An Exploration of Market Pricing Efficiency During the Dairy Options Pilot Program

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Objective Analysis

for Informed

Decision Making

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I. Introduction

Put options have been recommended as a substitute for price support programs (Gardner, 1977; also some more recent comments?), and subsidized option purchases have received some support in lieu of subsidized insurance programs (cite?). Put options are an interesting alternative to price supports because their market-determined price levels allow for flexibility and adjustments to relevant current and expected market conditions. Options markets should also be relatively free from the bureaucratic decision processes needed for administration of commodity price supports.

Put options as a substitute for commodity price supports have some unattractive features, however. From a producer's perspective, put options can smooth short- to medium-term price movements but for many commodities options cannot be purchased more than one crop year in the future. This limited time horizon for options purchases means that longer-term price variability due to supply and demand changes, or both, cannot be reduced effectively through the use of put options.

Another drawback to using put options as a substitute for commodity price supports is the relative thinness of these markets for some commodities. Market thinness is defined here as the absence of traders willing to take the necessary opposite position in the market in lieu of a relatively large price premium, particularly for a large number of contracts and is difficult to measure. Market thinness varies considerably across commodity options contracts. For example, a buyer of one, 10, or even 100 near the money put options for the upcoming November delivery of soybeans on the Chicago Board of Trade will likely be able to have any of these buy orders filled within a few minutes at a price close to the immediately previous trade. In contrast, a buyer of one, or 10 (to say nothing of 100) put options for November delivery of canola on the Winnipeg Commodity Exchange may wait many minutes or even hours for their order to be filled. This option buyer further is likely will pay more than the price for the previous trades.

We explore empirically how a thin market responds when trading increases as a result of a subsidized put option program. USDA initiated the Dairy Options Pilot Program (DOPP) in 1999 in an effort to provide dairy producers with real-world experiences trading options. Subsequently, additional rounds of DOPP occurred to give more producers a chance to participate. In total, over 1,300 producers bought 6,500 milk put option contracts through the DOPP program from 1999 to 2002. In contrast, over this four-year period total put options traded at the CME milk futures market totaled over 36,000 contracts. This, the volume from the DOPP program represented a fairly large share of total trading activity in the dairy put options market.

This case study of subsidized fluid milk options provides some useful features for the evaluation of how subsidized options purchases affects options markets. First, the fluid milk options market has relatively low volume (Figure 1), but trading volume has increased over time going from 190 contracts per day on average in 1999 to over 400 contracts per day on average by 2002. Nonetheless, trading volume in milk futures and options remain well below that for other agricultural commodities. For example, in 2002 average daily trading volume for the CME's Live Cattle futures market was over 15,000 contracts per day while the smaller Pork Belly futures market at the CME averaged 725 contracts per day. The subsidized options purchases explored here were touted as having the potential to increase market liquidity (thus reducing market thinness) in the fluid milk markets (need cite; if not, remove).

A second interesting feature of the subsidized milk options program is that dairy farmers may have made relatively little use of commodities markets due to the long-standing dairy price support programs. If this is the case, many of the dairy farmers making use of this subsidized options purchase program would have been relatively uniformed traders. Although DOPP may have increased trading volume, market performance may or may not have been enhanced due to the relative unfamiliarity with options trading by these dairy producers.

II. Policy and Market Setting

Farm Programs. Farm level milk prices have been supported under some type of federal price support program for more than 70 years (Cropp). Although efforts have been made to reduce these price supports in the late 1980s (The Food Security Act of 1985) and in the 1990s (the Food, Agriculture, Conservation, and Trade Act of 1990 and the Federal Agriculture Improvement and Reform Act of 1996), effective price support programs for fluid milk returned in the Farm Security and Rural Investment Act of 2002. Because effective price supports are thought to reduce producer interest in hedging, there was likely to be little producer interest in fluid milk futures or options markets prior to the price support reforms in the late 1980s and 1990s. Vandeveer et al. provides a very detailed description of historical dairy production, the dairy processing industry, and government dairy policy in the United States.

Dairy Futures and Options Markets. In December of 1995, fluid milk futures and options contracts were launched at the New York Board of Trade (NYBOT), joining cheddar cheese and nonfat dry milk futures and corresponding options contracts initially listed for trading at the NYBOT in June 1993. Futures and options contracts for butter on the NYBOT began trading in mid-October 1996. In addition to the NYBOT, the Chicago Mercantile Exchange (CME), began trading fluid milk contracts in January 1996.

The milk futures contracts on both exchanges initially used the USDA's Basic Formula Price [1] (BFP). Contract size was 100,000 BFP milk at the NYBOT and 200,000 at the CME, respectively. The USDA announced a new Class III formula in January, 2000 that replaced the BFP formula in response to the new component pricing structure for milk used for manufacturing hard cheese. In response to this definitional change by the USDA, both exchanges changed their contract specifications to Class III milk, with other contract details remaining unchanged. The CME added the Class IV contract in July 2000 in response to industry interest in a contract more closely related to butterfat price risk.

Milk futures and options trading was terminated on the NYBOT in June 2000 in response to low trading volumes. The CME continues to trade Class III and Class IV fluid milk futures and options, with some growth evident in trading volume for both futures and options markets (Figure 1).

The Dairy Options Pilot Program (DOPP). DOPP was developed by the USDA's Risk Management Agency in collaboration the NYBOT, the CME, the USDA's Economic Research Service, and the Commodity Futures Trading Commission, with a notice of availability published for DOPP in November, 1998. The development of the program represented an effort to address the increasing dairy price volatility that arose from the reduction in government price supports in the late 1980s and 1990s (Figure 2).

DOPP was designed to teach producers how fluid milk put options can be used to provide price protection. The USDA cost-share arrangement subsidized the purchase of these put options, paying 80% of the put option's price and up to $30 in commission fees. These and other pilot programs were permitted under Section 191 of the Federal Agriculture Improvement and Reform Act of 1996. Producers participating in DOPP were required to attend an options training program, and were limited to purchasing puts that were at least 10 cents out of the money. [2] These producers could qualify for DOPP minimum volume levels with even with a small number of cows, and could participate in multiple rounds (Vandeveer et al.). DOPP had four rounds:

- Round 1 began in January, 1999, available in 38 counties in 7 states;
- Round 2 began in January, 2000, available in 61 counties in 32 States;
- Round 3 began in January, 2001, available in 275 counties in 39 states;
- Round 4 trading began in May, 2002, available in 300 counties in 40 states.

The evaluation by Vandeveer et al. (2003) offers a complete description of the origin of DOPP and its administration.

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[1] An estimate, calculated and announced by the USDA, of the average price paid for Grade B (manufacturing) milk by plants in Minnesota and Wisconsin adjusted for contemporaneous changes in the prices of manufactured milk products.

[2] A put option is out of (in the) money if its strike price is less (greater) than the corresponding futures price.

Producers had put options purchase minimums of 100,000 lbs. of milk in a round, but could not exceed 600,000 lbs. of DOPP put options during a year, nor more than 200,000 lbs. in any given month (Vandeveer et al.). The minimum requirement would not have been binding for virtually all commercial milk producers, while the maximum requirement would have been for most producers. The options purchased under DOPP had to have at least 2 months but not more than 12 months remaining before expiration at the time of purchase. The producer was required under DOPP to hold the options until within 1 month of expiration, after which the producer could exercise the option, sell the put, or allow it to expire. This requirement to hold the option until at most 1 month remains until expiration would decrease the value of the option to the producer relative to the value of the option if it were not purchased through DOPP. The extent of this reduction in value is difficult to determine given available market data for the fluid milk options market.

More than 6,000 dairy producers participated in DOPP during its four rounds, somewhat over 5% of total U.S. dairy farms (Vandeveer et al.). As will be shown in our empirical section, DOPP trades significantly increased trading activity in the dairy put markets, which is reflected by the increase in the average daily market volume and open interest.[3] On the other hand, option market pricing efficiency did not greatly improve with the increased market volume stemming from the DOPP subsidized purchases.

The milk call options market, a counterpart to the puts, provides another test for the effects of on options pricing efficiency. The expectedly close price relationships between put options, call options, and futures markets for fluid milk due to arbitrage possibilities (Hull; Campbell, Lo, and MacKinlay) allow us to test the differential effects of subsidized put options purchases through DOPP on related options markets.

III. Measuring Market Performance

(A) Market Liquidity

Liquidity is defined as the ability to buy or sell significant quantities of a security quickly, anonymously, and with relatively little price impact (cite). Most previous research on market liquidity focused on stock markets or equity options markets, with little attention to the liquidity of commodity options markets.. Market liquidity changing events may themselves have a direct impact on stock prices such as that observed by Amihud *et al*. (1997) and Berkman and Eleswarapu (1998). Both of these studies find a strong positive relation between abnormal returns [4] and liquidity enhancing events on the Tel Aviv and Bombay Stock Exchanges, respectively.

While increasing market liquidity is generally viewed as desirable, liquidity is difficult to measure directly. One proxy is trading volume (Blume, Easley and O'Hara; 1994). [Note: moved to paragraph below]

(B) Pricing Efficiency

Trading volume, while expected to be positively related to pricing efficiency, offers only an indirect measure for it. There are other measures that more directly measure pricing efficiency and most importantly how it might differ between DOPP-subsidized and other trades. Of course, if there were enough trades to allow such a comparison, we could directly compare DOPP vs. non-DOPP options trading at roughly the same time. The dairy options markets are much too thin for these comparisons since there are long periods of time during which no trading occurs for options at many strike prices for a particular contract months. Indeed, it is common that no trades take place for a given contract month and strike over multiple days.

Bid-Ask Spread. One of the most frequent proxies for liquidity is the bid-ask spread, defined as the difference between what buyers are willing to pay and what sellers are asking for in terms of price. The bid-ask spread is reported by the exchange. A market is liquid if traders can sell or buy many shares quickly at relatively low bid-ask spreads.

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[3] the number of outstanding contracts

[4] the actual return minus the estimated return if there were no liquidity enhancing event.

The bid-ask spread reflects the average cost of a round-trip transaction and, therefore, compensates suppliers of liquidity and measures financial market friction. As a result, a negative relationship is expected between the bid-ask spread and liquidity.We do not use the bid-ask spread in our analysis because the dairy options market is thin enough that there may be recorded bids/asks for offers that appear from the data to go unfilled for the entire day. The data is not detailed enough to know how a bid or an ask price for a given day relates to the actual differences between potential buyers and sellers of options.

Predicted vs. Actual Options Prices. There are a number of models that provide predictions for options prices based on the characteristics of the options and its underlying futures contract. These models are widely used by traders at many levels, but require some important simplifying assumptions, particularly with respect to the assumed distribution for the underlying futures contract. The prices predicted by these models can be compared with the prices observed in the market, with these differences providing a measure of pricing efficiency. Our empirical analysis will make use of these price differences, focusing on how these differences change between DOPP and non-DOPP options trades.

When futures prices are assumed to be log-normally distributed, then Black's well-known formulas for computing the price of a (European) call and put option are: [5]

(1a) $$C = e^{-rT}[F\Phi(d_1) - S\Phi(d_2)]$$

(1b) $$P = -e^{-rT}[F\Phi(-d_1) - S\Phi(-d_2)]$$ where,

$$d_1 = [\ln(F/S) + (Tv^2)/2]/(\sqrt{T}v)$$
$$d_2 = [\ln(F/S) - (Tv^2)/2]/(\sqrt{T}v)$$

$\Phi()$ = standard normal distribution function
F = price of underlying futures contract
S = option strike price
v = volatility measure (%)
T = time to expiration (number of days until expiration / 365)
r = risk-free interest rate
C = call option price
P = put option price.

If the volatility parameter (v) is known, one can easily determine fair-market prices for a call and put option. On the other hand, an observed option price can be used to infer the market's assessment of the underlying futures price volatility, commonly referred to as the implied volatility (see Fackler and King (1990) and Sherrick, Garcia and Tiruppatur (1996)). The implied volatility measures the uncertainty that market participants have concerning the futures price over the remaining life of the option contract. Information flows and changes in market conditions change the implied volatility as traders adjust their forecasts of future price variability. Several studies have examined the behavior of option prices and implied volatility around news announcements (i.e., Ederington and Lee [1996], McNew and Espinosa [1994], Fortenbery and Sumner [1993] and Monroe [1992]). Although some empirical models have been developed to identify factors influencing actual price volatility in futures markets (Andersen [1985] and Kenyon et al. [1987]), relatively little empirical modeling has been done to explain changes in implied volatility based on market factors.

The assumptions of the Black model do not always hold. Sherrick, Garcia, and Tirupattur (1996) found the relative fit of the log-normal distribution for explaining options prices to be statistically inferior to that for more flexible distributional forms for soybean options contracts, though the resulting differences in estimated options prices were small in economic terms. Another application of tests for distributional forms in Buschena and Ziegler (1999) showed that the relative fit of the log-normal distribution to be comparable to that of more flexible forms for corn and soybeans. Assessing the relative fit of these distributions is particularly difficult when markets are thin. When the log-normal distribution fits poorly, a portion of the pricing error appears to be due to prices for options far in- or out-of-the-money, giving rise to options pricing patterns known as a "volatility smile" (Hull). This volatility smile may also be related to market thinness.

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[5] "European" options do not allow exercise before expiration, while "American" options do. This constraint should reduce the value of European relative to American options, but this difference is expected to be small for options of commodity futures (Hull; Campbell, Lo, and MacKinlay; and Buschena and Ziegler).

Despite their potential errors, the use of Black's pricing formulas are a tractable method that offers a useful way to evaluate the pricing efficiency of trades, particularly those involving DOPP purchases relative to those that were not. By correcting for measurable aspects of trading ─ the options moneyness (difference of the strike price and the futures price), the time remaining for the option, the volatility of the futures markets, calls and puts, and other factors ─ our analysis will evaluate differences between the theoretical prices in equations and (1) and (2) and the actual options sales prices. We are particularly interested in how these price differences vary between DOPP subsidized puts and non-DOPP puts, how they vary with volume, and how they vary with brokers who fill a large number of DOPP orders. This analysis will use data that encompasses both DOPP and non-DOPP trades and trading periods, and both puts and calls. Future work on these DOPP-subsidized options purchases will evaluate the differences between the actual and the predicted options prices using more flexible distributions.

Data Description

DOPP transactions data were made available by the USDA's Risk Management Agency. These data give information on each put option purchased through the DOPP program, where this information includes the producer, broker, option strike price, option premium, and the date/time of the transaction. The transacting producers and the brokers they contract with are identified through a unique number to preserve confidentiality.

Producers that participate in DOPP had the opportunity in some rounds to buy put options from different milk options markets as well as different contract sizes. Both the CME and the NYBOT (formerly the CSCE) allowed trading in milk futures and options markets during most of the DOPP periods, although each market offered different contract sizes. The CME milk futures contract is a 200,000-pound contract while the NYBT contract was a 100,000 pound contract of milk. Each contract offered options on corresponding futures contracts of the same contract size. However, they also offered alternative options. The CME offered 50,000 ,100,000, and 200,000 pound options contracts during the DOPP period (the 50,000 pound contract was discontinued after DOPP's Round 2), while the NYBT offered both a 100,000 and a 200,000-pound option contract.

While these two options venues provided producers with alternative sizes to more closely meet their needs, they also served to fragment an already thin market. Indeed, by June of 2000 the NYBOT delisted milk futures and options contracts due to lack of trading activity.

As such, we focus only on the CME's 200,000 pound option contract. Because this contract is the same size as the CME futures contract profitable pricing opportunities between these options market should have been arbitraged away in the corresponding futures market absent market friction.

Table 1 lists the options volume traded under DOPP for all four rounds. Along with the DOPP transactions data, we also acquired data on milk futures and options trading from the CME. Two datasets were utilized: (1) end-of-day data and (2) time and sales data. The former provides settlement prices for all available futures and options contracts, while the latter provides point-in-time transactions data on all futures and options.

We utilize these data in a two-step procedure to evaluate the pricing efficiency of DOPP options transactions. First, the end-of-day data is utilized to determine the implied volatility for each option contract. This is done utilizing Black's option pricing formulas presented earlier as (1a) and (1b) for a call and put, respectively. Given observed options premiums and futures prices at the end of each trading day, we then compute numerically the implied volatility that provides the closest theoretical premium to the observed premium.

Given the implied volatility for each option, we then examine the following day's trading activity utilizing the time and sales dataset. This data provides transaction-level observations on futures and options throughout the day. For each options transaction, we then compute the pricing error. The formula for the Put Pricing Error is:

$$\text{Put Pricing Error} = e_\tau = P_\tau - P(F_\tau, v_0)$$

where P_τ is the observed (actual) put option premium at time τ and P() is Black's put option pricing formula, where we utilize the implied volatility from the previous day's close (v_0) and the futures price (F) in time period τ. However, because of the thin nature of the markets the most recent previous futures price transaction is utilized in the formula.

In an efficient market with active trading, pricing errors are expected to be close to zero. The central hypothesis we test is that the systematic component of pricing errors differs for options purchased under the DOPP program from those purchased outside the program. The pricing errors are modeled generally as:

$$e_\tau = f(D, M, T, V, \underline{B}, v_0) + ,_{\tau};$$

where D is an indicator variable taking the value 1 for options purchased under the DOPP program (0 otherwise), M is the option's moneyness, T is the options time (remaining) to maturity, V is the option's trading volume, $\underline{B}$ is a vector of broker indicator variables, and v_0 is the previous day's implied volatility as discussed above.[6] The cross-section and time-series nature of our data allows us to test for the effects of each of these variables on pricing errors.

We hypothesize a non-zero effect for each variable. The DOPP variable will be tested using a two-tailed test. Moneyness is predicted to increase pricing errors in absolute (rather than relative) terms. The time to maturity is hypothesized to increase pricing error due to thin trading activity for options that are far from maturity. The options trading volume is a proxy for market efficiency and is hypothesized to decrease pricing errors. Indicators for those brokers with the largest DOPP volume will be tested for significance using two-tailed tests. The option's implied volatility will be tested using a two-tailed test.

Comparisons of Means

Options Trading Volume

The CME dairy futures and options market are a relatively small-volume market compared to futures and options markets for other agricultural products. However, volume and open interest in futures and options on the CME dairy contracts have grown over time. CME futures contract volume averaged only 283 contracts in January 1999, but by December 2002 the average daily volume and grown to nearly 500 contracts per day. Dairy options volume over this period also nearly doubled.

DOPP activity also occurred during this interval of time, making the effects of DOPP on trading volume difficult to determine. The first trades of DOPP's first rounds occurred in January 1999 and Round 4 of DOPP ended in early 2003. DOPP trading activity may have had an impact on the trading of futures, puts and calls. To address this issue, we calculated daily total volume across all delivery months for futures, puts and calls. Single-equation regressions for each market were performed using DOPP trading volume and a time trend variable. If the DOPP volume variable is statistically significant, this would indicate that DOPP volume had an impact on trading volume in the corresponding derivative market. Of most interest is the magnitudes of the DOPP volume coefficients in all three regressions. If this coefficient is larger than 1.0, there is a DOPP "multiplier effect" from this subsidized options program on volume. The values of the DOPP coefficients in the put options regression is expected to be larger than the estimated values for the call options and the futures regressions. The results of these regressions are given in Table 2.

Although the DOPP coefficient for the put equation is greater than 1 in Table 2, we cannot reject the hypotheses that it equals 1. The DOPP volume coefficients in both the futures and call options markets are not significantly different from zero. As such, there is no statistically significant multiplicative impact of DOPP volume in the put market. That is, beyond the initial trade of a DOPP put, there appears to be no statistically significant additional trading generated in any of the markets. These results cast some doubt on arguments that the DOPP program should increase market volume and efficiency as new participants are drawn into this market, at least in the short term. Note however that DOPP's educational component might have led dairy producers to explore the use of options in the long term; this potential effect cannot be effectively tested with the data we use in this paper.

[6] Moneyness defines the option's intrinsic value (if positive) if exercised today. For puts, moneyness is the difference between the strike price and the futures price; for calls, moneyness is the difference between the futures price and the strike price.

Note further that there was a significant positive time trend for trading volume in each market.

Pricing Errors. Population means for the pricing errors for DOPP and non-DOPP put options trading during the four DOPP rounds combined and separately are presented in Tables 3a-3e. These values are in cents per hundredweight (Kevin, is this correct?). The pricing errors for puts purchased under DOPP are significantly (statistically and economically) higher under DOPP in total and in every DOPP round separately. The pricing error differences between puts under DOPP, and both Population mean pricing errors for non-DOPP puts and calls are presented in Table 4 for both periods during DOPP rounds and periods outside of these rounds. These means are provided as a check for the potential differences in periods influencing the interpretation of the pricing error differences in Tables 3a-3e. Mean pricing errors were statistically different across these periods for the non-DOPP puts at very low p-values but these mean differences were not statistically significant for calls during these periods. Additional regression analysis in future work will allow us to control for additional factors simultaneously in order to more fully assess the effects of DOPP volume, the periods during which DOPP traded, and other variables.

Brokers filling DOPP option orders were identified in the data set. The mean pricing errors for each of the brokers are given in Table 5. There appear to be some brokers that have been quite active in filling these DOPP orders, with the top four brokers handling 64% of all DOPP trades. Some of these top brokers appear to be filling orders at relatively high prices for these options when actual and theoretical prices are compared. This broker price effect will be further addressed in the regression analysis in a future paper.

Conclusions

This paper provides a brief overview of the impact of the subsidized Dairy Options Pilot Program non-DOPP puts and calls, were significantly positive. DOPP options were significantly more expensive relative to their theoretical options price in their means, despite their theoretically lower value due to the program's restriction that they be held until a time at least one month prior to expiration. We are unable to distinguish the exact reason for this overpricing; it may be due to lack of options experience on the part of the DOPP participants, a desire to fill orders quickly, brokers taking advantage of this subsidized options purchase program, or other reasons.

(DOPP) on the underlying options market. This DOPP was designed as an educational tool to increase dairy farmers knowledge of options markets with an eye to the promise of such program toward reducing producer reliance on government price protection policies. Such programs have also been touted as having the potential to improve overall market performance through the increased trading volume brought about by the increased trading volume. This paper addresses this second and more elusive goal of DOPP.

We find that DOPP options purchases were expensive relative to these options theoretical options prices. This measured additional expense for DOPP trades was statistically and economically significant when measured at population means; these differences are significant for both non-DOPP puts and for calls, and in every DOPP trading period. We were able to identify and test for the effects of specific brokers who filled DOPP trades on the pricing errors and found statistical evidence consistent with some brokers appeared to be filling DOPP orders at inflated prices.

The results of the statistical analysis in this paper is supported by a more detailed analysis designed to further isolate the effects of DOPP from those from other factors. The results of this more detailed analysis are available from the authors, and will be discussed in a forthcoming paper.

Figure 1. CME Dairy Futures Trading Volume: 1999-2002

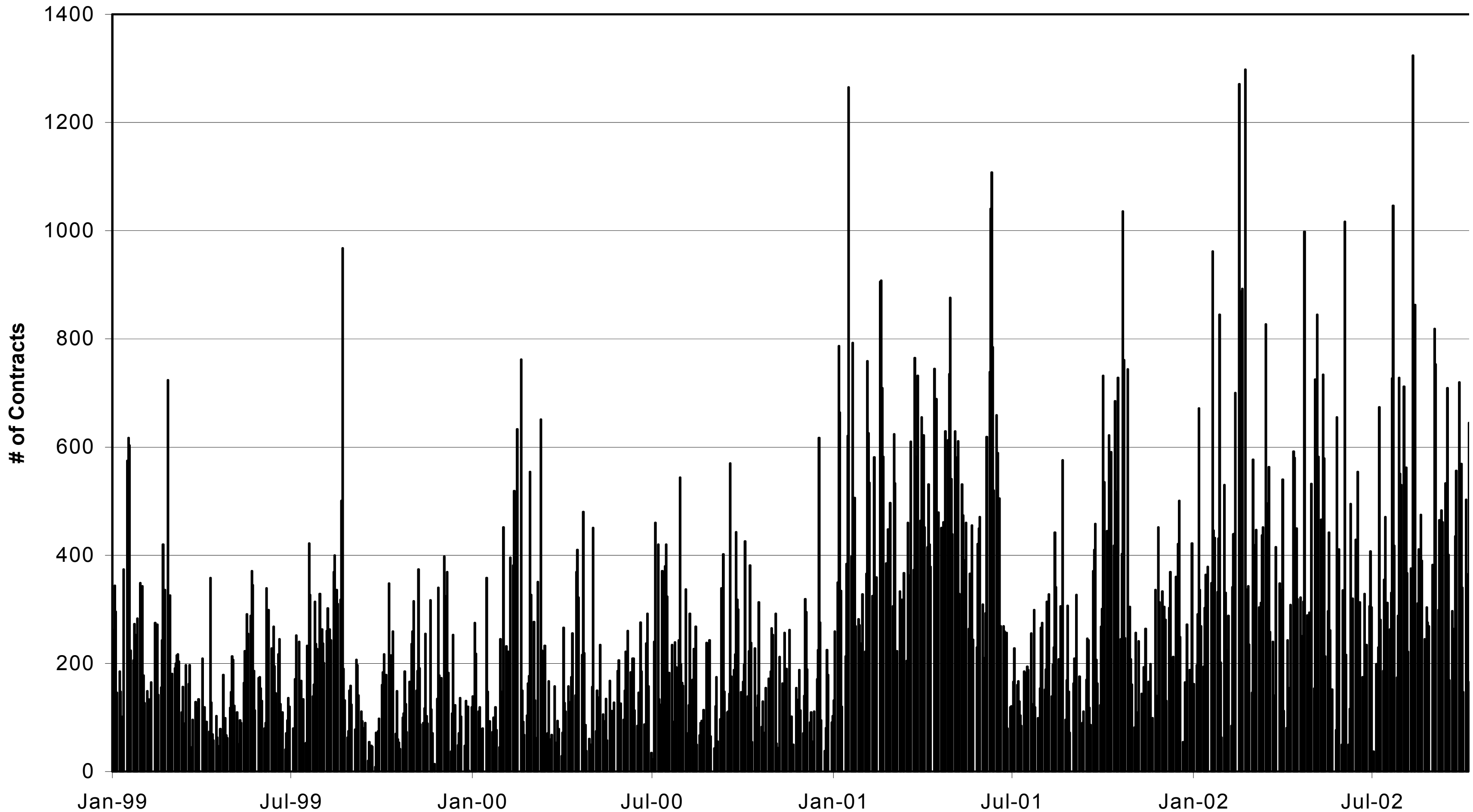

Figure 2: Fluid Milk Market and Support Prices

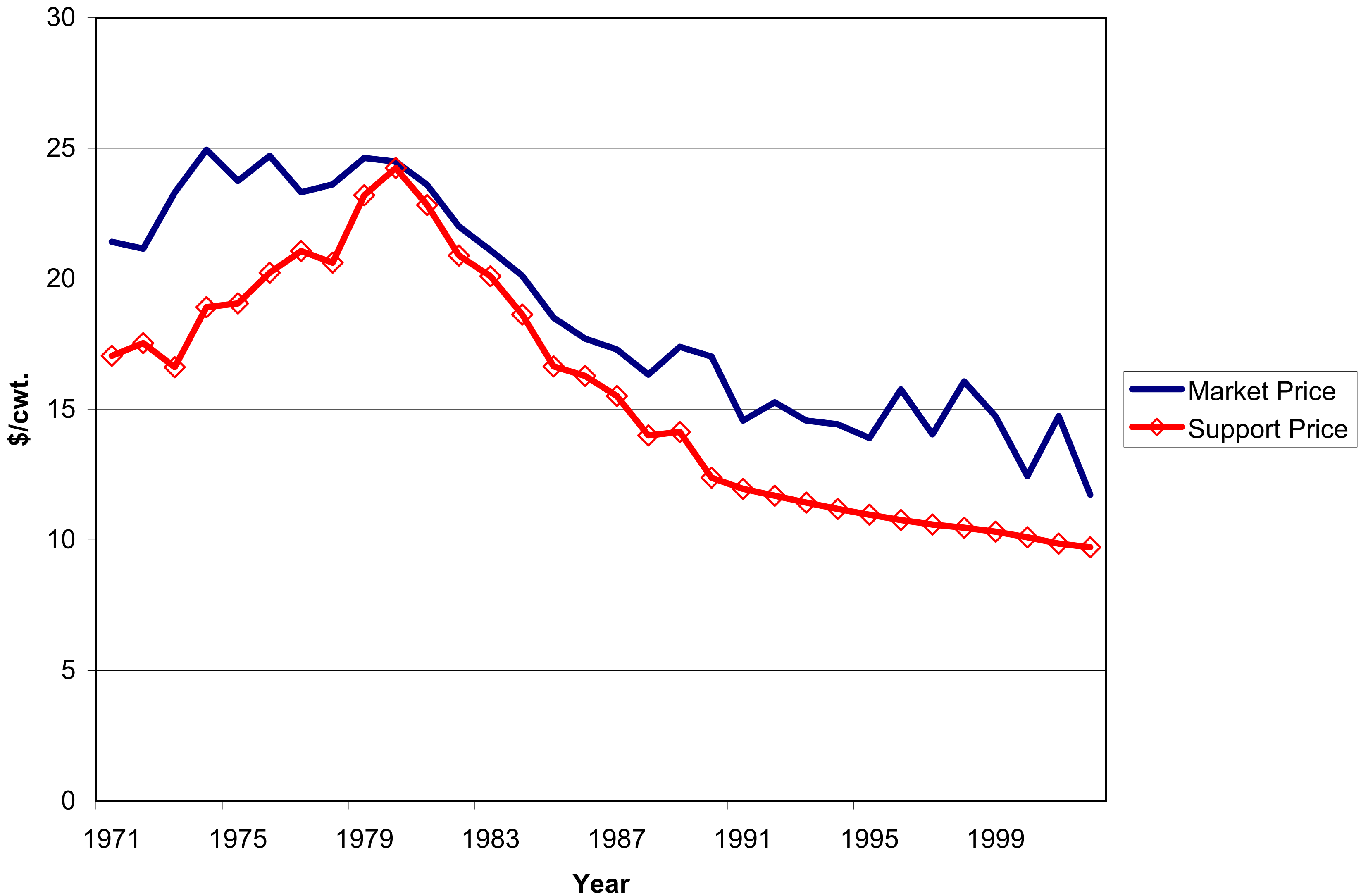

Table 1. DOPP Participation by Round and Number of Contracts.

	CME 200,000 Pound Options		Other Options[1]	
Round	**Producers**	**Contracts**	**Producers**	**Contracts**
1	160	324	339	1377
2	100	242	29	68
3	415	1013	458	1809
4	291	943	239	733

[1]Includes CME's 50,000 and 100,000 lb put options, NYBT 100,000 and 200,000 lb put options and CME's Class IV milk put options.

Table 2: Single Equation Regression Results for the Effect of DOPP Volume on Total Trading Volume

	Dependent Variable		
	Futures Volume	Put Volume	Call Volume
Intercept	127.5 (0.001)	18.55 (0.001)	16.13 (0.001)
DOPP Volume	0.969 (0.419)	1.362 (0.001)	0.014 (0.961)
Time Trend	0.298 (0.001)	0.028 (0.001)	0.036 (0.001)
R^2	0.174	0.060	0.052

p-values in parentheses

Table 3a: **Intra-Day Options Error Averages: January 1999 – October 2002.**

Option Type	Mean Error	Std Error	Observations	T-stat
DOPP Puts	6.20	0.169	1,158	36.70
Non-DOPP Puts	-0.26	0.088	5,146	-2.93
Calls	-0.65	0.096	3,851	-6.85

Table 3b: Intra-Day Options Error Averages During Round 1: January 20, 1999 – June 23, 1999.

Option Type	Mean Error	Std Error	Observations	T-stat
DOPP Puts	4.96	0.342	203	14.49
Non-DOPP Puts	0.06	0.177	663	0.35
Calls	-0.88	0.254	385	-3.46

Table 3c: Intra-Day Options Error Averages During Round 2: May 12, 1999 – January 23, 2001.

Option Type	Mean Error	Std Error	Observations	T-stat
DOPP Puts	4.67	0.381	168	12.28
Non-DOPP Puts	-0.11	0.385	467	-0.28
Calls	0.99	0.176	676	5.61

Table 3d: Intra-Day Options Error Averages During Round 3: March 30, 2001 – January 17, 2002.

Option Type	Mean Error	Std Error	Observations	T-stat
DOPP Puts	6.14	0.269	543	22.78
Non-DOPP Puts	-0.28	0.149	1645	-1.90
Calls	-1.78	0.271	902	-6.57

Table 3e: Intra-Day Options Error Averages During Round 4: May 22, 2002 – October 31, 2002.

Option Type	Mean Error	Std Error	Observations	T-stat
DOPP Puts	8.43	0.321	244	26.26
Non-DOPP Puts	0.05	0.251	516	0.21
Calls	-0.39	0.163	594	-2.39

Table 4: Intra-Day Options Error Averages for Calls and Non-DOPP Puts During a DOPP Period and Non-DOPP Period

Option Type	During DOPP	Not DOPP
Non-DOPP Puts	-0.136	-0.471
	(-1.28)	(-3.07)
	Se=0.1065	Se=0.1533
	N=3,291	N=1,855
Calls	-0.589	-0.784
	(-4.87)	(-5.07)
	Se = 0.1209	Se=0.15448
	N=2,557	N=1,294

t-stats in parentheses.

Table 5: DOPP Broker Means

Broker Id	Mean Error	Std Error	Observations	T-stat
89	7.71	0.643	101	11.99
91	7.26	0.336	351	21.61
94	5.92	0.338	291	17.06
98	8.67	0.429	251	20.20
99	6.12	0.796	49	7.69
100	5.71	0.734	49	7.78
101	1.33	.	3	.
103	-1.00	0.632	5	-1.58
104	5.89	0.730	38	8.07
106	5.42	0.709	36	7.63
107	4.67	0.505	64	9.24
109	3.56	1.074	25	3.31
110	4.55	0.277	281	16.46
112	3.89	0.465	80	8.36
115	6.56	0.922	18	7.11
117	1.63	0.905	8	1.80
118	2.18	0.732	33	2.98
122	5.75	1.234	8	4.65
124	-4.00	.	2	.
126	6.67	1.447	12	4.60
131	2.67	.	3	.
132	3.27	0.278	114	11.76

References

Amihud, Y., H. Mendelson, and Lauterbach, B. (1997) "Market Microstructure and Security Values:Evidence from the Tel Aviv Stock Exchange." *Journal of Financial Economics,* 45, 365-90

Andersen, R. "Some Determinants of the Volatility of Futures Prices." *Journal of Futures Markets*, 5(1985): 332-348.

Berkman, H. and Eleswarapu, V. (1998) "Short-Term Traders and Liquidity: a Test Using Bombay Stock Exchange Data." *Journal of Financial Economics*, 47, 339-55

Black, F. "The Pricing of Commodity Contracts." *Journal of Financials Economics*, 3(1976): 167-179.

Blume, L., Easley, D., and O'Hara, M. (1994) "Market Statistics and Technical Analysis: the Role of Volume." *Journal of Finance*, 49, 153-89

Buschena, D., and L. Ziegler. "Reliability of Options Markets for Crop Revenue Insurance Rating." *Journal of Agricultural and Resource Economics.* 24(1999):398-423.

Campbell, John Y., Lo, Andrew W., and MacKinlay, A. Craig, "*The Econometrics of Financial Markets*" 1997 Princeton University Press, P100

Cox, Thomas L., Chavas, Jean-Paul, and Jesse, Edward V., "Regional Impacts of Reducing Dairy Price Supports and Removing Milk Marketing Orders in the U.S. Dairy Sector." University of Wisconsin-Madison Staff Paper No. 377, Revised February 1997, 32p.

Cropp, Bob, "Dairy Price Support Program Options." University of Wisconsin-Madison. http://www.aae.wisc.edu/future/publications/supportprogram_cropp.pdf

Ederington, L. and J. Lee. "The Creation and Resolution of Market Uncertainty: The Impact of Information Releases on Implied Volatility." *Journal of Financial and Quantitative Analysis*, 31(1996): 513-539.

Fackler, P.L. and R.P. King. "Calibration of Option-Based Probability Assessments in Agricultural Commodity Markets." *American Journal of Agricultural Economics*. 72(February, 1990):73-83.

Fortenbery, T. and D. Sumner. "The Effects of USDA Reports in Futures and Options Markets." *Journal of Futures Markets*, 13(1993): 157-174.

Hull, John. "*Fundamentals of Futures and Options Markets, Prentice Hall*, 4th Edition, Summer, 2001.

Gardner, Bruce L., "Commodity Options for Agriculture", *American Journal of Agricultural Economics*, 59, (Dec 1977), 986-992.

Kenyon, D., K. Kling, J. Jordan, W. Seale, and N. McCabe. "Factors Affecting Agricultural Futures Price Variance." *Journal of Futures Markets*, 7(1987): 73-91.

Kyriacou, K. and B. Mase (2000) "Rolling Settlement and Market Liquidity", *Journal of Applied Economics*, 32, 1029-1036

McNew, K. and J. Espinosa. "The Informational Content of USDA Crop Reports: Impacts on Uncertainty and Expectations in Grain Futures Markets." *Journal of Futures Markets*, 14(1994): 475-492.

Monroe, M. "The Profitability of Volatility Spreads Around Information Releases." *Journal of Futures Markets*, 12(1992): 1-9.

Schwert, G. and Seguin, P. (1993) "Securities Transaction Taxes: an Overview of Costs, Benefits and Unresolved Questions." *Financial Analysts Journal*, 49, 27-53.

Sherrick, B. J., P. Garcia, and V. Tirupattur. (1996) "Recovering Probabilistic Information From Options Markets: Tests of Distributional Assumptions." *Journal of Futures Markets*. 16, 545-560.

Umlauf, S. (1993) "Transaction Taxes and Stock Market Behavior: the Swedish Experience." *Journal of Financial Economics*, 33, 227-40.

United States Congress. "Food Security Act of 1985." Pub. L. 99-198, 99 Stat. 1535, 7 U.S.C. 1631. Government Printing Office: Washington, D.C. 1985.United States Senate. "Food, Agriculture, Conservation, and Trade Act of 1990."
S.2830. Government Printing Office: Washington, D.C. 1990.

United States House of Representatives. "Federal Agriculture Improvement and Reform Act of 1996." H.R. 2854. Government Printing Office: Washington, D.C. 1996.

United States House of Representatives. "Farm Security and Rural Investment Act of 2002." H.R. 2646. Government Printing Office: Washington, D.C. 2002.

Vandeveer, M., Blayney, D., Buschena, D., Crawford, T, Heifner, R., and Maynard, L. An Evaluation of the Dairy Options Pilot Program: A Report to the Risk Management Agency, USDA. Draft: June 8, 2004.
