PRETIA EX MACHINA?:
PRICES AND PROCESS IN LONG-TERM CONTRACTS

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1. Introduction

Among the primary motives for writing contracts identified in both the law

and economics literatures is the desire to protect against the hazards

inherent to exchange where one or both parties have invested in reliance, or

relationship-specific assets, in support of the transaction.[1] Because such

investments have a higher value in their intended than next best use, parties

have an incentive to engage in haggling or other forms of opportunism in

hopes of influencing the distribution of the resulting quasi-rents.

Contracts promote efficiency by securing the distribution of those rents ex

ante, thereby avoiding costly repetitive bargaining over the terms of trade

and reducing the risk for each party of relying on the performance of the

other.

In reality, this description of the role and functioning of contracting is

oversimplified. As a number of legal and economic scholars have emphasized,

contracts are not the precise, mechanically-enforced documents often

encountered in economic theory.[2] Indeed, contracts are extremely imperfect

tools for controlling opportunism. Parties may resort to all sorts of

tactics to evade or chisel on performance of a contract. In that regard,

contracts not so much define the terms of trade as establish the procedures

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[1]See, for example, B. Klein, V. Crawford, and A. Alchian, 1978; O.E. Williamson, 1979; and S. Shavell, 1980.

[2]See, for example, MacNeil (1978); Clarkson, Miller and Muris (1978); Goetz and Scott (1981); Muris (1981); Goldberg (1976, 1985); Williamson (1979, 1985, 1988); and Klein (1984).

and alter the threat points from which parties compete over the division of transactional surpluses. An important element in designing contracts then becomes economizing on the costs associated with resolving disputes and governing exchange.

In this paper, we examine the processes by which parties adjust prices in long-term contracts from this more relational view of contracting. That contracts often contain provisions for the periodic adjustment of prices is not all that surprising. Both relative prices and the general price level can change substantially over the extended time periods covered by many contracts, making original prices inappropriate to future conditions. What is possibly more surprising is the variety of processes that contracting parties have devised to effect such adjustments. Pricing provisions vary from definite escalators that establish a predefined schedule of prices over the life of the contract to vaguely worded renegotiation provisions. But while there have been a number of recent explanations for why parties wish to provide for price flexibility[3] and some empirical work on how well contract prices track "market prices"[4], there has been little systematic analysis of how parties choose among alternative pricing processes.[5] By focusing on the

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[3]See Polinsky (1987); and Goldberg (1985); and Goldberg and Erickson (1987).

[4]See Carlton (1986); Joskow (1988).

[5]Perhaps the best work in this area has been Victor Goldberg and John Erickson's 1987 paper that looks at issues similar to those considered in this paper as they apply to price adjustment in petroleum coke contracts. That paper relies on case study methods to explain observed contractual provisions whereas this one employs more formal econometric techniques to evaluate contract design. Although our approach permits systematic tests on a larger set of contracts, we do miss much of the detail useful in evaluating contract terms that is available only through case studies. Paul Joskow's papers (1985 and 1988) also contain a considerable amount of useful case detail.

manner in which price adjustments are effected, we hope to provide additional insights into the role of various pricing provisions and the factors affecting contract design more generally.

We begin in the next section with a discussion of the tradeoffs involved in designing contracts implied by relational contracting theory. We then discuss in section 3 how these arguments relate to the design of processes for the adjustment of prices in long-term relationships. In section 4, we apply those insights to explain the specific price adjustment processes adopted in a sample of long-term natural gas contracts. Section 5 contains our conclusions.

2. Relational Contracting

Most of the economic literature on contracting treats contracts in a mechanistic fashion. Once a contract is entered, the obligations of the parties for the duration of the contract are fully prescribed. Contractors accommodate future uncertainty by stipulating contingent claims. Issues relating to the enforcement of the agreement are rarely afforded explicit discussion, but the presumption is clear that courts will either direct specific performance or apply appropriately measured damages to assure that the intentions of the parties are fulfilled. Overall, the incentives and the distribution of rents contained in the agreement are definitive and immune to efforts to evade performance or to reopen the agreement to further negotiation.

Familiarity with actual contracting reveals that contracts rarely exhibit the precise, unequivocal character suggested by this traditional view. First

of all, courts are not the reliable enforcers of contractors' intentions that are often envisioned. The legal system does not costlessly and unerringly assess remedies. On the contrary, there are reasons to believe that courts systematically deviate from efficient awards. Claims for damages, for example, are subject to a requirement of "proof with reasonable certainty." In cases where lost profits cannot be adequately established, recovery is likely to be limited to the cost of reliance, implying lower than optimal awards on average. And even if court determined damages were not systematically biased, the cost of adjudicating damage awards would diminish the attractiveness of litigated enforcement.

Second, and largely as a result of these imperfections in enforcement, parties often engage in conduct designed to escape performance or force renegotiation of contract terms. A short list of tactics contractors might exploit in attempting to effect a redistribution of the gains from trade includes capitalizing on ambiguous terms, suing for trivial deviations, making false claims of dissatisfaction, withholding relevant information, interfering with or failing to cooperate in the other party's performance, and failing to mitigate damages where a breach has occurred.[6] The success of any of these tactics depends upon, among other things, how easily they can be detected and substantiated in court, but the uncertainty associated with

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[6]For more extensive lists and further discussion see Goetz and Scott (1981); Muris (1981); Clarkson, Miller and Muris (1978); and Summers (1968). Such behavior "together with the other party's efforts to counteract them" create what Charles Goetz and Robert Scott refer to as "evasion costs" (1983, p. 977). The important points are that, although the nature of strategic behavior within a contract will differ, opportunism occurs within as well as outside contractual agreements; and that attempts to force a reallocation of contractual surpluses and efforts to counter them, whether through legal channels or less formal means, dissipate part of the rents accruing to exchange.

litigated outcomes will generally leave some such tactics potentially profitable.

Finally, rather than defining the full set of obligations under the contract at the outset as implied by the standard economic treatment, contracts often leave terms and duties to future determination. Where uncertainty about what will constitute optimal behavior at the time of performance is great, it may be better to leave aspects of that performance open to negotiation rather than to constrain parties to specific but potentially inappropriate actions. Contracts in which parties intentionally defer decisions about price, quantity or other aspects of the exchange until well into the term of the agreement are in fact quite common.[7]

These factors combine to suggest that contractual relationships, especially long-term ones, are rarely implemented in the mechanical way typically envisioned in economic theory but are characterized instead by an ongoing process of negotiations over the terms of trade. Contracts, from this perspective, become simply a means of structuring those negotiations, and litigation merely a negotiation tactic--a view supported by the fewness of cases that go to trial relative to the number of actions filed. In this more relational view of contracting, "formal legal procedures are but a step in a longer process of negotiation. Filing a complaint and pre-trial procedure can be tactics in settlement bargaining" (Macaulay, 1985, 468).

The problem is to devise a structure that encourages rent-increasing adjustments (flexibility) but discourages rent-dissipating efforts to redistribute existing surpluses (opportunism). The more detailed and precise the agreement, the less easy it will be to evade performance. But contingent

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[7]For specific examples, see Goldberg and Erickson (1987) and below.

claims contracting becomes costly very quickly in complex or uncertain environments. Failure to account adequately for uncertainty, on the other hand, may leave gains from adaptation unrealized or, if one party is greatly disadvantaged by ensuing developments, induce the types of costly efforts to evade performance or force a renegotiation described above.

The advantage of less precise, "relational" contracts that leave terms to future negotiation is that, because they do not attempt to explore and stipulate responses to every possible event, such agreements are considerably simpler to draft than contingent claims contracts yet at the same time remain flexible in the face of changing circumstances. As Victor Goldberg has argued, in designing relational contracts, emphasis shifts from devising "a detailed specification of the terms of the agrement to a more general statement of the process of adjusting the terms of the agreement over time-- the establishment, in effect, of a 'constitution' governing the ongoing relationship" (Goldberg, 1976a, p. 428.) The drawback is that such broad statements often afford the parties considerable latitude for dispute over what constitutes satisfactory performance and therefore introduce the prospect of having to engage in costly bargaining on a regular basis--the avoidance of which presumably motivated the use a long-term contracts in the first place.[8]

In practice, parties attempt to strike a balance between flexibility and opportunism in a variety ways. To limit the nature and scope of renegotiations in relatively open-ended agreements, parties may restrict either the set of permissible adjustments or the process by which such

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[8]See Klein, Crawford and Alchian (1978); and Williamson, (1979). Also see Joskow (1987) and Crocker and Masten (1988) for evidence that the size of quasi-rents affects the length of contractual agreements.

changes are to be implemented. For example, the contract may permit negotiation over price or quantity requirements only at specified intervals or may designate which party has the right to initiate such renegotiations. Certain types of bargaining tactics may also be excluded, such as strikes or refusals to accept delivery. Delay as a tactic in negotiations is often made less attractive by stipulating that renegotiated terms apply retroactively to all deliveries after renegotiations were initiated. Alternatively, parties may attempt to expand the scope for negotiation and adjustment within relatively precise agreements by including provisions such as *force majeure* or gross inequity clauses.

The relational view of contracting sees contracts as means of establishing procedures for adapting exchange and resolving disputes rather than purely as incentive mechanisms. The somewhat broader perspective this implies admits both greater scope for the strategic pursuit of rents than is commonly acknowledged in traditional treatments, and consideration of a class of contracts in which performance is only vaguely circumscribed by the terms of the agreement. Generally, the value of flexible, more relational exchange is enhanced the more difficult it is to devise definitive obligations due to the complexity of the transaction or its environment. Conversely, environments where opportunism is expected to be rife or where economic conditions are relatively simple and static will tend to favor more precise agreements. Ultimately, the degree to which parties leave the details of performance to future resolution will reflect the nature of the transaction. In the words of Oliver Williamson, "What is needed, evidently, is some way for declaring admissible dimensions for adjustment such that flexibility is provided under terms in which both parties have confidence. This can be accomplished partly

by (1) recognizing that the hazards of opportunism vary with the type of

adaptation proposed and (2) restricting adjustments to those where the

hazards are least" (Williamson, 1979, p. 251).

3. Price Adjustment Processes in Long-Term Contracts

Here we apply the relational contracting perspective described above to

analyze the nature of price adjustment processes. Unlike most earlier

studies of price adjustment that emphasize either the reasons why parties

might want to allow for price flexibility[9] or the correlation between

contract and market prices,[10] we focus on the question of how parties adjust

prices. Thus, our concern is less with what prices actually result than with

the processes by which they get determined.[11]

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[9]For discussions of alternative theories, see Goldberg (1985); Goldberg and Erickson (1988); Joskow (1988); and note 11 infra.

[10]See, for example, Carlton (1986) and Joskow (1988). There are reasons to question whether market prices are the appropriate standard against which to evaluate contract prices. As Goldberg has argued, "the relevant price to each party is its opportunity cost--the net price it could get from the next best trading partner. In a market for a standardized commodity, the list price and these two opportunity costs are roughly the same. However, in a long term contract in which the parties deliberately isolate themselves from the external market, these three prices are more likely to diverge" (1985, p. 540).

[11]Focusing on process obviously begs the question of what parties are trying to accomplish in adjusting prices. Generally, economists have identified three motives for price adjustment: risk-sharing, incentive alignment and, most recently, transaction-cost based arguments. Risk-sharing arguments see the goal of price adjustment as stabilizing the surplus of the more risk averse party (see, e.g., Polinsky). In the incentive explanation, prices in variable quantity contracts are adjusted to provide appropriate price signals to the transactor having discretion over quantity.

The third rationale interprets price adjustment in a more relational manner. According to Goldberg, a goal of price adjustment is to reduce relational frictions or "post-agreement jockeying." Changes in market conditions during execution of a fixed-price contract may leave one or the

3.a. Methods of price adjustment.

Redetermination provisions. Price adjustment processes can be divided
into two basic categories, redetermination processes and renegotiation
processes. Redetermination provisions establish prices by formula. The most
extreme, rigid form are definite escalators that adjust prices according to
an explicit, predefined schedule, for example, increasing prices at a
stipulated rate. While the price that applies at any a point in time is
easily determined by reference to the contract, definite escalators have the
obvious disadvantage of failing to make use of information arising over the
course of the relationship and thus suffer many of the deficiencies of fixed-
price contracts.

Indefinite escalators, in contrast, attempt to relate contract prices to
market conditions as they unfold. The process of determination is still
formulaic, but the equation now ties price to market data such as a general
price index or the price of some important input or substitute product.
Implementation thus remains straightforward, while prices become more
flexible. But the same factors that prompt the use of long-term contracts
limit the practicality of indexing. Specifically, the relationship-specific

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other party in a unfavorable position relative to his outside opportunities.
That party then becomes more likely to engage in rent-seeking activities
designed to evade performance or force a redistribution of contractual
surpluses. "If the probability of wasteful behavior increases as the
divergence between contract price and opportunity costs of the aggrieved
party widens, price-adjustment rules which narrow the gap become increasingly
attractive" (Goldberg, 1985, at 533; also see Speigel, 1981, at 373). An
implication of this argument is that parties will wish to set prices so that
ex post distributions of rents are divided equitably (see Masten, 1988) or to
effect what Oliver Williamson has called "hazard equilibration" (e.g., 1985,
at 34). We have implicitly adopted this relational explanation as our
maintained hypothesis. Although we do not attempt to test these three
alternative theories of price adjustment directly, evidence in support of one
or the other is occasionally noted.

nature of many of the assets used in producing, transporting, or consuming a product isolates the parties from market alternatives. The more isolated the transaction in question, the more likely is it that indexed prices will fail to track the parties' respective opportunities.

To make use of information more closely related to the transaction at hand, parties have devised adjustment provisions such as most-favored-nation and right-of-first-refusal clauses that tie contract prices to prices obtained in similar transactions or to best alternative offers. Still, even these may miss cost or demand changes specific to a particular transaction and thus adjust prices imperfectly. In addition, the need to seek out and validate outside prices makes these provisions more costly to implement than index formulae and, being less definite, introduce a somewhat greater prospect of strategic behavior.

Renegotiation provisions. Each of the indefinite pricing processes described above, while leaving price indeterminate at the time the contract is written, are still definite in the sense that the price at which the parties will trade is determined definitively by the contract once the state of the world has been verified. Under renegotiation provisions, however, the distribution of rents under the contract is indeterminate up to the point at which the parties reach agreement on price. The ability to take into account the full range of relevant information before settling on price affords the transaction a considerable degree of flexibility.

This is not to say that such negotiations are totally unconstrained. Parties may structure the negotiation process by, for example, defining in the contract the sequence of offers and acceptances or specifying the

defaults if agreement cannot be reached. Even contracts that place no

express restrictions on the strategies of the parties provide more structure

than no contract at all. As long as agreements are sufficiently definite to

be considered valid contracts,[12] the law imposes a duty of good faith in

execution of ambiguous terms.[13] Circumstances in which a duty to deal in

good faith might come to bear include situations where a contract leaves the

power to specify price or quantity to either or both parties. "Contract cases

condemn the abuse of these powers as a form of bad faith in performance, even

when the objectionable conduct is within the letter of the contract or when

the contract says nothing at all about how the powers are to be exercised."[14]

Thus, the law generally requires that quantity decisions in variable quantity

contracts be made in good faith and seeks to deter variations whose purpose

is to extort concessions from the other party.[15] More importantly for the

issue at hand, "good faith prohibits a party from setting unreasonably high

(or low) prices under an 'open price' provision."[16]

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[12]Although contracts that are too vague may be found void for want of definiteness, the Uniform Commercial Code states explicitly, "An agreement for sale which is otherwise sufficiently definite ... to be a contract is not made invalid by the fact that it leaves particulars of performance to be specified by one of the parties. Any such specification must be made in good faith and within the limits set by commercial reasonableness" (Section 2-311(1)).

[13]Generally, "[e]very contract [covered by the Uniform Commercial Code] imposes an obligation of good faith in its performance and enforcement" (UCC section 1-203). The duty to deal in good faith, moreover, applies only to the *execution* and not the *negotiation and formation* of a contract (Summers, 1968, at 220). Summers refers to good faith as "a phrase which has no general meaning or meanings of its own, but which serves to exclude many heterogeneous forms of bad faith" (at 201) and provides an extensive discussion of various practices constituting bad faith.

[14]Summers (1968) at 239.

[15]See generally Muris (1981) at 556-564, and cites therein.

[16]Summers (1968), at 239-240.

The advantage of renegotiation provisions is that they permit the parties
to take full advantage of current information in adjusting prices. Hence,
they provide a high degree of flexibility. But they also expose the parties
to the costs of having to negotiate mutually acceptable terms. Although the
good faith requirement places restrictions on the use of the most flagrant
negotiating tactics, considerable scope may remain for exercising more
subtle, though still costly, bargaining strategies.

3.b. The choice of adjustment process.

The choice between redetermination and renegotiation provisions will
reflect the relative costs of governing relationships under the respective
arrangements. In general, renegotiation provisions offer wider latitude to
respond to changing conditions but subject the parties to the need to
negotiate prices on a regular basis. Redetermination provisions, on the
other hand, reduce the frequency of negotiations but are less sensitive to
relationship-specific events and are therefore more likely to generate acute
hazards in extreme situations.[17] In the following, we draw on the relational
contracting literature and the previous discussion to develop a set of
propositions that relate the differential costs of redetermination and
renegotiation to the nature of the relationship.

Proposition 1: Complexity and uncertainty increase the costs of
redetermination relative to renegotiation. The tendency for contracts to be
more relational the more uncertain or complex the environment associated with

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[17]Witness, for example, Aluminum Co. of America v. Essex Group, Inc.,
499 F.Supp. 53 (W.D.Pa. 1980) or the well-known experience of Westinghouse
with its uranium supply contracts in the 1970's.

the transaction is a central tenet of the relational contracting
literature.[18] According to Charles Goetz and Robert Scott, contracts will
tend to be more relational in character where

> the parties are incapable of reducing important terms of
> the arrangement to well-defined obligations. Such
> definitive obligations may be impractical because of the
> inability to identify uncertain future conditions or
> because of inability to characterize complex adaptations
> adequately even when the contingencies themselves can be
> identified in advance.

In situations where the parties are fairly confident about future
conditions and performance is easy to specify, adoption of relatively
mechanical pricing provisions can avoid the costs of having to bargain
repeatedly over prices. Where the transaction is complex, however, devising
a satisfactory index may prove difficult. Similarly, the more uncertain the
circumstances surrounding the exchange, the greater the likelihood that
resulting prices will disadvantage one of the parties, leading to costly
efforts to evade performance and thus making mechanically redetermined prices
more hazardous. Renegotiation provisions, in contrast, institutionalize
responses to extreme conditions and thereby obviate the incentive to employ
evasion tactics and the need to defend against them. But they do so at a
somewhat greater cost of arriving at prices on a day-to-day basis.

**Proposition 2: The costs of renegotiation rise relative to
redetermination the larger the quasi-rents at stake.** This proposition
derives from the more basic hypothesis that the amount of resources devoted
to wasteful "rent seeking" activities increase with the size of the rents at

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[18]See for example, Macneil (1978) at 901; and Williamson (1979) at 238.

stake. Although usually applied to bargaining and hold-ups in noncontractual settings or at contract renewal, the logic can be extended to the choice between renegotiation and redetermination provisions. For example, in explaining the relative infrequency of renegotiation provisions in contracts between petroleum coke refiners and aluminum producers, Goldberg and Erickson reason:[18]

> The aluminum contracts generally entailed greater insulation from current market conditions. Reopening a contract would mean that the parties would haggle over how to share the pie. The more the parties are isolated from alternative trading partners, the larger the size of the pie. The larger the pie, the more resources the parties would devote to pursuing it. That is, the higher reliance interest in the aluminum contract would result in higher renegotiation costs, making frequent renegotiation relatively less attractive.

Good faith requirements or provisions of the contract may deter the most egregious forms of hold ups and thereby temper the effect of appropriable quasi-rents on the cost of renegotiations. Nevertheless, some bargaining costs will no doubt be incurred.

Proposition 3: The longer the duration of the contract the greater the costs of redetermination relative to renegotiation. In addition to exogenous factors like uncertainty and the level of quasi-rents, the design of price adjustment processes is likely to interact with other dimensions of the contract. In particular, the use of relational contracting is often associated with longer term agreements.[19] The proposition that contracts are

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[18]Goldberg and Erickson, 1989, at 391. The comparison is to upstream contracts between the coke refiners and suppliers of unrefined coke.

[19]See, for example, Williamson (1979), p. 238; MacNeil (1978), p. 901; and Goetz and Scott (1981), p. 1091.

likely to be more relational the longer their duration follows directly from

the first of our propositions and the tendency for short run parameters to

become long run variables. Given the greater dispersion of potential

contingencies associated with more distant horizons, flexible arrangements

will be more highly valued in longer-term contracts.

Proposition 4: The more restrictive or inflexible are other dimensions of the contract, the higher the cost of redetermination relative to renegotiation. Efficient exchange may also call for flexibility in nonprice

dimensions of the contract such as quantity, timing, and product

specifications. In a general sense, flexibility in price and in these other

dimensions can be thought of as substitutes. The more flexibility allowed in

quantity, for example, the less need there may be for flexibility in price.

But the tradeoff between price and, say, quantity flexibility is actually

more subtle. In fixed quantity contracts, price adjustments are zero-sum in

nature.[21] As a result, reaching agreement on adjustments to a contractually

established price is likely to be difficult. However, unlike renegotiation

provisions that provide expressly for such modifications and limit the

tactics that can be employed in arriving at a settlement, redetermination

provisions give much greater support to the status quo and actually provide

an arsenal of legal tactics to protect the existing distribution of rents.

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[21]Compare Williamson: "price adjustments have an unfortunate zero-sum quality, whereas proposals to increase, decrease, or delay delivery do not" (Williamson, 1979, p. 251). See also, Williamson, 1978. Notice that incentive arguments provide no role for price adjustment in fixed-quantity contracts. The implication that price flexibility should be more important in variable quantity agreements suggests a negative correlation between quantity restrictions and the use of renegotiation provisions in contrast to the relational arguments developed below.

The prospect of expensive delays, litigation and other tactics makes inflexible pricing extremely hazardous.

The relative disadvantage of redetermination provisions decreases when quantity is variable. First, in response to price increases, for instance, the buyer may temper his losses by reducing purchases, generally without exposing himself to the threat of costly litigation.[22] Second, and more importantly, where contract quantities are variable, there is a greater chance of finding modifications to price and quantity that will be mutually beneficial. The outcome is that disputes are more likely to be settled with minimum disruption to the relationship where mechanically determined prices are accompanied by flexibility in other substantive dimensions of the agreement.

4. Natural Gas Contracts

From the inception of the industry, sales of natural gas between producers and pipelines have been governed by long-term contracts averaging ten to fifteen years in length. The use of price adjustment provisions in those contracts was common prior to the introduction of well-head price regulation. The most frequently used provisions were two-party most-favored-nation clauses (MFN's), which indexed contract price to the price paid by the purchaser to other suppliers in a stipulated area, and renegotiation provisions typically calling for open-ended price discussions every four or five years.[23]

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[22] In fact, quantity variations also may be held to good faith requirements. In particular, the courts seek to deter variations made for strategic purposes (see Muris, (1981) at 556-564, and cites therein).

[23] See Neuner (1960) and Mulherin (1986a, 1986b).

Following the *Phillips* decision in 1954, however, the Federal Power
Commission began the process of regulating wellhead prices, culminating in
1960 in the introduction of area rate price ceilings for interstate gas
sales. As part of that regulation, the Commission also introduced
restrictions on the types of price escalators parties could adopt and the
frequency with which prices could be adjusted in contracts for gas sold below
ceiling prices. The Commission's objection to indefinite escalators was
based on the belief that such provisions permitted price increases based on
events having no relation to the economics of a particular sale.[24]
Nevertheless, in a decision to ease those restrictions soon thereafter, the
Commission indicated an grudging appreciation of the role of price
flexibility in facilitating long-term contractual relationships:[25]

> We reaffirm our earlier findings that the use of long-
> term contracts for the sale of natural gas by producers
> to pipelines or to others is desireable and appropriate
> in the public interest but that indefinite escalation
> provisions are, in general, contrary to the public
> interest. However, it also appears that elimination of
> all indefinite escalation provisions would be too
> restrictive to enable the industry adequately to cope
> with possible changing economic conditions over the span
> of long term contracts. Therefore, to permit pricing
> flexibility and to provide an incentive for long term
> contracts, we should permit future contracts to contain
> limited price-redetermination provisions.

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[24] See "Information on Contracts between Natural Gas Producers and
Pipeline Companies," Report by the Comptroller General of the United States,
February 22, 1983, p. 14 (hereafter cited as Report).

[25] Report, p. 26, emphasis added.

Although the nature and frequency with which prices could be adjusted during the period of gas regulation continued to be limited,[26] regulators permitted contract provisions that stipulated how gas prices were to be determined in the event that gas sales were deregulated.[27] As the prospect of deregulation increased prior to the passage of the Natural Gas Policy Act of 1978, the significance of such deregulation provisions increased. In the following, we examine evidence regarding the validity of the four propositions laid out in section 3 using data on these deregulation clauses collected at a time when many categories of gas were either already deregulated or scheduled to be so in the near future.

4a. Empirical results.

Our information on contract terms was obtained from a 1982 survey (EIA-758) conducted by the Energy Information Administration (EIA) covering wells that qualified for incentive pricing under sections 102, 103, 107 and 108 of the Natural Gas Policy Act (NGPA 1978). Through this survey, the EIA compiled detailed data on 659 contracts governing the sale of natural gas from 615 wells located in and off the coast of the lower 48 states. We then independently augmented this data with information on well characteristics from public records at the Department of Energy. Missing observations in the sample and limits on our ability to identify attributes of wells reduced the sample to 234 contracts governing on-shore gas sales under NGPA sections 102

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[26]Permissable pricing provisions were limited to (i) definite escalator clauses, (ii) tax reimbursal provisions, and (iii) limited indefinite escalators that adjusted price no more frequently than every five years. Later (1966), provisions that raised price to the highest allowed regulatory rate were also permitted (18 Code of Federal Regulations 154.93).

[27]Report, p.27.

("new" natural gas), 103 ("new" onshore production wells), and 107 ("high cost" gas from deep wells, tight sands, Devonian shales or geopressurized brine).

The majority of these contracts (79%) were written during or after the year in which the NGPA was passed. It was likely, moreover, that deregulation was anticipated some time before that. The NGPA established a time schedule for deregulation by gas category with high-cost section 107 gas deregulated as of November 1979, and sections 102 and 103 gas deregulated between January, 1985, and July, 1987, depending on the depth of the well.

Contract provisions relating to or affecting price can be remarkably complex.[28] A sense of the diversity of natural gas pricing provisions is

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[28]We had access only to the Department of Energy's survey data and not to the original contracts. The following, however, is a sample deregulation clause provided by the Energy Information Administration (EIA-0330):

> Redetermination may be requested at time of deregulation and at each succeeding January 1 thereafter by seller who will select a redetermined price from one of the following:
> (1) Initial price of $6.169 effective December 1, 1981, escalating monthly thereafter based on Section 102 escalation factors;
> (2) The price in effect immediately prior to redetermination;
> (3) Average of the two highest prices, selected by seller, being paid for substantially comparable gas produced in South Louisiana, onshore and offshore, escalated monthly by the Section 102 escalation factor, including taxes [a most-favored-nation clause]; or
> (4) A price equivalent to 80 percent of the price of No. 2 fuel oil. defined as 100 percent of the average price per MMBtu for No. 2 fuel oil as published in Platt's Oilgram for "South and East Terminals, New York Harbor District." The average fuel oil price each month will be calculated from the arithmetic average of the daily arithmetic averages of the high and low quotations for each day of the month used. To convert price per gallon to price per MMBtu, each gallon will be deemed to contain 0.138691 MMBtu [a fuel-tied provision].

provided by table 1. The column headings in table 1, "equal to," "highest of," "select by seller," and "based on," indicate the basic processes natural gas contracts employ to guide the establishment of prices, while the row headings list the most common reference prices or "adjustment factors," and the cells indicate the frequency with which each combination of processes and factors appears in the sample. Notice that more than one factor may be referenced in a given contract.

The adjustment processes are listed from least to most relational moving from left to right across table 1. The most precise of the processes used in natural gas contracts set price either "equal to" or as the "highest of" some combination of the adjustment factors. Once the reference price is established, the corresponding contract price is determined by the formula adopted in the agreement. An alternative that provides more flexibility is to permit the seller to select price from among a set of prices determined by the adjustment factors listed in the contract. In contrast to "equal to" and "highest of" contracts, giving the seller some discretion over price allows greater opportunity to conform price to unusual circumstances. Of course, the seller's pricing power also provides him control over the distribution of rents, which explains why "select by seller" contracts usually restrict the

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Redetermined prices, including tax reimbursement, shall
not exceed 110 percent of the price of No. 2 fuel oil as
determined above [a maximum price provision].

If buyer, at its sole discretion, determines that the
total price being paid for all or a portion of the gas is
not economical, buyer may elect not to pay the price and
notify seller of the price it is willing to pay. If
seller is unwilling to accept such price, it can cancel
the contract [a market-out provision].

set of permissible prices. In addition, by giving the buyer discretion over quantity, the buyer can counter selection of excessive prices with corresponding reductions in purchases. While this additional degree of flexibility increases the potential for strategic behavior, the possibility of trading price for quantity concessions fosters settlement. The zero-sum quality of fixed-quantity contracts, on the other hand, impede this source of compromise. Hence, we would expect "select by seller" processes to be more common in variable quantity agreements.

The final category, renegotiation provisions indicate only that renegotiations should be "based on" or take into consideration specific factors such as prices paid by other pipelines or simply "market factors." Unlike "select by seller," both parties must agree on price before the distribution of rents is determined. Most importantly, the prospect of using the contract to hold up another party or the incentive to evade performance because of dissatisfaction with resulting distribution of rents is greatly reduced.

Of course, the tradeoff between precision and flexibility is influenced not only by the adjustment process but also the adjustment factors selected. Definite escalators, for example, are extremely precise but inflexible. Fuel indices are also fairly precise but track only general market conditions, while most-favored-nation clauses use more well-specific information but must rely on the firm's ability to identify and document prices received by other producers.[29] Other provisions also influence the amount of flexibility in

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[29]Most-favored nation clauses may be either two-party or three-party. Two-party clauses tie price to the prices paid by the buyer to other sellers, while three-party MFN's tie price to prices paid by any buyer in a specified region. A number of papers have interpreted such MFN's as devices to facilitate collusion; see, for instance, Holt and Scheffman (1987) and cites

the contract. Maximum and minimum prices may limit price increases or decreases or may trigger renegotiation, as may "market out" provisions that allow a purchaser to refuse deliveries if gas is "unmarketable" at the current contract price. The nature and scope of renegotiations may, in turn, be structured by arbitration provisions or buyer-right-of-first-refusal clauses that give the purchaser the option of either meeting third-party offers or releasing the seller from the contract. Finally, contracts may differ with regard to how often adjustments can or must take place, and how and by whom adjustments are initiated.

Although the diversity of adjustment processes suggests a continuum of contract types, data and statistical limitations prevent estimation of the full variety of contract clauses.[30] Nevertheless, the propositions discussed in section 3 can be tested by partitioning the data in a variety of ways. We begin by examining the adoption of redetermination versus renegotiation provisions.

<u>Probit Renegotiation Estimations.</u> For estimation purposes, the propositions of section 3 can be restated in the following form. Let P^* be the adjustment process adopted and let P_n and P_d represent renegotiation and redetermination processes respectively. Then, assuming the parties adopt the process generating the lowest expected governance costs,

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therein. For alternative explanations, see Mulherin (1986) and Butz (1988).

[30]There are 7,620 possible combinations of the processes, factors, and other provisions listed in table 1 alone.

$$P^* = P_n \text{ , if } C_n < C_d \text{ ,}$$

$$= P_d \text{ , if } C_n \geq C_d \text{ ;}$$

where C_n and C_d represent the respective costs associated with renegotiation and redetermination processes. Thus, the probability that renegotiation provisions will be adopted over less relational adjustment processes equals $\Pr(C_n < C_d)$, where for estimation purposes we assume that

$$C_n = \alpha_0 + \alpha_1 \cdot Q + u$$

$$C_d = \beta_0 + \beta_1 \cdot \omega + \beta_2 \cdot \tau + \beta_3 \cdot \Gamma + e$$

and where Q represents the level of appropriable quasi-rents, ω the amount of uncertainty, τ the duration of the contract, Γ restrictions on nonprice dimensions of the agreement, and u and e are independently distributed random variables. The model is set up so that the coefficients, the α's and β's, are all positive.[31]

Substituting for C_n and C_d, the probability of adopting renegotiation provisions becomes $\Pr[u-e < (\beta_0 - \alpha_0) + \beta_1 \cdot \omega - \alpha_1 \cdot Q + \beta_3 \cdot \tau + \beta_4 \cdot \Gamma]$. Thus more uncertainty, lower quasi-rents, longer contract length, and greater quantity or other restrictions are expected to increase the probability of observing

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[31] For notational simplicity, we have written the process cost equations to reflect the main effects of the variables described in the hypotheses. The model could be easily reformulated to include each variable in both equations with the hypotheses stated in terms of the relative magnitudes of the coefficients.

renegotiation provisions. Stated in this form, the hypotheses are directly

amenable to standard qualitative choice estimation procedures.[32]

Table 2 lists and defines the variables employed in this and subsequent

estimations. In gas transactions, asset specificities are primarily

locational. Once in place, the immobility of pipelines and wells limits the

ability of both producers and purchasers to seek alternative trading partners

were the other to behave opportunistically. The smaller the number of buyers

and sellers in the immediate vicinity, the greater the hazards of ex post

negotiation. Accordingly, our proxy for quasi-rents, QUASIR, is inversely

related to the number of buyers and sellers serving the field in which the

well is located and reflects the hypothesis that each additional buyer or

seller has a diminishing effect on the size of quasi-rents at stake. OILVAR

is a measure of the volatility of oil prices during and just preceding the

applicable contract date and is intended to proxy for uncertainty. The

duration of the contract was identified by the survey and is represented by

the variable DURATION.[33]

Natural gas is a fairly homogeneous product and the main dimension other

than price over which the parties have control is quantity. The degree to

which the parties permit quantity variation is limited by take-or-pay

provisions which require purchasers to pay for a contractually specified

minimum quantity of output even if delivery is not taken. The size of these

obligations range from zero to one-hundred percent of the stipulated contract

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[32]See, e.g., Masten, 1984.

[33]In twenty-seven of the contracts in our sample, the deregulation
provision was added after the original contract was signed. In those cases,
DURATION is the number of years remaining on the contract beyond the
signature date of the deregulation provision.

maximum.[34] The lower the required take percentage, the more responsive the transaction to variations in demand.

Finally, our earlier results indicated that nonprice competition in response to price ceilings in place at the time the contract was written may influence other contract terms.[35] Although we have no specific hypothesis regarding how nonprice competition should affect the choice among price adjustment provisions scheduled to apply after deregulation, we include the variable REGCONST (see table 2) as a measure of the degree to which the price constraint was binding at the time the contract was written to control for this possibility.

In addition to the basic estimation, we perform two sets of corrections. Because contract duration and take percentages are endogenous contract terms,[36] we correct for the possibility of simultaneity bias by substituting predicted values, DURATION* and TAKEPCT*, from reduced form estimations following our earlier results (1985, 1988). In addition, there is a potential selection bias associated with truncation of the sample for contracts whose lengths were less than the date of the survey minus the date the contract was written. Estimations were also conducted including a variable, H, that corrects for this bias along lines first suggested by Heckman.[37]

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[34]For more detailed discussions of take-or-pay provisions, see Masten and Crocker (1985), Mulherin (1986a, 1986b), and Masten (1988).

[35]See Masten and Crocker (1985) and Crocker and Masten (1988).

[36]More flexible contracts, for example, may induce the parties to adopt longer term agreements.

[37]See Heckman (1979); and Maddala (1983), chapters 6 and 8. Specifically, $H = [(1/\sigma)g((L-X\beta)/\sigma)]/[1-G((L-X\beta)/\sigma)]$, where $L = 1981$ minus the year in which the contract was written, and g and G are the standard

Probit results of estimations of the use of renegotiation provisions are reported in table 3.[38] The coefficients in column 1 are uncorrected for simultaneity and selection biases. Column 2 results have been corrected for simultaneity, and column 3 for both simultaneity and selectivity. In addition, column 4 reports the corrected results omitting REGCONST for comparison.

The results in all four equations are similar. Neither our measure for quasi-rents nor uncertainty has a significant effect on the choice of price adjustment process. The absence of an effect from quasi-rents may be due to the quality of the proxy, or may reflect the success of "good faith" bargaining requirements in limiting negotiation and hold-up costs.[39] Although insignificant at conventional levels in all four equations, the coefficient on OILVAR is negative at the .10 level in a one tail test in equation (1), contrary to our prediction. A problem with this measure, however, is that

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normal density and distribution functions. Joskow faces the same selection problem in his 1988 paper. Note that the density in the numerator of Joskow's definition of H should be $g(L-\beta X)$, as above.

[38]The estimations use RENEG as the dependent variable. The argument could be made that because "select by seller" provisions give some discretion to one of the parties to choose price, "select by seller" is really more relational than the other redetermination processes. In addition to the probit estimations reported in table 3 and the multinomial logit estimations described below, we also ran probit estimations combining "select by seller" and "based on" as the dependent variable. The results were not qualitatively affected by this change.

[39]We have argued elsewhere (see Masten and Crocker, 1985; and Crocker and Masten, 1988) that drainage problems may also increase the potential for hold-ups in natural gas transactions; where a producer is exposed to the threat of drainage by other sellers operating in the same field, a purchaser might seek to force price concessions by delaying purchases from the producer. Additional variables included to reflect the extent of the drainage problem were, like QUASIR, insignificant and did not significantly influence other results.

the type of uncertainty that can be reasonably captured with a statistic is also the type that can be accounted for and incorporated in a contract by the parties themselves.[40] The uncertainty that poses the biggest hazard to contracting is specific to a particular transaction and therefore not so easily quantifiable. On the other hand, the results support the predicted effect of contract duration on the use of renegotiation provisions.[41] As outlined in proposition 3, the effect of duration on the choice of adjustment process derives from the increased uncertainty associated with more distant horizons. Hence, the positive coefficient on DURATION can be interpreted as providing indirect support for the proposition relating uncertainty to the relative costs of redetermination and renegotiation. Using column (3), the results indicate that at the mean values of the right-hand side variables, a one year increase in contract length increases the probability of selecting renegotiation as the adjustment process by approximately 3 percentage points.

The predicted relationship between the use of renegotiation provisions and take-or-pay percentages is also strongly supported. In all specifications of the equation, renegotiation provisions are significantly more likely to be adopted where quantity variation is limited.[42] The result suggests that the potential for mutually advantageous adjustments where quantity is variable reduces the disadvantage of redetermination relative to renegotiation. At

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[40] In fact, the use of fuel indices in the "equal to" and "highest of" categories is highly correlated with the level of energy market volatility measured by OILVAR.

[41] Both DURATION and TAKEPCT are obviously measured with greater precision than the characteristics proxied by QUASIR and OILVAR.

[42] Inasmuch as incentive arguments imply a positive correlation between price flexibility and quantity variation (see footnote 21), this result supports the relational approach over traditional incentive arguments.

the means, a percentage point decrease in take-or-pay obligations increases

the probability of adopting redetermination provisions by about 2 points.

Multinomial Logit Process Estimations. An alternative way of estimating

the process selection decision that makes use of more information is to

partition the sample by the four adjustment processes: "equal to," "highest

of," "selected by seller," and "based on." Both "equal to" and "highest of"

use relatively mechanical formulae for determining price and are in that

regard the least relational of the processes, other things the same. "Select

by seller" offers a greater degree of flexibility but usually constrains the

seller to choose from among a limited set of possible prices. "Based on"

merely sets a reference point--in the majority of cases, just "market

factors"--for negotiations and is thus the most relational.

Results of these estimations are reported in Table 4. Note that BASEDON

is the omitted category so that the coefficients reflect the effect that each

of the right-hand side variables has on the probability that a particular

adjustment process will be adopted relative to BASEDON.

The coefficients on DURATION and TAKEPCT are again all of the correct sign

and, with the exception of the coefficient on DURATION for the category

SELECBY,[43] significant beyond the .05 level. However, none of the three

included processes differ significantly *from each other* with respect to these

two variables. In addition, as in the probit equations, neither QUASIR nor

OILVAR contribute to our ability to distinguish among the categories, except

for weak evidence that increasing energy market volatility led to the

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[43]Results on SELECBY may reflect the small number of observations in
this cell.

adoption of more "highest of" processes relative to "equal to" processes (the

hypothesis that the coefficients on OILVAR for "highest of" and "equal to"

are the same can be rejected at the ten percent level in a one-tail test).[44]

Finally, the results indicate that "equal to" is more likely to be chosen

than "highest of" or "based on" the larger REGCONST.

Table 5 presents estimated probabilities of adopting each of the

adjustment processes for alternative take percentages and contract durations

based on the estimates reported in table 4. The first row reports the

probabilities evaluated at the means of each of the independent variables.

In the remaining rows, the probabilities associated with selected values of

the indicated variables (and the mean values of the other independent

variables) are presented. As indicated by the table, the relative

probabilities vary in directions consistent with our hypotheses. In addition

to the reported estimates, the probability of using "based on" increases

substantially for long-term and high take percentage contracts, rising to 66

percent for 20 year, 100 percent take-or-pay agreements; whereas "selected by

seller" has its highest probability for low take percentage (and long

duration) contracts.[45] The probability of adopting "highest of," in

comparison, reaches its maximum of 68 percent for single year, variable

quantity agreements. Again, the direction of movement in the estimated

probabilities with respect to these two variables is consistent with

propositions derived from relational contracting theory.

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[44]"Highest of" contracts are also more likely than "equal to" contracts
to contain a fuel index provision.

[45]A twenty year contract with zero take percent has a 25 percent
probability of using "select by seller" as the adjustment process.

5. Conclusions

The terms of trade in contractual relationships do not, like Athena, spring fully formed out of the brow of Zeus. Ultimately, they are the outcome of a process of negotiations guided broadly by the rules set out in the contract and by the applicable law. Occasionally, the contract is so clear and the law so obvious that application of the contract is virtually automatic. But frequently the contract or the law is vague and the responsibilities of the parties ambiguous, leaving ample room for opportunistic behavior. Such imprecision, moreover, is often intentional. Transactors deliberately adopt terms like "good faith" and "best efforts" to describe their obligations under contractual agreements.

Despite abundant evidence that contracts are not the precise, unequivocal documents originally envisioned, relational contracting theory has remained the province of legal scholars and a small group of economists. On their own, they have developed a largely informal and untested set of propositions bearing on the role and design of contractual relationships. Whether all of these propositions will stand up to rigorous scrutiny is an open question. At a minimum, relational contracting theory poses a challenge to more traditional economic analysts to account for and explain a widely used class of contracts.

In this paper, we have applied the theory of relational contracts to analyze the processes by which parties adjust prices in long-term relationships and to conduct some preliminary tests of propositions derived from that literature. Our results provide support for two main hypotheses. First, the greater probability of adopting renegotiation over redetermination

provisions as contract length increases supports the correlation between contract duration and the use of relational contracts often suggested in the literature. To the extent that the dispersion of contingencies increases with the distance of the relevant horizon, this finding also provides indirect support for the hypothesized relationship between uncertainty and the use of more relational agreements. Second, the negative relationship between price and quantity flexibility is consistent with a reduction in evasion costs where the possibility of mutually advantageous price and quantity modifications exists within the contract. Overall, the results suggest that relational contracting theory provides a useful framework for analyzing contractual relationships and is thus worthy of additional attention by economists.

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Table 1

Price Adjustment Provisions

| | Adjustment process | | | |
| | Redetermination | | | Renegotiation |
	Equal to	Highest of	Selected by seller	Based on
Total contracts	102	67	13	52
Adjustment factors:				
Definite escalator	10	37	5	2
Fuel index	--	31	6	1
Other price index	--	1	1	1
2 Party MFN	4	12	--	--
3 Party MFN	87	57	13	15
Market factors	--	13	1	39
Other	3	27	3	2
Other provisions:				
Market out	29	21	7	6
Maximum price	10	27	2	9
Minimum price	24	23	1	10
Right of first refusal	19	2	3	6
Price arbitration provision	40	40	7	34

Table 2

Data Definitions and Descriptive Statistics

		MEAN	MIN	MAX
RENEG	= 1 if renegotiation provision = 0 if redetermination provision	.222	0	1
BASEDON	= 1 if the adjustment process in the contract is "based on" = 0 otherwise	.222	0	1
EQUALTO	= 1 if the adjustment process is "equal to" = 0 otherwise	.436	0	1
HIGHEST	= 1 if the adjustment process is "highest of" = 0 otherwise	.286	0	1
SELECBY	= 1 if the adjustment process is "select by seller" = 0 otherwise	.056	0	1
DURATION	= the duration of the contract (in years)	12.979	1	20
TAKEPCT	= the contractually specified take percentage	79.085	0	100
QUASIR	= 1/[(the number of independent purchasers serving the field in which the well is drilled) X (the number of independent producers operating in the field)]	.199	.00	1.00
OILVAR	= the standard error of real oil prices over the eight quarters in and preceding the year in which the contract was written	.316	.00	1.01
REGCONST	= $p^* - \bar{p}$, if the price constraint is binding, where p^* is the predicted unconstrained price and $\bar{p}$ the ceiling price = 0 , otherwise	2.6614	0	7.48

Table 3

Probit Estimation of Adjustment Processes

(Dependent variable = 1 if Renegotiation Provision)

(t-ratios in parentheses)

	(1)	(2)	(3)	(4)
CONSTANT	-2.85160	-5.86105	-5.55308	-5.34007
	(-5.169)	(-4.993)	-(4.519)	(-4.444)
QUASIR	.116193	.0894184	.250413	.183061
	(.353)	(.269)	(.723)	(.540)
OILVAR	-.610790	-.220057	-.525018	-.456681
	(-1.632)	(-.574)	(-1.259)	(-1.108)
DURATION	.0670760			
	(3.499)			
TAKEPCT	.0146802			
	(3.073)			
DURATION*		.0955810	.0757232	.0780524
		(3.298)	(2.250)	(2.366)
TAKEPCT*		.0440879	.0476193	.0411660
		(3.575)	(3.695)	(3.498)
REGCONST	.0703153	-.0479919	-.113803	
	(.937)	(-.594)	(-1.313)	
H			-10.1294	-9.16021
			(-1.573)	(-1.376)
χ^2:	32.887	35.813	43.156	41.416
	(5 df)	(5 df)	(6 df)	(5 df)

Table 4

Multinomial Logit Estimation of Adjustment Processes

(Omitted category is "Based on")

(t-ratios in parentheses)

	Equal to	Highest of	Selected by seller
CONSTANT	13.1560	15.1251	12.8149
	(3.747)	(4.221)	(3.222)
QUASIR	-0.340730	-0.304543	-0.633058
	(-.524)	(-.429)	(-.545)
OILVAR	-0.138487	0.797736	1.05796
	(-.172)	(.952)	(.926)
DURATION*	-0.118348	-0.189396	-0.124344
	(-1.963)	(-2.690)	(-1.231)
TAKEPCT*	-0.130374	-0.141549	-0.15049
	(-3.605)	(-3.826)	(-3.736)
REGCONST	0.352129	0.0338269	0.224031
	(2.128)	(.189)	(.857)
H	17.7407	16.0577	19.9631
	(1.484)	(1.331)	(1.608)

χ^2: 71.009 with 18 degrees of freedom

Table 5

Estimated Probabilities for Selected Values
of Duration and Take Percents

	Based on	Select by Seller	Highest of	Equal to
At mean values of all variables	.123	.060	.303	.514
Duration				
= 20	.266	.056	.181	.497
= 1	.022	.049	.542	.387
Takepct				
= 100	.434	.032	.181	.353
= 0	<.0001	.210	.483	.308