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# LONG-TERM CONTRACTING AND MULTIPLE-PRICE SYSTEMS

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## ABSTRACT

This paper examines product markets in which long-term contracts and spot transactions coexist. Such markets are characterized by "multiple-price systems," wherein adjustment to supply and demand shocks occurs through spot prices, while contract prices are fixed, or adjust slowly. We derive the existence of contracts, as well as the equilibrium fraction of spot trade, in the framework of an optimizing model, and analyze the effects of shocks on market equilibrium when some buyers and sellers are "locked in" contractually. The model is employed to interpret the change in the copper market from a multiple-price system to one characterized solely by spot trade.

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## I. Introduction

Studies of price adjustment in commodity and industrial product markets have been a key element in macroeconomics and industrial organization for decades. Outside the instantaneous market clearing in textbook models, an important goal for economic theory is to provide an explanation of how prices move to clear markets. For a variety of issues from assessing the efficiency of commodity markets to testing price flexibility in industrial markets to measuring the sensitivity of aggregate prices and quantities to demand-management policies, it is not sufficient to maintain that Walrasian equilibria will be obtained, without describing the process of adjustment.

The limitations of the Walrasian, market-clearing framework in explaining movements in prices and quantities has attracted increasing attention (see, for example, Williamson, 1975; and Carlton, 1979a, 1986).[1] Previous efforts at motivating 'rigidities' -- non-instantaneous price adjustment -- have classifimd product markets into "auction" and "customer" categories (the terms are from Okun, 1981). When prices are neither rigid nor completely flexible -- as is the case in most product markets -- multiple prices will occur.[2] Multiple-price arrangements are prevalent in markets for commodities[3] and industrial goods.[4]

The principal goal of this paper is to characterize price flexibility in markets exhibiting both fixed-price and flexible-price behavior. Our approach is of interest as an immediate case between the "no contracting, instantaneous price adjustment" Walrasian model and the "contracting only, no price adjustment" models investigated by Carlton (1978, 1979b) and Gould (1978). We stress the role of risk in determining commodity market trading arrangements when insurance and futures markets are incomplete. The lack of these markets provides a role for forward contracting to mitigate income fluctuations.

A general discussion of the effects of risk on market organization in commodity sales can be found in Newbery and Stiglitz (1981). Our particular modeling framework builds on that of Carlton (1979a). Carlton constructed a model with two types of buyers -- those who must contract in advance for planning purposes and those who can purchase on auction (spot) markets -- and derived the relationship between spot and contract market equilibria. In our model (outlined in section II and the Appendix for competitive and monopolistic seller market structures, respectively), buyers and sellers choose the extent to which they rely on contracting. Roughly speaking, the tradeoff between the two types of purchases stems from the fact that while price is fixed for contract purchases, spot purchases can be tailored to meet demand exactly. In general, the degree of contracting and price flexibility depends on the variance of the spot price and the risk aversion (or more broadly, concern with the variability of cash flows) of the transacting parties.[5]

Contracting will depend on the income risk aversion of buyers and sellers and on the covariance of (producer and buyer) incomes and spot prices. With respect to the former, insurance intuition implies that the less risk-averse participant will insure the more risk-averse. The second factor adds interesting complications. The sign and magnitude of the covariances can be related to the sources of shocks (i.e., demand-side versus cost-side) and the variability of the spot price. It is the combination of the co-movement of market participants' (buyers' and sellers') profits and spot prices and the sources of underlying disturbances which determines the relative reliance on forward contracting to mitigate income fluctuations.

We find that high relative reliance on contracting corresponds to cases in which: (i) shocks come primarily from the cost sides, and buyers' profits are more vulnerable than sellers to spot price fluctuations; or (ii) demand shocks are more important, and sellers' profits are more vulnerable. In the case of commodities, it is likely that sellers' profits are more sensitive to price fluctuations than are buyers' (so long as the value of any intermediate good purchased is small relative to the value of output then produced). Hence, the relative importance of demand and cost shocks is a critical factor in determining the reliance on contracting. We illustrate these results by presenting closed-form solutions for the competitive case (for the case of linear demand and marginal cost curves) for the equilibrium reliance on contracting and the variance of the spot price.

The principal implications of these results are two. Within a market, the degree of price flexibility can change over time with changes in the variance of the spot price and in the relative importance of demand and supply shocks. Across markets, differences in reliance on contracting correspond largely to differences in the type of good produced -- e.g., raw materials versus intermediate goods versus finished goods -- with increasing average price rigidity (increased reliance on contracting) for industries further downstream in the production process. These interindustry differences are also related, *ceteris paribus*, to differences in the variance of the spot price and in the relative importance of demand and cost shocks.

In section IV, we discuss evidence on the predictions of the model, using the world copper market as a case study. As we discuss below, the copper market was for many years characterized by a two-price system, which has received considerable attention from economists. We argue that this market experienced a 'change in regime' corresponding to our emphasis on 'cost shocks' versus 'demand shocks;' the attendant change in contracting and price flexibility strongly supports the model. Some conclusions and directions for future research are discussed in section V.

## II. Contracting and Multiple-Price Systems

The coexistence of "predetermined" and "flexible" arrangements in a market requires at least two prices. For simplicity, suppose that contracts are identical, thereby reducing the number of prices to two -- the "contract price" and the "spot price." In a multiple-price system, the decision of how much to buy (to produce) is accompanied by a decision of how to divide purchases (sales) between spot and contract markets. Forward contracting is used to reduce fluctuations in the incomes of buyers and sellers. We define a "contract" as an agreement to purchase a commodity at a given price.[6] For simplicity, we do not model default risk here. Clearly, there can be no contract market if agreements are abrogated whenever the spot price is more favorable ex post to one of the parties than the agreed-upon contract price. Allowing contractual performance to be uncertain (through, for example, force majeure clauses or bankruptcy) would not affect qualitatively the results of the model set out below (see Weiner, 1986).

Aggregate production decisions are made when the spot price is revealed.[7] In other words, production decisions are made after contracting decisions. Because of the definition of contracts, shocks (here additive demand and cost disturbances) are absorbed through adjustment on the spot market. Below, we model the contracting decisions of buyers and sellers in turn and solve for the equilibrium extent of contracting.

*Buyers'Problem*

Buyers use the commodity purchased as an input in production and are subject to random demand disturbances. They can buy on both spot and contract markets. Again, while the price is fixed for contract purchases, spot purchases can adjust to current market conditions. Buyers maximize the expected utility of profit, where the utility function is characterized by constant absolute risk aversion.[8] Risk aversion <u>per se</u> will not be necessary for the form of our results; the incentive to offer long-term contracts could stem from any influence of cash flow variability on a firm's costs.[9] Expected profit $E\pi^b$ is given by

$$E_t\pi^b_{t+1} = E_tP_{t+1}Z(Q^s_{t+1} + Q^c_{t+1}) - E_tP^s_{t+1}Q^s_{t+1} - P^c_{t+1}Q^c_{t+1}, \qquad (1)$$

where $Q^s$ and $Q^c$ and $P^s$ and $P^c$ denote spot and contract purchases and prices, respectively; Z is the production function ($Z' > 0$, $Z'' < 0$); and P is the downstream output price. P and $P^s$ are random variables. $P^c$ is determined when the contract is signed at time t; hence no expectations operator is needed. In this paper, buyers are assumed to be price-takers in the input market (the case of seller market power is discussed later).

As described above, individual buyers

$$\max_{Q^c} E_t U^b(\pi^b_{t+1}) = E_t \pi_{t+1} - \frac{\gamma}{2} \operatorname{var}_t (\pi^b_{t+1}), \tag{2}$$

where $\gamma$ measures the degree of risk aversion, and $\operatorname{var}_t$ represents the conditional variance based on information available at time t. Total demand depends negatively on the spot price and is subject to additive shocks. The optimal contract purchase follows from the first-order condition associated with (2), so that

$$Q^{c*}_{t+1} = \max \left[ 0, \frac{E_t P^s_{t+1} - P^c_{t+1}}{\gamma \operatorname{var}_t(P^s_{t+1})} - \frac{\operatorname{cov}_t(P^s_{t+1}, \hat{\pi}^b_{t+1})}{\operatorname{var}_t(P^s_{t+1})} \right], \tag{3}$$

where $\hat{\pi}^b$ denotes the ex ante profit in the absence of contracting (i.e., if all purchases were accomplished through spot transactions), and $\operatorname{cov}(P^s, \hat{\pi}^b)$ represents the covariance of the spot price and $\hat{\pi}^b$. We discuss the importance of the covariance term in more detail later.

The first term in equation (3) demonstrates that desired contract purchases depend on the spread between the contract price and the expect-ed spot price, the degree of buyer risk aversion, and the variance of the spot price. Ceteris paribus, an increase in the variance of the spot price lowers the reliance on long-term contracts.

The second term in (3) represents the importance of the covariance of the spot price and the pre-contracting profit, and its sign depends on the origin of the shock (discussed in more detail later). For example, if $\operatorname{cov}(P^s, \hat{\pi}^b) < 0$, buyers could purchase through contracts even when the quoted contract price exceeds the expected spot price. When $\operatorname{cov}(P^s, \hat{\pi}^b) > 0$, purchasers desire contracting only when the contract price is offered at a discount to the spot price.

*Producers' Problem*

As with buyers, producers are assumed to maximize the expected utility of profit, and exhibit constant absolute risk aversion. Expected profit $E\pi^p$ is defined by

$$E_t\pi^p_{t+1} = P^c_t Q^c_{t+1} + E_t P^s_{t+1} Q^s_{t+1} - E_t C(Q^c_{t+1} + Q^s_{t+1}), \tag{4}$$

where C is the cost function (C' > 0). Supply-side uncertainty is generated because of additive disturbances in the marginal cost function. Producers choose the mix between contract and spot sales to

$$\max\ (E_t\pi^p_{t+1} - \frac{\beta}{2}\ \text{var}_t\pi^p_{t+1}), \tag{5}$$

where ß indexes the degree of risk aversion. For the case of competition (the polar case of monopoly is presented in section II), desired contract sales are given by

$$Q^{c*}_{t+1} = \max\left[0, \frac{P^c_{t+1} - E_t P^s_{t+1}}{\beta\ \text{var}_y P^s_{t+1}} + \frac{\text{cov}_t(P^s_{t+1}, \hat{\pi}^p_{t+1})}{\text{var}_t P^s_{t+1}}\right], \tag{6}$$

where $\hat{\pi}^p$ denotes profit in the absence of contracting (i.e., when all output is sold on the spot market).

The similarity between the general form of the optimal contract purchase in equation (3) and the optimal contract sale in equation (6) is clear. Ceteris paribus, producers prefer to sell more through term contracts the greater is the excess of the contract price over the expected spot price. When $\text{cov}(P^s, \hat{\pi}^p) > 0$, contracting can take place even if the contract price is less than the expected spot price. More generally, the second term in (6) can be negative, so that no contract trade occurs unless $P^c > EP^s$.

The covariance terms are important here, and it is useful to examine the effect of sources of shocks on their signs. It is straightforward to show that $\text{cov}(P^s, \hat{\pi}^p)$ is always positive in the case in which all shocks are downstream demand shocks. Similarly, if all shocks are cost shocks, increases in the spot price are associated with a reduction in buyers' profits, so that $\mathrm{cov}(P^s, \hat{\pi}^b) < 0$. The remaining cases are intuitive[10] (see the summary in Table 1) increases in the spot price are associated with an increase in buyers' profits under demand uncertainty, and in-creases in the spot price are associated with a decrease in sellers' profits if disturbances to the cost function are the source of uncertainty (see Weiner, 1986, for further discussion).

Hence, knowledge of both buyers' and sellers' contract decisions and of the source of uncertainty in the market is necessary to determine market equilibrium. So that we can determine the equilibrium from the contracting behavior of individual firms, we assume that the upstream and downstream industries consist of identical firms -- s sellers and b buyers. Under the assumption of rational expectations, the contract price in the market is

$$P_t^c = E_t P_{t+1}^s - \frac{\mathrm{cov}_t(P_{t+1}^s, s\ \hat{\pi}_{t+1}^p + b\ \hat{\pi}_{t+1}^b)}{(\frac{b}{\gamma}) + (\frac{s}{\beta})}. \tag{7}$$

The actual spot price is such that total supply and demand (including the effects of disturbances) are equilibrated.

Equation (7) reveals that the expected spot price is an unbiased predictor of the spot price only if at least one of the parties is risk-neutral (i.e, only if $\gamma = 0$ or $\beta = 0$). The difference between the two prices depends in sign and magnitude on the correlation between the spot price and total profits in the absence of contracting.

Two predictions surface here about the relationship between spot and contract prices within a market. First, since the covariance terms are positive under demand shocks, contract prices will be exceeded by expected spot prices. The opposite is true under a cost-shock regime. Second, while we strictly consider a single contract, we can imagine multiple contracts for a given good. Since the correlation between the spot price and profits in the absence of contracting is likely to be greater for transactions early in the chain of production, price

TABLE 1

Origins of Shocks and Contracting

| | Demand Shocks Only | Cost Shocks Only |
|---|---|---|
| cov $(P^s, \hat{\pi}^p)$ | Positive | Negative |
| cov $(P^s, \hat{\pi}^b)$ | Positive | Negative |

Note: Demand shocks are characterized by an additive (downstream) demand disturbance. Supply shocks are characterized by an additive disturbance to the marginal cost function.

heterogeneity should be greater, say, in markets for materials and intermediate goods than for final goods.[11]

When sellers are competitive, the equilibrium volume of total contract trades in the market is

$$Q^{c*}_{t+1} = \max[0, \frac{\beta \, \mathrm{cov}_t(P^s_{t+1}, \hat{\pi}^p_{t+1}) - \gamma \, \mathrm{cov}_t(P^s_{t+1}, \hat{\pi}^b_{t+1})}{(\frac{\gamma}{b}+\frac{\beta}{s}) \, var_t P^s_{t+1}}]. \tag{8}$$

No contract trade takes place unless the right-hand side of equation (8) is positive. The extent of contracting depends on a weighted average of the covariance of the spot price and (the opposite of) the covariance of the spot price with buyers' ex ante profits, with the weights being measures of the parties' risk aversion.

The components of the covariance terms in (8) have an intuitive interpretation. The standard deviations of profits in the absence of contracting indicate the variability of buyer and seller profit in auction markets. Signs and magnitudes of the correlations of the spot price with buyer and seller profits depend on whether the dominant source of uncertainty is on the demand or supply side of the market. As noted before, the correlation coefficients are positive when uncertainty stems from the demand side, and negative when uncertainty stems from the cost side. We measure the 'vulnerability' of market participants when there is no contracting by the absolute value of the product of the risk aversion coefficients and the covariance of profits with the spot price.[12] Some cases are reviewed below.

Assume for simplicity that var $P^s$, cov$(P^s, \hat{\pi}^b)$, and cov $(P^s, \hat{\pi}^p)$ are constant. If we let $\rho$ and $\sigma$ represent a correlation coefficient and standard deviation, respectively, we can rewrite (8) as

$$Q^{c*} = \max\ [0, \frac{\beta\rho(P^s, \hat{\pi}^p) \, \sigma(\hat{\pi}^p) - \gamma\rho(P^s, \hat{\pi}^b) \, \sigma(\hat{\pi}^b)}{(\frac{\gamma}{b}+\frac{\beta}{s}) \, \sigma(p^s)}], \tag{9}$$

so that contracting takes place whenever

$$\beta\rho(P^s,\hat{\pi}^p)\,\sigma(\hat{\pi}^p) > \gamma\rho(P^s,\hat{\pi}^b)\,\sigma(\hat{\pi}^b)\,. \qquad (10)$$

This condition is most easily understood as follows. If only sellers are risk-averse, then contracting takes place only if $\rho(P^s, \hat{\pi}^p) > 0$, that is, if demand shocks are the source of uncertainty. Similarly, if only buyers are risk-averse, contracting takes place if uncertainty stems from the cost side (i.e., $\rho(P^s, \hat{\pi}^b) < 0$). More generally, both demand - and cost-side uncertainty will be present, so that both the sources of disturbances (sign of the correlation coefficients) and the relative vulnerability (measured again by the absolute values of the product of the covariance of the spot price and profits in the absence of contracting weighted by the risk aversion parameter) are needed to determine the extent of contracting. A summary of possible cases is presented in Table 2. A discussion for the case of monopoly is presented in the Appendix.

One can depict the determination of the contract quantity graphically as well, as in Figure 1. On the vertical axis is the excess of the contract price over the expected spot price (drawn conditional on and) normalized by the variance of the spot price. For the competitive case, the equations of the demand and supply curves are the market equivalents of equations (3) and (6), so that the slopes reflect the risk aversion of buyers and sellers, and the intercepts reflect both risk aversion and the covariance of the spot price with (pre-contracting) profits. The intersection of the two curves determines the equilibrium contracted quantity and the difference between the contract and expected spot prices. The condition for contracting is that in (10) above -- namely that the supply and demand curves intersect to the right of the origin. Equation (10) and Table 2 suggest intuitively that contracts are signed when (i) shocks come primarily from the cost side and buyers' profits are more vulnerable than sellers' to spot price fluctuations; or (ii) demand shocks are more important and sellers' profits are more vulnerable.

We would expect that in general sellers' profits should be more

TABLE 2

Conditions Characterizing Contracting in the Market

| | Seller Profits More Vulnerable<br>$\lvert \beta\rho(P^s, \hat{\pi}^p)\sigma(\hat{\pi}^p)\rvert > \lvert \gamma\rho(P^s, \hat{\pi}^b)\sigma(\hat{\pi}^b)\rvert$ | Buyer Profits More Vulnerable<br>$\lvert \gamma\rho(P^s, \hat{\pi}^b)\sigma(\hat{\pi}^b)\rvert > \lvert \beta\rho(P^s, \hat{\pi}^p)\sigma(\hat{\pi}^p)\rvert$ |
|---|---|---|
| Demand Shocks Dominate<br>$(\rho(P^s, \hat{\pi}_b), \rho(P^s, \hat{\pi}^p) > 0)$ | Contracting | No Contracting |
| Cost Shocks Dominate<br>$(\rho(P^s, \hat{\pi}^b), \rho(P^s, \hat{\pi}^p) < 0)$ | No Contracting | Contracting |

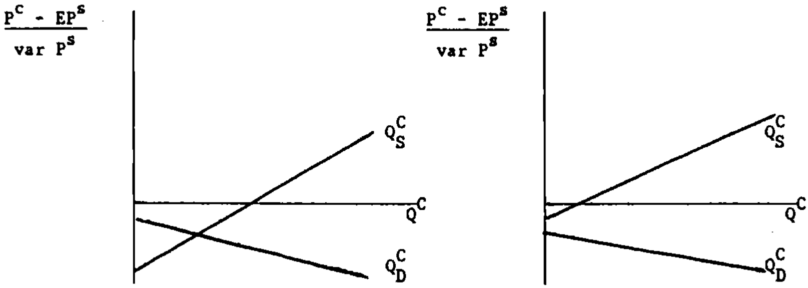
FIGURE 1

Equilibrium in the Contract Market

<u>Contract Demand Curve</u>
Slope = $-\gamma/b$
Intercept = $-\gamma \text{ cov } (P^s, \hat{\pi}^b)/\text{var } P^s$

<u>Contract Supply Curve</u>
Slope = $\beta/s$
Intercept = $-\beta \text{ cov } (P^s, \hat{\pi}^p)/\text{var } P^s$

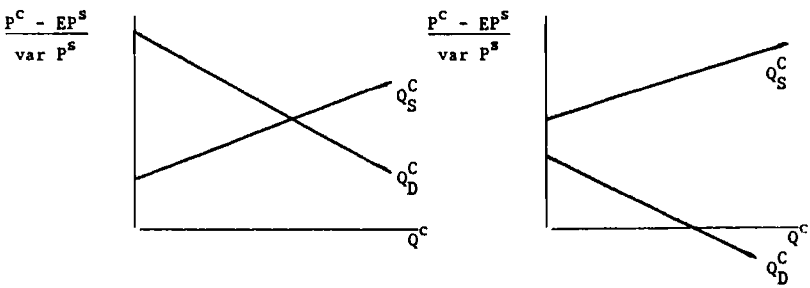
'DEMAND SHOCK' REGIME
(Both intercepts negative)




Contracting Equilibrium, $P^c < EP^s$

No-Contracting Equilibrium

'COST SHOCK' REGIME
(Both intercepts positive)




Contracting Equilibrium, $P^c < EP^s$

No-Contracting Equilibrium

vulnerable to spot price fluctuations than buyers' profits, so long as the value of any given intermediate good purchased is small relative to the value of output produced. Two testable implications surface here. First, prices should be more flexible (i.e., there should be less reliance on contracting) in industries in early stages of production where cost shocks are likely to be relatively more important and seller 'vulnerability' most pronounced than in finished-goods industries. Second, ceteris paribus, contracting is more likely the more important are demand shocks relative to supply shocks. These points illustrate potential problems with econometric price equations. Difficulties with estimating price equations with government price indices (e.g., Bureau of Labor Statistics data) are well known (Nordhaus, 1972; Carlton, 1979a). The influence of demand fluctuations on prices has been difficult to isolate. In our model, a dominance of demand fluctuations would lead to nominal price rigidity, and precisely to an inability to estimate demand influences on prices.

Returning the Figure 1, for the case in which sellers' profits are more vulnerable to spot price fluctuations that buyers', a shift from a regime in which demand shocks dominate to one in which cost shocks dominate would eliminate reliance on contracting as indicated in the bottom panel.

As a convenient summary statistic, we can write the average fraction of trades carried out under contract[13] $\alpha$ as

$$\alpha = \frac{1}{\frac{\gamma}{b} + \frac{\beta}{s}} \{\max[0, \frac{\beta \operatorname{cov}(P^s, \hat{\pi}^p) - \gamma \operatorname{cov}(P^s, \hat{\pi}^b)}{C'^{-1}(P^s)(\operatorname{var} P^s)}]\}. \tag{11}$$

Equation (11) does not yield a "solution" for $\alpha$, since $\alpha$ and var $P^s$ are simultaneously determined (i.e., $\partial\alpha/\partial \text{var } P^s < 0$ from (11), and $\partial \text{var } P^s/\partial\alpha > 0$; the greater the fraction of trades carried out under contracts, the more variable the market-clearing spot price). We take up this issue in the section III.

## III. Equilibrium Contracting and Price Flexibility

Obtaining closed-form solutions for $\alpha$ and var $P^s$ requires the specification of functional forms for the demand and marginal cost curves. Consider the competitive case described above. For the purpose of illustration, suppose that the demand function is linear and of the form

$$Q_t^D = a - dP_t^s + \varepsilon_{Dt} \quad , \tag{12}$$

where the additive demand shock $\varepsilon_D$ is independently and identically distributed with mean zero and variance $\sigma_D^2$, and that the cost function is such that

$$C(Q_t) = F_t + \frac{1}{2}c\ Q_t^2 + \varepsilon_{St}Q_t, \tag{13}$$

so that

$$C'(Q_t) = cQ_t + \varepsilon_{St} \quad , \tag{14}$$

where the shock to the cost function $\varepsilon_{St}$ is independently and identically distributed with mean zero and variance $\sigma_S^2$.

In the competitive case, buyers and sellers carry out planned spot purchases and sales equal to $(1 - \alpha)(a - dP^s)$ and $(1 - \alpha)c^{-1}P^s$, where $\alpha$ is an equilibrium parameter determined as before with respect to 'normal sales.' Supply and demand shocks are absorbed on the spot market. Given an optimal choice of $\alpha$, equilibrium in the spot market requires that

$$(1 - \alpha)c^{-1}P_t^s - c^{-1}\varepsilon_{St} = (1 - \alpha)(a - dP_t^s) + \varepsilon_{Dt}, \text{ or} \tag{15}$$

or

$$P_t^s = \frac{a}{d + c^{-1}} + \frac{\varepsilon_{Dt} + c^{-1}\varepsilon_{St}}{(1 - \alpha)(d + c^{-1})} \quad , \tag{16}$$

Again, the larger is the fraction of trades carried out under contracts, the greater are the effects of demand and cost shocks on the spot price. The variance of the spot price is

$$\text{var } P^s = \frac{\sigma_D^2 + c^{-2}\sigma_S^2}{(1 - \alpha)^2(b + c^{-1})^2}, \tag{17}$$

where $\partial \text{var } P^s/\partial\alpha > 0$. While the use of long-term contracts is often seen as an instrument of price stability, this inequality indicates that maintenance of contract prices in the presence of fluctuating supply and demand increases variability in the spot market. Equations (11) and (17) constitute a pair of nonlinear relationships between $\alpha$ and $P^s$. These nonlinearities can cause problems of nonuniqueness and nonexistence of rational expectations equilibria (see McCafferty and Driskill, 1980). Given our assumptions of linear demand and marginal cost curves and the results in equations (11) and (17), we can write the implicit expression for $\alpha$ as the solution to

$$\frac{\alpha}{1 - \alpha} = \frac{b + c^{-1}}{\frac{\gamma}{b} + \frac{\beta}{s}} \max[0, \frac{\beta \text{ cov}(P^s, \hat{\pi}^P) - \gamma \text{ cov}(P^s, \hat{\pi}^b)}{c^{-1}(\sigma_D^2 + c^{-2}\sigma_S^2)^{1/2}}] . \tag{18}$$

It can be easily shown that the signs of the derivatives of $\alpha$ with respect to the underlying parameters -- measures of risk aversion, the correlations of buyer and seller profits with spot price movements, the variability of profits in the absence of contracting, and the variances of demand and cost shocks -- are exactly as in equation (11).

Some comparative-static experiments are of interest here. An increase in the variance of demand or cost shocks, <u>ceteris paribus</u>, lowers the relative reliance on contracting. The effect of exogenous shifts in the covariance terms on contracting depends upon the regime (as outlined in Tables 1 and 2). In a regime in which demand shocks dominate, an increase in the covariance of seller profits with spot price movements raises reliance on contracting, while an increase in the covariance of buyer profits with the spot price raises reliance on spot transactions. The opposite is true for a regime in which cost shocks dominate. A switch from the former to the latter is likely to result in a decrease in contracting so long as seller profits covary more with spot price movements than do buyer profits.

It is this sort of change in regime as an explanation of shifts in the relative importance of multiple price systems (in particular, the occasional disappearance of such system) in which we are interested. In the next section, we consider a prominent example -- the two-price system in the world copper market.

## IV. Contracting and Price Flexibility: A Case Study of the World Copper Market

Two types of data are useful in testing models of contracting and price adjustment. At the firm level, individual transaction data can provide insight into price adjustment and contractual relationships. Such data are exceedingly scarce, however. The one survey with broad industry coverage has been employed fruitfully by Stigler and Kindahl (1970) and Carlton (1986). Industry-level data are less 'micro' in character, but for a homogeneous industrial good such as copper, are well-suited for time-series tests. Elsewhere (Hubbard and Weiner, 1989), we have conducted statistical tests on the two-price system in copper (as well as oil); here we interpret the system in the context of our theoretical model.

The two-price system was a prominent feature of the world copper market from the price decontrol that followed World War II to mid-1978. Major North American copper producers sold copper to their customers through term contracts at the "producer's price." The remaining trade was carried out at prices linked to the "spot" price from the London Metal Exchange (LME).[14] Because the two-price system differs so markedly from textbook descriptions of markets, its functioning has been investigated and described by economists in some detail (see Herfindahl, 1959; Mikesell, 1979; Felgran, 1982; De Kuijper, 1983; and Wagenhals, 1984). The discussion here is limited to the features of the system most salient to this paper.[15] In particular, we argue that (i) the institutional features of the copper market can be easily related to the model outlined above; (ii) the market experienced a 'change in regime' corresponding to our emphasis on 'cost shocks' versus 'demand shocks;'

and (iii) the attendant change in contracting and price flexibility accords well with the predictions of the model.

Differences between the producer price and the LME price were long lasting and often substantial. The visibility and longevity of the two-price system elicited considerable interest from economists and policy-makers. Fisher, Cootner, and Baily (1972) discussed the system as part of their econometric model of the world copper market. Their story embodies an information-based approach to price adjustment: Producers' prices are "administered," set to clear expected supply and demand, and changed when sufficiently out of equilibrium, as indicated by LME prices and inventory changes. The LME price serves to clear the market.

McNicol (1975) analyzed the system differently. Ignoring the periods when the producer price exceeded the LME price, he explained producers' decisions to ration rather than raise their prices to LME levels as the optimal response to unexpected demand shocks if buyers differ in their ability to substitute, and outright price discrimination is infeasible. MacKinnon and Olewiler (1980) estimated copper demand under the assumption of market disequilibrium with rationing a la McNicol.[16]

The key characteristic of the two-price system was that the producers adjusted their contract prices infrequently. They were able to retain their customers when the producer price exceeded the LME price because they supplied their contract customers at below-LME prices when the LME price rose above the producer price. Customers that declined to take copper at higher-than-LME prices were given lowered "book positions," meaning less favorable treatment, (i.e., greater likelihood of being rationed) when the price relationship reversed (Mikesell, 1979). Although less information is available on other metals with two-price systems, Slade (1991) reports rationing by producers of molybdenum and zinc under similar circumstances. Although producer prices are not described as contract prices in the metals industry, what is important is the ongoing relationship between producers and customers that transact at these prices, which constitutes an implicit contract.

The copper market has been characterized by substantial change on the producer (seller) side, and a relatively stable demand (buyer) side. In the late 1960s and early 1970s, the four largest copper-exporting countries -- Chile, Peru, Zaire, and Zambia -- nationalized their domestic copper industries, which theretofore had been run largely by North American and European multinational corporations. The forced exit by publicly-held multinationals and entry by state-owned enterprises result-ed in three changes in seller market structure that are of interest here.

First, because the ownership of these companies was no longer in the hands of diversified investors, the management was more risk-averse. Although difficult to demonstrate empirically, state-owned enterprises are usually regarded as risk-averse in comparison with private firms (see Aharoni, 1986).[17] Separation of ownership and control is likely to be great in state-owned enterprises, and the private market solution of compensating manages with stock in their firms is not available. The tendency toward increased risk aversion was magnified by the weakness of political competition in copper-exporting companies. Thus, managers in those state-owned enterprises were responsible to principals whose objectives were themselves likely to differ from profit maximization in the direction of stabilizing revenues.[18]

Second, in pursuit of objectives other than profit maximization, the state-owned enterprises tended to operate at very high rates of capacity utilization. The optimal response to this policy by U.S. producers was to reduce their own output levels, implying a lower level of capacity utilization. Third, the nationalizations disrupted the network of existing contracts. The state-owned enterprises tended to sell on the LME, rather than through the long-term arrangements used by the multinationals.

Economists have advanced several hypotheses regarding the decline of the two-price system in the 1970s. Felgran (1982) associated the system with the exercise of market power, and claimed that the U.S.

producers' shrinking share of the copper market eventually made such "oligopolistic pricing" untenable. De Kuijper (1983) showed that, in markets with two-price systems, equilibria were likely to be unstable, so that small disturbances could lead to the system's "unraveling."

One view of market institutions is that they arise out of forces that are exogenous, at least in neoclassical models. In this case, such an explanation would imply that the forced exit by multinationals and entry by state-owned enterprises was such an exogenous change, and that the state-owned enterprises simply lacked the contracts, expertise, or traditions of doing business associated with long-term vertical relation-ships, so that they sold through spot markets.

The view presented above is that contracting behavior is the result of optimizing behavior by buyers and sellers. In our model, <u>changes</u> in such behavior can arise from two sources. First, the attitudes toward risk of the contracting parties can change, as when state-owned enterprises replaced multinationals in the copper industry. Second, the mix of supply and demand shocks can change.

Tests to distinguish among these hypotheses would ideally use data from markets with a variety of horizontal and vertical structures. With only a few available case-study markets evidence in support of the various hypotheses is suggestive rather than definitive.[19]

The claim that the existence of a two-price system is itself evidence that copper producers were engaged in oligopolistic behavior is doubtful. As shown above, two-price systems are not only consistent with either monopoly or perfect competition, but appear similar under these two extremes of market structure.[20] Further, since entry into copper production occurred primarily through takeover, rather than new discoveries, it is difficult to see why the industry should be considered to have been less competitive before the period when entry occurred.

Evidence from other commodities points in the same direction. The disappearance of the two-price system in crude oil in the late 1970s and early 1980s was not associated with a decline in market power.[21] A recent study by Slade (1988) finds that changes in horizontal concentration contribute relatively little to explaining the variance of price changes for six commodities with two-price systems. Erceg, et al. (1989) analyze the two-price system in steel, concluding that it is not related to market power, but rather is a form of risk sharing, in the sense of our model.

We turn now to the question of whether changes in the extent of copper contracting were endogenous or exogenous, in the sense discussed above. Where in fact such changes are exogenous regime shifts, it can be shown that shocks to supply or demand are most persistent (so that prices are "sticky") in regimes in which most trade is tied up in contracts (see Hubbard and Weiner, 1989). Intuitively, with an exogenous shift from a regime in which most trades are carried out under contracts to one in which most trades are carried out in the spot market, the variance of the spot price should decline -- i.e., a "thin" spot market is no longer required to equilibriate shocks to the entire market.

Empirical tests comparing the pre-mid-1978 and post-mid-1978 periods reveal that the variance of spot prices actually increased (and that the increase was statistically significant at conventional levels) in the latter periods, when prices were more flexible, exactly the opposite result from that predicted by the exogenous-regime-change model (see Hubbard and Weiner, 1989).

Evidence on the relative importance of supply and demand shocks over time is difficult to come by, since the shocks are not directly observable. Behrman (1978) conducted simulations of buffer-stock schemes designed to stabilize prices for various commodities for the period 1963-1972, and concluded that the copper market was dominated by demand shocks. (In contrast, agricultural commodities tended to be dominated by supply shocks.) This conclusion is consistent with the view of this period as one of rapid demand growth and high utilization of copper productive capacity, so that price uncertainty came from the demand side.

In contrast, demand for copper in the 1970s and 1980s is viewed as stagnant (see, e.g., Takeuchi, et al., 1986). Supply shocks have come largely in the form of increased investment capacity by copper-producing state-owned enterprises, even in the face of uneconomic returns (Takeuchi, et al., Table 6.3) and the tendency of these state-owned enterprises to operate at higher capacity utilization rates than private multinational firms (Takeuchi, et al., Table 6.4).

Three other potential sources of supply shocks in the more recent period should be mentioned, although their quantitative importance is difficult to assess. First, some of the state-owned enterprises have continued to have difficulty maintaining production levels, due in part to political problems and difficulties obtaining foreign exchange (and hence imported capital). At the same time, the declining copper industry in North America was hit by a series of strikes. Second, the largest copper-exporting countries have formed a cartel, CIPEC, which tried to influence production during the 1970s. The effectiveness of this cartel was problematic, but there is evidence for the view that it exerted some influence (Zorn, 1978). Finally, while we cannot determine whether the copper market is characterized by oligopoly pricing, if it is, then the theory of strategic groups in industrial organization (see, e.g., the discussion in Scherer, 1980) suggests that oligopolistic consensus will be more likely to break down (hence enhancing supply instability) when there are groups with different objectives (here the multinationals and the state-owned enterprises).

U.S. domestic copper production continued to be sold at the producer prices until mid-1978, when the two-price system unraveled. Customers deserted their suppliers more and more, unwilling to pay above-LME prices. The two-price system became untenable, and in June 1978, Kennecott, the largest domestic producer, announced that its producer price would track the LME price. Referring to Table 2, the equilibrium moved from the lower-right to the lower-left box. With the market dominated by supply shocks in the 1970s, buyers had been willing to pay a "security premium" to sellers (lower-right box). Indeed, producer prices exceeded spot prices from 1974 until the end of the two-price system. With the increasing share of the market being captured by state-owned enterprises in the 1970s, seller profits become more vulnerable (due to sellers' greater risk aversion), and the system whereby buyers paid a security premium became untenable, giving way to the no-contracting equilibrium (lower-left box) by 1978.

## V. Conclusions and Implications

Economists have devoted considerable attention to the issueon "sticky prices" and consequences for market equilibrium, and the search for microeconomic foundations of non-Walrasian outcomes in labor and product markets has spawned many studies of contracting. In this paper, we emphasize the role of contracts in markets (for many raw materials and industrial commodities) in which long-term contractual arrangements and spot markets coexist.

Our theoretical results generate testable hypotheses for differences in price flexibility within markets and between markets. Simply put, reliance on contracting within a market can change over time in response to changes in the variance of the spot price and the relative importance of demand and supply fluctuations. Differences in price flexibility between markets correspond primarily to differences in the type of good produced.

The analysis of econometric models of price determination in individual commodity markets is an obvious application of the 'two-price' model presented here. As noted before, many commodity markets have experienced multiple-price regimes; we discussed evidence from the copper market which is particularly supportive of our approach.

While we have concentrated our attention on multiple-price regimes in individual markets for primary or industrial commodities, the approach may have important implications for aggregate models. If contracting arrangements in product markets are endogenous, then models of price adjustment designed to examine the impacts of demand and supply shocks on market equilibrium and the potential for effective policy intervention must go further than determining price as a simple markup over standard unit input costs. Moreover, to the extent that price "rigidity" implied by contracting is the result of an optimizing process, opportunities for effective policy intervention may be circumscribed.[22]

## APPENDIX

## OPTIMAL CONTRACTING UNDER MONOPOLY

The monopolist's problem is to choose the contract price $P^c$ or contract sales $Q^c$ so as to maximize the certainty equivalent of profit (the monopsony case is analogous). We let the producer choose $P^c$ to maximize (5) subject to

$$Q^s_{t+1} = R^{-1}(E_t P^s_{t+1}) - Q^c_{t+1} , \tag{A1}$$

where R denotes the marginal revenue function.

Incorporating the information about the buyer's spot and contract demands conditional on $P^c$ and $P^s$, we can rewrite (5) as

$$\max_{P^c} \{P^c_t[\frac{E_t P_{t+1} - P^c_{t+1}}{\gamma \, var_t P^s_{t+1}} - \frac{cov_t(P^s_{t+1}, \hat{\pi}^b_{t+1})}{var_t P^s_{t+1}}] \tag{A2}$$

$$+ [E_t P^s_{t+1} R^{-1}(E_t P^s_{t+1}) - E_t P^s_{t+1} Q^c_{t+1}] - E_t(R^{-1}(E_t P^s_{t+1}))$$

$$- \frac{\beta}{2} var_t [E_t P^s_{t+1} R^{-1}(E_t P^s_{t+1}) - E_t P^s_{t+1} Q^c_{t+1} - E_t((R^{-1}(E_t P^s_{t+1}))]\}.$$

The contract price can be solved from the first-order condition and the market equilibrium condition to be

$$P^c_t = E_t P^s_{t+1} - \frac{cov_t(P^s_{t+1}, \hat{\pi}^p_{t+1} + (b + \frac{\gamma}{\beta})\hat{\pi}^b_{t+1})}{(\frac{2}{\beta} + \frac{b}{\gamma})} , \tag{A3}$$

Again, if the buyer is risk-neutral, the contract price and expected spot price are equal.

Given the expression for the contract price in (A3), the equilibrium spot and contract volumes are

$$Q^{s*}_{t+1} = R^{-1}(P^s_{t+1}) - Q^{c*}_{t+1} , \tag{A4}$$

and

$$Q^{c*}_{t+1} = \frac{b}{b\beta + 2\gamma} [\frac{\beta \, cov_t(P^s_{t+1}, \hat{\pi}^p_{t+1}) - \gamma \, cov_t(P^s_{t+1}, \hat{\pi}^b_{t+1})}{var_t P^s_{t+1}} ]. \tag{16}$$

The relative importance of the contract trade depends on the degree of risk aversion, the source of uncertainty, and the variance of the spot price; the higher is the variance of the spot price, the lower is the fraction of trades carried out under contract.

It is useful to compare the monopoly and competitive solutions under the two-price system. As long as the market can be described as "demand-shocks-only" or "cost-shocks-only," the relationship between the spot and contract prices is similar to that in the competitive case. As under competition, the contract and expected spot prices are equal when buyers are risk-neutral. That is not true, however, under seller risk neutrality; the monopolist does not provide "contract insurance" without additional compensation. Finally, we can compare the contract volumes under competition and monopoly. With seller risk neutrality, we obtain the usual result that the monopoly volume is half of the competitive volume.

The relationship between market structure and price flexibility has figured prominently in debates in industrial organization since Means's advancement of the "administered prices" hypothesis. Focusing on the polar cases of competition and monopoly, we can address in the context of our model whether, <u>ceteris paribus</u>, monopolists have sticker prices than competitive firms. The hypothesis of a positive relationship between industry concentration and price rigidity implies that $\alpha$ should be larger under monopoly. That is, holding constant across market structures the values of the risk aversion parameters and the covariances of buyer and seller profits with the spot price, contracting and price rigidity are more extensive under monopoly if

$$\left(\frac{1}{\frac{2\gamma}{b} + \beta}\right)\left(\frac{1}{C'^{-1}(P_m^s)}\right) > \left(\frac{1}{\frac{\gamma}{b} + \beta}\right)\left(\frac{1}{C'^{-1}(P_c^s)}\right) \text{, or} \tag{A5}$$

$$\frac{C'^{-1}(P_c^s)}{C'^{-1}(P_m^s)} > \frac{2\gamma + b\beta}{\gamma + b\beta} , \tag{A6}$$

where $P_c^s$ and $P_m^s$ represent the prices corresponding to the equilibrium quantities where price equals marginal cost and marginal revenue equals marginal cost, respectively.

The value of the expression on the left-hand side of the inequality in (A6) is at least unity, since total competitive production must exceed monopoly production. The expression on the right-hand side is bounded between one and two.

No unambiguous result can be delineated, but some special cases are illustrative. In the case wherein marginal cost curves and demand curves are linear, contracting (and "price rigidity") is necessarily greater under monopoly only if buyers are risk-neutral. In general, the result depends on the slopes of the demand and marginal cost curves. Price flexibility will be relatively greater under monopoly the steeper the marginal cost curve or the flatten the demand curve. Associating changes in marginal cost with changes in capacity utilization, the former implies that a monopolist would be more likely to raise prices during booms in this case.

NOTES

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[1] The debate over price stickiness in product markets is decades old. For example, Means's (1935) assertion that market power led to sticky 'administered' prices prompted an ongoing line of research in industrial organization. Other early treatments of price stickiness can be found in Mills (1927) and Tucker (1938).

[2] Price dispersion can occur for two other reasons: (i) imperfect information about prices, combined with costly search and heterogeneous buyers and sellers; and (ii) price discrimination. The first is likely to be important for differentiated retail goods (Pratt, Wise, and Zeckhauser, 1979), but less so for homogeneous commodities, whose prices are widely quoted. The second is illegal per se under U.S. antitrust law, unless cost differences can be demonstrated.

[3] Copper and petroleum are oft-cited examples here; others worth mentioning are coal, natural gas, aluminum, iron ore, steel, molybdenum, lead, zinc, and oil tanker services.

[4] See Stigler and Kindahl (1970) and Carlton (1986).

[5] This approach is similar in spirit to that of Kawai (1983), who examines the impact of futures contracts or spot price. The models differ in their treatment of supply and demand disturbances. In Kawai's setup, all disturbances are on the demand side, and production is not continuous. Since Kawai is concerned with the effect of organized futures markets on spot-market behavior, speculators play an important role in his model. In markets with multiple-price systems, speculation

is far more costly, and less prevalent, than in futures markets, because speculators must be able to accept, hold, and deliver the physical commodity. For simplicity, our model omits speculators entirely.

[6]For simplicity and clarity, we model contract prices below as fixed. In the real world, contracts are often indexed. It should be clear that our results hold qualitatively as long as the indexation results in spot and contract prices that are not perfectly correlated.

[7]This timing convention is a natural one for the sort of continuous (e.g., nonagricultural) production that we have in mind.

[8]This form is restrictive, but is necessary to obtain linear equations and closed-form solutions (see, e.g., Carlton, 1979a; Newbery and Stiglitz, 1983; and Turnovsky, 1983). Newbery (1988) has shown that the errors in solving for prices that result from using this form to approximate more complicated risk-aversion functions are negligible.

[9]Though we cast the arguments in our model in terms of 'risk aversion,' this emphasis is not necessary. All that is required is a concern by the managers of firms with the variability of cash flows, as well as the expected value of cash flows. Later, in section IV, we address this issue in terms of the risk preferences of state-owned enterprises (see also Aharoni, 1986). More generally for private firms, models of asymmetric information in capital markets explaining cost differences between internal and external finance imply that the variability of cash flows is a concern for firm decisionmakers (see the reviews of studies in Fazzari, Hubbard, and Petersen, 1988; or Hubbard, 1990).

[10]Under reasonable assumptions about the production function and demand curve, it can be shown that the covariances are positive when most uncertainty stems from the supply side (see the derivation in Weiner, 1986). The case of additive shocks is intuitive; for example, a positive supply shock means more output, which means higher seller profits because the marginal cost curve shifts, so $\text{cov}(P^s, \tilde{\pi}^p) < 0$.

[11]In our model, the spread between spot and contract prices within

a market depends on the magnitude of the covariance terms in equation (7). A large variance of the spot price, ceteris paribus, would be associated with greater heterogeneity of prices. Carlton (1986) provides evidence that price heterogeneity is not uncommon even in markets for standardized industrial commodities. Such heterogeneity can be associated with either price stickiness or price flexibility, depending upon whether shocks in the market come primarily from the demand side or supply side, respectively.

[12] In any model wherein external finance is more costly than internal finance (or wherein firms are risk averse), there will be gains from merging firms with imperfectly correlated cash flows. We assume that vertical integration is ruled out here as too costly, or prohibited. In the copper industry case study below, many of the upstream firms are state-owned enterprises in less developed countries, which were not permitted to acquire downstream firms abroad.

[13] Note that under the assumption of competition, total production is equal to $C'^{-1}(P^s)$. The parameter $\alpha$ represents the fraction of trades carried out through contracts in the absence of shocks.

[14] Copper, zinc, and several other metals are traded on the LME. The LME is a centralized market in spot and forward contracts, rather than a futures market, due to its lacking a clearinghouse and the right to cancel positions through offsetting contracts. Wolff (1980) points out that this structure has led to contracting on the LME's being conducted primarily between producers and users, with very little activity by speculators.

[15] One feature of the copper market that we do not discuss here is the large role of competitive secondary supply from scrap recovery that is sold on the spot market (Radetzki and Van Duyne, 1985; Slade, 1988). Note that if we subtracted a competitive spot-price-responsive source of supply from our demand equation (19) -- and reinterpreted $Q_t^D$ as residual demand -- the derivation would go through exactly, with only the values of "a" and "d" changed.

[16]Dissatisfaction with the results of such econometric price equations has led to disaggregate studies of copper demand in particular uses. See Holmes (1988) for a survey.

[17]Supporting evidence for greater risk aversion in state-owned enterprises is presented by Davies (1981) for the banking sector.

[18]Radetzki (1985) discusses behavior of state-owned enterprises in the copper industry in detail.

[19]A statistical analysis based on a few metals with two-price systems can be found in Slade (1988). Erceg, et al. (1989) analyze the two-price system in the steel market.

[20]The similarity extends to intermediate forms of market structure (Weiner, 1986).

[21]Indeed, Loderer (1985) claims (based on recent event-study results) that the early 1980s were a period of increased market power for OPEC, the cartel in the crude oil market. We discuss the decline of long-term contracting in the crude oil market elsewhere (Hubbard and Weiner, 1989).

[22]See for example the discussion of government stockpiling schemes in the crude oil market in Hubbard and Weiner (1986a, 1986b).

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