Contracts, Price Rigidity, and Market Equilibrium

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This paper presents a model of a market characterized by uncertainty and transaction costs. The uncertainty and transaction costs create incentives for firms to use both long- and short-term fixed-price contracts. The model sheds light on several puzzling empirical observations. I explain why long-term-contract prices can move by different magnitudes and even in different directions than short-term prices, why econometric price equations are likely to find costs, but not demand forces, mattering, and why "rigid" prices and delivery lags are not necessarily disequilibrium phenomena but, rather, can be perfectly understandable and predictable equilibrium phenomena.

I. Introduction

This paper presents a simple model of equilibrium for a market characterized by uncertainty and transaction costs. The uncertainty and transaction costs create incentives for firms to use both long- and short-term contracts for sale of their output. Contracts are also desirable because they provide information about future demands that is helpful to the supplier who must plan production in advance. I examine the interrelationship of the price movements of contracts of

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different durations. This is an important issue to address because a large fraction of industrial purchasing is done by contracts (Stigler and Kindahl 1970).

Transaction costs often preclude the establishment not only of complete contingent claims markets, but also of recontracting markets. One interesting issue I address is how a market reaches equilibrium in such a setting. I argue that firms may use delivery lags as a mechanism to reallocate goods over time among customers in an effort to duplicate the efficient allocation of goods that would result if recontracting were not so costly. More generally, I argue that the market chooses to use as an equilibrating mechanism those dimensions of product characteristics (including price) that are "best" to use from the viewpoint of suppliers whose costs are affected by the good's characteristics and demanders whose valuation of the good depends on the good's price and quality dimensions. Depending on supply and demand conditions, some markets will mainly use price, others quality, and others both price and quality to equilibrate a market. Because of the widespread interest in cases where markets are cleared by changes in quantities, I focus in this paper on delivery lags as the only other dimension in addition to price.

Within the equilibrium framework of the model, I am able to explain a number of empirical facts that have often been described either as puzzling or as evidence of the failure of markets. In particular, I explain why long-term-contract prices can move by different magnitudes and even in different directions than short-term prices. I explain why reduced-form econometric price equations are likely to be unable to find demand forces mattering. Finally, I explain why "rigid" prices and delivery lags are not necessarily disequilibrium phenomena but, rather, can be perfectly understandable and predictable equilibrium phenomena. Therefore, the paper provides a logically consistent equilibrium explanation of the facts that have been used to support the "administered price thesis" of Gardiner Means (1985) in the voluminous literature on that subject.

In the next section, I review some of the previous literature on rigid prices and contract-price movements. I then introduce contracts into a simple model and derive equilibrium for the model with no delivery lags. Delivery lags are discussed next, and, finally, the role of contracts in providing information is examined. I relate the arguments of this paper to the issues of rigid prices, firm size, and market equilibrium.

II. Rigid Prices and Contract Prices

The idea that prices are rigid and do not clear markets appears persistently throughout the economic literature of the past 50 years.
There are several interrelated lines of thought that argue for rigid prices. The first is the line of thought associated with Keynesian macroeconomics. In that body of literature, rigidity of prices, especially wages, is an important ingredient in a theory that attempts to explain quantity movements. The justification for these nonequilibrium rigid prices usually relies on some type of transaction-cost argument (see, e.g., Okun 1975). Transaction costs prevent supply and demand shifts from affecting price. Other nonprice market responses such as product quality variations are usually not considered, and instead it is assumed that markets are in disequilibrium at the rigid price. It is the existence of this disequilibrium that provides an opportunity for beneficial Keynesian macroeconomic policy. The recent attempts by Baily (1974), Azariadis (1975), and Gordon (1976) to use employee risk aversion to analytically explain wage rigidity would seem to fit in very well with the attempts by earlier writers in the macroeconomic area to find explanations for price and wage rigidity. Whether or not one accepts the risk-aversion justification for rigid wages, it does not seem likely that such risk-aversion stories have much hope of explaining the inflexibility of prices of industrial commodities traded between firms, which are much more likely than workers to be risk neutral.

A second line of thought related to rigid prices is represented in the voluminous outpouring of writings in industrial organization on "administered" prices and on business pricing policy. Means's (1935) discovery of the infrequency of price change among many industrial commodities was a startling finding to most economists and was directly responsible for the administered price thesis whereby some prices do not fluctuate according to the laws of supply and demand (see Beals [1975] for a good survey on administered prices). Means does not offer a convincing alternative theory to explain price movements. Although Means's thesis remains shrouded by doubts as to its validity (Stigler and Kindahl 1970; but see Weiss [1977] for an alternative view), his notions of rigid prices caught the fancy of

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1 See Gordon (1977) for a criticism of the risk-aversion explanation.
2 It is unclear why the earlier work of Mills (1927) is not cited as the research which discovered administered prices. Perhaps it was because Means attracted widespread political attention by arguing that changes in the U.S. economy had altered the laws of supply and demand, made prices rigid, and were responsible in part for the severity of the depression. In contrast, Mills mainly presented data, drew few dramatic conclusions about market behavior, and found that prices had become more flexible in the 1920s. By 1940, several researchers (Humphrey 1937; Pedersen and Petersen 1938; Tucker 1938) had shown that, as Mills had suggested, inflexible prices had characterized many sectors of the U.S. and other economies as far back as 1800. Means's claim that the rise of large firms had been making prices more and more rigid over time is therefore false. Still, Means's arguments continue to attract attention and support.
economists, not only of his time but also of subsequent generations, and attracted the concern of policymakers.

A third line of research related to rigid prices appears in the literature on reduced-form econometric price equations. Researchers attempt to relate the BLS price index to measures of supply and demand. The demand indices for many manufacturing industries are usually some variant of unfilled orders divided by capacity, a variable which is a very good estimate of delivery lags. A not infrequent finding is the difficulty of identifying any demand influences on price. There are several problems with these studies (see Nordhaus 1972, 1975). One problem is their use of BLS price data whose deficiencies in accurately representing transaction prices (see McAlister 1961 and Stigler and Kindahl 1970) might be so severe as to mask any demand influence. Another problem is the frequent use of a delivery-lag variable as an exogenous demand influence. I will soon argue that price and delivery lag are simultaneously determined so that price equations relating price to delivery lag and supply costs are neither structural nor reduced-form equations.

Recent work by Stigler and Kindahl (1970) revealed that many industrial commodities are bought on either implicit or explicit contracts whose typical duration is 1 year, or longer. One fascinating yet puzzling finding of Stigler and Kindahl was that their index of price (based mainly on long-term-contract prices) behaved differently over time than the BLS index (which is probably closer to an index of spot price than of long-term-contract price). It was expected that the Stigler-Kindahl index would move more smoothly than the BLS index, yet there was no expectation that the trend in the two indices should differ.

If purchase by contract is the dominant mode of buying in industry, then any theory purporting to explain price movements must delve into (a) the incentives for contracting, (b) the function performed by contracts, (c) the incentives for contracting for different durations, and (d) the pricing and interrelationship of different-duration contracts. It would not be at all surprising that an analysis that ignores the complexity of contracting and equates spot supply and spot demand might provide a less than adequate explanation of price movements for many markets.

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3 E.g., Cagan (1974, p. 22) argues, "Empirical studies have long found that short-run shifts in demand have small and often insignificant effects [on price] and that, instead, costs play a dominant role." Exceptions include Gordon (1975) and Maccini (1978), who do find "demand" influencing price. The Gordon and Maccini studies both suffer from the simultaneity problem mentioned below.
III. Price Movements and Interrelationships of Different Duration Contracts

Industrial purchases are commonly done by contracts (Stigler and Kindahl 1970). Understanding the pricing of contracts of different durations is necessary if one wishes to explain how average price, long-term price, and short-term price move. The task of this section is to explain the interrelationships of prices in a short- and long-term-contract market within the context of a simple model. In this section I consider contracts that specify both a price and a quantity. Later, I will allow quantity to be unspecified. I do not consider contracts which are contingent on future random events. Such contracts do not seem to be prevalent, presumably because of high monitoring costs (Wachter and Williamson 1977).

We first need to discover why a firm might have an incentive to offer a long-term contract. Long-term contracts are a mechanism by which a firm can reduce the costs of operating in an uncertain environment characterized by transaction costs. (See Williamson [1975] for a detailed discussion of transaction costs.) I am not assuming that firms dislike risk because of risk aversion. Rather, I am arguing that real costs are associated with operating in a variable market. For example, one reason for contracts is that transaction costs of finding buyers on the spot market are eliminated by a long-term contract. This transaction cost of finding buyers is likely to depend on the variability of the spot price. (More variability implies more likely initial dispersion of prices which in turn implies more search.) Another justification for contracts is that they may reduce the variability of an individual firm’s cash flow. Variability of cash flow imposes extra transaction costs on a firm for exactly the same reasons as occur in inventory explanations for the demand for money. Moreover, variability of cash flow may be avoided by firms for signaling purposes. A bank may not be able to distinguish perfectly the “able” from the “unqualified” when firms with large negative asset positions desire to borrow. By reducing possibilities of large negative asset positions, a firm may reap large expected benefits by distinguishing itself as an able firm. (The same reasoning could apply to a worker in a large firm.) As is argued in Section V below, long-term contracts may be desired because they can provide information about future levels of demand and thereby better enable suppliers to plan production. Variability of quantity produced imposes costs on a firm (with U-shaped average-cost curves) that could be lowered if plants of appropriate flexibility (Stigler 1939) could be redesigned far enough in advance.

To keep the analysis simple, let us postulate in this section that
variability of a firm's cash flow influences a firm's costs and therefore gives firms an incentive to offer long-term contracts to reduce this variability. By making this assumption, I do not wish to imply that other reasons for contracting are unimportant. I am only trying to develop some understanding of how a market will behave when variability imposes costs on a firm (for whatever reasons) and when this variability can be influenced by long-term contracts. The particular justification of variability of cash flow is chosen because it is simple to understand and simple to handle in an illustrative analytic example that I wish to present.

I want to postulate a simple production technology and profit function so that I can analytically present some results. First, assume that variability of cash flow imposes on every firm a cost that rises linearly with variability, so that profits equal revenues minus variable production costs minus cash-flow variability minus a fixed cost. Let the fixed cost be \( F \), and let the constant marginal cost of production be \( c \). The capacity of each firm is \( q^* \). No firm can ever produce more than \( q^* \). The average cost (AC) curve, ignoring the cost due to variability, is drawn in figure 1. We further assume that when variability costs are taken into account the minimum average-cost point occurs at output \( q^* \) when spot sales are positive. This last assumption is not crucial to the analysis, but it simplifies the exposition. (I later indicate how the analysis can be easily altered when this assumption is relaxed.)

Let there be two types of competitive markets, a long-term market and a short-term (spot) market. I assume that production decisions must be made before random spot price can be observed but after long-term-contract price is established. Production decisions and decisions about the number of long-term contracts to accept then depend on expected spot price and long-term-contract price. We will assume that both spot and long-term markets exist and that firms fully utilize their productive capacity \( q^* \). We also assume that, once goods are produced, it is always more profitable to sell the goods on the spot market than to dispose of the goods (at some disposal cost) and affect cash-flow variability. Using the assumptions made above, we can write that the firm's expected profits are \( \hat{p}q + E(\hat{p}q^*) - c(\hat{q} + q^*) - F - \text{var}(\hat{p}) \)

\(^4\) It should be clear that the main qualitative results will hold for any U-shaped average-cost curve and for any of the justifications that put variability into the profit function.

\(^5\) As long as some commitment to production (e.g., purchase of capital) must be made before spot demand is observed, the same type of results follow. The assumption that production decisions depend only on expected price makes each firm's output insensitive to random spot-price variations. This makes it very easy to isolate the main implications of the analysis. These implications would be unchanged if we allowed short-run supply responses, though the analysis would involve a calculus of variations problem rather than a simple calculus problem.
\[-c)q^*, \text{ where } \hat{p} = \text{long-term-contract price}, \hat{q} = \text{output sold on long-term contract}, \hat{p} = \text{random spot price}, q^* = \text{amount sold on spot market } (\hat{q} + q^* = q^*), \text{ and } E( ) = \text{expectation operator}. \text{ Using the relation that } q^* = q^* - \hat{q}, \text{ we can rewrite expected profits as}

\[\Pi^e = \hat{p}\hat{q} + \hat{p}(q^* - \hat{q}) - cq^* - F - (q^* - \hat{q})^2 \sigma^2,\]  

(1)

where \(\sigma^2 = \text{var } \hat{p}\) and \(\hat{p} = E(\hat{p})\). By differentiating (1) with respect to \(\hat{q}\), it is straightforward to establish that the supply curve of a firm for long-term contracts will be given by

\[\hat{q} = q^* - \frac{\hat{p} - \tilde{p}}{2\sigma^2}.\]  

(2)

A firm devotes more of its plant to long-term-contract production the greater is spot-price variability, the higher is the long-term-contract price, and the lower is average spot price. (These results follow from the assumptions that imply that \(\hat{p} > \tilde{p} > c\).)

A long-term contract is insurance for the firm. It guarantees that the firm will be able to make a sale at a stipulated price. Long-term and spot contracts sell at different prices because the two contracts impose different marginal costs on the firm. It follows from (2) that if positive amounts of long-term contracts are to be provided then \(\hat{p}\) must exceed \(\tilde{p} - 2\sigma^2q^*\). In other words, for there to be an interior solution to the firm’s maximization problem, the (assumed positive) marginal profit \((\hat{p} - c)\) of supplying a long-term contract must exceed the lowest marginal profit of supplying a spot contract \((\tilde{p} - c - 2\sigma^2q^*)\). Similarly, for positive amounts of spot contracts to be pro-
vided, it is necessary for \( \hat{p} \) to be below \( \hat{p} \). Although we will soon assume that all firms are alike, it is interesting to note from (2) that, even if firms differed in their \( c, F, q^* \), and variability-cost parameters, as long as \( \hat{p} \) exceeded \( \hat{p} \), no firm would completely specialize in long-term contracts (i.e., \( \hat{q} < q^* \)), though some firms may specialize in short-term contracts (i.e., \( q^* = q^* \)).

To examine equilibrium in such a model, we need to postulate a demand sector for each type of contract (long and spot). I assume a simple demand structure. There are two types of demanders. One type knows its demands far enough in advance so that it can sign long-term contracts. The other type does not know its demands far enough in advance and must rely on a spot market. I assume that recontracting costs are sufficiently high that a buyer would not sign a long-term contract unless he knew he needed the goods. For simplicity, I assume that demanders wish to purchase at lowest expected cost. Long-term demanders have the option of relying on the spot market to satisfy their demands. For computational purposes, I take demands to be linear. Initially I take the demand for long-term contracts to be perfectly inelastic (provided \( \hat{p} < \hat{p} \)) at some quantity \( \hat{Q} \). (I later relax this condition and discuss why a long-term-contract demand that is not perfectly inelastic is a very important consideration in understanding delivery lags.) Suppose the random spot demand is given by \( Q_s = a - p + \varepsilon \), where \( \varepsilon \) is a random variable whose range is sufficiently restricted so that only positive quantities are possible in equilibrium. Since a fixed quantity of output will be sold spot each period (remember production decisions occur before the random spot price \( \bar{p} \) is observed), it is clear from the form of the demand curve that \( \text{var} \, p = \text{var} \, \varepsilon = \sigma^2 \).

There are two types of equilibria that I will examine. First, I examine the usual short-run equilibrium in which I hold the number of firms constant. Next I investigate the long-run equilibrium in which the number of firms in the industry adjusts to insure that all firms

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6 I thank G. Stigler for bringing my attention to this issue of specialization.
7 We have not introduced middlemen into the analysis for simplicity. Depending on the cost function of middlemen (who just buy and sell), there may be an incentive for middlemen to buy on long-term contract and sell spot. As long as middlemen incur some cost of variablility in the equilibrium solution, the simple qualitative points made below will hold. The cost function in (1) can be thought of as the cost function of the most efficient transactors. In a more complicated model, the decision of demanders to buy spot or on long-term contract would be the outcome of a maximizing problem and could depend on price variability, long-term-contract price, expected spot price, and recontracting costs. Notice that the long-run results below are independent of the demand-side assumptions, and the result that in the short run \( \hat{p} \) and \( \hat{p} \) can move differently would also be unaffected in general by different assumptions about demand.
earn zero expected profits. In each case, I examine the effect of parameter changes on equilibrium prices.

If there are \( n \) identical firms, we require for short-run equilibrium that both the spot market and long-term market clear and that firms are rational in that their expectation of spot price coincides with the mean of the equilibrium distribution of spot prices. The market clearing prices (see Appendix A for details) will satisfy

\[
\hat{p} = a - (2\sigma^2 + n)(q^* - \frac{\bar{Q}}{n})
\]  

(3)

and

\[
\tilde{p} = a - (q^* - \frac{\bar{Q}}{n})n, \quad \text{var } \hat{p} = \sigma^2.
\]

(4)

One implication of (3) and (4) is that the long-term-contract price, \( \hat{p} \), is below the expected spot price, \( \hat{p} \). We saw earlier that this is a necessary condition for a firm to supply spot demand. In equilibrium, long-term contracts sell at a discount relative to short-term (spot) contracts because the marginal cost of satisfying long-term demand is lower than the marginal cost of satisfying spot demand.

Even with such a simple model, we can observe certain interesting differences between short-run movements in the long-term-contract price \( \hat{p} \) and the average spot (short-term-contract) price \( \tilde{p} \). An increase in variability of spot demand leaves the expected spot price unchanged, but drives down the long-term price, and hence average price paid. This result occurs because in the short run changes in variability have no effect on the amount offered for spot sale since long-term demand is assumed to be totally inelastic. Therefore, expected spot price will not change. However, since increases in variability raise the marginal cost of providing spot sales, the price of long-term contracts must fall in order to keep firms indifferent at the margin between supplying long- and short-term contracts.

An increase in demand need not affect expected spot- and long-term-contract price equally in the short run. An increase in spot demand (an increase in \( a \)) causes \( \hat{p} \) and \( \tilde{p} \) to rise by the same amount. However, an increase in long-term demand (\( \bar{Q} \)) causes \( \hat{p} \) to rise more than \( \tilde{p} \). The greater is \( \sigma^2/n \), the larger will be the differential increase in \( \hat{p} \). Similarly, \( \hat{p} \) and \( \tilde{p} \) respond differently to supply-side influences. As the number of firms, \( n \), expands or capacity, \( q^* \), expands, \( \hat{p} \) falls by more than \( \tilde{p} \) falls. These short-run comparative static properties are

\* If price variability enters demand curves, then the specific effects derived below could be altered. The general point that \( \hat{p} \) and \( \tilde{p} \) are not equally affected by exogenous changes remains valid.
summarized in Table 1 for the reader's convenience. The third column of Table 1 calculates what happens to the expected discount one gets by buying on the long-term instead of spot market. The table also shows that average spot price can respond less to certain supply and demand shocks than does the long-term-contract price.

If firms are in long-run equilibrium (zero expected profits), then it must be the case that $c \leq \hat{\hat{p}} < (F/q^*) + c \leq \hat{\hat{p}} < (F/q^*) + c + \sigma^2 q^*$. The inequalities become strict if we limit attention, as we will now do, to situations where both long and spot contracts are offered. The first inequality was discussed earlier. The second inequality follows from the observation that, if $\hat{\hat{p}} > (F/q^*) + c$, then firms could completely specialize in long-term-contract production and earn positive profits. The third inequality follows from the observation that, if $\hat{\hat{p}} < (F/q^*) + c$, then, since $\hat{p} < \hat{\hat{p}}$, it would be impossible for the firm to earn zero profits. The last inequality follows from the fact that, if $\hat{\hat{p}} > (F/q^*) + c + \sigma^2 q^*$, then expected profits would be positive if a firm specialized in spot sales. There is one additional inequality that it is useful to establish. Notice that, if $\hat{\hat{p}} < c + (F/q^*)$, then if expected profits are to equal zero it must be the case that the expected spot price must cover the average variable plus fixed cost plus the average total cost due to variability. If $q^*$ is spot sales, then we have that $\hat{\hat{p}} > c + (F/q^*) + \sigma^2 q^*$.
We know from the derivation of the supply curve (2) that $\hat{p} = \hat{p} - 2 \sigma^2 q^*$, or, substituting the inequality just derived, we have $\hat{p} > c + (F/q^*) - \sigma^2 q^*$. But, since $q^* \leq q^*$, we have that $\hat{p} > c + (F/q^*) - \sigma^2 q^*$. Therefore, in long-run equilibrium when both long- and short-term contracts are sold, $c + (F/q^*) - \sigma^2 q^* < \hat{p} < (F/q^*) + c < \hat{p} < (F/q^*) + c + \sigma^2 q^*$. 

What happens in long-run equilibrium as either long-term demand ($\bar{Q}$) or spot demand ($a$) increases (i.e., as the number of firms, $n$, changes so that $\Pi^e = 0$)? Shifts in the composition of demand between long- and short-term contracts will alter the marginal costs of producing these two contracts and will therefore affect price. The differential in marginal cost between long- and short-term contracts will depend positively on the fraction of a firm's output sold spot.

Consider increases in $\bar{Q}$ first. As $\bar{Q}$ increases, $n$ increases. Since spot demand is finite, it could not occur that spot supply increases per firm. Spot supply per firm must approach zero as $n$ increases. Therefore the fraction of a firm's output used to satisfy long-term demand increases to unity as $\bar{Q}$ expands. Since the variability of cash flow from the spot market becomes infinitesimal for each firm as $\bar{Q}$ expands, we obtain the result that the average cost of production will fall to $(F/q^*) + c$. Since expected revenues must cover costs in long-run equilibrium, we obtain the result that, as $\bar{Q}$ increases, average price paid must fall. Such a result is reasonable since, as $\bar{Q}$ increases, the randomness of spot price becomes an insignificant cost for an individual firm. Since virtually all the firm's revenues are coming from the long-term-contract market, we see that for expected profits to equal zero the long-term-contract price, $\hat{p}$, must rise to $(F/q^*) + c$ as $\bar{Q}$ expands. (Recall that $\hat{p} > (F/q^*) + c$ in any long-run equilibrium.) As the fraction of a firm's output sold on long-term contract approaches one, the marginal cost due to variability of satisfying spot demand approaches zero. This implies that, if the firm is to make any spot sales, then it must receive a spot price close to $\hat{p}$ (identical with $\hat{p}$ in the limit) if its behavior is to be consistent with profit maximization. In other words, the price difference $\hat{p} - \hat{p}$ must approach zero as the differential marginal cost of long and spot sales approaches zero. Therefore, the average spot price must decline to $(F/q^*) + c$. (Recall that $\hat{p} > (F/q^*) + c$ in long-run equilibrium.)

As spot demand (i.e., $a$) grows, the equilibrium number of firms in the industry increases. Since long-term demand is unchanged, each firm devotes less of its output to long-term contracts as spot demand increases. Each firm must then incur more cost of variability, causing

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9 If the minimum average cost when spot sales are positive occurs not at $q^*$, as assumed, but at some $q^{**}$, then just replace $q^*$ by $q^{**}$ in the last term of the inequality.
average cost and hence average price paid to rise. As the fraction of a
firm's output sold spot increases to one, the average spot price must
rise to \((F/q^*) + c + q^*\sigma^2\) in order to generate zero profits. (Recall that
\(\hat{p} < (F/q^*) + c + q^*\sigma^2\) in long-run equilibrium.) In order to create an
incentive for each of the many firms to supply only an infinitesimal
amount of output for the long-term-contract market (remember \(\hat{Q}\)
is fixed), we require (see the supply curve [2] for \(\hat{q}\)) that \(\hat{p}\) approach \(\hat{p} - 2\sigma^2 q^*\), or \(c + (F/q^*) - q^*\sigma^2\). Since we have previously established that
\(\hat{p}\) always exceeds \(c + (F/q^*) - q^*\sigma^2\), we see that increases in spot
demand cause long-term prices to fall.\(^{10}\)

What happens when both spot and long-term demands increase by
the same multiple? In that case it should be obvious that prices will
remain unchanged, but the number of firms will increase by the same
multiple as demand increases. (To verify this point analytically, re-
solve [3] and [4] for arbitrary spot-demand-price slope \(b\)—remember
\(b = 1\) for convenience in this section. Notice then that the solutions for
\(\hat{p}\) and \(\hat{p}\) are unaffected if \(a, b, \hat{Q},\) and \(n\) are all multiplied by the same
number.)

Long-run effects of changes on the cost side are easy to trace
through. Increases in either \(c\) or \(F\) cause profits to drop, creating an
incentive for firms to leave the industry. As firms exit, table 1 reveals
that both short-term- and long-term-contract prices rise, with long-
term prices rising more than the expected spot price.

In summary, long- and short-term-contract prices display sig-
nificant differences in the magnitude of their responses to demand
and supply shifts in both the short and long run. In the long run,
long- and short-term-contract prices can move in different direc-
tions.\(^{11}\) In the long run, expansion of the long-term-demand markets
lowers average price, raises long-term price, and lowers average spot
price, while expansion of the spot market raises average price, raises
spot price, and lowers long-term-contract price. In the long run, cost
increases raise both spot and long-term prices, with the long-term
price increasing more.

This simple but instructive model sheds considerable light on the
complexities of modeling price behavior. The analysis emphasizes
that spot price, long-term-contract price, and average price are three
distinct variables that can move differently over time. A price equa-
tion estimated from spot-price data may poorly predict movements in

\(^{10}\) The argument in the text establishes only limiting behavior of prices. It can be
established (see Appendix A) by comparative static proofs that \((\partial \hat{p}/\partial a) < 0, (\partial \hat{p}/\partial \hat{Q}) > 0, (\partial \hat{p}/\partial a) > 0,\) and \((\partial \hat{p}/\partial \hat{Q}) < 0\) hold everywhere under conditions of long-run equi-
lbrium.

\(^{11}\) These results are somewhat analogous to results of Sheshinski and Drèze (1976),
who compare average price paid with expected price in markets with demand uncer-
tainty but no difference in cost between short- and long-term contracts.
the other price variables which might be more relevant than spot price in understanding market behavior if the bulk of transactions are carried out by long-term contract.

Since demand increases can move spot prices either up or down, while cost increases can move spot prices only up, the model can explain why econometric price equations which use BLS prices (which are more like spot than long-term prices) are quite likely to be able to establish a positive relation between price changes and cost changes but be unable to find much relation between demand changes and price changes even though certain demand shifts do influence price. The model can also explain why an index of long-term-contract prices can behave differently than an index of spot prices.

IV. Downward-sloping Demand for Long Contracts

In the previous section, I analyzed equilibrium in the long-term and spot markets under the assumption that the long-term demanders had perfectly inelastic demands. Such an assumption guaranteed that after the spot market cleared only those with the highest willingness to pay obtained the good. A reconstructing market would not change the allocation of goods between spot and long-term demanders. In this section, I explore what happens when long-term demanders do not have perfectly inelastic demands. We first see in Section IVA how comparative static results of table 1 change and then in Section IVB explore the incentives for reconstructing. I argue that direct recontracting between spot and long-term buyers may often be too costly to occur but that delivery lags can be a mechanism by which a supplier can perform recontracting among its demanders. Delivery lags, a type of quantity rationing, can be viewed, then, as a very sophisticated market response to the high costs of establishing a recontracting market. Sections IVC and IVD discuss and compare reasons for rigid prices.

A. Comparative Statics

Let the problem be the same as in the previous section, except now let the demand curve for long-term contracts be given by \( Q = C - D\hat{p} \); \( \hat{p} < E(\hat{p}) \). As before, I assume that because of transaction costs no recontracting markets develop when the spot market opens. To obtain the equilibrium \( \hat{p} \) and \( \hat{p} \) I equate supply and demand in the spot and long-term markets and require that firms are rational in the sense that firms' expected spot price is the mean of the equilibrium spot-price distribution (see Appendix A for details). The equilibrium prices satisfy
\hat{p} = \frac{1}{G} \left[ a + (2\sigma^2 + n) \left( \frac{C}{n} - q^* \right) \right], \quad (5)

\tilde{p} = \frac{1}{G} \left[ \frac{(C - q^*)}{n} + a \left( 1 + \frac{2\sigma^2 D}{n} \right) \right], \quad (6)

and \( \var \tilde{p} = \sigma^2 \), where \( G = 1 + D \left[ 1 + (2\sigma^2/n) \right] \). Notice that (5) and (6) reduce to (3) and (4) when \( D = 0 \).

The long-run comparative static results are unchanged from the analysis in the previous section. The short-run comparative static results are presented in table 2. Since most of the qualitative results are the same as those of table 1 and since the previous section discussed in detail the implications of these results, I only discuss the main differences between tables 1 and 2. First, as in table 1, \( \partial \hat{p} / \partial \sigma^2 < 0 \). Increased spot-demand variability causes long-term prices to fall. However, now \( \partial \tilde{p} / \partial \sigma^2 > 0 \) (in table 1, \( \partial \hat{p} / \partial \sigma^2 = 0 \)), so that average spot prices rise as demand variability increases. The direction of spot- and long-term-contract price movements can differ even in the short run. (The analysis of the previous section established this fact for the long run. Notice that the additional assumption \( C/n - q^* > 0 \) is required to establish this fact for the present case.)

Another difference between tables 1 and 2 is that now \( \hat{p} \) rises less

<table>
<thead>
<tr>
<th>Expected Spot Price</th>
<th>Long-Term Contract Price</th>
<th>Discount for a Long-Term Contract</th>
<th>Description of Price Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{\partial \hat{p}}{\partial \sigma^2} &gt; 0 )</td>
<td>( \frac{\partial \tilde{p}}{\partial \sigma^2} &lt; 0 )</td>
<td>( \frac{\partial (\hat{p} - \tilde{p})}{\partial \sigma^2} &gt; 0 )</td>
<td>LT prices fall, ST prices rise</td>
</tr>
<tr>
<td>( \frac{\partial \hat{p}}{\partial C} = \frac{1}{G} )</td>
<td>( \frac{\partial \tilde{p}}{\partial C} = \frac{1}{G} (2\sigma^2 + n) )</td>
<td>( \frac{\partial (\hat{p} - \tilde{p})}{\partial \sigma^2} &lt; 0 )</td>
<td>LT prices rise more</td>
</tr>
<tr>
<td>( \frac{\partial \tilde{p}}{\partial n} = \frac{1}{G} \left( 1 + \frac{2\sigma^2}{N} D \right) )</td>
<td>( \frac{\partial \tilde{p}}{\partial n} = \frac{1}{G} \left( 2\sigma^2 + n \right) )</td>
<td>( \frac{\partial (\hat{p} - \tilde{p})}{\partial \sigma^2} &gt; 0 )</td>
<td>ST prices rise more</td>
</tr>
<tr>
<td>( \frac{\partial \hat{p}}{\partial q^*} = -\frac{n}{G} )</td>
<td>( \frac{\partial \tilde{p}}{\partial q^*} = -\frac{1}{G} (2\sigma^2 + n) )</td>
<td>( \frac{\partial (\hat{p} - \tilde{p})}{\partial q^*} &lt; 0 )</td>
<td>LT prices fall more</td>
</tr>
<tr>
<td>( \frac{\partial \hat{p}}{\partial m} &lt; 0 )</td>
<td>( \frac{\partial \tilde{p}}{\partial m} &lt; 0 )</td>
<td>( \frac{\partial (\hat{p} - \tilde{p})}{\partial m} &gt; 0 )</td>
<td>LT prices fall more*</td>
</tr>
</tbody>
</table>

Note.—LT = long term, ST = short term.

*We have assumed that \( (C/D) > a \) and that \( (C/n) - q^* < 0 \).
than $\hat{p}$ in response to increases in spot demand ($\partial \hat{p}/\partial a < \partial \hat{p}/\partial a$). This differential price movement is analogous to the differential price movement that occurs in response to increases in long-term demand ($\partial \hat{p}/\partial C > \partial \hat{p}/\partial C$).

A final difference between tables 1 and 2 is that, in order to establish $\partial \hat{p}/\partial a > \partial \hat{p}/\partial n$ (i.e., long-term prices fall more than average spot prices as supply expands), it is necessary to add the assumption that the highest price that a long-term demander would pay for the good exceeds the highest price that a spot demander would pay.

Herschel Grossman has noted that an implication of the model is that the variability of spot price is greater than it would have been in the absence of long-term contracts. This result is similar to an argument in Grossman (1978).

B. Delivery Lags

When the demand for long-term contracts is not perfectly inelastic, it could happen that the willingness to pay of spot demanders exceeds the willingness to pay of long-term-contract buyers who have been promised delivery of the good. If there were zero transaction costs, we expect a recontracting market to develop, with some long-term-contract holders selling their contracts to spot demanders. However, such a policy on the part of buyers may entail large transaction costs. Certainly if the spot price sufficiently exceeds the long-term-contract price, some recontracting will occur despite the transaction costs. My point is only that such direct recontracting among buyers may often involve large transaction costs.

Are there any other means by which buyers with vastly differing willingness to pay can profitably trade in ways that can avoid high transaction costs of recontracting? One way might be to have the supplying firms hold an auction on delivery day. Such an approach would insure that those with high willingness to pay obtain the good. However, organizing such an auction market involves heavy costs. The fact that well-organized futures markets and spot cash markets exist for so few commodities suggests that "solving" the recontracting problem by establishing well-organized auction markets is infeasible for many commodities.

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12 If transaction costs were zero, then markets contingent on each state of the world would have developed at the initial period, and recontracting problems would not arise. In such a world, there is no meaningful distinction between a long-term and spot contract, and therefore the issues we are studying vanish.

13 An implication of this argument is that well-organized exchanges will develop only when large gains to trade exist. Volatility of spot price, differences in willingness to pay between long- and short-term-contract holders, and large volume of spot buyers are necessary conditions for the existence of well-organized exchanges (see Telser and Higinbotham 1977).
Another possible solution would be to have each long-term buyer specify prices at which he would willingly be bought out of specified fractions of the contract. Such a solution involves each long-term demander revealing his demand curve to the supplier and then allowing the supplier to act as a "market" and clear trades.\textsuperscript{14} Penalty clauses in contracts appear to be a rough reflection of the practice of specifying a price to be bought out of a contract.\textsuperscript{15} It is conceivable, though, that this procedure of specifying a demand curve for each long-term buyer might require complex calculations on the buyers' part. Moreover, the problem is really much more difficult than specifying a demand curve at one point in time. Substitution in time of delivery as well as price are both of paramount concern to a firm. To "properly" allocate supplies over time, a supplying firm would have to know the demand relations of a demander as a function of the price vector $p_t$, where $p_t$ is the vector of prices at time $t$ for delivery at all future times. (Again, penalty clauses that make the penalty depend on the discrepancy between actual and promised delivery can be viewed as a rough approximation to conveying a firm's willingness to pay as a function of time.) If the buyers' specification of demand at a single point in time involves large transaction or decision-making costs, it is likely that the buyers' specification over time and price must involve even more costs.\textsuperscript{16}

Another way to achieve reallocation of goods is for the supplying firm to use its own judgment in deciding who should receive delivery first. In this way, the supplying firm can obtain the benefits (profits) of a high temporary spot price\textsuperscript{17} and can pass along this increase in its profitability in the form of lower average prices. Provided the supplying firm's judgment is accurate, buyers prefer this arrangement to one in which no reallocation of goods occurs. But how would a supplying firm reach accurate (certainly not perfect) predictions

\textsuperscript{14} The practice of using at least two suppliers, prevalent in the U.S. economy, and repeat business help guard against monopolistic exploitation of buyers.

\textsuperscript{15} Colleagues at the University of Chicago Law School inform me that courts are often reluctant to enforce a liquidated damage clause unless the stipulated damage represents a reasonable forecast of a measurable dollar loss resulting from the breach. With no damage clause, damages caused by delivery delays are recoverable only if the supplier foresaw that his delivery delay would impose these damages on the buyer. Even when the conditions for damage recovery are met, businessmen often prefer to avoid the high court costs associated with a damage suit (see Wachter and Williamson 1977).

\textsuperscript{16} Airline tickets are a market where a scheme specifying a buy-out price might not involve large transaction costs and might provide a solution to the "bumping" problem. Vickery (1978) has noted that a person denied the good should receive the lowest buy-out price of the customers served, in order to elicit truthful responses.

\textsuperscript{17} Since satisfying long-term-contract demand is not as costly as satisfying short-term-contract demand (see Section III), the spot price must exceed the long-term-contract price by a finite amount before a firm would profit from delaying delivery to a long-term customer and giving delivery to a spot customer.
about buyers' preferences? It must be that repeat dealings between firms enable firms to obtain ideas about each others' requirements. (A buyer of course always has the option of switching suppliers or of vertically integrating.)

A buyer who is very flexible about delivery time is an "ideal" customer, since the supplying firm with such a customer is in a position to cash in on high spot prices. Such a customer therefore should obtain a relatively low price. A "fussy" customer who cancels orders when delivery is not on the exact date agreed upon undoubtedly pays a higher price for his long-term contract than does the ideal customer. (Of course, the different prices charged mean that the supplying firm has no preference between serving the ideal or fussy customer.) This quantity rationing or queuing of back orders is not at all a sign of disequilibrium. It is, rather, a sophisticated market response by which goods are allocated over time to those who "need" them the most and the quickest.

If firms use delivery lags to reallocate (i.e., effectively recontract) goods over time among their customers in an efficient manner, it is clear that the potential for achieving an efficient allocation increases with size of firm. In other words, the larger the number of customers a firm has, the easier it is to recontract efficiently. Of course, the costs of keeping track of exactly which customer likes rapid delivery and which will tolerate slow delivery might very well increase sufficiently fast that a finite firm size is optimal. Still, we expect the size of firms to be larger in industries in which delivery lags play a prominent (equilibrium) role in clearing markets with random demands than in industries in which delivery lags are not important.

C. Market Equilibrium with Rigid Prices and No Transaction Costs

In the previous section I argued that firms may use delivery lags in order to allocate goods efficiently over time. Whenever firms must equate supply with demand, they (or the market in a competitive setting) can choose the dimensions of product characteristics (including price) to vary. The adjustment mechanism used to clear the market will depend on the seller's costs of providing product characteristics and the preferences of buyers. Even in the absence of the transaction (variability) costs discussed in the previous sections, some industries will vary product quality, keeping price constant, while other industries will vary price, keeping product quality constant, while other industries will vary both price and quality. It is in markets where the equilibrium price (in the absence of transaction costs) remains relatively unchanged over time (to buyers of each specified
type) that we most expect to see the use of long-term fixed-price contracts. It is in markets where the equilibrium price fluctuates greatly that we least expect to see the use of fixed-price contracts (or if such contracts are used they will be of short duration). In these markets, any transaction-cost saving from the use of contracts is likely to be outweighed by the inefficiency costs that result from the failure to allow price changes to allocate resources. The condition for the existence of contracts occurs when the saving in transaction costs exceeds the inefficiency of not using the price mechanism to clear markets.

Imagine a simple two-period world with no transaction costs in which there are some buyers ("waiters") who are indifferent (at a constant price) as to which period they obtain delivery. A standard Walrasian equilibrium will equate supply and demand in the two periods. As long as the waiters are sufficiently large in number, market clearing will require a rigid price for the commodity over time. To understand "price rigidity," it is necessary to understand the industry supply and demand elasticity with respect to price and with respect to time. Understanding intertemporal substitution possibilities on both the demand and supply sides is necessary to explain equilibrium price movements in a market. In practice, the waiters who get delivery in period 2 are reported as new orders that are unfilled in period 1. Period 1's price will influence the endogenous quantity, unfilled orders. Unfilled orders or delivery lags are not an exogenous indicator of demand—they are, instead, a market-clearing product characteristic that is determined simultaneously with price (and other product characteristics). Delivery lags can simply be the manifestation of a simple Walrasian equilibrium over time.

The above example suggests how it is possible to predict which markets are likely to have rigid prices (i.e., heavy use of explicit or

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18 Clearly, buyers that impose different costs on the firm are charged different prices. Sections III and IVB discussed this point in detail. To avoid cluttering the argument of this section with unnecessary details, we do not focus on the differences in buyers in this section. Therefore, we talk of an equilibrium price rather than an equilibrium price structure.

19 As in Section III, some transaction (variability) costs are needed to explain the use of contracts. It is important to emphasize that in the above discussion it is not transaction costs that are the fundamental cause of the long-run price rigidity. Instead, the characteristics of supply and demand (in the absence of transaction costs) explain why the equilibrium price does not move much over long time periods.

20 Despite the importance of delivery lags as an equilibrating mechanism, very little attention is paid to delivery lags in the literature, except as "exogenous" ad hoc indicators of "demand pressure." As seen above, delivery lags are definitely not exogenous. It is therefore incorrect to use a proxy for delivery lags (usually unfilled orders divided by shipments) as a demand indicator in a reduced-form equation for price. Zarnowitz (1962, 1973) is one of the few who stress the importance of delivery lags as an equilibrium concept. This section was heavily influenced by Zarnowitz's work.
implicit long-term fixed-price contracts). Suppose the demand curve for some industry is very elastic with respect to delivery lags but inelastic with respect to price. For that industry we expect price fluctuations to clear the market, while delivery lags remain relatively constant. We do not expect to see this market characterized by long-term fixed-price contracts and varying delivery time, though long-term relations with suppliers may exist. Alternatively, consider a market demand that is totally inelastic with respect to delivery lags but elastic with respect to price. For this market, we expect delivery-lag changes to clear the market while prices remain relatively fixed. We expect to see many long-term fixed-price contracts, with great variability in delivery lags over time.

Similarly, supply-side elasticities with respect to price and delivery lags will influence how the market adjusts to demand and supply shocks. These supply elasticities will depend on cost of adjustment considerations (Maccini 1973). Estimating supply and demand curves as a function of both price and delivery lag should reveal which industries should be characterized by rigid prices and quantity rationing over time. The evidence that is used to support the administered price thesis may very likely be consistent with the normal equilibrium functioning of markets.

The idea that delivery lags in addition to price can equilibrate markets is part of the broader notion that in response to supply and demand shifts all dimensions of product quality may change (see Rosen 1974). Faced with high demand, a restaurant may employ slower service, or crowded tables, or watered-down soup, or higher prices to allocate supply and demand. If people’s preferences are such that a price rise is less desirable than poorer quality, prices are likely to be kept rigid. Rigid prices need not be the result of high transaction costs of varying price. Instead, they may be the outcome of an equilibrium process with little or no transaction costs.

D. Types of Rigid Prices

There are at least two quite different explanations for price rigidity, which I interpret to mean prices that do not fluctuate in response to supply and demand shifts. The prices can be spot prices or prices stipulated in a fixed-price contract. One explanation which relies on transaction costs postulates that the cost of detecting the need for a price change, of actually changing price, and of disseminating the information is so large that frequent price changes are infeasible.22

21 This is the subject of a forthcoming paper.
22 See Appendix B for further discussion of the detection problem.
One example of these markets is hotels, whose published rates usually remain fixed from day to day even though demand may vary considerably from day to day. In such a market, rationing on a first come, first served basis is a natural feature of market operation, and there is no reason to expect that those who obtain the goods are necessarily the ones who have the highest willingness to pay for them. The behavior of such a market is much different (see Carlton 1975, 1977, 1978; Gould 1978; and Saving and De Vany 1978) from the markets studied in this paper. This paper argued that there will be fixed-price contracts for a set of demanders when there is a transaction cost to a variable price. Like the hotel example, transaction costs explain the price rigidity. However, unlike the hotel example, among each class of demanders, allocation of the good is efficient, and no rationing will occur. I further argued that, when the different groups of demanders have very different willingness to pay, then the supplying firm will have an incentive to use delivery lags to reallocate the goods efficiently among the two groups of demanders—provided the supplying firm knows who values the good the most. Notice that, if the firm did not know who valued the good the most, then we would be back to a situation of a rationing scheme by type of buyer—which may lead to an outcome in which those who do not receive the good are willing to pay a much higher price for the good than those who obtain it. Clearly, price is the best information source about willingness to pay. Suppression of the price mechanism (by, say, a fixed-price contract) means that a firm must use its judgment about buyers' willingness to pay in deciding whom to give delivery. The more difficult it is for the firm to judge different buyers' willingness to pay, the greater will be the incentive to have a freely fluctuating price for everyone.  

A second completely different explanation for price rigidity given in Section IVG postulates that the cost of detecting the need for a price change, changing price, and disseminating price information may be quite low but that the equilibrium price to any class of buyer does not vary much even though other product characteristics (such as delivery time) may vary considerably in equilibrium.

In any of the explanations for price rigidity, the period over which prices are rigid is endogenous (Barro 1972; Gray 1978). Therefore, models or discussions (Okun 1975; Fischer 1977; Phelps and Taylor 1977; Hall 1978) which postulate that (contract) prices are rigid because of transaction costs for some fixed time period (and therefore can create allocative inefficiency) and then show that government

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23 Retail stores which usually have too many customers to keep track of each buyer's willingness to pay will sometimes limit the quantity purchased during times of great uncertainty (as, e.g., with recent coffee and sugar episodes) in order to insure that low-willingness-to-pay buyers do not buy up all the goods.
intervention can be helpful should include a feedback effect onto contract duration (or rigid-price duration). It is the size of this feedback which will determine how effective government intervention can be in influencing unemployment.

From a policy viewpoint, it seems important to determine why prices are rigid. If large transaction or information costs in certain markets are the cause of rigid prices, then policies aimed at those markets may be useful in improving efficiency. If, instead, the rigid prices are the natural outcome of an equilibrium process involving small transaction costs, then rigid prices do not create serious allocative inefficiencies and therefore are the cause neither of depressions (as Means [1935] argued) nor of excessive unemployment (as Okun [1975] implied), nor do these markets provide an opportunity for beneficial government intervention.

V. Contracts as Sources of Information

When production takes time, advance information on likely levels of future demand can be of great value to a supplying firm. By being able to plan production far in advance, a firm can often lower its average production cost by making more effective decisions regarding quasi-fixed factors (i.e., factors whose use cannot be expanded instantaneously without incurring adjustment costs). In a world with no transaction costs, contingent markets solve the information problem for a firm. Futures markets, when they exist, also help firms with their planning problems by providing information about future price levels (which of course contain information about future demand levels).\textsuperscript{24} In the absence of contingent or futures markets, long-term contracts are a mechanism by which demanders who know their demands in advance can convey this information to supplying firms, which can then use such information for planning purposes. (See Carlton [in press] for a more detailed analysis of planning and market structure.)

Imagine that a firm has several possible technologies available for producing output which must be produced before spot demand is observed. Even in the absence of cost differences arising from variability (as in the previous sections), a long-term contract may sell at a

\textsuperscript{24} Futures markets provide less information about future demands than contingent markets for several reasons. First, a futures contract does not specify a quality of product but, rather, several usually closely related product qualities. Second, futures markets exist only at selected locations, and the difference between the future price and spot price (the "basis," in Chicago Board of Trade terminology) need not be a precise deterministic relation.
discount relative to a short-term contract because of the cost savings
that come from the ability to plan production.25 For example, suppose
initially that all output is sold spot and that the amount demanded is a
random variable. Suppose that one-half the demanders really know
their random spot demands in advance. Then, by the revelation of
this known random demand through long-term contracts, suppliers
may be able to meet demand more efficiently.

The value of contracts in revealing future demands is closely re-
lated to the concept of value of information in statistical decision
theory. Let $E_p$ be the expectation operator when $\hat{p}$, the long-term-
contract price, ranges over all its possible values, and $E_{\hat{p}|\hat{p}}$ the expec-
tation operator when the spot price, $\tilde{p}$, ranges over its possible values,
but $\hat{p}$ is fixed. The expected profits in the scheme where long-term
contracts are used is

$$\Pi^e = E_{\hat{p}} E_{\tilde{p}|\hat{p}} \max_{T,q,\hat{q}} [\hat{p} \hat{q} + \tilde{p} \hat{q} - C(\hat{q} + q^s; T)],$$  \hspace{1cm} (7)

where $T = \text{technology}$, $C(\cdot) = \text{cost function}$, and all other notation
has been defined previously. Notice that the decision variables $T,q^s,\hat{q}$
are all chosen after $\hat{p}$ is observed.

In the case in which the firm only looks at spot demand, we have

$$\Pi^e = E_{\tilde{p}} \max_{T,q} \hat{p} q - C(q; T).$$  \hspace{1cm} (8)

In this second case the same technology is used regardless of the
value of the "knowable" part of random demand. Profits represented
by (7) may exceed those represented by (8) because in (7) the technol-
ogy can be optimally adapted to each different realization of the
knowable component of demand. The difference between (7) and (8)
is a reflection of the value of the information that contracts provide to
a firm. Depending on the technology and demand randomness, it is
perfectly possible to obtain firm specialization whereby some firms
satisfy only plannable demand, while other firms satisfy unplannable
demand.

Transaction costs may preclude varying $\hat{p}$ every time long-term
demand changes. Instead, firms may prefer to sign a contract

25 To avoid a digression on the public value of information, for simplicity assume that
only if a firm participates in the long-term-contract market can it observe the long-
term-contract price, $\hat{p}$, and thereby benefit from information contained in $\hat{p}$. Secrecy of
prices and quantities sold on long-term contract is a characteristic of many industrial
markets. A resolution of the information problem could follow the lines of Grossman
and Stiglitz (1976). Alternatively, we could carry out the analysis under the assumption
that a single monopolist serves the market, and the same type of conclusions would
emerge.
specifying price, \( \hat{p} \), for some time period\(^{26}\) and not stipulating specific quantity levels—but with the understanding that the quantity to be purchased at \( \hat{p} \) must be ordered far in advance. If we replace \( \hat{p} \) by \( \hat{q} \) in the subscript of the expectation operator in (7), then we will have the expression describing the expected profits of the typical firm. Again, since the optimal choice of technology occurs after \( \hat{q} \) is observed, profits may be higher than would be the case if the same technology had to be used regardless of the value of \( \hat{q} \). The lower costs that result from the ability to choose \( T \) after \( \hat{q} \) is observed means that a firm would willingly sell output on long-term contracts at a price below expected spot price. It is the information value of contracts that generates the price “discount” for long-term contracts.

It is possible to envision circumstances under which the information value of contracts will be especially important. The following circumstances would argue for a sharp discount in long-term-contract price for the information provided by contract: (1) Industries whose short-run expansion path involves very high costs (Nadiri and Rosen [1973] identify such industries) and industries whose inventory holding costs are very high; (2) industries whose demanders place a large premium on prompt delivery; (3) industries involving “lumpy” production processes; and (4) times when interest rates are high, raising inventory costs for all firms.

VI. Contracts as Cost Reducers and Sources of Information

Sections III and IV argued that contracts provide a way for firms to reduce the cost that dealing in a variable market imposes. In those sections, I considered contracts that for some time period specified a price and a quantity to be delivered. Section V considered the information value of contracts. By learning about part of demand in advance a firm may be able to improve its operating efficiency. The contracts considered in Section V specified a price for some time period but not a quantity—however, it was understood that quantity would be announced far enough in advance to allow for planning.

Real-world contracts combine considerations of both Sections III and IV and Section V. Firms desire repeat business and long-term relationships (e.g., contracts) to avoid having to incur transaction costs (costs of dealing in a variable market). When a firm signs a long-term contract at a preset price, the seller usually has a good idea of the average level of the buyer’s likely quantity purchases.\(^{27}\) The seller can

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\(^{26}\) It should be clear that the duration of the contract will be important. Trading off the benefits from reduced transacting versus the (efficiency) cost of an unchanging price will determine optimal duration.

\(^{27}\) Typical industrial contracts (see Stigler and Kindahl 1970) specify a price for some
use this knowledge of the average level of the buyer's demands together with his ideas of how far in advance the buyer will revise his quantity demanded, so that the seller can better calculate the appropriate fixed and variable factors to use in output production. Both the cost-reducing aspect of contracts and the information aspect of contracts must be analyzed to fully understand the pricing of contracts of differing durations. Moreover, the use of fixed-price contracts, or, more precisely, the likely length of a fixed-price contract, will depend on how necessary price adjustments are to equilibrate the market.

VII. Conclusions

Whenever there are uncertainty and transaction costs, it will be less costly to satisfy the demand of a customer who announces his demand early than to satisfy the demand of a customer who announces his demand late. In such situations, contracts of different durations may be used, with the price paid being related to the duration of the contract. In response to supply shocks both spot (short-term) price and long-term-contract price will move in the same direction but by different magnitudes. In response to certain demand shocks, the two prices can move in different directions. The model of this paper can therefore provide some explanation for the puzzling finding of Stigler and Kindahl (1970) that an index derived mainly from long-term-contract prices moved differently than an index of BLS list prices (which is probably closer to an index of short-term-than long-term-contract prices). Moreover, the model also shows why it is plausible that econometricians would have a hard time explaining BLS prices with demand indicators but have an easier time with cost indicators.

I argued that delivery lags are a mechanism to reallocate goods among customers over time. Moreover, delivery lags are an endogenously determined quality characteristic of the good. By investigating the preferences of consumers and the costs of firms it should be possible to predict in which markets the main response to exogenous shocks is through price, in which markets through delivery lags (or other quality dimensions), and in which markets through both price and delivery lags.\textsuperscript{28} It is quite conceivable that a rigid price and

\textsuperscript{28} It should also be possible to characterize in which markets changes can be recognized quickly and therefore be responded to. See Appendix B.
varying delivery lags characterize equilibrium behavior for some markets. This equilibrium explanation for rigid prices over long time periods may be more believable for certain markets than one that relies exclusively on the high transaction cost of changing price. It is in markets where the main equilibrium adjustment response is not price that we most expect to see long-term fixed-price contracts being used.

Appendix A

1. Derivation of Equilibrium

The supply curve of long-term contracts is obtained by setting \( \partial \Pi^r/\partial \hat{q} = 0 \), where \( \Pi^r \) is given by (1). This yields the long-term supply curve per firm,

\[
\hat{q} = q^* + \frac{\hat{p} - \hat{p}}{2\sigma^2}, \tag{A1}
\]

and the short-term supply curve per firm is \( q^* - \hat{q} \), or

\[
q = \frac{\hat{p} - \hat{p}}{2\sigma^2}. \tag{A2}
\]

Consider equilibrium in the spot market. Spot demand is \( a - \hat{p} + \epsilon \), while spot supply is \( nq \) where \( q \) is given by (A2). Hence, setting supply equal to demand, we obtain

\[
a - \hat{p} + \epsilon = nq = n\frac{\hat{p} - \hat{p}}{2\sigma^2}. \tag{A3}
\]

Equation (A3) implies that \( a - \hat{p} = n[(\hat{p} - \hat{p})/2\sigma^2] \), or

\[-n\hat{p} + (2\sigma^2 + n)\hat{p} = 2\sigma^2 a. \tag{A4}
\]

Equating supply to demand in the long-term market (long-term demand is \( C - D\hat{p} \)) yields \( C - D\hat{p} = n\{q^* + [(\hat{p} - \hat{p})/2\sigma^2] \}, or

\[(2\sigma^2 D + n)\hat{p} - n\hat{p} = n\left(\frac{C}{n} - q^* \right)2\sigma^2. \tag{A5}
\]

Solving (A4) and (A5) for \( \hat{p} \) and \( \hat{p} \) yields equations (5) and (6) in the text. Setting \( D = 0, C = \bar{Q} \), and solving (A4) and (A5) yields (3) and (4) in the text.

2. Long-Run Comparative Statics

The zero-profit condition can be written as

\[
\hat{p}\hat{q} + \hat{p}\left(q^* - \frac{\bar{Q}}{n}\right) - c\left(q^* - F - \sigma^2\left(q^* - \frac{\bar{Q}}{n}\right)\right) = 0. \tag{A6}
\]

Notice that \( \hat{p} = \hat{p} + 2\sigma^2 [q^* - (\bar{Q}/n)] \), so we can rewrite (A6) as

\[
\hat{p} q^* + \sigma^2\left(q^* - \frac{\bar{Q}}{n}\right)^2 - c q^* - F = 0, \tag{A7}
\]

where \( \hat{p} \) is given by (3).
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Totally differentiating (A7) with respect to \( a \) and \( Q \), we can find how \( n \) varies as demand conditions change. (We ignore the integer requirement on \( n \) in [A7].) Since \( \dot{p} \) and \( \dot{p} \) are given in (3) and (4) as functions of \( a, Q, \) and \( n \), we can then calculate \( \frac{dp}{da}, \frac{dp}{dQ}, \frac{dp}{dQ}, \) and \( \frac{dp}{dQ} \).

Performing the necessary differentiation, we obtain

\[
\frac{\partial n}{\partial Q} = \left( \frac{q^* + 2\sigma^2}{q^* + 2\sigma^2} \right) / \left( \frac{q^* + 2\sigma^2}{q^* + 2\sigma^2} \right),
\]

\[
\frac{\partial n}{\partial a} = q^*/\left(q^* + 2\sigma^2\right),
\]

\[
\frac{dp}{dQ} = \frac{2\sigma^2}{n} + 1 + \frac{\partial n}{\partial Q} \left( -\frac{2\sigma^2}{n^2} - q^* \right),
\]

\[
\frac{dp}{da} = 1 + \frac{\partial n}{\partial a} \left( -\frac{2\sigma^2}{n^2} - q^* \right),
\]

\[
\frac{dp}{dQ} = -1 - q^* \frac{\partial n}{\partial Q},
\]

and

\[
\frac{dp}{da} = 1 - q^* \frac{\partial n}{\partial a}.
\]

Using the fact that \( nq^* > Q \) allows one to establish from the above six expressions that

\[
\frac{dp}{dQ} > 0, \quad \frac{dp}{da} < 0, \quad \frac{dp}{dQ} < 0, \quad \frac{dp}{da} > 0.
\]

Appendix B

Information Costs and Price Adjustment

One explanation for rigidity or sluggish price adjustment in response to large quantity variations deals with the uncertainty of the demand environment. Suppose a monopolist must set price before demand is observed and must meet demand. Suppose his demand curve at time \( t \) is \( q_t = a_t - bp_t + \epsilon_t \), where \( q \) is quantity, \( p \) is price, \( a_t \) and \( b \) are parameters of demand, and \( \epsilon_t \) is a random variable independent over time. Even if \( a_t \) and \( b \) are known and unchanged over time, the optimal price will be unchanged over time even though \( q_t \) may fluctuate wildly over time.

Now suppose that demand changes over time. Suppose that \( b \) is known and that only \( a_t \) changes over time and suppose \( (a_t) \) represents a random walk. An observation on \( a_{t-1} \) would be helpful to the monopolist in inferring what \( a_t \) is likely to be. However, the monopolist must disentangle the noise \( (\epsilon_t) \) from the signal \( (a_t) \), and his ability to do so will depend directly on the relative variances of \( \epsilon_t \) and of the step size, \( a_t - a_{t-1} \), of the random walk. For simplicity, suppose that \( \text{var} \epsilon_t \) and \( \text{var} a_t - a_{t-1} \) are known. (These two variances can be consistently estimated from observations on \( q_t \) and \( p_t \). If \( z_t = q_t + bp_t \), then \( \text{var} \epsilon_t \) can be estimated as \( \frac{1}{T} \Sigma_{t=1}^T \frac{[z_t - z_{t-1}]}{[z_{t-1} - z_t]} \) and \( \text{var} a_t - a_{t-1} \) can

...
be estimated as $-2\sigma_{\epsilon}^2 + [1/T] \sum_{t=1}^{T} [z_t - z_{t-1}]^2$, where $\hat{\sigma}_{\epsilon}^2$ is the estimate of var $\epsilon_t$. Also, suppose that $\epsilon_t$ and $a_{t+1} - a_t$ are independent normal random variables with variances $\sigma_{\epsilon}^2$ and $\sigma^2$, respectively. The monopolist wishes to set price to maximize expected profits. Assuming zero production costs, the optimal price at $t + 1$ is $\bar{\alpha}_t/2b$, where $\bar{\alpha}_t$ is the expected value of $a_t$ calculated from a posterior distribution after $q_t$ has been observed. If $u_t$ is the (normal) prior mean on $a_t$, $\sigma_{\epsilon}^2$ the (normal) prior variance on $a_{t-1}$, then the posterior mean of $a_t$ after observing $q_t$ can be calculated (see Raiffa and Schlaifer [1960, chap. 11]) from $\bar{\alpha}_t = [1/(1 + \tau)]u_t + [\tau/(1 + \tau)]z_t$, where $\tau = (\sigma_{\epsilon}^2 + \sigma^2)/\sigma^2$, and $z_t = q_t + b\phi_t$.

The price will change only as $\bar{\alpha}_t$ changes. As long as the ratio of relative variances $\sigma_{\epsilon}^2/\sigma^2$ is large, the monopolist’s behavior will be characterized by very gradual price adjustment. When prices are determined by the systematic changes in demand and when nonsystematic changes complicate the signal extraction problem, we can expect sluggish price adjustments to demand changes. The larger the randomness of demand ($\sigma_{\epsilon}^2$), the slower the price adjustment. On the other hand, to the extent that cost changes are easily observable, we would expect to see rapid response to supply-side shocks.

References


