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TRANSACTIONS/LIST PRICING

by

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ABSTRACT

Suppose that a representative downstream firm must buy relationship-specific capital before an upstream monopolist is privately informed of its unit costs. We show that the upstream firm will write a contract before the downstream firm invests, specifying a maximum (list) price which may be discounted when costs are low. This model therefore rationalizes transactions/list pricing: a prevalent mode of inter-firm trading. We use our results to explain Stigler and Kindahl's findings on medium-term price dynamics.

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Introduction

Inter-firm trade is often conducted in the following fashion. A supplier sends a list price to all potential customers with the understanding that the transactions price will equal the list price except on a (possibly empty) set of 'favorable realizations of cost or demand, when the transactions price will be less than the list price; each customer can dictate the size of its purchase at a consumer- and quantity-independent unit price. This paper explains why sellers who can commit to prices before observing their marginal costs would choose contracts of this type.

In our model an upstream monopolist supplies its output to small downstream firms after the latter have invested in relationship-specific capital - the other input in their production processes. The upstream product is resaleable, so the monopolist does not price discriminate. Capital and the upstream product are complementary; and the absolute elasticity of demand for the upstream product is higher, the greater is a representative downstream firm's capital stock. The monopolist therefore has an incentive to contract to a relatively low price in order to induce greater investment, which results in higher demand for the upstream product at each price.

We assume that downstream firms invest before random upstream (marginal) costs are realized; so the contract conditions price on the upstream firm's announcement of its costs. We suppose, crucially, that the realization is revealed only to the upstream firm. We can then focus wlog on incentive compatible contracts. In addition, we direct attention to contracts with the property that the upstream firm would not prefer to reduce its price after any realization of its costs.

We demonstrate that any contract satisfying these two properties must specify a maximum (list) price and a 'critical' value of marginal costs, above which the upstream firm charges the list price. Moreover, at any cost realization below the critical value the upstream firm charges the spot price: that is, the profit-maximising price, given the cost realization and the capital which the representative downstream firm has already chosen.

Two types of contract satisfy these conditions. The first category consists of fixed-price contracts, for which the critical value is the lowest possible cost realization. The second category consists of transactions/list contracts, which involve spot prices for some cost realizations. In particular, transactions/list contracts include the spot-pricing rule: the unique set of contingent prices which the upstream firm would charge in equilibrium if it could not write a binding contract. In this (and only this permissible) contract the list price is only charged at the highest possible cost realization.

We demonstrate the existence of an optimal contract, and show that it must differ from the spot-pricing rule. Hence, the upstream firm must charge its list price for a significant proportion of cost realizations. We also use an example to distinguish between conditions under which the upstream firm chooses a fixed-price and a transactions/list contract: in our example fixed-price contracts are chosen iff the interest rate is low enough. Finally, we use these results to explain Stigler and Kindahl's (1970) intriguing finding that the trend in the Wholesale Price Index lags that in their buyers' price index iff the movement is downwards.

The problem that we study incorporates several features that are emphasized in the transactions cost literature (cf. Williamson (1985) Ch.2): principally the asset-specificity of capital, which distinguishes the surplus before and after the downstream firm has invested; and 'opportunism', represented in our model by the upstream firm's capacity to misreport its private information. Our results indicate that transactions/list pricing - a nonstandard contracting practice in Williamson's terms - is explicable as an efficient response to the combination of opportunism and asset-specificity. However, in our model the firms which engage in relationship-specific investment are each small and anonymous (so that the upstream firm never chooses to price discriminate), whereas the transactions cost literature addresses bilateral bargaining.

Incomplete information and relationship-specific capital are each familiar features in recent economic theory (cf. Myerson (1979) and Grout (1984) respectively). However, the interaction between these two features seems not to have been formally modelled hitherto.

In section 1 we present and discuss the model and assumptions. Section 2 contains our main theoretical results, which we apply to the Stigler-Kindahl evidence in section 3. We conclude in section 4.

1. The Model

This section describes the theoretical model that we will analyze. Section 1A presents the extensive-form game, while Section 1B introduces our assumptions on functional forms and discusses their ramifications.

A. The game

We study an extensive-form game played by an upstream monopolist and a downstream industry composed of a large number of small, identical firms. We will refer to the monopolist as 'firm u', and denote a representative downstream firm by 'firm d'.

We denote firm u's (resaleable) product by x. Firm d uses x and relationship-specific capital (k) to produce its output according to the production function G(k,x). Firm d purchases k on a competitive market at price r and sells its output on a competitive market for a price which we normalize to unity. (We briefly allude to the endogenous determination of firm d's output price in Section 2C.)

Firm u's production technology involves constant average costs, denoted by c. At the beginning of the game all players are known to share the same beliefs about the distribution of c. The game proceeds as follows:

Stage 1. Firm u writes a contract - that is, a mapping $p(c^a)$ from each announced value of $c(c^a)$ to a unit price (p) for x.

Stage 2. The realization of c is revealed to firm u alone, while firm d chooses k.

Stage 3. Firm u announces a value of c and sets some $p \leq p(c^a)$.

Stage 4. Firm d reports its demand for x, which firm u then meets.

Our specification of price-setting at Stage 3 implicitly supposes that no third party can prevent firm u from charging $p \neq p(c^a)$ after announcing c^a, provided that firm d agrees to waive the contract. We can clearly focus on contracts such that firm u chooses not to reduce its price without losing any generality.

We analyze the game by characterizing optimal non-negative contracts: where firm u's return from contract $p(c^a)$ is its expected return in some Bayesian equilibrium of the ensuing game. Now firm u's choice of contract is a standard mechanism design problem. The Revelation Principle therefore implies that any optimal contract is equivalent to one in which each c-type of firm u chooses to reveal honestly. Consequently we lose no generality by concentrating on contracts that are 'credible': viz. each c-type truthfully reveals and charges the contractual price. This allows us to denote any relevant contract by p(c) - that is, without explicit reference to the announced state. Furthermore, extra-equilibrium beliefs play no role in our analysis.

B. **Assumptions**

Let $x(p;k)$ denote firm d's demand for firm u's product, we write firm u's profit function as

$$\Pi^u = (p - c)x(p;k);$$

A1(i) c is a random variable with support [0,1], and an atomless distribution function denoted by $F(z)$;

(ii) Firm u is risk-neutral. □

We now turn to our more substantive conditions on firm d's production, and thence firm u's profit function:

A2 Firm d's production function, denoted $G(k,x)$, satisfies the following conditions:

(i) $G(\cdot,\cdot)$ is strictly increasing and strictly concave in (k,x);

(ii) $G_{222}(k,x) \le 0$;

(iii) For any $k \ge 0$, the equation $G_2(k,x) = p$ has a positive solution in x; and for all $(k,x) \ge 0$, $G_2(k,x)$ is bounded above;

(iv) $G_{12}(k,x) > 0$;

(v) $G_{122}(k,x) \le 0$;

(vi) $G_1(0,0) > r$ and $\lim_{k\to\infty} G_1[k,x(0;k)] < r$;

where $G_{iii}(k,x)$, for example, is G's third partial derivative with respect to its i^{th} argument.

Finally,

(vii) Firm d is risk-neutral. □

In section 2C we present a simple example which satisfies A1 and A2.

A2(ii) implies that firm d's input demand function, $x(p;k)$, is strictly concave in firm u's price. A2(ii) and the boundary conditions in A2(iii) jointly imply that, for all $c \in [0,1]$ and all $k \geq 0$, $\Pi^u(\cdot;c)$ is strictly concave in p and has a unique, positive maximand. We will refer to the latter as a spot price, denoting it by $p^s(c;k)$. It is important to emphasize that 'spot' prices are a theoretical construct in our model: they refer to the price that type-c of firm u would choose if it were not constrained by a prior contract. Notice that $p^s(\cdot;k)$ is strictly increasing in c.

A2(iv) and A2(v) characterize spot prices as a function of k. The former states that k and x are complements, and the latter that an increase in k raises $p^s(c;k)$. Both assumptions will play a crucial role, to which we return at the end of the subsection.

A2(vi) and A2(vii) concern firm d's investment decision. The boundary conditions of A2(vi) and strict concavity imply that firm d's choice of k is finite and unique. Moreover, since $x(\cdot;\cdot)$ is differentiable in (p,k) there is a differentiable function $k[p]$ specifying firm d's investment in response to a fixed price contract $p(c) = p$: all $c \in [0,1]$. Nothing serious hangs on risk-neutrality (A1(ii) and A2(vi)).

We now strengthen A2(vi) so as to ensure existence and uniqueness of the 'spot-pricing rule', that is, a spot-pricing function $p^s(c;k^s)$ which induces firm d to invest k^s.

Notice that $p^s(c;\cdot)$ is strictly increasing in k, while $x(\cdot;\cdot)$ is strictly decreasing in p and increasing in k. Consequently k^s must be unique if it exists. Twice-differentiability of G(k,x) and the following boundary condition ensure that k^s exists.

A2(vi)' $G_1(0,x[p^s(1;0);\, 0]) > r$ and $\lim_{k\to\infty} G_1(k,x[p^s(0;k);k]) < r.$ □

A2(vi)' implies that firm u would charge $p^s(c;k^s)$ in state c if there were no enforceable contracts.

We return, finally, to the roles that A2(iv) and A2(v) will play in our analysis. These assumptions imply that $k[p(c)] > k^s$ only if there is some $C \subseteq [0,1]$ such that $\int_C dF(c) > 0$ and $p(c) < p^s(c;k^s) < p^s(c;k[p(c)])$ for every $c \in C$. Firm u therefore raises its profit at $c \in [0,1]\backslash C$ by cutting its price at every $c \in C$. This observation has important implications for our analysis, which can best be seen by turning to a related game in which the realization of c is public information:

Remark: Consider a game with payoffs satisfying A1 and A2, but in which the realization of c is publically revealed at Stage 2. Since c is public information, the announcement process can be omitted, and with it the requirement that p(c) be incentive compatible. A small decrease in price at every $c \in [0,1]$ starting from the spot-pricing rule has two effects on firm u's (equilibrium) expected profits. Firstly, it has a first-order effect on firm d's investment, raising firm u's profits in each c-state at the associated spot price. Secondly, by definition of spot prices, the variation in price has only a second-order effect on firm u's profit in each c-state, given k^s. Hence, a standard envelope theorem establishes that firm u can always improve on the spot-pricing rule in this public information game, and that equilibrium investment exceeds k^s.[1] □

In the private information game presented in Section 1A credibility constraints prevent firm u from raising k by reducing price in every c-state. Nevertheless, A2(iv) and A2(v) imply that it can improve on the spot-pricing rule by reducing prices in some subset $C \subseteq [0,1]$, and thereby raising investment above k^s (Theorem 2). Our proof also uses an envelope theorem, in which we compare second-order effects of variations within the set of credible contracts.

2. Results

This section presents our main theoretical results. Section 2A demonstrates that every credible contract either specifies a fixed price (FP) or is a transactions/list (TL) contract; that is, one which charges spot prices when c is less than some critical value $\underline{c} \in [0,1]$, and charges the list price otherwise. It also characterizes the set of FP and TL contracts that might be chosen in equilibrium, demonstrating in particular, that both are compact sets, and that TL contracts are indexed by $\underset{\sim}{c} \in [0,1]$. Section 2B shows that an optimal contract exists and that firm u can always improve on the spot-pricing rule, a boundary element of the set of TL contracts. Thus firm u always utilizes its capacity to contract by charging its list price for a significant proportion of realizations. Finally, section 2C uses an example both to extend this characterization and to prepare the ground for our explanation of the SK data in section 3.

A. **Credible consistent contracts**

Let firm d's equilibrium response to some contract $p(c)$ be k. Credibility requires that $p(c) \leq p^s(c;k)$ for all $c \in [0,1]$, as firm u would subsequently choose to reduce its price at every c which violated this condition. This observation and strict concavity of $\Pi^u(\cdot;c)$ in p imply that every credible contract is continuous in c for all $c \in [0,1]$. To see this, suppose per contra that a credible contract is discontinuous at some c_1. If $p(c_1) = p^s(c_1;k)$ then the contract must be incentive incompatible either at $c < c_1$ or at $c > c_1$. If $p(c_1) < p^s(c_1;k)$ then strict concavity and incentive compatibility jointly require that $p(c) > p^s(c;k)$ for some c close to c_1, contradicting the credibility of $p(c)$. Thus the range of $p(c)$ is an interval.

Finally, suppose that $p(c_1) < p^s(c_1;k)$ for some $c_1 \in [0,1]$. Since $p(\cdot)$ is continuous at c_1 there must be an ϵ-neighborhood of c_1 on which $p(c)$ is constant: for if not, then continuity of $p(c)$

implies that there is either c_2 such that $0 < c_2 - c_1 < \epsilon$ and $p(c_2) < p(c_1)$ and/or a c_3 such that $0 < c_1 - c_3 < \epsilon$ and $p(c_3) > p(c_1)$. In the former case $p(c_2) < p(c_1) < p^s(c_1;k) < p^s(c_2;k)$ so $p(c)$ would be incentive incompatible at c_2; in the latter case $p(c_1) < p(c_3) < p^s(c_3;k) < p^s(c_1; k)$, so $p(c)$ would be incentive incompatible at c_1.

These observations imply that every credible contract falls in one of the following categories:

(a) Transactions/list (TL) contracts:

$$p(c) = p^s(c;k) \quad : \quad c \leq \underline{c}$$
$$\quad = p^s(\underline{c};\ k) \quad : \quad c \geq \underline{c}$$

for some $\underline{c} \in [0,1]$;

(b) Fixed-price (FP) contracts:

$$p(c) = p \leq p^s(0;\ k) : c \in [0,1].$$

We will refer to $\underline{c}$ as the 'critical value'.

It is straightforward to check that (a) and (b) are each sufficient for a contact to be credible. A TL contract with $\underline{c} = 0$ is, of course, an FP contract; while the TL contract with $\underline{c} = 1$ is the (unique) spot-pricing rule.

Our characterization of credible contracts has thus far only used properties of equilibrium play from Stage 3 onwards: that is, conditional on the capital induced. We now exploit an additional property of equilibrium contracts which we will call 'consistency': any TL contract must induce the investment level with which its spot-pricing section is associated. The following Lemma is crucial to our characterization.

LEMMA: *There is a unique* k^* *such that an FP policy with price* $p^s(0;k^*)$ *induces an investment of* k^*.

PROOF: Define $k[p]$ as the investment induced by an FP contract with price p. Clearly, $k[p^s(0;k^s)] > k^s$, since k^s ie the optimal response to $p(c) = p^s(c; k^s)$, and $p^s(\cdot;k^s)$ is strictly increasing in c. Furthermore, A2(vi)' implies that $k[p^s(0;k)] < k$ for k large enough. Twice-differentiability of $G(k,x)$ implies that $k[\cdot]$ is continuous in p; so there exists a k^* such that $k[p^s(0;k^*)] = k^*$. Since $p^s(0;\cdot)$ is strictly increasing in k, k^* must be unique. □

We now use the Lemma to characterize the set of consistent TL contracts:

PROPOSITION 1: *The set of TL contracts is indexed by* $\underset{-}{c} \in [0,1]$.

PROOF: The only consistent TL contract with $\underset{-}{c} = 0$ is $p(c) = p^s(0;k^*)$: all $c \in [0,1]$, while the spot-pricing rule is the only consistent TL contract with $\underset{-}{c} = 1$.

Define the function

$$p(k) = p^{s}(c;k) \ : \ \text{all} \quad c \le \underline{c}$$
$$\quad = p^{s}(\underline{c};k) \ : \ \text{all} \quad c \ge \underline{c}$$

for fixed $\underline{c} \in (0,1)$. A2(v) implies that $p(k^{s})$ induces $k > k^{s}$, and that $p(k^{*})$ induces $k < k^{*}$. Now A2(i) and A2(iv) imply that the capital induced by $p(k)$ is continuous in k; so for every $\underline{c} \in (0,1)$ there is a $k(\underline{c}) \in (k^{s}, k^{*})$ such that $p(k(\underline{c}))$ is a consistent TL contract.

Now $k(\cdot)$ must be strictly decreasing in its argument for $\underline{c} \in (0,1)$: for if there were two consistent TL contracts $p_1(c)$ and $p_2(c)$ such that $\underline{c}_1 < \underline{c}_2$ and $k(\underline{c}_1) \le k(\underline{c}_2)$ then A2(v) would imply that $p_1(c) \le p_2(c)$ for all $c \in [0,1]$ with strict inequality for $c \in (\underline{c}_1, \underline{c}_2)$; so A2(iv) implies that $k(\underline{c}_1) = k[p_1(c)] > k[p_2(c)] = k(\underline{c}_2)$, contrary to supposition. Since $k(\underline{c})$ is a strictly decreasing function, there is a unique TL contract associated with each $\underline{c} \in (0,1)$.

□

COROLLARY: *The set of consistent TL contracts is compact.* □

We illustrate two consistent TL contracts in Figure 1 below:

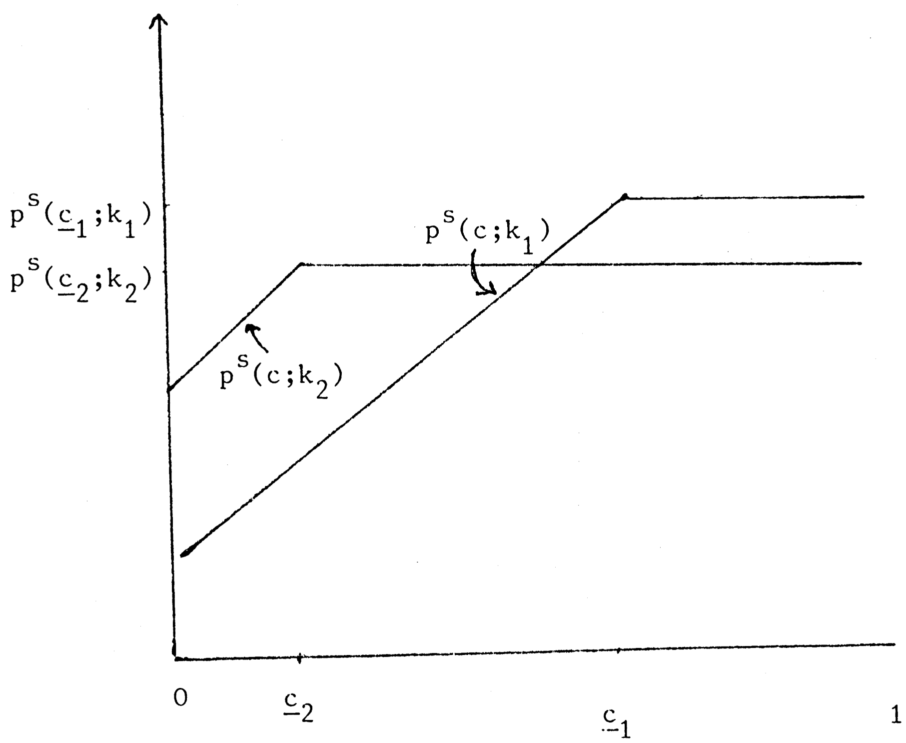

Figure 1

We conclude our characterization of consistent TL contracts by describing the function $k(\underset{\sim}{c})$:

PROPOSITION 2: *(i)* $k(\underset{\sim}{c}) \in [k^s, k^*]$ *for all* $\underset{\sim}{c} \in [0,1]$;

(ii) $k(\cdot)$ *is differentiable and strictly decreasing in the critical value for* $\underset{\sim}{c} \in (0,1)$;

(iii) $dk/d\underset{\sim}{c}(1)$, *the left-hand derivative at* $\underset{\sim}{c} = 1$, *is zero.*

PROOF: (i) Obvious.

(ii) See the proof of Proposition 1 for a demonstration that $k(\underline{c})$ is strictly decreasing.

Define the function

$$p(\underline{c}) = p^s(c;k): \text{ all } c \leq \underline{c}$$
$$= p^s(\underline{c};\, k): \text{ all } c \geq \underline{c}$$

for fixed $k \in (k^s, k^*)$. Choose $(\underline{c}_1, k_1)$ such that $k_1 = k(\underline{c}_1)$, and let $0 < \underline{c}_1 - \underline{c}_2 < \delta$. Since $k(\cdot)$ is strictly decreasing in $\underline{c}$, A2(v) implies that

$$k[p(\underline{c}_1)] = k(\underline{c}_1) < k(\underline{c}_2) < k[p(\underline{c}_2)].$$

Continuity of $k(\underline{c})$ therefore follows from continuity of $k[p(\cdot)]$ in $\underline{c}$. Since $k(\underline{c})$ is continuous, the price charged at $c \in [0,1]$ changes continuously with $\underline{c}$ within the set of consistent TL contracts; so A1(i) implies that firm d's demand for x changes continuously with $\underline{c}$. A1(i), A2(i) and A2(vii) then imply that $k(\cdot)$ is differentiable in $\underline{c}$.

(iii) A marginal decrease in $\underline{c}$ starting from the spot-pricing rule $(\underline{c} = 1)$ can only reduce the price charged for a set of c-states with arbitrarily low probability, and therefore cannot raise $k(\underline{c})$.

□

Finally, it is obvious from the Lemma that

PROPOSITION 3: *The set of credible FP contracts is compact with prices in the interval* $[0, p^s(0;k^*)]$. □

B. Results

We can now use Propositions 1-3 to prove our main results.

The set of credible contracts is compact, being the union of two compact sets (Corollary and Proposition 3). Firm u's choice of an optimal contract is equivalent to the selection of a maximum price $p \in [0; p^s(1;k^s)]$. As p varies, firm u's expected profits clearly change continuously. Thus

THEOREM 1: *There exists an optimal contract.* □

We will now demonstrate that firm u's optimal contract cannot be the spot-pricing rule by showing that firm u's expected profit function has a local minimum in $\underline{c}$ at $\underline{c} = 1$.

Any marginal reduction in the critical value starting at $\underline{c} \in [0,1]$ has two effects on expected profits. Firstly it may induce firm d to increase its investment, which raises the (spot) price charged when $c \in [0,\underline{c})$. Secondly, it lowers the price charged when $c \in (\underline{c}, 1]$. Proposition 2(iii) states that a small reduction in the critical value starting at $\underline{c} = 1$ cannot raise k. Thus a reduction in $\underline{c}$ from the spot-pricing rule has a zero first-order effect on firm u's expected profits. The inferiority of the spot-pricing rule cannot be demonstrated by a standard envelope argument. We show, rather, that a reduction in the critical value from $\underline{c} = 1$ yields a second-order gain and a third-order loss.

Proposition 2(i) states that a reduction in the critical value raises k whenever $\underline{c} \in (0,1)$. Since firm u charges spot prices if $c \leq \underline{c}$, the increased investment raises firm u's profits whenever $c \leq \underline{c}$. This observation and Proposition 2(iii) imply that a reduction in the critical value from $\underline{c} = 1$ yields firm u a positive second-order gain. On the other hand, since firm u charges spot prices for every c when $\underline{c} = 1$, a marginal reduction in the list price has no effect on its profits at $\underline{c} = 1$. The loss from reducing the critical value is therefore zero to the second order. Thus, the net effect on firm u's expected profits of marginally reducing the critical value below unity is second-order positive. Consequently

THEOREM 2: *The spot-pricing rule is not firm u's optimal contract.*[2]

Notice the contrast between the envelope theorems used in proving Theorem 2 and in the Remark concerning the public information game at the end of Section 1B. The latter result demonstrates that firm u could always improve on the spot-pricing rule by slightly reducing price in every c-state, thereby inducing a first-order increase in investment. In the private information game, however, this deviation from the spot-pricing rule is incredible. Indeed, as demonstrated, the only credible small deviation from the spot-pricing rule has a zero first-order effect on firm u's expected profits; so demonstration of Theorem 2 requires a comparison of second-order effects.

Despite the difference in proof strategies, both results illustrate a simple intuition. While spot-pricing at c_1 maximizes type-c_1's profit given k, the anticipation that type-c_1 will spot-price tends to reduce firm d's investment lowering the profits of other c-types (and possibly also those of c_1); so firm u uses its capacity to contract in order to induce an investment above k^s. This intuition turns on A2(iv) and A2(v): complementarity implies that firm u wants as high an investment as possible when it charges approximately spot prices, while the fact that the price elasticity of firm d's demand increases with k implies that spot-pricing yields too high a level of prices (on average).

C. **Example**

Theorems 1 and 2 state that firm u either chooses an FP or a TL contract with $\underline{c} < 1$. They neither guarantee uniqueness nor establish conditions under which a TL contract is chosen. Indeed, inspection of the first-order condition reveals the difficulty of establishing either of these conditions with any degree of generality. Instead of pursuing this objective, we present a simple example in this subsection which has a unique, closed-form solution. In this example the form of the contract is determined by the value of the interest rate r (given firm d's output price). We focus on the role of r in preparation for our explanation of the Stigler-Kindahl data in Section 3. This explanation involves two assertions about the comparative statics of contract choice: that an increase in r reduces the list price and raises the critical value. We demonstrate that the example's solution satisfies these conditions, and provide an informal argument to suggest that these properties are not entirely example-dependent. Finally, we briefly discuss a generalization of our model in which firm d's output price is endogenously determined, and show that this would not alter the qualitative effects of nominal interest rate variations in the example.

EXAMPLE

$G(k,x) = kx - k^2 - x^2 + \delta k$; $c \sim U(0,1)$. We impose the condition $R \equiv r - \delta \leq -15/8$ in order to ensure non-negative sales at all prices charged with positive probability in equilibrium. □

Firm u's demand x, given p and k, is

$$x(p;k) = (k-p)2.$$

Consequently, each spot-price function is given by

$$p^S(c;k) = (c+k)/2.$$

For any contract $p(c)$, firm d's investment satisfies

$$k[p(c)] = - [Ep(c) + 2R]/3;$$

so $k^s = -(1 + 8R)/14$.

It is easy to confirm that[3] firm u's expected profits can be written as the following function of the critical value for $\underline{c} \in [0,1]$:

$$E\Pi^u(\underline{c}) = k^2(\underline{c}) - k(\underline{c}) + \underline{c} - \underline{c}^2 + \underline{c}^3/3,$$

where $k(\underline{c}) = - (\underline{c} + 4R - \underline{c}^2/2)/7$.

Consequently $E\Pi^u(\underline{c})$ has an interior maximum iff the equation $\underline{c}^2 + 47\underline{c} - (56 + 8R) = 0$ has a solution in $(0,1)$. If $R \leq -7$ then $E\Pi^u(\cdot)$ is strictly increasing in the critical value for all $\underline{c} \in (0,1)$; so Theorems 1 and 2 imply that firm u must choose an FP contract. We will now show that firm u chooses a TL contract if $R \geq -7$.

Notice that $p^f = \arg\max(p - Ec)x\{p;k[p]\} = (1-R)/4$, and that the contract $p(c) = p^f$: all $c \in [0,1]$ induces an investment of $k^f = -(1+7R)/12$. Hence $p^s(0;k^f) = -(1+7R)/24$. A necessary condition for firm u to choose an FP contract is that $p^f \leq p^s(0;k^f)$: for if not, then there must be a consistent TL contract which induces firm d to choose k^f and yields higher profits in almost every c-state. This TL contract would therefore dominate all credible FP contracts. Using the expressions above, the necessary condition for firm u to choose an FP contract is $R \leq -7$; so Theorem 1 implies that firm u chooses a TL contract if $R \geq -7$. We therefore conclude that

PROPOSITION 4: *Firm u chooses a TL contract iff* $R \geq -7$. □

If $R \in [-15/8, -7)$ then firm u chooses a TL contract with critical value $\underline{c} = \{(2433+32R)^{1/2} - 47\}/2$, whereas firm u's optimal contract has a fixed price of $(1-R)/4$ if $R \leq -7$. We will henceforth concentrate on the (TL) case of $R > -7$.

Imagine that the nominal interest rate (R) exogenously increases. The effects on firm u's choice of contract and on firm d's investment (with firm d's output price held constant) are described below:

PROPOSITION 5: *If* $R > -7$ *then*

(*i*) $d\underline{c}/dR = 8(2433+32R)^{-1/2} > 0$;

(*ii*) $dp^s[\underline{c};k(\underline{c})]/dR = -10(2433+32R)^{-1/2} < 0$;

(*iii*) $dk(\underline{c})/dR = -\{4 + (1-\underline{c})d\underline{c}/dR\} < 0$. □

Thus an increase in the nominal interest rate (ceteris paribus) reduces the list price and raises the probability that $c < \underline{c}$ (so that the transactions price is lower than the list price).

Proposition 5(iii) provides the key to understanding the effects of a change in R. Let $(\underline{c}_i, \underline{k}_i)$ denote equilibrium values when $R = R_i$ $(i = 1,2)$. Consider, firstly, the effect on the list price. If R increases from R_1 to R_2 then the initial investment of $\underline{k}_1$ can only be induced if firm u reduces its list price by lowering the critical value to $\underline{c}^1$ in Figure 2 below - a requirement which reduces firm u's incentive to induce $\underline{k}_1$. Consequently, firm u reduces its price in all c-states, choosing the lower list price of $p^s(\underline{c}_2;\underline{k}_2) \in (p^s(\underline{c}^1;\underline{k}_1), p^s(\underline{c}_1;\underline{k}_1))$, and inducing a lower investment of $\underline{k}_2$.

There are two forces working in opposite directions on the critical value. The direct effect of an increase in R is a reduction of investment to $\underline{k}_2$. If R were still equal to R_1, then firm u would charge the list price for $c \geq \underline{c}^2 > \underline{c}_1$. This effect therefore tends to raise the critical value above $\underline{c}_1$. On the other hand, the increase in R lowers the list price required to induce firm d to choose $\underline{k}_2$, ceteris paribus reducing the critical value. In this example the direct effect dominates, so that an increase in R reduces the probability that firm u charges its list price.

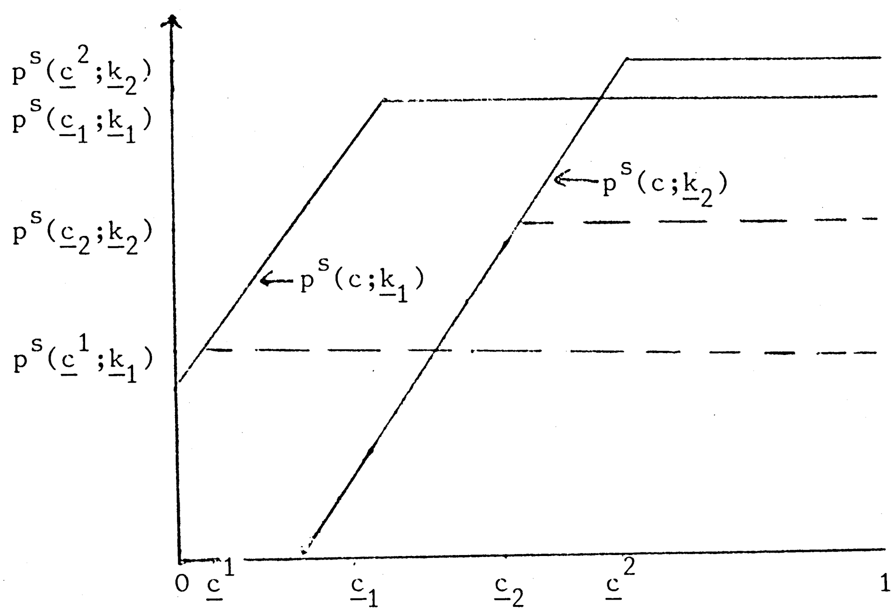

Figure 2

We will use Proposition 5 in Section 3 to explain the effects of variations in the nominal interest rate. Now Proposition 5 describes comparative statics with firm d's output price held constant. One might reasonably ask whether the effects would be altered if firm d's output price were determined endogenously?[4]

Imagine that there is a large number of islands, on each of which an upstream firm sells x to its local downstream industry, with each upstream firm's average cost determined independently. All downstream firms buy capital and sell output on a market common to all islands; so their output price is determined by the nominal interest rate and (approximately) the expected price of x across islands. Finally, imagine that there is free entry into the downstream industry on each island, but that each upstream firm is a local monopolist. Using Proposition 5 we can confirm that an increase in the nominal interest rate reduces firm d's expected profit, requiring an increase in its output price to maintain zero expected profits in each island's downstream industry. This price increase partially offsets the impact of a higher interest rate, raising the list price and investment level and reducing the critical value. The net effect of an increase in the nominal interest rate is to reduce list price and to increase the probability that the list price is discounted.

Proposition 5 is difficult to generalize beyond the Example because the effects of interest rate variations depend on terms, determined by almost all features of the model, which are difficult to sign a priori. Nevertheless, our explication suggests that Proposition 5 is not peculiar to the example. The effects on list price and investment are, surely, to be expected in a model with complementary inputs. Our discussion also suggests that the critical value will vary inversely with the list price if the dominant effect on optimal contract choice is the reduction in investment. We apply Proposition 5 to the Stigler-Kindahl data with this informal argument in mind, while acknowledging the necessary caveats.

3. STIGLER/KINDAHL ON PRICE DYNAMICS

In this section we consider one of the more puzzling findings reported by Stigler and Kindahl (1970) (henceforth SK) in their comparison of buyers' prices with published price indices. We will argue for the inadequacy of SK's explanation, and suggest that an alternative model in which a significant proportion of trade is conducted through TL contracts, might explain their findings.

A. Stigler/Kindahl

Means' (1936) renowned claim of inflexible prices in concentrated industries raised widespread doubts as to the accuracy of his data: the Wholesale Price Index (WPI) compiled by the Bureau of Labor Statistics. These doubts led a number of economists, principally located at the NBER, to compare WPI with independently generated price series. These efforts culminated in SK's remarkable study which contains arguably the most detailed, accurate buyers' price panel data yet published.[5]

WPI is compiled from trade journal quotations and from reports voluntarily sent by suppliers on the current price of commodities which have been pre-selected as 'typical'. These prices are conventionally identified with the list price in contracts. While the WPI questionnaire inquires as to the size of orders filled, the small number of quotations and reporters per commodity allows WPI to be based on thin markets: an effect which might lead to spurious inflexiblity in the published series.[6] By contrast, SK obtained prices from customers for commodities which they bought regularly over the data period: 1957-66. These commodities were explicitly selected from industries that were reputedly concentrated, and therefore do not constitute a random sample. Individual price series were then aggregated into indices (henceforth NB) and compared with WPI for the same industries.

SK's respondents typically bought on long-term contracts, although their nature and duration were not studied (cf. SK's regrets: p.6). SK suggested that buyers sign contracts in order to reduce the search costs associated with repeated once-off purchases. This suggests that contracts specify a fixed (list) price approximately equal to expected price over the duration of the contract. Buyers pay this list price unless current prices vary excessively (p.6). SK additionally interpreted WPI as consisting of list prices in new contracts: an interpretation which would surely be valid if the indices were primarily compiled from trade journal quotations. The relationship between WPI and NB therefore depends on the term structure of contracts implicit in NB.

SK analyzed their series in terms of short-run, cyclical and trend variations. The data period contained two recessions (July 1957-April 1958 and May 1960-February 1961), a boom (April 1958-May 1960) and a sustained expansion from February 1961 until the end of the period.[7] SK reported a similar pattern in output series for the commodities covered (p.64 and Appendix D). They also divided the series into two sections, 1957-61 and 1962-66 to compare monthly trends of NB and WPI, and reported a finding which they described as "truly surprising" (p.56): for most commodities the trend of NB is significantly lower than WPI during 1962-66 when both series fell, but there is no significant difference in trends during 1957-61 when both series were nondecreasing. The timing of cycles over the two periods and the coherence of WPI and NB over these cycles (cf. Weiss (1977)) suggest that SK's trend findings cannot be explained by adapting standard accounts of cyclical pricing by cartels.[8]

SK tentatively suggested the following explanation. Since transactions prices reflect new information through contingency clauses in old contracts, we might expect NB to lead WPI, which is determined by expected future prices. Sellers were slow to adjust list prices downward when transaction prices fell (1962-66) because of a belief, based on behaviour of the general price level, that price reductions were transitory (pp.7 and 58).[9] There are several reasons for finding the explanation unpersuasive. Firstly, while the general price level rose, NB's trend was downward for the whole period. SK's implicit expectations would therefore have been inconsistent (at least) with perfect foresight. Secondly, if contracts contain contingency clauses then it is unclear why it should be costly to adjust list prices. Thirdly, SK's study of monthly data did not find that either series led the other.

Subsequent work has focused on SK's claim that prices charged by firms in concentrated industries are less flexible than those charged by competitive firms, and on whether NB's cyclical behaviour is consistent with standard economic theory? See, in particular, Means (1972), Stigler and Kindahl (1973) and Weiss (1977). Carlton (1986) used the individual price series collected by SK to show that their short-term findings could largely be attributed to their aggregation procedures. None of this work, however, seems to bear on SK's trend findings, which we address below.

B. **Explanation**

In this subsection we suggest that Proposition 5 might be used to explain SK's findings. In contrast to SK, we shall interpret WPI as the list price in existing (rather than new) contracts - a plausible interpretation if WPI were primarily compiled from reports - and NB as the expected transactions price. On this account NB diverges from WPI in TL contracts when low average costs result in discounting. Our explanation therefore supposes that a significant proportion of contracts were TL rather than FP.

Under the conditions of the Section 2C Example an increase in the nominal interest rate raises the probability that the list price is discounted (by increasing the critical value) while reducing the price charged in every c-state, including the list price. A trend increase in the nominal interest rate should therefore cause a trend decrease in both list price (WPI) and expected transactions price (NB), with NB falling faster than WPI because of the trend behaviour of the critical value. This pattern corresponds to the variations in WPI and NB during 1962-66. On the other hand, if the interest rate were low then we would expect relatively little divergence between WPI and NB: a pattern which corresponds to their trend behaviour during 1957-61.

The behaviour of nominal interest rates over the two periods is consistent with this explanation: during 1957-61 interest rates (on, for example, 3-month Treasury bills) were low, but exhibited a significant positive trend over the period 1962-66.

We therefore suggest that our model provides a possible explanation for SK's findings. This explanation rests, of course, on application of the comparative statics of a particular example, and must therefore be treated with caution. Nevertheless, the absence of plausible alternative explanations in the literature suggests that it might be taken seriously.

4. Conclusions

Transactions/list contracts are prevalent in inter-firm trade. We have shown that an (ex-post) privately informed upstream firm will choose either a fixed-price or a transactions/list price contract in order to induce downstream firms to increase their relationship-specific capital. We have also suggested that the comparative statics of transactions/list contracts may explain Stigler and Kindahl's (1970) findings on long-term price dynamics.

FOOTNOTES

1 This argument does not establish that optimal contract prices are below $p^s(c;k^s)$ in every c-state in the public information game; though this claim is true in the Example (to be presented in Section 2C), where the optimal public information contract is $p(c) = c/2 - R/4 < c/2 - (1+8R)/28 = p^s(c;k^s)$.

2 A formal proof is available on request from the author. We are grateful to a referee for suggesting the intuitive account above.

3 Detailed proofs of assertions in this subsection are available on request from the author.

4 We are grateful to a referee for suggesting this question.

5 See SK Ch.2 for a survey of previous work at the NBER.

6 See Bureau of Labor Statistics (1976) Ch.14 for details of the procedure and a sample questionnaire.

7 The precise dating of these cycles was disputed by Means (1972), but the disagreement is immaterial for current purposes.

8 See, for example, Green and Porter (1984) on price wars during recessions, and Rotemberg and Saloner (1986) on price wars during booms.

9 SK also suggested that sellers were reluctant to lower prices because of the fear of future government-imposed price ceilings.

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