of assets whose value is dependent on the particular buyer in question, and more participation in the design of the input. The stereotypical Western supplier is provided with a blueprint and detailed specifications, and simply required to produce accordingly; but the typical Japanese supplier is expected to conduct its own research and provide ideas for improvement of the input design in order to reduce costs.[8] Thus, an emphasis has been placed on the idea of Japanese supplier relationships as 'partnerships,' or 'cooperative' arrangements, in contrast to 'antagonistic' supplier relations in the West.[9]

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emphasized by Dyer (1996), who documents Chrysler's study and imitation of the Honda supplier system in the early 1990's. One of the key features is the equal sharing of the benefits of cost reductions between buyer and supplier. Nishiguchi (1994, p. 6), in summarizing the strengths of the Japanese system, asserts that "the establishment of rules to share fairly the profits from collaborative design and manufacturing has encouraged the subcontractors' entrepreneurship and their own symbiotic relationships with their customers;" see also pp. 126-8.

[7]For example, Dyer (1996, p. 52) discusses this in the case of Chrysler under the old system, and Nishiguchi (1994, pp. 173-4) in the case of British electronics firms.

[8]This is forcefully emphasized by a large literature, including Clark (1989), Nishiguchi (1994), Liker et al. (1996), and Dyer (1996).

[9]See Johnston and Lawrence (1988). This difference in attitudes comes across starkly in Nishiguchi's interview study of electronics firms. For example, a Japanese manufacturer summarized its supplier relations with the remark: "It's not that all is well if you alone are well. Without cooperation from your subcontractors, you'll all lose in the long run," while a British manufacturer explained: "We don't really care what happens to subcontractors. We subcontract in order to protect our own work force," and a British subcontractor complained, "How nice it would be if our customers came to us and asked for our help in design, manufacturing, and so on! But in this country, it never happens. They see us as a cheaper and dirtier version of their machines." Nishiguchi (1994, pp. 176-7).

The point of this paper is that these differences can emerge in a simple economic model,[10] driven not by differences in culture or attitude, but by differences in the market context. The heart of many supplier problems is arguably that there are actions that can be taken by the supplier to enhance the quality of the input or the efficiency of the process, and which are non-contractible because they are either unobservable to the buyer or because they are unverifiable to a third party. We postulate here that there may be two types of these actions. The first are actions that the supplier can undertake effectively on its own, which we will call *autonomous investments*. These could take the form of improvements in training of technical staff, refurbishment of facilities, rigourous quality control, and the like. This kind of investment is the focus of the classical principal-agent literature, and in procurement problems is exemplified by the seminal analysis of Laffont and Tirole (1986). The second kind are actions that might substantially reduce costs down the road only if they are accompanied by complementary actions by the buyer. These we will call *joint investments*. These might involve changes in the design of the part, for example, that would make it cheaper to produce and that require a small adjustment in the design of the larger unit into which the buyer will install it.[11] Joint investments are enormously important in practice, and are the source of a

[10]Needless to say, since actual supplier relations are very complex, any simple model will omit much that is important. Some limitations of this approach are discussed in the concluding section of the paper.

[11]Dyer (1996, p. 54) offers an example of a supplier that found that a part could be made out of plastic instead of magnesium, at a savings of $100,000 per year, and another supplier that found that a decorative woodgrain part could be made of a cheaper material than that originally required by the buyer, at a savings of $250,000 per year. Both proposals needed ancillary work by the buyer to become viable. Nissan in the 1960's developed a straight tail-pipe, based on a supplier's proposal and developed jointly by the supplier and Nissan, which represented a substantial improvement over the previous 'twisted' design. Nishiguchi (1994, p. 127).

huge amount of productivity improvements over time under the Japanese model.[12] However, their evident non-contractibility implies that incentives to undertake them must be given indirectly, through the design of the supply relationship.

For any supply arrangement, at the equilibrium determined by that arrangement, we can define the share of cost reductions resulting from autonomous investment that the supplier would receive at the margin, which will in the model be denoted θ_A; and the corresponding marginal supplier's share of benefits from joint investment, which will be denoted θ_J. In order to give a supplier the incentive to undertake the optimal level of autonomous investment, it is naturally necessary that θ_A be equal to 1, as in a fixed-price contract, so that the supplier receives the full marginal value of these investments. However, this approach will not work for joint investment. If θ_J is set equal to 1, the supplier will do virtually no joint investment, because it knows that the buyer will have no incentive to do follow-up work (since it will capture none of the benefit at the margin), and thus any joint investment the supplier does will be wasted.[13] A similar argument predicts a lack of joint investment if θ_J is set equal to zero. Thus, in order to get significant amounts of joint investment, θ_J must take

[12]This is the main theme of Nishiguchi (1994). This kind of investment is sometimes called 'value engineering,' and its quantitative importance in affirmed in Liker et al. (1996). Dyer (1996, p. 55) estimates that as of December 1995, Chrysler had saved $1.7 billion through implementation of these supplier ideas since it had begun imitating Japanese supplier systems in the early 1990's.

[13]This problem -- that the buyer may refuse to invest the resources needed to put a supplier idea into practice, thus removing the incentive to innovate on the part of the supplier -- is cited by Dyer (1996, p. 53) as a long-running problem in Chrysler's supplier management system before it tried Japanese techniques. See also Nishiguchi (1994, pp. 126-8) on the importance for cooperation of sharing rules.

an intermediate value strictly between zero and 1; in other words, *cooperation requires cost sharing at the margin*.[14]

If a contract can be conditioned at most on the realized production cost, it will not be possible to set θ_A and θ_J separately, and either a compromise between joint and autonomous investment will be struck, or one of the two will be sacrificed. Now suppose, by contrast, that there is no contract. Call this situation an 'informal arrangement' (IA). In an IA, the outcome will be determined by bargaining; the supplier can always get the buyer to share the costs *ex post*, so it has suboptimal incentives to make autonomous investments *ex ante*; but at least cooperation will be high. However, *IA's work better, the more unintegrated firms there are,* because the presence of the unintegrated firms strengthens the supplier's incentive to make autonomous investment. This is because the more potential alternative buyers there are for its input, the stronger is the supplier's incentive to produce an input that is attractive to them, in order to enhance its bargaining power relative to its intended buyer.[15] Thus, if the industry is relatively non-integrated, the supplier's concern for its *ex post* bargaining power can take care of its incentive to make autonomous investment without a contract. This is what drives the predictions of the model.

[14]This is an instance of the problem of moral hazard in teams (Holmstrom, 1982). There is also an interesting parallel between this problem and the sharecropping theory of Eswaran and Kotwal (1985), in which the problem is how to get the tenant and the landlord to perform complementary non-contractible tasks by choosing the share parameter appropriately.

[15]The IA gives the same incentives as would a contract with θ_J equal to ½ and θ_A greater than ½, if it were possible to set those parameters separately; and the effective θ_A increases with the number of non-integrated firms.

This exercise is related to a number of strands of industrial organization theory. The model is quite similar in many respects to the frameworks of Grossman and Hart (1986) and Hart and Moore (1990), who analyzed the effect of ownership patterns on incentives for non-contractible investments. In that line of work, it is assumed that the only type of contract possible is a contract assigning ownership of a firm, whereas here the focus is naturally on the option of using procurement contracts. An interesting strain of contract theory focuses on the possibility that very good *ex ante* investment incentives can sometimes be provided by simple contracts that are expected to be re-negotiated. Examples are MacLeod and Malcomson (1993) and Nöldeke and Schmidt (1995). The informal arrangements in this paper are very much like this. The main differences are the role of vertical integration of the other firms in the market in this model; and the fact that with the cost structure assumed in Section 2, no renegotiation could be possible for any contract, because the indicated allocation of inputs to buyers is always *ex post* efficient. Relaxation of these assumptions could blur the distinctions between a contract and an IA in interesting ways, making the model more complicated but also substantially more realistic, since the dichotomy between unbreakable contracts that are never renegotiated, and no contract at all, is much starker than what is observed in practice. Finally, the paper has much to do with the literature on vertical integration (see Perry (1989) for a summary), and deals with many of the same issues. Clearly, the main difference is that here the level of vertical integration in the industry is taken as exogenous. McLaren (1996) deals with the question of the degree of vertical integration in a similar model with no contracts.

A number of other approaches are available in analyzing these questions. Cultural differences are often cited in explaining national differences in procurement strategies (for example, Hutcheson, Pearson, and Ball (1996, p. 35)). The repeated nature of the relationship in many cases is often cited as a reason informal arrangements may work (stressed, for example, by Macaulay (1963) and by much of the writing on Japanese arrangements). In sociology, the fact that transactions between firms often are conducted by people who have social relationships with each other is often advanced as a reason that non-contractual procurement may work well; each partner knows that the other will abstain from opportunistic behavior in part because of a desire to maintain the social relationship. This is a form of the 'embeddedness' argument, forcefully articulated by Granovetter (1985).

Each of these is clearly a piece of the story; the market-context explanation for informal arrangements advanced here is merely one more. However, it does have an advantage relative to the others, in that it provides some very clean predictions. It predicts that informal arrangements are more likely to be chosen, the larger the number of non-integrated firms in the same industry; and, as will be seen, it predicts more informality over time as the costs of international transactions fall. These are testable and falsifiable, and appear to fit the broad facts. In addition, the market-context theory can be quite complementary to these other explanations. A climate of 'trust' is often cited as a driving force behind cooperation in successful supply relationships. In this model, 'trust' is endogeneous; how much cooperative investment each partner does depends on how much it expects the other to do; and we can make explicit the conditions under which each trusts the other to do a lot. Further, this theory can in a sense stand beside the idea of 'embeddedness' as an alternative set of reasons for which a transaction between two parties can be very strongly affected by the identity and nature of the group (here, the rest of the industry) to which those two parties belong.

The next section presents an overview of the model. Section 2 details the assumptions the model makes on the nature of technology; in order to make formally the above points on the nature of bargaining power in an informal arrangement, it is necessary that the inputs being produced by non-integrated suppliers are 'semi-specialized' in a sense made precise in that discussion. Section 3 discusses contracts, Section 4 informal arrangements, and Section 5 the choice between the two. It is this section that contains the main conclusion of the paper, Proposition 3, which states that the choice between contractual and non-contractual procurement is determined by the number of non-integrated firms in the industry. Section 6 discusses the application of the model to changes that have been observed in procurement over time, but also notes some limitations of the model.

1. Overview of the Model.

Consider an industry with N downstream firms, each of whom needs to procure a fixed quantity, normalized to 1 unit, of an indispensable input. Suppose that $N - n$ of these are vertically integrated firms that can produce the input themselves, but the other n are unintegrated and must procure the input from the market. There are two ways of doing so: Purchasing a standardized input on a competitive world input market, and commissioning a supplier to produce a tailor-made input. Suppose that the latter option is more attractive, because of the costs involved in adapting a standardized input for the needs of this particular downstream firm. We will number the firms such that downstream firms 1 through *n* are unintegrated, and buyer *i*'s supplier is supplier number *i*. No one supplier or integrated firm has the capacity to provide more than one unit of the input, and so there is exactly one buyer for each seller. All buyers are *ex ante* identical, as are all sellers. All firms maximize expected profit. Since the quantity of the input required is fixed, downstream marginal costs will be unaffected by this procurement process; thus, there will be no effects from this procurement process on the downstream market, so each buyer's objective will be simply to minimize the expected cost of procuring its input.

There are two ways in which the input could be procured from a supplier, both summarized in Figure 1. Under the first option, the two firms could work out an unbreakable contract, which would require supplier *i* to deliver a unit of the input, fully adapted to be usable to the buyer, at a fixed date, and would specify a payment according to a fixed schedule. This may involve, for example, a partial reimbursement for cost overruns. Under the second option, the two form a verbal agreement that the supplier will produce the part, under the understanding that the payment would be worked out later through bargaining. Call this second option an 'informal arrangement' (IA).

In either case the costs of producing the input are to some degree uncertain *ex ante*, but the supplier can reduce expected costs by undertaking process investments. These come in two forms. The first are investments the supplier can undertake on its own, which we will call *autonomous* investments. The second kind are investments that might substantially reduce costs down the road only if they are accompanied by complementary investments by the buyer. These we will call *joint* investments. We will assume that both kinds of investment are unverifiable to third parties and hence non-contractible. Further, the investments are made simultaneously by all firms, so that their levels are determined by a Nash equilibrium. In a vertically integrated firm, autonomous, upstream joint, and downstream joint investment decisions are all made together by the firm's centralized management.

After these investments have been made, the input passes to the production stage, and cost uncertainty is realized. At this point, if a contract has been signed, the input is produced and delivered and payment is made according to the contract. (Under cost assumptions made explicit below, it will never be true that both parties are willing to renegotiate the contract.) If the two firms have an informal arrangement, they bargain over the production of the input and its price; if bargaining should break down, the seller will be forced to purchase a standardized input instead, at a cost, including price plus adaptation costs, of $S > 0$; and the supplier will look for another partner with whom to bargain. If this second round of bargaining fails to occur or breaks down, the supplier will not produce the input.

2. Technological Assumptions.

Distinguish two kinds of cost to producing an input: *ex ante* costs, which take the form of the investments mentioned above, and *ex post* costs, which are the actual production costs and are not known precisely until the production stage is reached.[16] When specifying the

[16]These costs could reflect the failure rate of the input supplied; what is relevant is the cost of providing one unit of *useful* input, which *ceteris paribus* is an increasing function of the failure rate. Keeping down the failure rate of inputs supplied by subcontractors is major issue in

latter, we take into account the possibility that under some circumstances the supplier may conceivably wish to consider selling to one buyer an input that was originally intended for another, at a higher cost reflecting the costs of adapting the input for the alternative use. With this in mind, we denote the *ex post* cost of producing for buyer *j* an input originally intended for buyer *i* as c_{ij}.

There are two different technological strategies available for producing an input. First, there is a 'highly specialized' strategy. If supplier *i* produces an input in this way, its *ex post* cost is given by:

$$c_{ii} = \tilde{\kappa} - \tilde{\phi}(I_i) - \tilde{\psi}(J_{U,i}, J_{D,i}) + \epsilon_{ii} \text{ and}$$

$$c_{ij} = \tilde{\kappa} - \tilde{\phi}(I_i) + \epsilon_{ij} \text{ if } i \neq j, \tag{1a}$$

where $\tilde{\kappa} > 0$ is a constant; $I_i \geq 0$ is the level of autonomous investment undertaken by supplier *i*; $J_{U,i} \geq 0$ is the level of joint investment undertaken by upstream firm (supplier) *i*, and $J_{D,i} \geq 0$ the level undertaken by downstream firm (buyer) *i*; $\tilde{\phi}(I_i)$ is the reduction in production costs due to the autonomous investment; $\tilde{\psi}(J_{U,i}, J_{D,i})$ is the reduction due to the joint investments; and ϵ_{ij} is the random portion of the cost. Note that the joint investment is entirely relationship specific: It does not reduce the cost of producing the input for an alternative buyer.

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industrial sourcing; see, for example, Nishiguchi (1994, pp. 171-2, 182-4). In addition, the argument of the paper would be virtually identical if the focus was on input quality, rather than production cost.

Second, the input may be produced with a more flexible strategy, which we will call 'semi-specialized.' In this case, its production cost is:

$$c_{ii} = \kappa - \phi(I_i) - \psi(J_{U,i}, J_{D,i}) + \epsilon_{ii} \text{ and}$$

$$c_{ij} = \kappa - \phi(I_i) + \epsilon_{ij} \text{ if } i \neq j, \tag{1b}$$

where the notation is analogous to the highly specialized case. Both kinds of investment are normalized to have a unit price, so that the full cost of the input to the supplier is $I_i + J_{U,i} + c_{ij}$. We assume that $\phi(0) = \psi(0, 0) = 0$; ϕ', ψ_1, and $\psi_2 > 0$ but ϕ'', ψ_{11}, and $\psi_{22} < 0$ everywhere, where subscripts indicate partial derivatives; $\phi'(0)$, $\psi_1(0, x)$, $\psi_2(x, 0) = \infty$ for all x; and $\phi'(x)$, $\psi_1(x, y)$, $\psi_2(y, x) \to 0$ as $x \to \infty$ for all y. Further, assume that $\psi_{12} > 0$ everywhere, so that the joint investments are complementary, and that $\psi_{11} + \psi_{12} < 0$ and $\psi_{22} + \psi_{21} < 0$, which will later be called the 'stability' assumption. In addition, ϵ_{ii} has a mean of zero, and can take on values between $-\bar{\epsilon}$ and $\bar{\epsilon}$; for a given realization of ϵ_{ii}, ϵ_{ij} can take values between ϵ_{ii} and $\bar{\epsilon}$. The distribution of ϵ_{ii} is continuous, and identical and independent across i; and conditional on ϵ_{ii}, the ϵ_{ij} are identical and independent across j.[17]

The distinction between the two technology strategies can be laid out as follows. Define the first-best level of investments under the flexible strategy by I^{opt}, J_U^{opt}, and J_D^{opt}, where:

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[17]The distribution of ϵ_{ij} is assumed to be the same under both technology strategies. This assumption is made purely to economize on notation.

$$\phi'(I^{opt}) = \psi_1(J_U^{opt}, J_D^{opt}) = \psi_2(J_U^{opt}, J_D^{opt}) = 1.$$

Define the first-best investments in the highly specialized case analogously. Then we assume that if used as intended with the optimal investments, a highly specialized technology strategy is superior to a semi-specialized one:

$$\begin{aligned} &\tilde{\kappa} - \tilde{\phi}(\tilde{I}^{opt}) - \tilde{\psi}(\tilde{J}_U^{opt}, \tilde{J}_D^{opt}) + \tilde{I}^{opt} + \tilde{J}_U^{opt} + \tilde{J}_D^{opt} \\ &< \kappa - \phi(I^{opt}) - \psi(J_U^{opt}, J_D^{opt}) + I^{opt} + J_U^{opt} + J_D^{opt}. \end{aligned} \tag{2a}$$

Further, with optimal investments the finished input is more attractive *ex post* if it is highly specialized:

$$\begin{aligned} &\tilde{\kappa} - \tilde{\phi}(\tilde{I}^{opt}) - \tilde{\psi}(\tilde{J}_U^{opt}, \tilde{J}_D^{opt}) + \overline{\epsilon} \\ &< \kappa - \phi(I^{opt}) - \psi(J_U^{opt}, J_D^{opt}) - \overline{\epsilon}. \end{aligned} \tag{2b}$$

In turn, a semi-specialized input is always better *ex post* than a standardized one (even without *ex ante* investments):

$$\kappa + \overline{\epsilon} < S. \tag{2c}$$

However, even worse than a standardized input is a highly specialized one used for other than its intended buyer:

$$\tilde{\kappa} - \tilde{\phi}(I^{opt}) - \overline{\epsilon} > S. \qquad (2d)$$

Thus, the highly specialized input is inherently the most effective, provided it is used for its intended buyer and with the right *ex ante* investments, but it is naturally less flexible than its less specialized counterparts.[18]

Finally, note that the assumptions on the ϵ_{ij} imply that $\epsilon_{ii} < \epsilon_{ij}$ for j ≠ i, so that in all cases:

$$c_{ij} > c_{ii}\,, \qquad (3)$$

or in other words, every input, whether highly specialized or semi-specialized, is most effective when used by its intended buyer.

3. Contracts.

3.A. A Benchmark: 'Discerning' Contracts.

Let us initially imagine a quite unrealistic type of contract, which will be useful to have in mind as a benchmark. Assume that for upstream and downstream firm *i* the semi-specialized technology strategy has been chosen; the analogue for the highly specialized case

[18]Another way of putting this is that $\tilde{\kappa}$ is much larger than κ, but the $\tilde{\phi}$ and $\tilde{\psi}$ functions are much steeper than the ϕ and ψ functions.

will be obvious. Suppose that at the time of production, the production cost can be audited and verified to a third party such as a judge. Further, assume - for the moment - that the reduction in cost due to autonomous investment, $\phi(I)$, and the reduction due to the joint investment, $\psi(J_U, J_D)$, can also be verified (suppressing the *i* subscript). This is most unrealistic and will be made only briefly to establish a useful benchmark; the main argument made later will assume that these can not be separately verified. Define a *discerning contract* to be a contract that conditions payment on these two forms of measured cost reduction as well as the total cost. We will assume that it is differentiable.[19] Without loss of generality, such a contract can be written as follows:

$$P = c_{ii} + F + \theta_A\ \phi(I) + \theta_J\ \psi(J_U, J_D)\ ,$$

where P is the price to be paid on delivery of the input; F is the fixed fee; and θ_A and θ_J are constants giving the marginal shares of cost reductions accruing to the supplier.[20] This is a

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[19]This is not very restrictive in this case. If the two components of cost reduction were observed to within a random error with a continuous density and compact support, and the contract specified price as a bounded, measurable function, then the *expected* price would be differentiable, and thus we could use the logic of the next footnote to write an equivalent contract in a differentiable form. The same logic will apply even without any measurement error to the more realistic contracts of the next subsection, because of the ϵ_{ii}.

[20]To see that we can always write the contract this way, first note that for any discerning contract, the expected price conditional on the two cost reductions can be written as some function $\rho(\phi(I), \psi(J_U, J_D))$. The expected supplier profit is then $\rho - \mathrm{E}[c_{ii}] - I - J_U$, and the expected buyer profit $-\rho - J_D$. At the investments chosen under this contract, the supplier's first order condition $(1 + \rho_1)\phi' = 1$ and $(1 + \rho_2)\psi_1 = 1$ and the buyers' first order condition $-\rho_2\psi_2 = 1$ will be satisfied. Then if we replace this contract with a linear contract in which $\theta_A = 1 + \rho_1$ and $\theta_J = 1 + \rho_2$, it is easy to verify that those same investments will satisfy the first order conditions ((4) and (5)) under the new contract. Thus, the new contract supports the same

consequence of the assumption that both parties are risk neutral, and is a well-known property of a wide class of procurement models; see Laffont and Tirole (1986), for example.

Given this contract, each party would choose investments to maximize its expected profit, given what the other partner is expected to do. The supplier's expected profit[21] is:

$$\mathrm{E}[\,\Pi_U\,]$$

$$= \mathrm{E}[\,P - c_{ii} - I - J_U\,]$$

$$= F + \theta_A\,\phi(\,I\,) + \theta_J\,\psi(\,J_U\,,\,J_D\,) - I - J_U\,,$$

and the buyer's expected profit is:

$$\mathrm{E}[\,\Pi_D\,]$$

$$= -\,P - J_D$$

total surplus, and by adjusting F can deliver the same expected profit to both partners.

[21]Profit net of investments (*ex ante* profit) will be denoted with a capital Π. Profit gross of investments (*ex post* profit) will be denoted with a small case π.

$$= - \kappa - F + (1 - \theta_A)\phi(I) + (1 - \theta_J)\psi(J_U, J_D) - J_D.$$

This leads to the first order conditions:

$$\theta_A \phi'(I) = \theta_J \psi_1(J_U, J_D) = 1 \tag{4}$$

for the supplier and:

$$(1 - \theta_J)\psi_2(J_U, J_D) = 1 \tag{5}$$

for the buyer. We can then think of these investments as functions of θ_A and θ_J, and write $I(\theta_A)$, $J_U(\theta_J)$, and $J_D(\theta_J)$. It is useful to define

$$C^*(\theta_A, \theta_J) \equiv \kappa - \phi(I(\theta_A)) - \psi(J_U(\theta_J), J_D(\theta_J)) + I(\theta_A) + J_U(\theta_J) + J_D(\theta_J),$$

the total expected cost from a given discerning contract under semi-specialized technology. For the highly specialized case, denote the analogue $\tilde{C}^*(\theta_A, \theta_J)$.

The optimal discerning contract would then pick these two parameters to minimize $C^{*}(\theta_A, \theta_J)$.[22] The choice of θ_A is straightforward. A rise in θ_A shifts up the supplier's marginal return to autonomous investment, raising *I*. The optimal level, I^{opt}, can be attained by setting $\theta_A = 1$. The choice of θ_J is considerably more involved. Given a value for J_D, a rise in θ_J raises the supplier's marginal return to joint investments, increasing J_U, but at the same time it *lowers* the *buyer's* marginal return from joint investments, lowering J_D. Because the supplier's investment needs ancillary efforts on the part of the downstream firm in order to be very effective, the result may be that the supplier's investment falls. This is illustrated in Figure 2. The curve R_U represents the supplier's 'reaction function,' or the choice of J_U given the expected choice of J_D for a given value of θ_J. The curve R_D represents the buyer's reaction function. The Nash equilibrium joint investments for the given contract are indicated by the intersection of the two.[23] Each of these curves is shown for two values of θ_J, θ' and $\theta'' > \theta'$. A rise in θ_J shifts R_U to the right, but R_D down, with an ambiguous net effect on both partners' investments (which here move from point A to point B). In the extreme case, with $\theta_J = 1$, we know that the buyer will make no investment at all, so the supplier will make very meager investments, despite capturing the full return from them. A similar problem arises if θ_J is set equal to zero; at this level the supplier will make no joint investment, and so the

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[22]Once again, because of risk neutrality, the choice of *F* is separable from the determination of θ_A and θ_J. The share parameters are set to maximize the joint surplus, and the fixed payment is set by *ex ante* bargaining to divide that surplus. We are concerned here only with the share parameters, so for our purposes, we can ignore the determination of *F*.

[23]This is unique, because R_U must have a slope exceeding unity while R_D must have a slope less than unity. This is guaranteed by the 'stability assumption' made in the previous section. In addition, (0, 0) is not an equilibrium because $\psi_i(0, 0) = \infty$ for i = 1, 2.

buyer's investment will be meager. The broken curve traces the path of investments as θ_J is varied.

Typically, then, the optimal level of θ_J in a discerning contract will be somewhere in the middle.[24] This is an important point for what follows: The optimal scheme is one that gives the full return from autonomous investments to the supplier, but that shares the cost on joint investments. Even then, the joint investments will be suboptimal, since each partner will receive only a fraction of the marginal product of its investment.[25] Denote the optimal discerning contract by $(\theta_A^* , \theta_J^*) = (1 , \theta_J^*)$ in the semi-specialized case, and $(\theta_A^* , \theta_J^*) = (1 , \theta_J^*)$ in the highly specialized case.

3.B. 'Non-discerning' contracts.

Now assume that the only variable that can be observed and verified to third parties, hence the only contractible variable, is the realized production cost, c_{ii}. This is enourmously

[24]For a simple example, suppose that $\psi(J_U , J_D) = eJ_U J_D - (a - bJ_U)^2 - (c - dJ_D)^2$, where a, b, c, d, and e are positive constants. It can be shown that in this case the optimal value of θ_J is given by $[1 + (b/d)^{1/4}]^{-1}$. This is always between zero and 1. Since b and d are the steepnesses of the respective marginal product of investment curves for the two partners, this can be read as saying that the optimal θ_J is a function only of the relative responsiveness of each partner's investment choice to its own marginal return. If the two are equally responsive, so that $b = d$, the optimal share is $\theta_J = 1/2$.

[25]This is a special case of the problem of 'moral hazard in teams' within contract theory. It is well-known that this problem can be alleviated by committing to certain types of *ex post* inefficient behaviour through the contract; in this case, this would correspond to both firms burning some money in the event of a high realization of c_{ii}. We do not allow for such contracts here, since they would not be renegotiation proof. See Holmstrom(1982) for a full account.

more realistic.[26] Call a contract that is a function only of realized production cost a 'non-discerning' contract. In this case, again without loss of generality, it can be written in the following form:

$$P = F + (1 - \theta_N)c_{ii},$$

where θ_N is a constant giving the marginal share of the cost borne by the supplier, and hence the marginal share of cost reductions accruing to the supplier (the 'N' stands for 'non-discerning'). The three first order conditions for the investments ((4) and (5)) are exactly as they were before, except that now both θ_A and θ_J are replaced by θ_N. Thus, the behaviour of both parties is a special case of what it was in the discerning case. Using the above notation, the optimal non-discerning contract is a choice of θ_N that minimizes $C^*(\theta_N, \theta_N)$ with respect to θ_N. Call this optimal value θ_N^*. Its determination is portrayed in Figure 3, for the case in which $\theta_J^* = ½$. In that figure, the optimal discerning contract is represented by point C, and the optimal non-discerning contract, by point D, at which the 45° line is tangent to an iso-expected-cost contour.

Clearly, we must have $\theta_J^* < \theta_N^* < \theta_A^* = 1$. A non-discerning contract uses one instrument (realized cost) to try to provide incentives for two different types of investment. It is therefore a compromise between the high-powered incentives required to get the

[26]In practice, the two parties generally know whose efforts were responsible for which cost reduction, but this is of course not sufficient to write an enforceable contract stipulating rewards for these efforts, since it may be very difficult for an outsider to make these distinctions.

autonomous investment right, and the cost-sharing principle required to maximize joint investments.[27]

4. Informal Arrangements, and the Role of the Market Context.

Now, by contrast with the previous section, suppose that upstream and downstream firm *i* have no contract, but only a verbal understanding. The outcome of the transaction must now be determined by bargaining (recall Figure 1).[28] Suppose that once the input is ready for production, the two firms bargain, understanding that, being bound by no contract, each has the option of walking away from the table. If bargaining between these two firms indeed breaks down, the buyer will need to find another source for the input, and the supplier must find another buyer or give up on producing the input. In this case, a new round of bargaining will occur. We will use the Nash bargaining solution[29] to provide an outcome to bargaining at both stages. Again, for the moment assume that the semi-specialized technology is being used.

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[27]Note that in this setting there is never any scope for the renegotiation of contracts. This is because from condition (3), the allocation of input *i* to buyer *i*, as called for by the contract, is Pareto-efficient.

[28]The following model of the price determination process in the absence of a contract is a somewhat artificial construct adopted for its simplicity. It could be replaced by a number of other approaches without qualitatively changing the outcome. See McLaren (1996) for some examples, including a simple auction model and a Walrasian mechanism, in a model with a similar *ex post* price determination problem. Those variants are more conventionally constructed pricing games that give essentially the same behaviour, but are substantially more technically involved.

[29]Thus, each party to an agreement will receive as a profit its threat-point profit plus one half of the total surplus of the transaction relative to the threat point.

Note that the *ex post* surplus from the bargaining between upstream firm *i* and downstream firm *i* is always positive. This because of condition (3), which implies that buyer *i* could never bid another buyer's tailor-made input away from that buyer, and that supplier *i* could never find another transactions partner as attracted to its input as buyer *i*. Thus, under Nash bargaining, the discussions between the two will always be successful, and the breakdown will never actually occur. However, we must examine what *would* happen if it *did*, because that determines the threat point for negotiations between buyer and seller *i*.

Thus, suppose that the initial talks have broken down. Buyer *i* may inquire about purchasing another buyer's tailor-made input, but because of condition (3), no buyer would be willing to sell at a price buyer *i* would be willing to pay. The only option left is to acquire and adapt a standardized input, so buyer *i*'s threat point profit is $-S$.[30]

On the other hand, supplier *i* may have more luck. Despite condition (3), it may be that for some *j*, $c_{ij} < c_{jj}$, so that supplier *j* could actually buy from supplier *i* to meet the needs of buyer *j* more cheaply than by producing its own input. This is due to the unpredictable nature of many aspects of industrial cost; supplier *j* may be suffering from generalized cost overruns and be eager to jump at an opportunity to subcontract out to a supplier with some excess capacity, such as *i*, despite the fact that supplier *i* has been optimally adapted for a different customer.

Suppose that supplier *i* chooses supplier *j* as its partner for the second round of bargaining, and that the outcome of the bargaining is given by the Nash solution. Again, we

[30]This loss does not include any prior investment costs (that is, J_D) the buyer may have incurred. Those costs are sunk by the time the bargaining occurs, and thus may be ignored in this part of the analysis.

need to look at what will occur if the bargaining breaks down. In that case, supplier *i* will not produce the input at all and thus has a threat point of zero;[31] and supplier *j* will produce the input for buyer *j* and receive a profit of $P_j - c_{jj}$, where P_j is the price buyer *j* pays to supplier *j*.

To keep the argument simple, suppose that P_j is determined *before* the second round of bargaining, either by the first round of bargaining, if buyer and supplier *j* have an informal arrangement, or by the verification of c_{jj} and the contract terms, if they have signed a contract. If, in the second round of bargaining, supplier *j* acquires the input from supplier *i* and thus incurs costs below c_{jj}, there will be no reassessment of P_j, because buyer *j* will not even be aware of this reduction in costs and will not bother to audit supplier *j* to check. This is not irrational on buyer *j*'s part; the point is that it knows that in equilibrium there will be no second round of bargaining because in fact buyer and supplier *i*'s first round of bargaining will be successful. This assumption enormously simplifies the analysis, but it will be clear that with a different assumption the same broad results would occur.[32]

Given this, if supplier *i* sells input *i* to supplier *j* for a price of P', supplier *i*'s profit is $P' - c_{ij}$ and supplier *j*'s profit is $P_j - P'$. Thus, the total surplus from this bargain relative to the threat point is:

$$[(P' - c_{ij}) + (P_j - P')] - (P_j - c_{jj}) = c_{jj} - c_{ij},$$

[31]We assume that time constraints do not allow for a third attempt at finding a buyer. The model could easily be extended to allow for this without substantially changing the results.

[32]We could, for example, conceive of the second round of bargaining as one in which supplier *i*, supplier *j* and buyer *j* bargain together, in which case buyer *j* would gain some of the incremental surplus. This would barely change the results.

the cost savings the transaction would enable. Splitting the surplus under Nash bargaining implies a profit to supplier i of $[c_{jj} - c_{ij}]/2$. Recalling that supplier i would have chosen the second-round partner with whom it would find the highest profit, and that a second round bargain is possible only if the surplus is positive, this implies that supplier i's second round profit is:

$$\pi'_{Ui} = \tfrac{1}{2} \max \{ \max\{c_{jj} - c_{ij}\}_{j \neq i}, 0\}.$$

This is, then, supplier i's threat point in the first round of bargaining.

Now it is easy to analyze the first round of bargaining. If buyer and supplier i settle on a price of P, their profits are $-P$ and $P - c_{ii}$ respectively. The threat point profits are given by $-S$ and π'_{Ui}. Thus, the total surplus relative to the threat point is equal to:

$$[-P + (P - c_{ii})] - [-S + \pi'_{Ui}] = S - c_{ii} - \pi'_{Ui}.$$

Splitting this surplus under Nash bargaining gives supplier i an *ex post* profit of:

$$\pi_{Ui}$$

$$= \pi'_{Ui} + \tfrac{1}{2}[S - c_{ii} - \pi'_{Ui}]$$

$$= \frac{1}{2} (S - c_{ii}) + \frac{1}{4} \max \{ \max\{ c_{jj} - c_{ij} \}_{j \neq i} ,0 \}. \tag{6}$$

This is readily interpreted. The supplier comes away from the bargaining with one half of the cost savings from using its input instead of the standardized one (the first term), plus one quarter of the cost savings that it *could* offer to the most attractive alternative transactions partner (the second term). The latter effect is a pure bargaining power effect, which gives the supplier an additional incentive to produce an effective input. Similarly, the buyer's *ex post* profit is:

$$\pi_{Di} = \frac{1}{2} (- S - c_{ii}) - \frac{1}{4} \max \{ \max\{ c_{jj} - c_{ij} \}_{j \neq i} ,0 \}. \tag{7}$$

Note that this is decreasing in S as well as in the attractiveness of the supplier's outside opportunities. The reason is that an increase in either will worsen the buyer's bargaining power.

Now it is straightforward to analyze the *ex ante* investment incentives set up by this arrangement. The supplier's investment first order conditions are $\partial E[\pi_{Ui}]/\partial I_i = \partial E[\pi_{Ui}]/\partial J_{U, i} = 1$. From (6), $E[\pi_{Ui}]$ has two terms. The first term is the expectation of $\frac{1}{2}(S - c_{ii})$. Recalling (1b), the partial derivative of this term with respect to I_i equals $\frac{1}{2}\phi'(I_i)$. The second term is one quarter times:

$$\text{E}[\ \max \{ \max\{ c_{jj} - c_{ij} \}_{j \neq i}, 0 \}],$$

or the bargaining power effect. This is the expectation of a function whose value is zero in states for which $\max\{ c_{jj} - c_{ij} \}_{j \neq i} < 0$, and whose partial derivative with respect to I_i thus equals zero in those states; but which has a value of $\max\{ c_{jj} - c_{ij} \}_{j \neq i}$ in states for which this is positive, and whose partial derivative with respect to I_i thus equals $\phi'(I_i)$ in those states (recalling (1b)). As a result, we have:

$$\partial \text{E}[\ \pi_{Ui}\ ]/\partial I_i \quad = \quad \tfrac{1}{2}\ \phi'(I_i) + \tfrac{1}{4}\ \text{Prob}[\ \max\{ c_{jj} - c_{ij} \}_{j \neq i} > 0\ ]\phi'(I_i),$$

where the probability is calculated with respect to the random ϵ matrix. A marginal increase in autonomous investment increases the supplier's expected *ex post* profit because it improves the effectiveness of the input for its intended buyer, thus increasing the surplus it can expect to share; and because it increases the input's attractiveness to *alternative* transaction partners in the event that there are any who would be interested, thus raising the supplier's bargaining power and hence the *share* of the surplus that it will receive. A rise in the supplier's joint investment can be analyzed in a similar way, except that the bargaining power term is unaffected by it, since (from (1b)) the joint investment is entirely relationship-specific. Thus, the supplier's first order conditions are:

$$[\ \tfrac{1}{2} + \tfrac{1}{4}\ \text{Prob}[\ \max\{ c_{jj} - c_{ij} \}_{j \neq i} > 0\ ]]\ \phi'(I_i) = \tfrac{1}{2}\ \psi_1(J_{U,i}, J_{D,i}) = 1. \qquad (8)$$

It is immediate that the buyer's first order condition is:

$$\tfrac{1}{2}\ \psi_2(\ J_{U,\,i}\ ,\ J_{D,\,i}\ ) = 1. \qquad (9)$$

Comparing (8) and (9) with (4) and (5) shows the tremendous difference between an informal arrangement and a contract. The contract forces the supplier's share of the marginal return to both kinds of investment to be equal, but given that constraint it allows that share to be set at the optimal level. By contrast, the informal arrangement allows the supplier's share of the marginal return to the two kinds of investment to be different. In an informal arrangement the share for the joint investment is always equal to ½ , but because autonomous investments raise the supplier's bargaining power, the share for those investments can range from ½ to ¾ , depending on the probability that there will be another potentially interested buyer. This can be summarized by the following:

Proposition 1. The outcome of an informal arrangement is exactly the same as a discerning contract in which $\theta_J = \tfrac{1}{2}$ and $\theta_A = [\ \tfrac{1}{2} + \tfrac{1}{4}\ \text{Prob}[\ \max\{\ c_{jj} - c_{ij}\ \}_{j \neq i} > 0\ ]]$.

It is in this sense that the market context is important to the working of the informal arrangement. The number and behaviour of the other suppliers on the market will affect the probability that at least one j exists such that $c_{jj} > c_{ij}$, thus affecting the supplier's investment incentives and the attractiveness of the arrangement, as will be analyzed more fully in the next section. No such effect is relevant to the performance of a contract, in the analysis of which the market context could be ignored.

5. The Choice Between Formal and Informal Arrangements.

Now we can discuss the choice between a contract and an informal arrangement. As noted above, evaluating the benefit from the informal arrangement requires consideration of the behaviour of other suppliers and will thus involve a Nash equilibrium. The choice between the two will turn out to hinge critically upon the degree of vertical integration in the industry.

To simplify the analysis, make one last assumption on the technology:

$$C^*(\theta_A^*, \theta_J^*) - \bar{\epsilon} > S, \tag{10}$$

or in other words, coordination of joint investments is so important for a highly specialized input that even the best possible incentives in a discerning contract do worse than a standardized input. The worst disaster imaginable is to try to fine-tune the input to the peculiarities of the buyer's product, and then to have poor coordination between buyer and supplier. This is a natural assumption in that one should expect joint investments to be more crucial, the more specialized the product is to the particular buyer. The reason it simplifies the analysis is that it ensures that no unintegrated firm would produce using the highly specialized technology. Thus, if supplier i is unintegrated, by (10) and (2c), it will use the semi-specialized technology strategy; while if firm *i* is vertically integrated, because of the greater efficiency of high specialization if used properly (that is, (2a)), it will always use highly specialized technology, making use of its centralized decision making to ensure that the optimal investments (I^{opt}, and so forth) are carried out. Thus, *n*, the number of unintegrated buyer/supplier pairs, is also the number of inputs produced with semi-specialized technology.

Further, this has important implications for the way informal arrangements work. The reason is that, as noted above, incentives for autonomous investment under an informal arrangement are affected by the probability that a given supplier *i* will be able to find an interested alternative buyer, in other words, the probability that $c_{ij} < c_{jj}$ for some *j*. Given assumption (2b) on the superiority of highly specialized inputs when used as intended with optimal investments, this can not occur if input *j* is highly specialized. Thus, the set of potential alternative buyers for a given input is limited to the set of suppliers using semi-specialized technology, in other words, to the set of unintegrated suppliers.

Given that all upstream firms and downstream firms are *ex ante* identical, we can focus on Nash equilibria in which either all unintegrated firms use contracts or all of them use informal arrangements. For the universal adoption of contracts to be an equilibrium, it must be that the *i*th buyer/supplier pair incurs lower total costs with a contract than with an informal arrangement, given that all other pairs are using a contract. For informal arrangements to be an equilibrium, it must be that the *i*th buyer/supplier pair incurs lower total costs with an informal arrangement than with a contract, given that all other pairs are using an informal arrangement. Total costs under a contract are unaffected by the market context, and are given by:

$$C_C \equiv C^*(\,\theta_N^*\,,\,\theta_N^*\,).$$

On the other hand, from Proposition 1, costs under an informal arrangement are given by:

$$C_{IA} \equiv C^*(\,\theta_A\,,\,½\,),$$

where θ_A = [½ + ¼ Prob[max{ $c_{jj} - c_{ij}$ }$_{j\neq i}$ > 0]]. Clearly, θ_A is endogenous and depends on n and on the investments made by all 2n independent firms (except for buyer i). The Appendix derives the following characterization for it:

Proposition 2. Both in the case in which all unintegrated buyer/supplier pairs other than i use contracts, and in the case in which they use informal arrangements, we have:

θ_A = ½ if n = 1;

θ_A is increasing in n; and

$\theta_A \rightarrow$ ¾ as $n \rightarrow \infty$.

The point is that the more of the industry that is unintegrated, the more likely it is that supplier i will be able to find an alternative customer *ex post*; so the more likely it is that its bargaining power will be helped *ex post* by an increase in the general attractiveness of its input; and thus the stronger is its *ex ante* incentive to undertake autonomous investments. It is in this sense that the market context affects the performance of an informal arrangement. A less vertically integrated industry results in a thicker market, which improves incentives under informal arrangements.

Clearly, if $n = 1$, then an informal arrangement is equivalent to a contract with $\theta_J = \theta_A = ½$, which is a particular non-discerning contract, and is hence inferior to the optimal non-discerning contract. This is illustrated in Figure 3 as the point A; the optimal discerning contract is at point C and the optimal non-discerning contract is point D. On the other hand, as n rises (still continuing under the assumption that all other non-integrated firms use contracts), the appeal of the informal arrangement from buyer/seller pair i's point of view rises, because the effective θ_J does not change but the value of θ_A rises toward 1. This is illustrated by the horizontal arrows in Figure 3, moving from A to B. When n rises enough that the contract equivalent to the informal arrangement crosses the $C^*(\theta_A, \theta_J) = C_C$ iso-expected-cost contour, it is optimal to switch to an informal arrangement. We have immediately the following proposition.

Proposition 3. If the industry is sufficiently vertically integrated (n is low enough), all firms will use contracts in equilibrium. If $C^*(\,¾\,,\,½\,) < C^*(\,\theta_N^*\,,\,\theta_N^*\,)$, there is a critical level of n, say, n', such that if $n > n'$, all firms will use informal arrangements in equilibrium.

Thus, we have the result that in a highly vertically integrated industry, those firms that do outsource use rigid contracts; while in a relatively non-integrated industry outsourcing is achieved through handshakes. Further, if autonomous investments are sufficiently important compared to joint investments, then θ_N^* will be close to 1, so that under outsourcing by contract, almost all of the residual cost will be borne by the supplier, as in the classic American-style supplier contract. However, under an informal arrangement, joint costs will be shared evenly by buyer and seller at the margin, and as a result there is much more cooperation, as in the classic Japanese-style supplier relationship. We thus have derived a stylized version of the three key properties of supplier relations noted at the outset, and have driven the differences entirely by the level of vertical integration in the two economies.

6. Concluding Remarks.

The story told in the model has been expressed as a static comparison, but it should be pointed out that it can deal to some degree with change as well. For example, US manufacturing has seen a large increase in the amount of outsourcing in a number of its manufacturing industries, including automobiles (see Bamford (1994), *Economist* (1991), and Maynard (1996), for example). Thus, the model predicts pressures for a move in the direction of less formality in contracting, more cost sharing and more cooperation in outsourcing. In addition, although it was not emphasized in the exposition of the model, in a slightly expanded model the progressive drop in the cost of international transactions brought on by falling transportation costs and trade barriers would provide a prediction in the same direction.

This is because it has precisely the same effect on the effective θ_A as a rise in n: by raising the probability of finding an alternative buyer, globalization makes bargaining power effects more important.

In the light of this, it is interesting to note that there are indeed strong signs of such a movement. This is argued by Johnston and Lawrence (1988); in the automobile industry, this is supported by the automotive supplier surveys of Helper (1991) and Liker et al. (1996), which find that US suppliers are now in many cases making substantial cooperative investments, still not at the level of their Japanese counterparts but at much higher levels than had been suggested by earlier work. Further, the case study of Chrysler by Dyer (1996) makes the point very dramatically. Traditionally, Chrysler had attempted to impose strict cost discipline on its suppliers with fixed price contracts.[33] Typically, the suppliers produced to detailed specifications given to them by Chrysler and had no part in the design process. There were some instances of suppliers suggesting design improvements, but Chrysler authorities ignored the suggestions because they would involve some resources in running tests and adapting the idea to the larger structure, including the use of engineers' time (p. 53). This situation was very much like the outcome of the model with low n, with $\theta_N \approx 1$ and consequently $J_D \approx 0$.

In 1989, Chrysler management, after exhaustive study of Honda's supply management system, announced a new approach, its 'SCORE' program to convert its supplier relations to a real partnership. This, they hoped, would generate large savings through suggestions from the

[33]"Historically, Chrysler had put constant pressure on suppliers to reduce prices, regardless of whether the suppliers had been able to reduce costs; the automaker did not feel responsible for ensuring that suppliers made a reasonable profit." (p.52)

suppliers, but a major obstacle was the difficulty in convincing the suppliers that their suggestions would now be taken seriously. This was accomplished through a public relations campaign, the creation of institutional channels for suggestions, the pushing through of some pilot examples, and the creation of an incentive program that provided for the equal sharing of the cost savings from the program between buyer and seller (pp. 53-5). Suggestions poured in from suppliers, and over the next few years thousands of them were implemented. Cumulated savings from the SCORE program to Chrysler as of the end of 1995 have been estimated at \$1.7 billion (p.55). Thus, the new regime has $\theta_J = ½$ and a very high level of both J_U and J_D.

The model of this paper suggests that these large and significant changes in business practice may be a consequence of the progressive drop in the level of vertical integration of the industry and of the drop in the cost of international transactions. Of course, there are alternative explanations. It could be that the ‘culture’ of American business is changing, but of course that is tantamount to giving a name to the change rather than explaining it. It could be that Chrysler was in such financial trouble that it had to adapt the more efficient method to survive; but that begs the question: If the new method was always more efficient, why would Chrysler management not have wanted it all along? It could be that the managers were responding to recent business research showing the superiority of the system they imitated (Liker et al., 1996, pp. 83-4). In contrast to these explanations, the model of this paper suggests a set of causes that are concrete changes in the economic environment and that operate within the framework of profit-maximizing behaviour. This may give them a certain operational advantage as part of a positive theory. At any rate, they are serious candidates that appear to have been completely absent from the literature on these questions so far.

As a final note, it should be emphasized that this is a highly stylized model which omits much that is interesting about supplier relations in practice. The ‘tier’ structure, which seems to be an important part of the Japanese system, is absent here (Nishiguchi, 1994). Risk aversion seems to place a role in some aspects of supplier management, but it has been assumed away here. There are no unions in the model, but in the US the relationship between unionized autoworkers and the non-unionized subcontractors has been an important and contentious issue. The number and selection of suppliers has been eliminated from the problem here by mere assumption, as has the question of the length of contract. Further, the picture painted here of contracts is legally naive, since it assumes that they are costlessly enforceable, rather than making realistic assumptions about breach. It is hoped that the argument developed here could continue to shed some light when these complicating factors are allowed to enter.

Appendix: The Proof of Proposition 2.

Assume first that all unintegrated pairs $j \neq i$ are using contracts. Then the autonomous investments of supplier *i*, which we will denote I_i, are given by the first order condition (8):

$$[\, \tfrac{1}{2} + \tfrac{1}{4}\, \text{Prob}[\, \max\{ c_{jj} - c_{ij} \}_{j \neq i} > 0 \,]]\, \phi'(\, I_i \,) = 1.$$

The left hand side of this is the marginal benefit to the autonomous investment (for the supplier), and the right hand side is its marginal cost. The determination of the probability within the square brackets is key. Reviewing (1), we can write it as:

$$\begin{aligned} &\text{Prob}[\, \max\{ c_{jj} - c_{ij} \}_{j \neq i} > 0 \,] \\ &= 1 - \text{Prob}[\, (\, c_{jj} - c_{ij} \,) < 0 \text{ for all } j \neq i \,] \\ &= 1 - \text{E}_{\epsilon_{ii}}[\, \text{Prob}[\, (\, c_{jj} - c_{ij} \,) < 0 \text{ for all } j \neq i \mid \epsilon_{ii} \,]] \\ &= 1 - \text{E}_{\epsilon_{ii}}[\, \gamma(\, \psi(\, J_U(\, \theta_N^* \,), J_D(\, \theta_N^* \,)) + \phi\,(\, I(\, \theta_N^* \,)\,) - \phi\,(\, I_i \,) \mid \epsilon_{ii} \,)^{n-1} \,] \\ &\equiv \Pi(\, I_i \,, n \,), \end{aligned} \tag{11}$$

where $\gamma(\, A \mid \epsilon_{ii} \,)$ is the probability that $\epsilon_{jj} - \epsilon_{ij} < A$, conditional on the value of ϵ_{ii}. Since $\gamma(\, A \mid \epsilon_{ii} \,)$ is an increasing function of *A*, the probability $\Pi(\, I_i \,, n \,)$ is an increasing function of I_i. In words, the probability that supplier *i* will be able to find an alternative customer for its input is higher, the harder supplier *i* works *ex ante* to create an attractive input. The quantity in square brackets in the fourth line of (11) is simply the probability that input i is unattractive to all other unintegrated suppliers, conditional on input i's cost shock. Since the $\{\epsilon_{jj}\}_{j=1}^{n}$ are independent and the $\{\epsilon_{ij}\}_{j=1}^{n}$ are independent given ϵ_{ii}, this is given by the probability that input i is unattractive to any one of the firms, raised to the power of the number of possible candidate firms, $n - 1$. The value of I_i is then determined by the condition that the marginal benefit, $\phi'(I_i)$ times one-half plus one-quarter of $\Gamma(I_i , n)$, equals 1. This is shown in the top quadrant of Figure 4. The value of θ_A is then equal to $[½ + ¼\Gamma(I_i , n)]$, which can be read off of the lower quadrant of Figure 4. It is immediate from the construction of the function Γ and from the Figure that if $n = 1$, $\theta_A = ½$; a rise in n shifts the Γ function up, and so increases I_i and θ_A; and that $\theta_A \to ¾$ as $n \to \infty$.

The case in which all unintegrated pairs $j \neq i$ are using informal arrangements is exactly the same, except that we have $\Gamma(I_i , n) = 1 - \mathrm{E}_{\epsilon}[\, \gamma(\psi(J_U(½), J_D(½)) \mid \epsilon_{ii})^{n-1}]$.

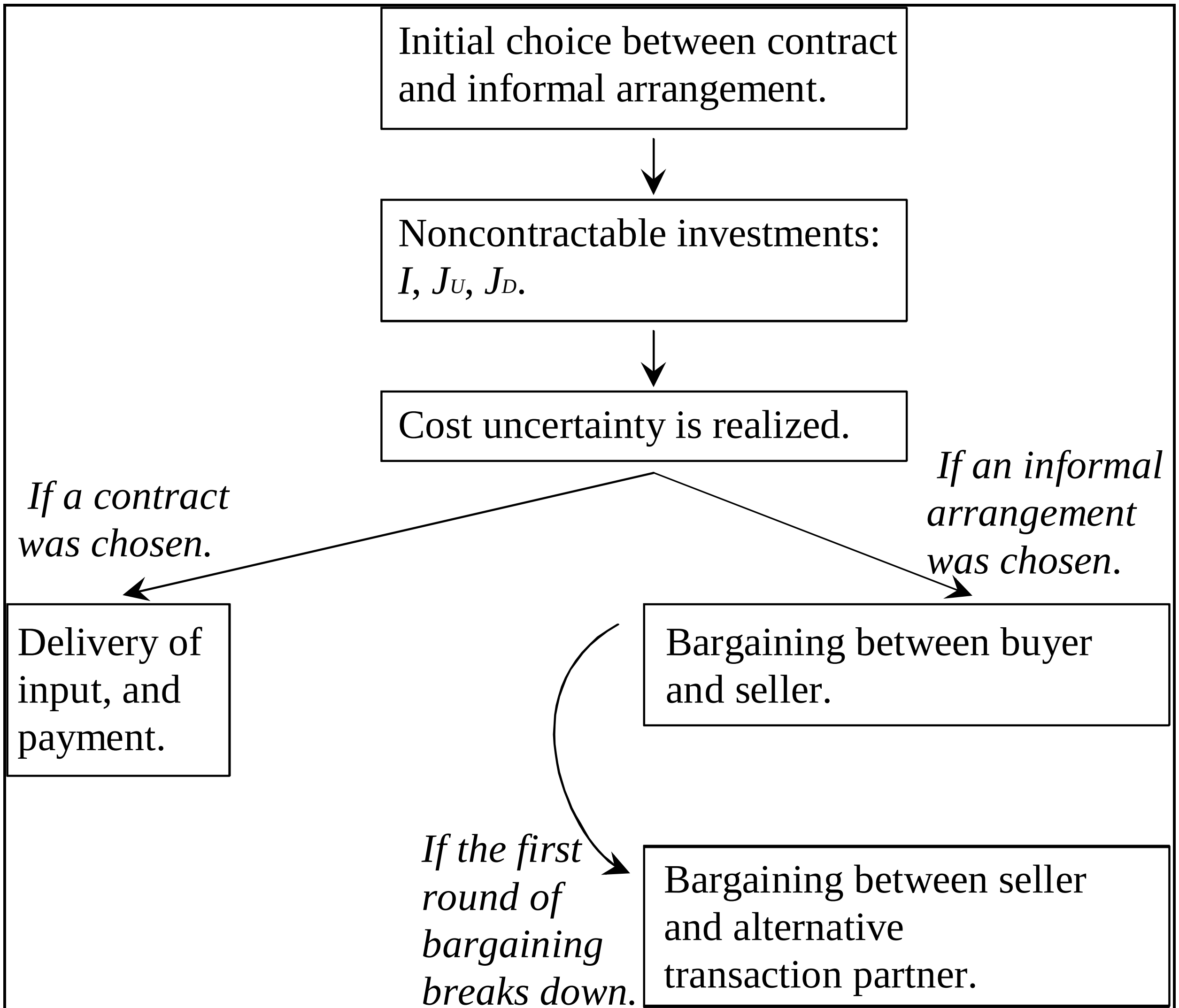


Figure 1: The Sequence of Events.

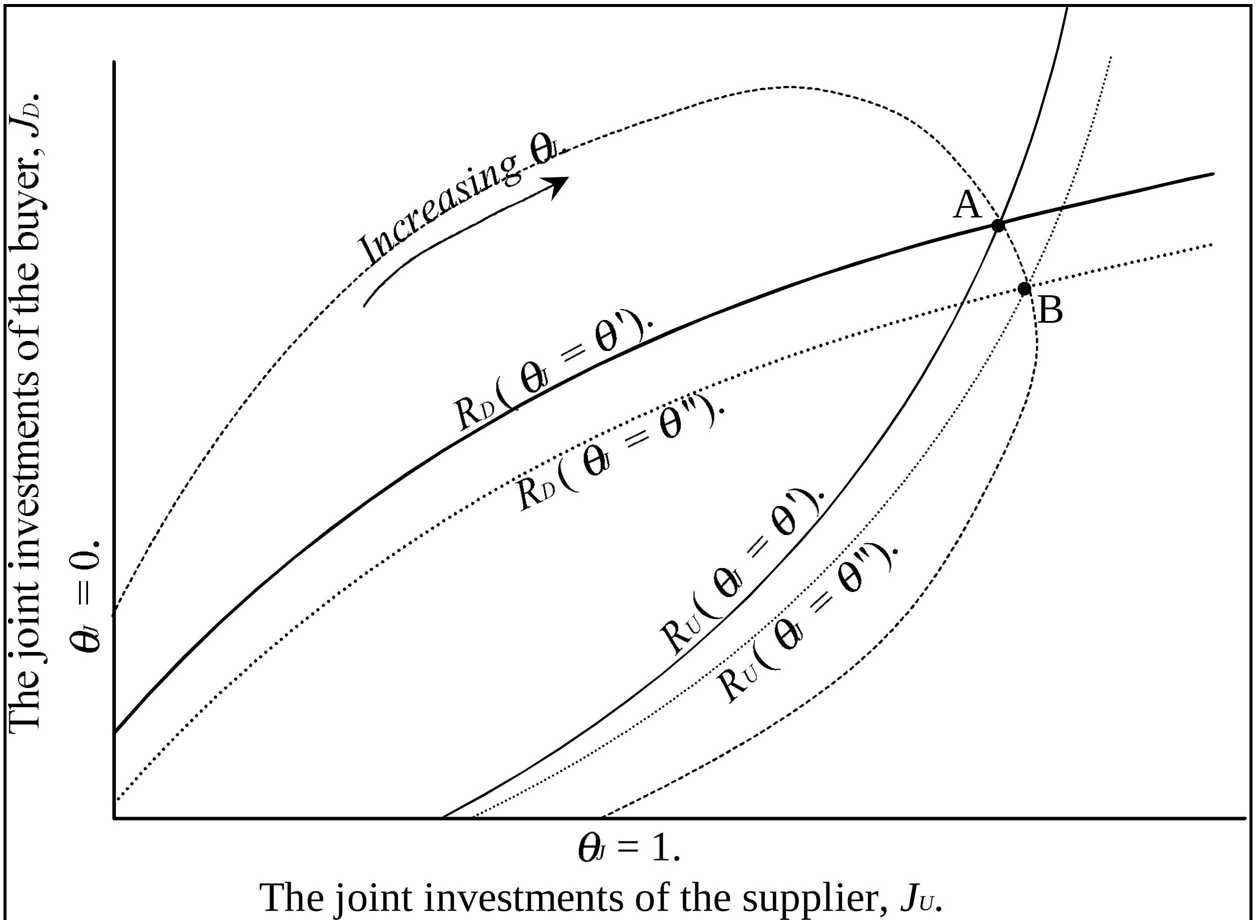
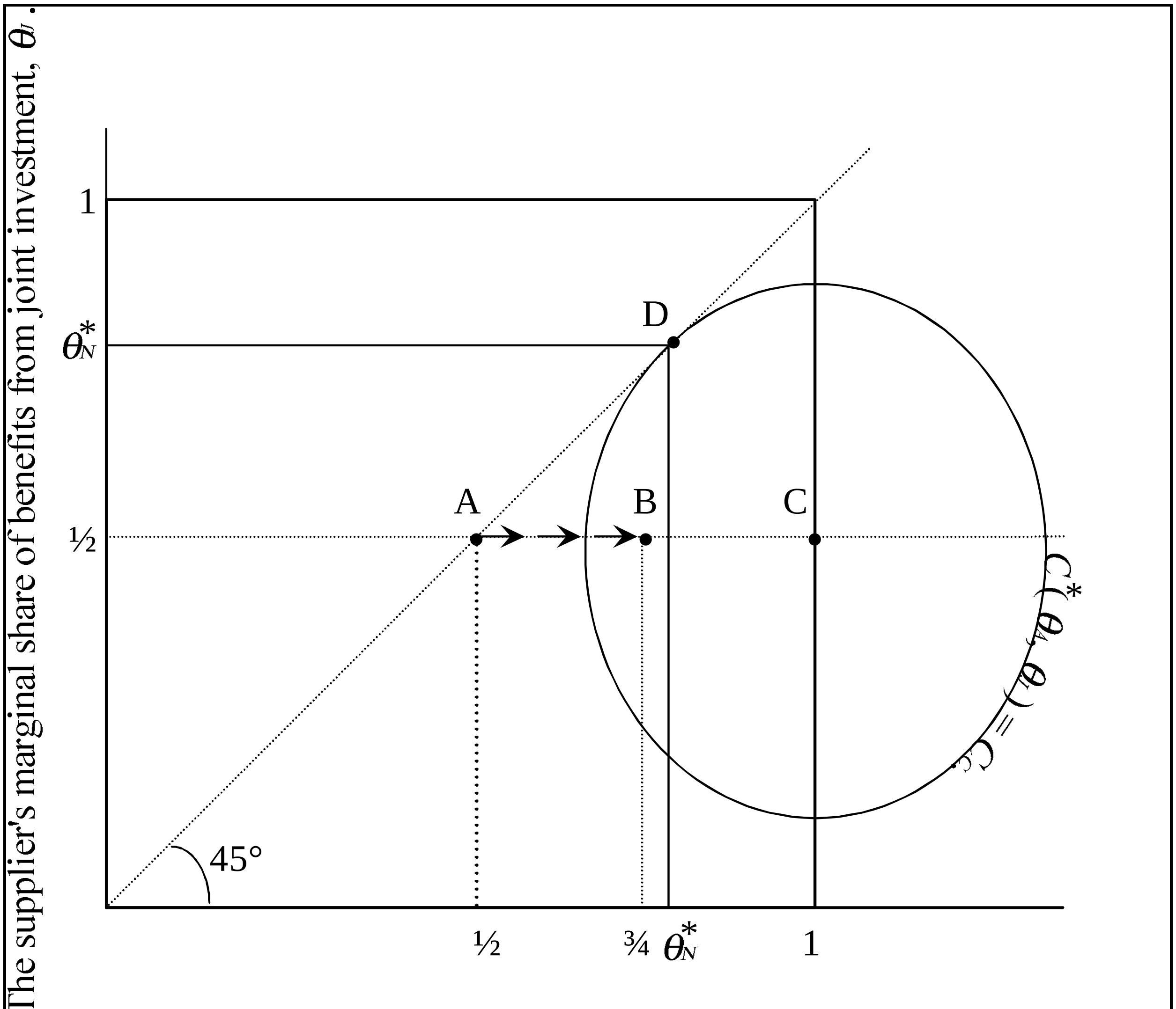


Figure 2: The Effect of the Sharing Rule on Joint Investments.



The supplier's marginal share of benefits from autonomous investment, θ_A .

Figure 3: The Choice between a Contract and an Informal Arrangement.

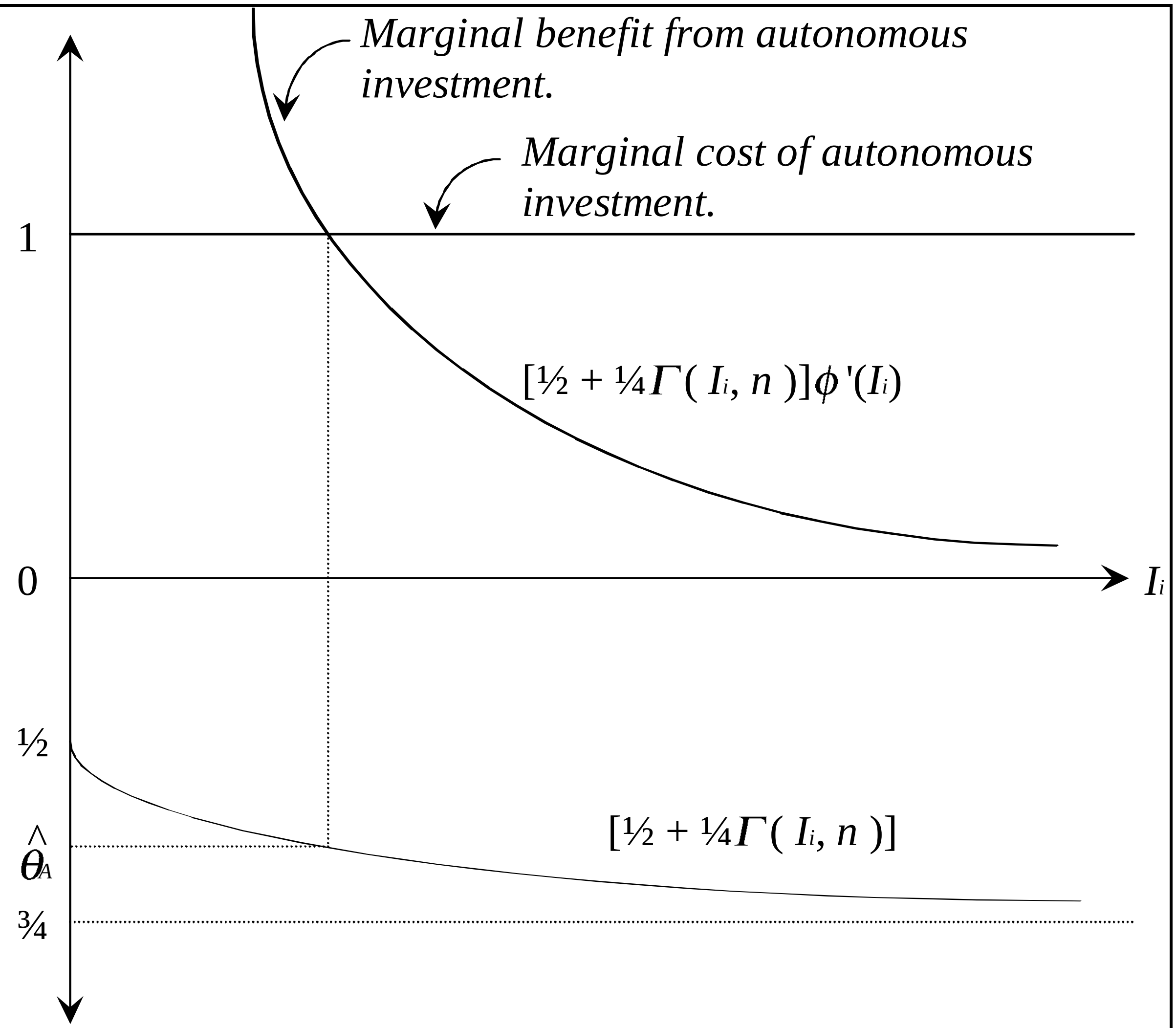


Figure 4: The incentive to make autonomous investment under an informal arrangement.

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