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Futures trading and supply contracting in the oil refining industry

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Abstract

This paper examines the relation between commodity futures trading and the real side contracting behavior of firms dealing in the commodity. I argue that futures serve as a flexible form of physical contracting and should be examined in the context of the firm's contracting activities, and not strictly in the context of its financial activities. Data from an oil refining company are used to empirically study this relation. The results are consistent with a contracting view of futures use and appear inconsistent with implications of hedging theories.

JEL classification: G11; L14

Keywords: Futures trading; Supply contracting

1. Introduction

Futures markets have long been considered a price insurance mechanism for risk-averse traders of commodities (Marshall, 1920; Keynes, 1930). The literature on futures markets and trading is dominated by this hedging concept, and has paid little attention to other potential motivations for futures trading or to the implications of futures trading for other aspects of firm behavior, such as the trading of the underlying physical commodity.

That futures trading and firm contracting behavior are related was made clear

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by the experience of Metallgesellschaft's MG Refining and Marketing (MGRM) subsidiary. After unwinding its petroleum futures positions in December 1993 in response to large paper losses, MGRM found it necessary to cancel several corresponding long-term gasoline sales contracts. The entire affair, including the then-realized losses on futures trades and the repurchase costs of its sales contracts, cost the company a reported $1.3 billion. [1]

Despite such examples, the focus of the received literature continues to be on the purely financial role of futures market use. [2] Even among those who take issue with the notion of risk-aversion as the underlying motive for futures trading, futures continue to be viewed primarily, if not exclusively, in the realm of financial decision-making. Smith and Stulz (1985) argue that hedging can be used to reduce tax, bankruptcy and agency costs within the firm. Nance et al. (1993) provide empirical evidence supporting hypotheses that futures and other off-balance-sheet hedging instruments are used in conjunction with other corporate financial tools to minimize tax, bankruptcy, and managerial agency costs.

The purpose of this paper is to examine the role of futures contracts in the context of a firm's overall contracting activities. As illustrated by the MGRM case, there are linkages between futures trading and contracting for physical exchange. The traditional literature on futures trading largely ignores the relation between the financial and real side of firm behavior. However, the unique characteristics of futures contracts as opposed to other methods of physical contracting suggest a non-financial role for futures market use. In particular, this paper views the futures contract as a form of synthetic storage, providing the flexibility of a spot contract with the advanced coordination features of a forward contract, that lowers the costs of contracting for advance supplies of the commodity. [3]

This paper also breaks from the received literature in its methodology by using futures position data for an individual firm to examine the relation between futures trading and the firm's inventory and supply contracting decisions. To date, little empirical work has examined any aspect of futures trading behavior at the firm or trader level. What work has been done has uniformly overlooked the implications of futures trading for other firm activities. [4] This study provides an empirical

[1] Culp and Miller (1995) provide a thorough analysis of MGRM's futures program and its relation to the firm's long-term supply marketing program.

[2] For example, Mello and Pearsons (1995) argue that MGRM was engaged in a traditional hedging program, despite rather sound arguments by Culp and Miller to the contrary.

[3] The term *synthetic storage* was first used by Culp and Miller (1995) to describe MG's futures program. It lends itself well to the view and use of futures contracts presented here.

[4] Even the basic assumption of risk aversion has not been empirically tested in the literature. Instead of asking *if* risk aversion exists, empirical studies have instead tried to determine *what type* of risk aversion exists (see Park and Antonovitz, 1992).

examination of one firm's futures trading and physical contracting behavior over a period of 40 months from February 1990 through June 1993.

The results suggest that the firm's futures position inversely affects the firm's inventory and forward contracting positions, but that the reverse is not true. These results seem to be inconsistent with theories of hedging, which suggest that futures are traded to hedge the value of the physical position. More importantly, the results show that futures trading should be viewed in the context of a firm's physical contracting activities, and not strictly as a financial tool.

The paper proceeds in Section 2 with a brief review of the existing literature and its treatment of futures market use. In Section 3, the futures contract is examined in a transaction cost framework as an alternative form of supply contract that provides the coordination properties of long-term contracts with the flexibility of spot transactions. Section 4 presents the empirical analysis. The conclusion discusses the implication of the empirical results for our understanding of futures market use and points to important areas for further research.

2. The futures market literature

The futures market literature can be characterized by two broad categories: risk trading and strategic/competitive trading. The traditional hedging literature is by far the dominant theme in futures research and is based upon the idea that risk-averse traders of a commodity use the futures market to protect against adverse price movements. Some recent work breaks with the assumption of risk aversion to consider other motivations for futures use, including strategic trading, liquidity arguments, and borrowing and lending of the commodity. Regardless of the risk assumptions or motivation involved, each of these explanations of futures use implies some effect on related activities within the firm that have escaped examination.

2.1. *Risk aversion and futures trading*

The traditional hedging literature dates back to Marshall (1920), although most studies of futures markets note Keynes (1930) as the significant early work. [5] The hedging literature regards the futures market as a means of transferring risk between individuals. Whether hedgers are defined by their risk attitudes or by their involvement in the cash market, the basic premise is that risk-averse traders in the commodity hedge the value of their cash positions by taking opposing positions in

[5] It is interesting to note that Marshall's discussion of futures (p. 258) is under the heading "The services rendered by constructive speculation on a Wheat Exchange, illustrated by its efficacy in lightening the burden of risks borne by grain merchants and millers".

the futures market. Thus, traders with opposing cash positions may trade with one another in the futures market, or hedgers may trade with speculators who are willing to assume the price risk.

Most work in this area focuses on issues surrounding the hedging role. The informational and predictive efficiency of futures prices, the optimal hedging strategy, and the existence of a risk premium are frequent subjects of research. Little thought is given to implications beyond the futures market itself, and virtually none to the underlying premise of risk aversion. While the latter is an important issue in and of itself, this paper is more interested in the former.

The received literature makes no differentiation between individuals and widely-held corporations as potential hedgers. However, such work as Mayers and Smith (1982) and Rubin (1978) suggests that risk aversion arguments are less applicable in the case of widely-held corporations. The fact that such corporations, including large petroleum companies, are observed trading in the futures market suggests that risk-averse motivations for futures use may not fully encompass the value to the firm of engaging in futures trading. Smith and Stulz (1985) and Nance et al. (1993) suggest that hedging provides other benefits that induce even risk-neutral firms to engage in hedging activity. These benefits include reduced bankruptcy, agency, and tax costs.

However, this work continues to view futures trading in isolation from other, non-financial decisions in the firm. Even in a world of hedging, the introduction of a futures market has direct implications for resource allocation within the firm. The futures market is only one of many possible tools a firm may use to manage risk. Robison and Barry (1987) discuss a myriad of risk-response strategies, including use of inventories, production scheduling, forward contracting, and financial positioning to name a few. The introduction of the futures market to this repertoire of instruments implies substitution between tools. While such substitution presumably would be most obvious at the time of introduction, changes in the relative costs and effectiveness of different risk-management tools would imply a continuing reallocation between futures trading and one or more of these alternate measures.

Despite the tremendous volume of work in this area, only two studies have used firm-level data to examine futures trading. Hartzmark (1987) studied a large panel of firms in seven agricultural and two financial futures markets to determine whether speculators in the market earn positive profits as a risk premium, as suggested by Keynes and others. His results suggest that a risk premium does not exist, but is driven to zero by the competitive supply of speculative services. However, he provides no insight to the determinants or consequences of futures use. Park and Antonovitz (1992) use futures trading data from one cattle feedlot to evaluate which functional representation of risk aversion best characterized the firm's observed trading patterns. They did not consider alternative motivations for futures use or the implications of that trading on other aspects of the firm's behavior.

2.2. Market power and futures trading

The strategic trading literature is relatively new, beginning with the work of Anderson and Sundaresan (1984) and Newbery (1984). This research breaks from the more traditional literature primarily in that it examines the case of a futures market for a commodity that is not traded in a perfectly competitive cash market. As a result of the imperfect underlying cash market, wherein at least one producer has some appreciable market power, a strategic role for futures markets appears that is absent in the more traditional literature.

Although the strategic use of the futures market would necessarily affect the real side of the firm, such effects are not considered beyond the resulting changes in output levels. In addition, it is not clear that the conditions that allow strategic manipulation of the futures market price to occur are actually observed in modern markets. Since no empirical evidence is provided to support this theory, it is difficult to determine its generality or its usefulness in explaining observed futures market behavior.

2.3. Transaction costs and futures trading: Hints at something more

The notion that futures markets might provide a valuable service absent risk aversion or imperfect commodity markets was introduced by Working (1953, 1962)) and advanced by the work of Telser and Higinbotham (1977), Telser (1981), and Williams (1986, 1987)). Working argued that futures provide a means of managing carrying charges for stored commodities (particularly grains) and could best be described as an arbitrage of the basis spread between spot and futures prices rather than as a hedge against absolute price movements. The latter papers join Working in shunning the risk aversion story. These papers employ a general transaction cost analysis to illustrate why firms might engage in futures trading.

Telser and Higinbotham (1977) and Telser (1981) skirt the motivation for hedging and instead ask the question of why futures would be used as opposed to forward contracts, since both provide protection against subsequent price movements. They suggest the liquidity of the futures market makes the futures contract a lower cost alternative to forward contracts. As Telser and Higinbotham (1977, p. 969) write, ''A futures contract is to a forward contract as payment in currency is to payment by check''. Thus, they do not necessarily take issue with the hedging hypothesis, only its proclivity toward futures. Furthermore, they simply compare the characteristics of the two contracts outside the context of actual firm behavior.

Williams (1986, 1987)) suggests that the futures market serves as a medium for borrowing and lending the commodity. First, he establishes the idea that traders of a commodity value access to the commodity. Users of the commodity want it to be available at a specific time. Sellers want to be able to fill orders upon demand. The problem is intertemporal supply. At any point in time, one firm may have more or less than it requires. Since inventories are expensive to hold and stock-outs are costly, having excess or insufficient supplies creates costs. At the same time, no firm is willing to part with its stock permanently.

The futures market, Williams argues, reduces the cost of access by allowing those with surplus access in the present to loan a portion of their stock by selling the excess in the spot market and buying it back in a futures contract. The firms in need of the commodity today borrow by purchasing in the spot market and repaying the quantity in the future (via a futures contract). Since this use of the futures market constitutes a repurchase agreement, like a monetary loan, Williams likens the futures market to a money market. Williams' arguments suggest a unique perspective on futures trading and the demand for access. However, as with most futures research, Williams fails to offer any empirical evidence to support his arguments.

2.4. *Summary*

Each of the above theories of futures market use implies some relation between a firm's futures trading activity and its physical contracting and supply decisions. However, none of these literatures considers the extent or importance of these implications for firm behavior. The dominant literature focuses narrowly on the financial hedging role of futures. While more recent transaction cost studies of futures contracting have broadened the scope of futures market analysis, the unit of analysis remains the futures contract itself, independent of any physical contracting activity. Furthermore, each of these literatures is characterized by a lack of empirical hypothesis testing.

3. Contracting costs and contract choice in crude oil supply

Firms have several ways to access supplies of an input. The good can be purchased in the spot market on an as-needed basis, it can be purchased in advance and held in inventory, or it can be formally contracted for in anticipation of future need (a forward contract). Supply of a good can also be arranged through either long-term contracts or integration with an up stream source. Each of these forms of exchange has different characteristics that affect the costs and benefits of that particular contract form. Futures contracts provide yet another form of supply contract.

The firm's objective is to select a portfolio of supply contracts that minimizes the full cost of acquiring its required inputs. Coase (1937) suggested that the purpose of the firm is to minimize the costs of exchange in the production of a good or service. The make-or-buy decision considers the relative costs of contracting and the costs of bureaucratic control to determine whether an activity should be conducted through the external market or brought within the firm. Given the decision to buy, the operations literature suggests an optimal ordering rule whereby the manager chooses how frequently and in what lot sizes to order an input to minimize the combined ordering (contracting) and carrying (inventory) costs. The same transaction cost-based reasoning applies to the selection of contractual forms when faced with a set of different contracting options, each with its own characteristics. It is this tradeoff between contract forms that the literature has ignored, and that this paper hopes to address.

3.1. Alternative forms of contracting

Each contractual form has its own costs and benefits. The spot market may involve information and search costs as well as coordination problems. In the case of the crude oil industry in the early 1980s, the spot market was characterized by a large degree of price uncertainty. Although crude oil price lists were available on a daily basis, prices changed more frequently. Furthermore, price lists tended to be anonymous market averages. Individual buyers and sellers could not identify the best price available. In addition, traders in the industry that reduced search costs between producers and refiners benefitted by arbitraging price differences. One could argue that the lack of competitive price information was an implicit cost of search services provided by traders. Even so, the argument leaves open the possibility of a more efficient contracting mechanism.

Another problem with the spot market is coordination of production. Crude oil cannot be produced and delivered instantaneously. Transportation of crude may require days to weeks depending on the source. Storage at terminal locations is not sufficient to handle immediate delivery on a large scale. Without advanced coordination, it is possible that, at any point in time, supplies simply may not be available for prompt delivery.

This problem leads to the consideration of forward and long-term contracting mechanisms. Forward and long-term contracts, though related, are not synonymous. Where a spot transaction calls for instantaneous exchange of goods and payment, a forward contract calls for future exchange of goods at terms set today. Forward contracts may or may not be repeated or call for multiple deliveries at different points in time. A forward contract is transaction specific. A long-term contract, on the other hand, implies on-going, repeated exchange. Whereas a forward contract covers the terms of a transaction, a long-term contract covers the terms of a series of repeated transactions.

The crude oil industry had been characterized by vertical coordination and long-term contracts up until the 1970s. Nationalization of production facilities, particularly in the Middle East, and embargoes against Western oil companies broke down many of those long-standing contractual arrangements. Major oil companies that used to sell their excess oil stocks to independent refiners through long term contract channels found themselves without the stock to continue providing those supplies. As the newly nationalized countries sought to market their product, a system of traders arose to service the abandoned independents. Within a decade, the amount of oil traded through vertical arrangements and long term contracts dropped from 95% to 60% of world crude (see Anderson, 1984, p. 59).

Forward contracts offer the coordination of future supplies that long-term and vertical arrangements had previously provided. However, forward contracts legally oblige both parties to perform. If conditions change such that the full contracted amount is no longer required, the forward contract is inflexible in terms of performance. When contract terms become especially binding, renegotiation is costly. If such negotiations fail, there is always a possibility of non-performance. Uncertainty over future market conditions only increases the potential cost of a forward contract's inflexibility. For example, when MGRM liquidated its crude oil futures positions, some of its long-term contracting partners, recognizing a greater degree of uncertainty in MGRM's supply position, sued for adequate assurance that MGRM would still be able to fulfill its sales commitments over the remaining nine years of the product sales contract. [6]

A remaining alternative would be to buy in favorable spot markets and hold large inventories for future needs. However, the purchase of inventory requires full payment up front, and there is the additional cost of storage. A producer can effectively store crude oil by not pumping it from the ground. The cost of storage at that point is simply the foregone revenues from the sale. Once the oil is above ground, however, the storage cost involves the physical plant costs and the insurance typically carried in case of damage (fires, leakage, etc.). A typical monthly storage charge would be about $0.20/bbl, in addition to the foregone return on the value of the oil and the cost of the physical storage plant. Although the possibility of non-performance by a supplier is eliminated, inventory is costly. [7]

3.2. Futures contracting

The futures contract provides an alternative to the contracting mechanisms discussed above by combining the coordination of a forward contract with the flexibility of spot market transactions. Using futures, a refiner can assure itself access to its necessary supplies by buying in the futures market and, due to the liquid nature of the contract, still retain flexibility to adjust its commitments according to its later needs.

The disadvantage of futures contracts is that they are standardized along rather

[6] See *Thornton Oil Corp. v. MG Refining and Marketing, Inc.* Civ. Act. No. 94-CI-01653, Jefferson Curcuit Court Div. Five, Ky. (March 24, 1994).

[7] Mulherin (1986, p. 108) has a similar discussion on the expense of holding inventory. Edwards and Canter (1995) estimate MGRM's carrying cost for crude to have been about $0.24/barrel. Litzenberg and Rabinowitz (1993) also state that "... the physical storage cost per unit of value is extremely high" for crude oil.

narrow specifications. Consequently, they may not fully suit the needs of individual companies, either in lot size, quality, or delivery point. If delivery of the commodity is desired, these margins must be negotiated at various premiums or discounts to the benchmark specifications. Therefore, the futures contract provides flexibility to the firm by allowing it to adjust its supply contracts as needs change over time, but at a cost of foregone individualized supply contracts.

Comparing the characteristics of the futures and forward contracts clearly shows the margins of substitution between the two. The costs of using a forward contract increase with the period of time between contracting and delivery of the good. The further ahead the contract, the more uncertain the input requirements. Locking in a specific amount through a forward contract exposes the firm to potential costs should the realized requirements differ from original expectations. The benefit lies primarily in the customized nature of the forward contract.

The futures contract's benefits and shortcomings are inverse to those of the forward contract. The time-dimension is the futures contract's strong point: the futures contract is flexible enough to adapt the position to uncertain future needs at a low cost. The negative aspect is the delivery of the standardized contract. The standard quantity or quality may not coincide with a firm's operations. In the case of crude oil, there are several grades of oil. Different refineries may be geared to one or another of the crude types. Although the WTI crude contract incorporates price adjustments for different grades of crude, the anonymous matching of contracts through the clearinghouse may not be optimal. At the time of delivery, the customized forward contract may be superior to the futures contract.

So the longer the time horizon, the better are futures contracts. As the time horizon shortens, the relative benefits of forward positions become more important. These relative costs and benefits explain the rolling over phenomenon observed in futures trading. As the futures contract nears its delivery month, parties with offsetting futures positions may exchange physical commodity to settle their futures positions. This method of settlement, called EFP (exchange of futures for physicals) is the predominant settling mechanism for physical trade on the NYMEX.

The difference in the two contracts' abilities to deal with uncertainty also lies at the heart of Telser and Higinbotham's and Telser's argument about liquidity. The only reason liquidity is important is if there is an uncertainty about future needs. Otherwise, a rigid forward contract would perfectly meet future requirements and there would be no need for a secondary market. In the environment of the early 1980s, forward contracts did not prove a satisfactory tool for dealing with the high level of uncertainty in petroleum markets. [8] This explains, in part at least, not only

[8] Several events led to the high level of uncertainty in the early 1980s. One factor was the deregulation of oil prices in the United States in 1981. Another was the radical shift in the structure of the petroleum industry caused by the nationalization of several producing facilities, particularly in the Middle East and the increasing importance of the spot market in crude oil trade.

the introduction of the crude oil futures market in 1983, but also its rapid growth – by 1987, the NYMEX crude contract replaced gold as the highest volume futures contract in the world.

3.3. The relation between futures, forwards, and inventories

This description of futures and forward contracts suggests that the two serve as substitutes. One would expect a negative relation between the use of futures and forward contracts. Likewise, in the case of a net user of a commodity, one would expect a negative relationship between either futures or forward transactions and inventories. The more of the input held as inventory, the less is needed to buy through either the futures or forward market. The more is purchased from either market, the less is needed in inventories.

The prevailing literature on futures markets also predicts a negative relation between physical (forward or inventories) and futures positions. The key differentiating factor, however, is the direction of causation. If a firm is hedging its physical position, then the futures position should be dependent on the physical side. If a refiner buys 1,000 barrels of crude oil on the forward market and wants to hedge that position, it would sell one futures contract for the delivery month. This would create a net short (negative) futures position. If on the other hand, the refiner forgoes purchasing its expected requirements for the time being and hedges that open position, it would buy the oil on the futures market. For every 1,000 short barrels in the forward market, the refiner would be one futures contract long (positive). [9] Again, the forward position should negatively influence the futures position. A similar argument may be made for inventories.

The role of futures as an alternative supply contract, however, suggests a negative relation from futures to the physical position. In fact, given the characteristics of the futures and forward contracts discussed above, one might expect a more direct tie from futures to forwards than the reverse. If futures contracts are used as the advanced purchase tool, taking advantage of the low time-related costs of futures, then a futures position at any particular point in time would depend more on expected future needs than the contemporaneous forward position. Hence, the forward position is less likely to impact on the futures position. However, since a futures contract can be liquidated for delivery prior to the contract month, the futures position would still have a negative influence on the forward position.

4. Examining the use of contracts

The above section proposes a negative relation between the use of futures and forward contracts, and between futures and inventory positions. The nature of

[9] This assumes an optimal hedge ration of 1. The relationship may be scaled by some factor ($0 < r < 1$), but the direction of causation would not change.

these relations would seem to depend on the motivation for futures use: hedging or substitution in contracting. The hedging theory suggests that the firm's forward position should have a negative impact on its futures position. Given the time-related costs and characteristics described in Section 3.2, the contracting argument suggests that the futures position should have a negative impact on its forward position, but not the reverse. Consequently, the distinguishing feature in the results is the suggested direction of the relationship.

Using positions information from an independent refining company over a period of 40 months (February 1990 through June 1993), this paper moves toward filling this gap in the literature. Admittedly, the results of this case study are limited to the subject firm. They can, however, provide a useful and necessary first step toward understanding how these commodity derivatives are used within firms. The subject firm ranks among the top 30 refining companies in the United States in terms of production levels and capacity. As such, it would seem fairly representative of the typical independent refiner

4.1. Data

The data set consists of the weekly futures positions, physical sales positions, and inventory figures for the refiner's crude oil input and the unleaded gasoline output from February, 1990, through June, 1993. [10] Production and input volumes were reported monthly through the same period. The futures and forward contracting positions were listed separately by sales (shorts) and purchases (longs).

The weekly futures positions include all futures contracts held. This means that near-month and second-month positions are combined. In order to reduce the importance of this aggregation, I used the month-end values of the weekly series. At month's end, almost the entire futures position is in the near-month contract. This also has the advantage of coinciding with the monthly-reported production and input volume variables.

Daily price data for the near-month futures contract were used to calculate monthly price figures as well as to measure price uncertainty for each observation period. Monthly prices are a simple average of the daily prices up to the last trading day of the month. The price uncertainty measure is the standard deviation of the price of crude oil in a six-week window around the month-end date. The window includes a four week lead and two week lag around the last trading day of the month. This window is meant to capture the uncertainty during the trading period and some expectation of uncertainty in the near future. A similar window was used by Park and Antonovitz (1992). [11]

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[10] The subject firm's position records prior to February, 1990, were not available. Consequently, the more desirable time periods around the introduction of the futures contract or the advent of futures trading by the firm were unobtainable.

[11] Other similar windows were examined, but the results were not significantly affected. Consequently, I chose to present the results using the same window used previously by Park and Antonovitz.

Table 1
Summary statistics of key variables

Variable	Mean	Standard deviation	Minimum	Maximum
Net crude futures position (*NFC*)	121	1921.70	−3987	4377
Net gas futures position (*NFU*)	−577	907.48	−2414	1534
Net crude forward position (*NWC*)	2061	598.21	994	3333
Net gas forward position (*NWU*)	−252	482.21	−1526	588
On-hand inventory (*INV*)	4141	654.49	2908	5588
Month average price ($/bbl) (*P*)	21.82	4.05	16.98	36.08
Stand. deviation of price (*UNC*)	0.918	0.944	0.196	3.805
One-month spread ($/bbl) (*SPD*)	0.079	24.02	−8.17	5.52

[a] This table provides descriptive statistics of the key variables. *NFC* is the net futures position in crude oil; *NFU* the net futures position in unleaded gasoline. *NWC* is the net forward contract position in crude oil; *NWU* the net forward position in unleaded gasoline. All net positions are calcuated as net purchases (purchases minus sales). *INV* is the amount of crude oil held in inventory. Physical positions are denominated in thousands (000's) of barrels, and thus correspond to the futures position on a one-to-one basis. *P* is the average price of crude oil (in $/bbl) for the month. *UNC* is the standard deviation of the daily crude oil price calculated over a 6 week window (+4, −2) around the last trading date of each month. *SPD* is the one-month spread between near- and second-month crude oil prices. The sample covers the period of February 1990 to June 1993, including 40 monthly observations.

The final variable constructed from the price data is the one month price spread for crude oil. The spread is the difference between the near-month and second-month contract prices. These price spreads would lead to intertemporal substitution. If prices are expected to be lower in the second month, the refiner would delay purchases. Given the time-related characteristics of the futures and forward contracts, this intertemporal substitution may also increase substitution between the two types of contract purchases. Table 1 contains summary statistics of the key variables.

4.2. Estimation

The data were analyzed using least-squares regression techniques. There is no theoretical structural formulation suggested for the empirical model. Data necessary to estimate a production or theoretical cost function are not available. However, refinery production planning is generally managed using complex linear programs, suggesting that a simple linear model relating futures and physical positions is appropriate. [12]

[12] Differenced equations, ARMA, and ARIMA specifications were run to check robustness. The results reported here stand up to these various specifications.

The estimated OLS equations are:

$$NWC = a + b1(P) + b2(UNC) + b3(SPD) + b4(NFC) + b5(INV) + b6(NWU) + \boldsymbol{b7}(\boldsymbol{QTR}) \quad (1)$$

and

$$NFC = c + d1(P) + d2(UNC) + d3(SPD) + d4(NWC) + d5(INV) + d6(NFU) + \boldsymbol{d7}(\boldsymbol{QTR}) \quad (2)$$

where *NFC* is the net futures crude position, *P* is the price per barrel of crude, *UNC* is the measure of price uncertainty, *SPD* is the one month price spread, *NWC* is the net position in the forward market, *INV* is the on-hand inventory, *NFU* is the net futures position in unleaded gasoline, and *NWU* is the net forward position in gasoline. The net positions are defined as Long less Short, or net-buying positions. If the net position is positive, the firm is buying; if negative, it is selling. The last term in each (***QTR***) is a quarterly seasonal adjustment vector. Of these, the price-related terms (*P*, *UNC*, and *SPD*) are exogenous to the firm.

The price and spread terms are expected to be negative, reflecting the basic law of demand and the possibility of intertemporal substitution, respectively. The price uncertainty measure is expected to be positive. While this could be considered a hedging term, it could also reflect the increased cost of forward contracting under volatile prices and a resulting increase in futures use. While there is no rigorous way to distinguish the two, a significant estimate in both equations would be more consistent with hedging. An insignificant or negative result for the forward estimate, combined with a positive estimate in the futures equation, may be more consistent with the contracting story.

The futures position and the inventory holdings (*NFC* and *INV*) in Eq. (1) should both have negative coefficients, reflecting substitutability between the various forms of input supply. This prediction holds even when accounting for the different time-related characteristics of futures and forwards. Although the futures position may be considered a long-term supply, the liquidity of the futures contract allows for early settlement, and could therefore be converted to a physical position in the short run.

The hedging hypothesis has little to add to this prediction, as the extant literature has not considered the impact of futures trading on supply contracting. However, if hedging indeed provides a form of price insurance for forward commitments, and thereby lowers the implicit cost of fixed-price forward contracting, one might expect a positive relation between the futures position and the forward position.

The physical position terms (*NWC*, *INV*) in Eq. (2) should be non-positive. A hedging argument would suggest a negative relation between the physical and futures positions, as futures are used to offset the price exposure of a given physical position. The contracting argument suggests little or no relation between

Table 2
Correlation matrix of key variables [a]

	NFC	*NWC*	*NFU*	*NWU*	*INV*	*P*	*UNC*	*SPD*
NFC	1.000							
NWC	−0.222	1.000						
NFU	−0.855	0.228	1.000					
NWU	−0.596	−0.318	0.569	1.000				
INV	−0.480	−0.261	0.476	0.301	1.000			
P	0.219	−0.172	−0.200	−0.023	−0.182	1.000		
UNC	0.341	−0.098	−0.244	−0.122	−0.091	0.765	1.000	
SPD	0.012	−0.163	−0.077	0.259	−0.314	0.284	0.062	1.000

[a] This table presents the correlation coefficient between the set of key variables, as defined in Table 1.

these variables, given the contract characteristics and the time dimension of the contracting process discussed above. The contemporaneous physical position represents short-term supply contracts, and consequently has little bearing on the longer-term synthetic storage of the futures position, except insofar as the physical position could be stored in on-hand inventory for the future period.

The net output positions (*NFU*, *NWU*) are meant to capture the firm's derived demand for the input and should have negative coefficients by construction. When an output commitment is made, either long-term or short-term, the corresponding inputs need to be acquired. Because the position terms are all calculated as net-purchases, a sale of output (negative) should lead to an (positive) increase in the corresponding supply position. The quarterly dummies simply control for seasonal effects.

Given the endogeneity of the quantity-related variables, one might expect simultaneity between the two systems and/or a high degree of multicollinearity between regressors. Tests for the restriction of endogeneity failed to reject the null that the systems are independent. This is probably due to the timing issue discussed above. Although the two contract forms are generally substitutes, their relative costs and benefits with respect to time suggest that the contemporaneous futures and forwards positions are not determined in a simultaneous fashion.

With respect to multicollinearity, Table 2 shows the correlation matrix between the several variables. Of these, only two suggest possible problems: those between the future crude and forward gas positions ($\mathrm{Cor}(NFC, NWU) = -0.596$), and between price and uncertainty ($\mathrm{Cor}(P, UNC) = 0.765$). [13] The potential downward bias in the respective t-statistics created by multicollinearity would only work

[13] I recognize that simple correlation coefficients do not capture potential collinearity between more than two variables. Additional manipulations of the data failed to suggest more intricate multicollinear relations.

Table 3
OLS results for forward and futures position regressions [a]

Dependent variables:	Eq. (1) Net forward		Eq. (2) Net futures	
Independent variable	Coefficient estimate	t-statistic	Coefficient estimate	t-statistic
Constant	3876.800	5.000 ***	1037.700	0.535
P (price)	−77.316	−2.424 **	−45.994	−0.651
UNC (uncertainty)	290.900	2.361 **	340.340	1.270
SPD (spread)	43.783	1.021	−139.250	−1.504 *
NFC (futures)	−0.208	−3.782 ***		
NWC (forwards)			0.370	1.160
INV (inventory)	−0.263	−2.006 **	−0.406	−1.460 *
NWU (fwd gas)	−0.908	−4.436 ***		
NFU (futr gas)			−1.772	−10.022 ***
$QTR2$	752.410	3.927 ***	−1180.900	−2.352 **
$QTR3$	708.550	2.977 ***	−595.450	−1.057
$QTR4$	480.29 **	2.200 **	318.720.	0.697
R^2	0.644		0.835	
Adjusted R^2	0.537		0.785	
Durbin–Watson	1.755		1.955	

[a] This table presents the regression estimates for Eqs. (1) and (2). The dependent variables in the two equations are NFC (the net futures crude oil position) and NWC (net forward crude oil position), respectively. The futures position is the net number of (1,000 barrel) contracts purchased. The forward position is measured in thousands of barrels. These estimates were generated using OLS estimation techniques using 40 observations of monthly data over the period February 1990 to May 1993.

*** 1% significance level (1-tail test).

** 5% significance level.

* 10% significance level.

against the hypotheses under consideration. The possible effects of any such bias will be discussed in the context of the results.

5. Results

The results of the estimations are reported in Table 3. All coefficient estimates have the expected signs, with varying degrees of statistical significance. The Durbin–Watson statistic for the forward Eq. (2) is in the indeterminate range. A corrective estimation did not materially change the results and is therefore not reported. No problem with autocorrelation was detected in the futures equation.

The most significant results for this paper are the contracting position terms (NFC, NWC, INV). The results in column one show that the futures position (NFC) is negatively related to the forward position held by the firm and is statistically significant. Likewise, the inventory (INV) level also is negatively and significantly related to forward purchases. Both of these are consistent with the notion of substitution between contract forms. That futures trading is directly and significantly related to the supply contracting behavior of the firm has not previously been established. This result alone suggests that the scope of the existing literature of futures trading has been too narrow.

The interpretation of the coefficient estimate for the futures position must also take into consideration the potential of collinearity between the futures position and the forward gasoline position, as noted above. First, any problems of multicollinearity would bias downward the estimate of the t-statistic, which was estimated at -3.78, well above the critical value at $\alpha = 0.01$. Furthermore, multicollinearity does not introduce bias to the estimator itself. The inflated standard error of the estimator is a cause for concern in interpreting the coefficient estimate. Given the small standard errors for each coefficient estimate, I feel confident in accepting these estimates as they appear.

In the second column, there is little evidence that the physical positions of the firm are related to the futures position. The coefficient on the inventory term is negative and weakly significant at the 10% level. The coefficient on the forward position, however, is positive and not statistically significant. This is a curious result if the theory of hedging is correct. Given that on-hand inventory tends to be no more than a few days' supply of crude stock, the idea that the firm might be hedging its inventory position and not its forward position would seem odd. Since the forward position creates the greater price risk exposure, one would expect that if the firm is hedging it would be the forward position rather than the inventory position being hedged. This result suggests the need for a more rigorous study of the hedging hypothesis than can be conducted here given the limitations of the data set.

In both columns, the respective induced demand proxies (NWU and NFU) are driving forces in the estimations. Particularly in the futures equation (column 2), the firm's gasoline futures position is the single most important variable in explaining the crude futures position. This is not surprising given the view of futures as a flexible form of synthetic inventory. Since the gasoline futures position represents expected input requirements, there should be an extremely strong relation between the two.

The price and uncertainty terms are significant at the 5% level for the forward position (column 1), but not significant for the futures position (column 2). It is possible that the flexibility and low trading costs of futures contracts make futures use less sensitive to absolute prices (note the relative intertemporal (spread) price is marginally significant). However, given the relatively high correlation between the two, the estimated t-statistics in one or both equations would be downward biased. As the interpretation of these coefficients is not particularly important for the primary objective of this paper, I leave any further inference to the reader.

Of the remaining terms, the one-month price spread appears marginally significant for the futures position, but insignificant for the forward position. Again, this is consistent with the long-term/short-term difference in futures and forwards as supply mechanisms. The shorter-term forward position does not lend itself to purchase delays as does the futures position. The quarterly seasonal adjustments all proved significant at the 5% level or better for the forward position. Only the second quarter dummy variable appears significant for the futures.

6. Conclusions

The futures market provides many opportunities to a firm dealing in the market commodity. The established literature on futures trading posits three different explanations for futures use based on risk-averse hedging behavior, imperfect market competition, and money market-like lending. The two features common to each of these literatures are a collective oversight of the importance of futures trading on other activities within the firm, particularly supply contracting behavior, and a lack of firm-level empirical evidence on virtually any margin of futures use.

This paper sets a new course for futures market research by focusing on futures contracts not solely as a financial instrument, but also as one contracting tool in a portfolio of contractual forms the firm has at its disposal. As such, the implications of futures trading for firm behavior are much more clear, and illustrate that the scope of previous futures market research is too narrowly focused on the futures market or contract itself. This broader perspective may also prove important for the policy debate over the roles and impacts of commodity derivatives on firm behavior and performance

This paper also offers an empirical examination using data on futures trading behavior at the firm level. In addition to being one of few studies to use such a data set, it is the first to consider the effect of futures trading on firm supply decisions and to specifically examine the variables that affect the futures position of the firm. The results show that the firm's futures position does in fact affect the firm's physical market position in a manner that is consistent with the view of futures as a longer-term synthetic storage mechanism. Contrary to the predictions of hedging theory, the relation between futures and forwards is uni-directional – the forward contracting position of the firm does not appear to affect its futures position. While these results are necessarily limited to one firm, they do suggest the promise of additional empirical research.

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