NCCC-134

APPLIED COMMODITY PRICE ANALYSIS, FORECASTING AND MARKET RISK MANAGEMENT

Ethanol Futures: Thin but Effective? — Why?

by

Roger A. Dahlgran

Ethanol Futures: Thin but Effective? — Why?

Roger A. Dahlgran*

---

* Roger Dahlgran (dahlgran@u.arizona.edu) is an Associate Professor in the Department of
Agricultural and Resource Economics, 403C Chavez Bldg, University of Arizona, Tucson,
Arizona 85721-0023.

Ethanol Futures: Thin but Effective? — Why?

Practitioner's Abstract

This study examines the paradox where the ethanol futures market provides effective hypothetical hedges yet the use of this market is shunned by those with ethanol cash market positions because of its limited volume and open interest. Examining this issue requires describing ethanol cash, futures, and swaps markets, and ethanol contracting practices. We observe that ethanol futures open interest is about two percent of annual U.S. usage compared to nine percent in gasoline markets. We also observe that an attempt by a single refiner to fully hedge its production would significantly alter the volume/open interest profile of the ethanol futures market. In this respect, the ethanol futures market is thin. The ethanol futures market is nonetheless efficient except in the final month of a contract's life. We examine causality relationships between the ethanol futures and swaps markets and find that the futures market adjusts to swaps market disequilibrium but the converse does not hold. The implications of these findings are (1) because futures equilibrium open interest adjusts to changes in swaps equilibrium open interest, the futures price reflects conditions in the deeper swaps market as well as in the futures market, (2) because of (1) using the futures settlement price for marking swaps to market provides secure bonding in the over-the-counter ethanol derivatives (swaps) market, and (3) inefficiencies in the futures market during the last month of a contract's life are likely due to the swaps market's use of the cumulative average of the futures prices during the last month of the swap contract's life.

Keywords: ethanol, hedging, swaps, corn crushing, price risk management.

Introduction

A new futures contract's success is typically defined by its trading volume reaching a threshold that provides hedgers with the opportunity to pass their price risk to speculators without suffering a significant pricing penalty. If a new contract's trading volume fails to grow, then speculators are reluctant to enter the market to provide liquidity. Without liquidity, both speculators and hedgers are reluctant to trade because individual transaction-induced price movements may be disadvantageous in the execution of the trade (Joost and Meulenberg, 1997). We wish to examine this issue as it affects hedging in the developing ethanol futures market.

Ethanol futures began trading on the Chicago Board of Trade on March 21, 2005. Average trading volume through December 2008 was 37 contracts per day. Trading was more active in the last half of 2008, when average daily volume was 135 contracts and the most active day saw 646 contracts traded. For comparison, daily trading volume for corn futures over the same period averaged 138,211 contracts with a maximum of 516,000 contracts. Thus, the ethanol futures contract has a relatively modest trading volume and could be described as thin.

Dahlgran (2009) examined the hypothetical hedging performance of the ethanol futures contract over this period and found that the contract provided effective hedging for corn crushing, ethanol storage, and ethanol acquisition. He also found that the ethanol futures contract was a more effective ethanol hedging vehicle than was the gasoline futures contract. This brings us to the question posed by the title of this paper — how does the ethanol futures contract provide

effective hedging in the face of such modest trading volume? This paper addresses this question by examining the ethanol futures and swaps complex.

The objectives of this paper are first to describe the ethanol cash market, the ethanol futures market, and the ethanol swaps market. We will report on trading practices in the ethanol cash market, the thinness of the ethanol futures market, and trading practices in the related over-the-counter ethanol swaps market. The second objective of this paper is to test for efficiency in the ethanol futures market in order to determine if hedgers consistently pay a risk premium to use the ethanol futures market. The third objective is to determine how the depth of the swaps market adds virtual depth to the futures market. This will lead us to the conclusion that the futures market can be thin but yet provide effective hedging as it serves as the public price discovery mechanism for a broader but opaque over-the-counter swaps market.

The Ethanol Cash Market

Since 1996 U.S. ethanol production has grown 20% annually (figure 1). The ban on the gasoline additive MTBE in California and New York beginning in January 2004 and subsequent bans in other states, and the substitution of ethanol for MTBE accounts for most of this growth. MTBE was banned because it is a known carcinogen and mixes easily with ground water. The absence of liability protections for petroleum companies in the contamination of groundwater by MTBE led petroleum companies to focus on ethanol as the most economically viable MTBE substitute.
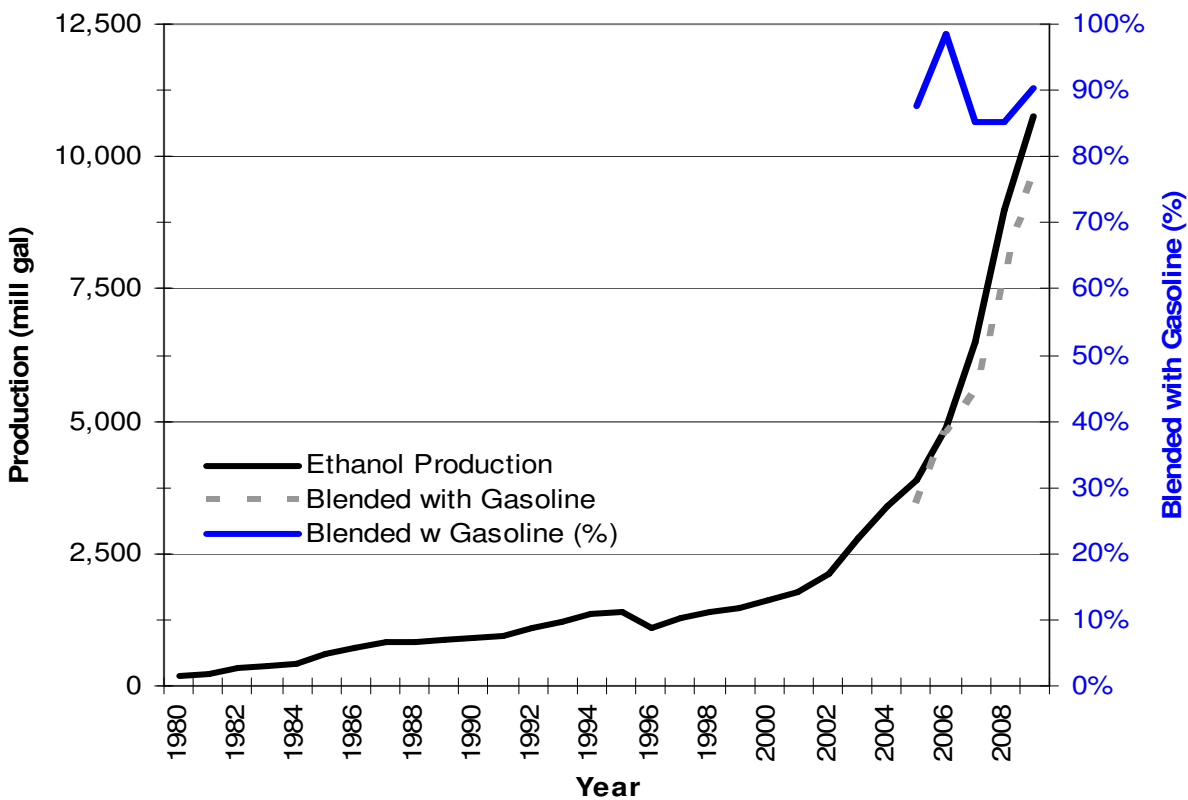

Figure 1 U.S. Ethanol Production and Utilization.

The popular notion expressed by politicians and the media is that ethanol is a substitute for gasoline.[1] This is not the case. To date, ethanol has served primarily as a complement to gasoline. In 2009, 10.76 billion gallons of ethanol were produced by 191 operating U.S refineries (Renewable Fuels Association). About 90% of this ethanol was blended with gasoline, typically at blending facilities located at gasoline pipeline terminals (figure 1). Blending ethanol with gasoline provides three benefits. First, ethanol has a higher octane rating than gasoline meaning that it burns more slowly than gasoline. Fuels that burn quickly result in engine "knock". Blending ethanol with gasoline raises the octane rating of the blend and reduces the incidence of engine knock. Second, ethanol alters the characteristics of the blend so that other lower value petroleum distillates, such as naphthalene, can also be added and sold with the resulting gasoline blend. And third, adding ethanol to gasoline "oxygenates" the blend, causing it to burn more completely thereby reducing the polluting emissions such as carbon monoxide. Currently, retail gasoline in the U.S. is a blend containing from 7 to 10% ethanol.

Most transactions between ethanol refiners and blenders are brokered. In these transactions an ethanol broker typically offers the refiner a fixed price contract for future production and offers ethanol to a blender (frequently a major oil company) under a fixed price contract. Because of the continuous nature of ethanol production and blending, both refiners and blenders see advantages in using "strip" contracts covering three to six months of production and utilization. Other contracting scenarios also occur. These include major oil companies offering forward contracts to large ethanol refiners, and some ethanol refiners selling some of their production on the cash market capping the anticipation of higher spot prices.

Ethanol Futures Markets

The ethanol futures contract was developed to help ethanol refiners and blenders manage ethanol price risk. Brokers also use these markets to manage the price risk of negotiating contracts between refiners and blenders. These risks occur during negotiations between the counter parties.

The ethanol futures contract calls for the delivery of 29,000 gallons (approximately one rail car) of ethanol meeting The American Society for Testing and Materials standard D4806 for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel plus California standards. Trading takes place on both an open outcry and an electronic platform with the electronic platform trading overnight and then trading simultaneously with the open outcry platform during the day. Traded contracts mature in each calendar month and for three years forward. The last trading day for each maturity is the third business day of the delivery month. Contract settlement occurs by either physical delivery, or exchange for physicals, or exchange for risk, but not by cash settlement.

For the first year and a half following the introduction of the ethanol futures contract, a market maker was used to provide market liquidity and to insure tight bid-ask spreads in this very small market. This arrangement has been discontinued as growth in the ethanol futures market has made it unnecessary. Ethanol futures open interest and trading volume is indicated in figure 2.

---

[1]   See for example President Bush's "Twenty in Ten" initiative outlined in the 2007 State of the Union Address. This initiative will "… require 35 billion gallons of renewable and alternative fuels in 2017 …. In 2017, this will displace 15% of projected annual gasoline use" (The White House, Jan 23, 2007).
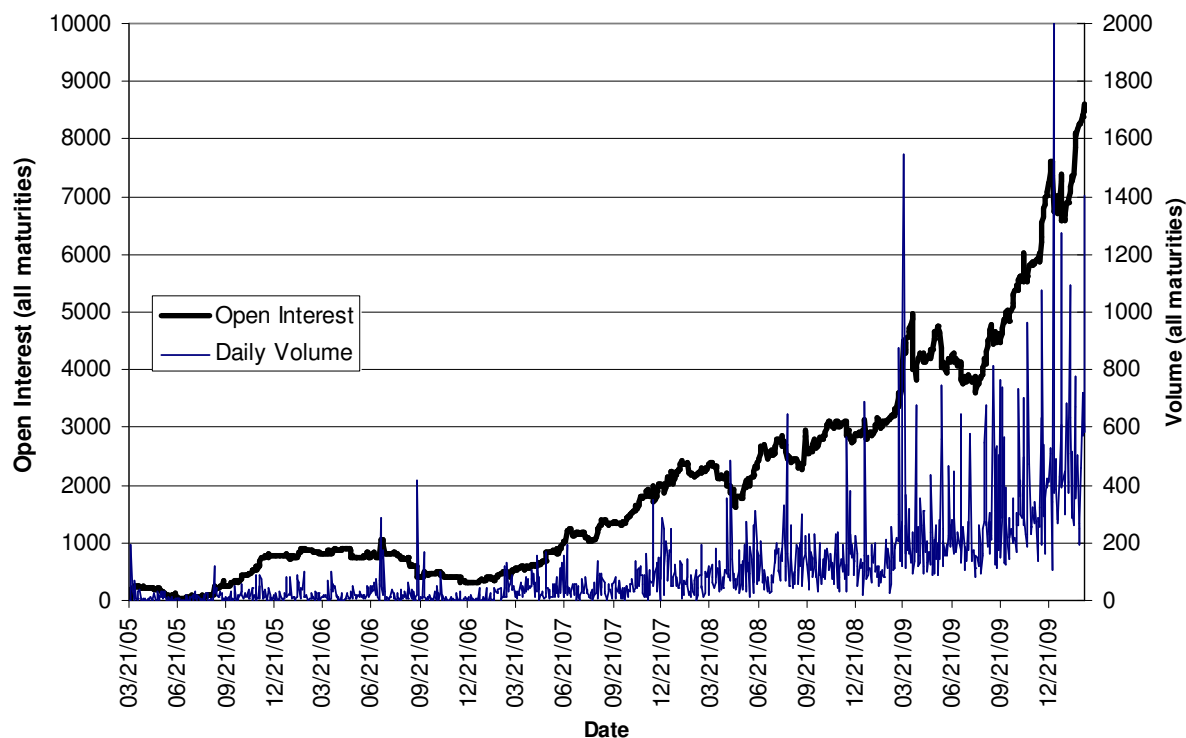
Figure 2. Trading volume and open interest in ethanol futures, all maturities.

Table 1. Measures of ethanol hedging effectiveness.

	Hedge Effectiveness / Horizon				
Type of Hedge	**1 wk**	**2 wks**	**4 wks**	**8 wks**	**13 wks**
Soybean crushing[a]	0.34	0.55	0.74		0.87
Corn crushing[b]	0.45	0.43	0.64	0.78	
Ethanol Inv with Ethanol Futures[b]	0.002	0.29	0.66	0.85	
Ethanol Inv with RBOB Futures[b]	0.004	0.02	0.19	0.36	

a/ Source: Dahlgran (2005).
b/ Source: Dahlgran (2009).

By February of 2010, open interest in all maturities of the ethanol futures contracts had grown to 8,500 contracts and daily trading volume averaged 400 contracts.

Ethanol Futures – How Effective?

Dahlgran (2009) evaluated the effectiveness of hypothetical ethanol hedges using the new ethanol futures markets (table 1). The columns of table 1 indicate hedges of various lengths because hedging studies generally find that hedging effectiveness increases with the length of the hedge. The rows of table 1 show different types of hedges.

For comparison the first row of table 1 indicates the effectiveness of the soybean crush hedge, a hedge that utilizes deep and liquid futures markets (Dahlgran, 2005). The effectiveness of this hedge depends on its length and varies from 0.34 to 0.87. These findings closely match those of similar studies (Garcia, Roh and Lethold, 1995; Fackler and McNew, 1993).

The second row of table 1 shows the effectiveness of corn crushing hedges. Comparison with the first row of table 1 indicates that the corn crush hedge and the soybean crush hedge have similar price risk reduction capabilities. Thus, the effectiveness of the hypothetical corn crush hedge is at a level that is commercially acceptable in a similar processing sector.

The third row of table 1 examines the effectiveness of using the ethanol futures contract for inventory hedges. These effectiveness levels are applicable for either an ethanol broker who wants to manage price risk while negotiating a contract, or a blender (refiner) who wants to manage price risk for anticipated ethanol purchases (sales). This row shows that for a one week hedge horizon, the ethanol futures contract does not offer a level of price risk reduction that is commercially or statistically significant. Interviews with risk managers in the ethanol sector indicate that hedge horizons are typically from three to six months. For these longer hedge horizons, the level of price risk protection is commercially and statistically significant.

For comparison, the fourth row of table 1 shows the effectiveness of using gasoline futures to cross hedge the price risk of ethanol inventory holding or anticipated purchases as studied by Franken and Parcell (2003). Comparison of the third and fourth rows of table 1 indicates that the ethanol futures contract provides greater ethanol price risk protection than does the gasoline futures contract.

In summary, table 1 shows that, at least hypothetically, the ethanol futures contract is an effective price risk management tool that ethanol refiners, blenders, and brokers can use.

Ethanol Futures – How Thin?

Pennings and Muelenberg (1997) point out " … in thin markets, transactions of individual hedgers may have significant price effects and can affect hedging effectiveness." While Nelson and Turner (1995) did not detect this effect in their experimental study, it is widely perceived to exist and risk managers in the ethanol industry explicitly cite it as a reason for not using the ethanol futures market.

Some simple arithmetic provides a perspective on the thinness of the ethanol futures market. The annual production of the 191 U.S. ethanol refineries in operation in March of 2010 is equivalent to 413,500 contracts while ethanol futures open interest in all maturities is 8,500 contracts so futures open interest represents two percent of annual production. The corresponding statistic for gasoline futures is nine percent.

Alternatively, annual average production for the 191 operating refineries is 56.3 million gallons per refinery. A 100-car unit train is equivalent to 2.9 million gallons (29,000 gal per car) so the average plant produces roughly 1.6 unit trains of ethanol per month. Figure 3 shows average daily futures volume and open interest by months-to-maturity for 2008 and 2009 and the 100 contracts corresponding to a single unit train. This figure demonstrates that if a single refiner or blender wanted to hedge a single unit train, (less than one plant's monthly production), then this action would significantly alter the market's volume and open interest profile. In this regard, these markets could be described as thin.
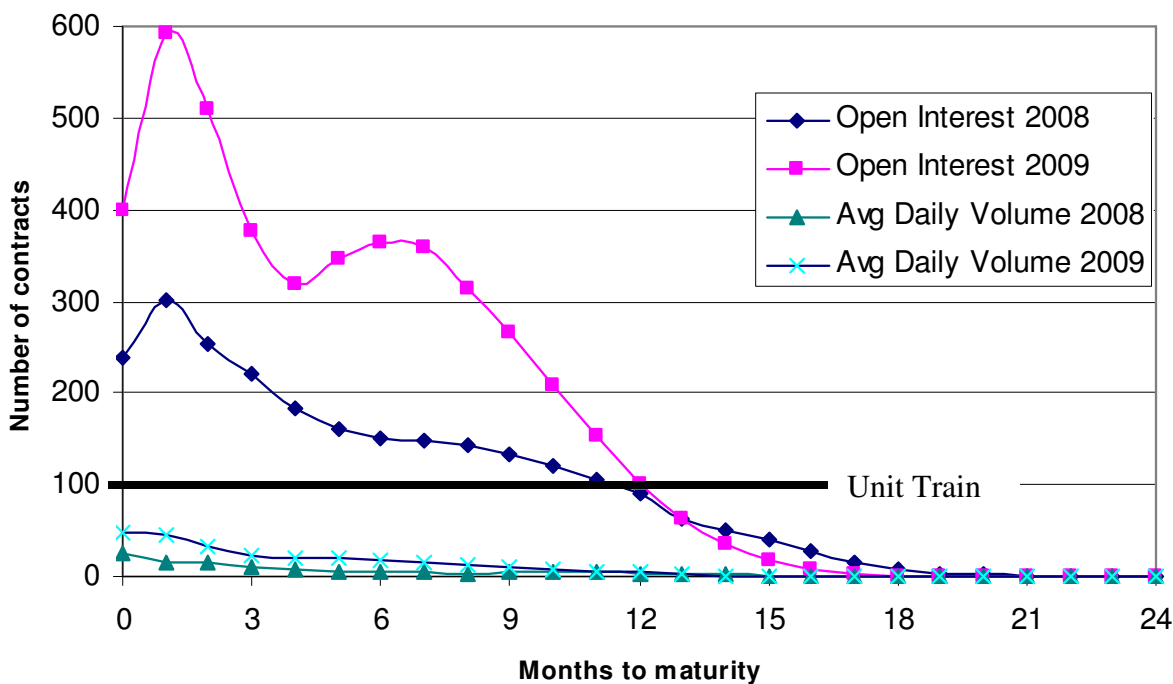
Figure 3. Ethanol futures: average daily volume and open interest by maturity, 2008 and 2009.

Ethanol Futures – How Efficient?

If we accept the notion that the ethanol futures market is thin, then does it follow that they are also inefficient? To answer this question we first distinguish between allocative and informational efficiency (Fackler and Goodwin, 2001).[2] Allocative efficiency in futures markets requires

---

[2] One might be tempted to differentiate between spatial and intertemporal arbitrage based on the notion that spatial arbitrage is bi-directional, while storage only moves commodity forward through time. Such a

(1a) $F_{Tt} \le P_t + C_{Tt}$

where F_{Tt} is the futures price at time t for delivery at time T, P_t is the spot price at time t, and C_{Tt} is the cost to arbitrage the spot market against the futures market   When transactions costs (δ) are included, the allocative efficiency condition becomes

(1b) $|\, F_{Tt} - P_t - C_{Tt}\,| \le \delta.$

If arbitrage transactions are costless, then allocative efficiency requires equality in (1a). This equality maximizes the risk transfer capabilities of futures markets as futures and spot prices move in lockstep and hedgers substitute basis risk for price risk.

Informational efficiency was defined by Fama (1970, p. 383) with "A market in which prices always 'fully reflect' available information is called 'efficient'." Fama further defined 'available information' so that a market can be classified as weak-form, semi-strong-form, or strong-form efficient. If markets are found to be inefficient in some sense, then speculators possessing the corresponding type of information can earn rents.

Bigman, Goldfarb and Schectman (1983) applied Fama's efficiency definition to futures markets with

(2a) $E\,(P_T - F_{Tt} \mid \Omega_t\,) = 0$

where Ω_t represents the information set at time t appropriate to the type of efficiency defined. Because F_{Tt} is known at time t, efficiency requires

(2b) $F_{T,t} = E\,(\,P_T \mid \Omega_t\,).$

When $F_{T,t} > (<)\, E\,(\,P_T \mid \Omega_t\,)$ long (short) hedgers can expect to pay a risk premium for hedging. Thus, consistently inefficient ethanol futures markets can drive hedgers to use cheaper contracting markets.

A more general efficient market hypothesis applicable to any financial asset is

(2c) $F_{T,t} = E\,(\,F_{T,t+1} \mid \Omega_t\,).$

We distinguish between (2b) and (2c) as long-run and short-run informational efficiency, respectively, because (2b) involves current expectations about the contract maturity period while (2c) involves current expectations about the next market period. [3] Informational efficiency is

---

distinction overlooks that a lack of storage incentives (i.e. $F_{Tt} - P_t < C_{Tt}$) is arbitraged by reallocating commodity away from storage to current consumption.   This reallocation drives down the spot price and reduced inventories increases the futures price. These price movements are consistent with "reverse storage" arbitrage.

[3]   The expectation of futures and spot price convergence at contract maturity makes (2b) and (2c) equivalent. If $F_{Tt} = E_t(\,F_{T,t+1} \mid \Omega_t\,)$, then $F_{T,t+1} = E_t(\,F_{T,t+2} \mid \Omega_t\,)$, $F_{T,t+2} = E_t(\,F_{T,t+3} \mid \Omega_t\,)$ … and $F_{T,T-1} = E_t(\,F_{T,T} \mid \Omega_t\,)$. Continuous substitution gives $F_{Tt} = E_t(\,F_{T,T} \mid \Omega_t\,)$. To establish the equivalence, we need $E_t(\,F_{T,T} \mid \Omega_t\,) = E_t(\,P_T \mid \Omega_t\,)$. Such an expectation would be rational in the face of a certainty of convergence of spot and futures prices at contract maturity. A certainty of convergence requires unfettered arbitrage, $\delta = 0$, and $C_{Tt} = 0$ as $t \to T$ in (1b).

more general than allocative efficiency in that a futures market for a seasonally-produced commodity may be allocatively efficient for a pre-harvest contract but not for a post-harvest contract and yet be informationally efficient in both.[4]

Many researchers have used Fama's definitions to investigate the efficiency of futures markets. Early studies (Bigman, Goldfarb and Schectman, 1983; MacDonald and Hein, 1993) estimated the regression model $P_T = \alpha + \beta F_{Tt} + \varepsilon_t$ then tested the null, efficient-market hypothesis that $\alpha = 0$ and $\beta = 1$. Recent refinements recognize the possible integration of the futures and spot price series and the possibility that these series are cointegrated (Bessler and Covey, 1991; Chowdhury 1991; Lai and Lai, 1991). Current interpretations of the efficient-market hypothesis necessitate that a linear combination of the spot and futures prices is stationary (Enders, 1995, p. 357). Alternatively stated, "The concept of cointegration posits that two efficient markets for the same asset whose prices are each nonstationary by themselves should have an equilibrium relationship which is stationary." (Schroeder and Goodwin, 1991, p. 686)

Ethanol futures market efficiency can be analyzed with several different models. For example, we could fit

(3a) $P_{T(m)} = \alpha + \beta F_{m,T(m)-\tau} + \varepsilon_m$, m = 1, 2, 3, … M

where m represents an element of a set of M available contract maturities, T(m) converts the contract's maturity to a point on a timeline that corresponds to the contract's last trading date, and $F_{m,T(m)-\tau}$ designates the price of a futures contract with maturity m that is quoted τ days prior to maturity. Efficiency is tested with H_0: $\alpha = 0$, $\beta = 1$. The parameter τ can be varied to test for efficiency at various points in the contract's life.

In addition to (3a) we could also fit

(3b) $F_{m,m} = \alpha' + \beta' F_{m,T(m)-\tau} + \varepsilon_m$, m = 1, 2, 3, … M

which allows us to test whether the futures price quoted τ days before contract maturity is the futures price expected to prevail at contract maturity. Differences in results between (3a) and (3b) would be due to lack of convergence between $P_{T(m)}$ and $F_{m,m}$. The model does not explain the cause of the lack of convergence, though the possibilities include locational differences and delivery costs. We could also fit (3b) for the RBOB (gasoline) futures contract to compare the efficiency of a thin market (ethanol) to that of a similar though liquid market (gasoline).

Before fitting models (3a) and (3b) we test for unit roots (H_0: $\gamma = 0$) and the possibility of cointegrated series with the following

(4a) $\Delta P_m = \gamma P_{m-1} + e_m$

(4b) $\Delta F_{m,m} = \gamma F_{m-1,m-1} + e_m$

---

[4]   Suppose the price of the pre-harvest contract is $P_t + C_{Tt}$ while the post-harvest contract, in anticipation of the harvest, has a significantly lower price. Both could be informationally efficient but the post-harvest contract would fail to be classified as allocatively efficient.

(4c) $\Delta F_{m,T(m)-\tau} = \gamma\, F_{m,T(m-1)-\tau} + e_m$

where $\Delta F_{m,m} \equiv F_{m,m} - F_{m-1,m-1}$ (i.e., the change in the final settlement prices of the maturing contracts) and $\Delta F_{m,T(m)-\tau} \equiv F_{m,T(m)-\tau} - F_{m-1,T(m-1)-\tau}$ (i.e., the change in the price of the imminently maturing futures contract τ days from its final settlement).

The results of fitting (4a) through (4c) for various values of τ are summarized in table 2. These results clearly and consistently indicate that the unit root hypothesis cannot be rejected for either ethanol (a thin market) or gasoline a not-so-thin market, regardless of τ, the time to contract maturity when the futures price is drawn.

We proceed under the assumption that each of the data series in (4a), (4b), and (4c) are integrated. If the series are also cointegrated, then efficiency test results from fitting (3a) or (3b) are biased. Under these conditions, a vector error correction model can be used to test for the efficiency condition as the equilibrium relationship between the two integrated series. Specifically, we estimate

$$ (5) \qquad \begin{bmatrix} \Delta P_m \\ \Delta F_{m,T(m)-\tau} \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} \begin{bmatrix} 1 & -\beta & -\alpha \end{bmatrix} \begin{bmatrix} P_{m-1} \\ F_{m-1,T(m-1)-\tau} \\ 1 \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,m-1} \\ \varepsilon_{2,m-1} \end{bmatrix}. $$

Cointegration is tested by the rank of Π and efficiency is tested by $H_0\!: \alpha = 0,\ \beta = 1$.

Table 2. Unit root test results.

| τ (wks)	M	$\hat{\gamma}$	s.e. $\hat{\gamma}$	Pr > DF	M	$\hat{\gamma}$	s.e. $\hat{\gamma}$	Pr > DF
			Spot Ethanol Prices					
	35	-0.0103	0.0180	0.4618				
			Ethanol Futures				Gasoline Futures	
0	54	-0.0053	0.0206	0.5893	45	-0.0107	0.0196	0.4738
1	54	-0.0037	0.0189	0.6116	45	-0.0102	0.0207	0.4954
2	54	-0.0031	0.0188	0.6218	45	-0.0096	0.0181	0.4799
3	54	-0.0036	0.0181	0.6096	45	-0.0154	0.0203	0.3837
4	54	-0.0057	0.0194	0.5764	45	-0.0117	0.0189	0.4438
8	54	-0.0020	0.0149	0.6333	44	-0.0092	0.0185	0.4941
13	53	-0.0040	0.0155	0.5888	43	-0.0083	0.0166	0.4924
17	52	-0.0029	0.0143	0.6088	42	-0.0064	0.0166	0.5381
22	51	-0.0032	0.0148	0.6031	40	-0.0083	0.0174	0.5015
26	50	-0.0002	0.0142	0.6744	40	-0.0068	0.0179	0.5397
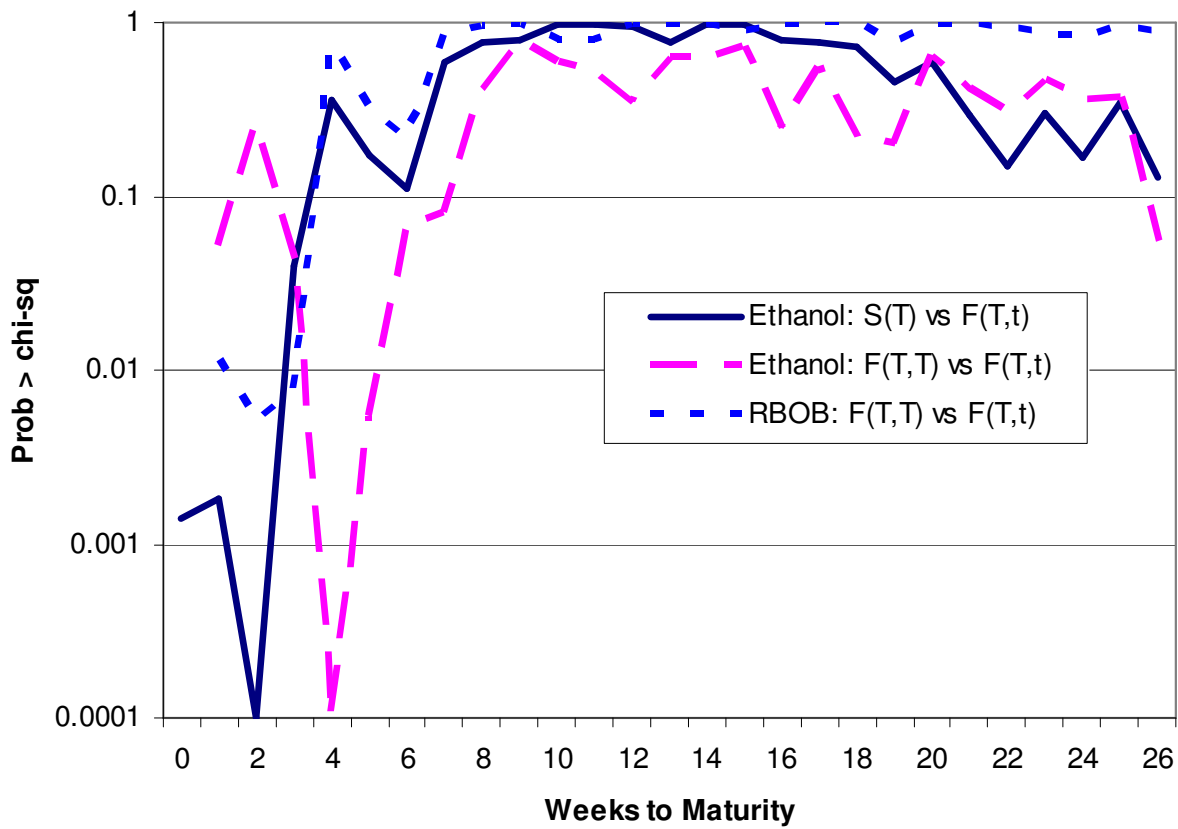
Figure 4. Significance levels for efficiency tests, for various times to maturity.

The results of these tests are summarized in figure 4. The horizontal axis indicates the number of weeks prior to contract maturity when the futures market is observed. The vertical axis shows the test statistic (Prob $> \chi^2$) for H_0: $\alpha = 0$, $\beta = 1$, in the cointegrating relationship of (5). Small values lead to the rejection of the hypothesis. The model was applied to (a) ethanol spot prices at contract maturity versus ethanol futures prices τ days prior to contract maturity [Ethanol: S(T) vs F(T,t)], (b) ethanol futures prices at contract maturity versus ethanol futures prices τ days prior to contract maturity [Ethanol: F(T,T) vs F(T,t)], and (c) gasoline futures prices at contract maturity versus gasoline futures prices τ days prior to contract maturity [RBOB: F(T,T) vs F(T,t)].

Figure 4 indicates the following. Market efficiency is rejected for the last month of the ethanol contract's life, a time when most hedgers close positions to avoid making or taking delivery under the contract. This conclusion applies whether one compares the futures price with either the contract maturity futures price or the contract maturity spot price. Before the futures contract enters this final month, efficiency cannot be rejected. This conclusion also applies whether one compares the futures price with the contract maturity futures price or the contract maturity spot price.

The gasoline futures market also displays this dichotomy of inefficiency in the contract's final month, but efficiency over the longer term. This relationship is less pronounced in the gasoline futures market and the test statistics for rejection of the efficiency hypothesis test are generally less significant. This result is noteworthy because the gasoline futures market is not generally thought of as thin. These results and their comparisons lead us to conclude that the thinness of the ethanol futures market does not necessarily imply that it is inefficient.

Ethanol Swaps

The ethanol swaps market provides an explanation of how the ethanol futures market can be efficient except during its last month, offer effective hedging opportunities, and yet still be small relative to its hedging applications.

Swap contracts are fundamentally forward contracts that are used, like futures contracts, to establish a fixed price for future delivery (CME Group, 2009). As compared to futures contracts, forward contracts have the advantage of being more customizable. Forward contracts are negotiated in an opaque market where prices and quantities are not observable but on December 4, 2006 the CME Group began a clearing service for ethanol calendar swaps. Subsequent additions to this over-the-counter market included ethanol basis swaps, options on calendar swaps, and cash settled options on ethanol futures. These exchange-cleared derivative contracts are for 14,500 gallons of ethanol, and they mature every month up to 24 months forward. The calendar swap is the most important of these contracts and approximately forty percent of all ethanol calendar swaps are now exchange cleared.

Exchange-cleared swaps are cash settled only. For marking to market and settlement, they use the futures settlement price for the month after the swap's maturity (i.e., the November swap settles at the December futures price). In the swap's maturity month it is settled at the cumulative monthly average of the spot-month futures settlement price. For example a November swap is settled in November at the cumulative monthly average of the December futures price during the month of November.[5]

Calendar swaps are of two varieties, forward month and previous month. They have identical terms except for how they are settled relative to their stated maturity. A November forward-month calendar swap, for example, will be marked to market at the December ethanol futures price and during the month of November will be cash settled at the cumulative average of the daily settlement prices for the December ethanol futures contract. A November previous-month calendar swap will be marked to market at the November ethanol futures settlement price and will be cash settled in October using the cumulative average of the November futures settlement price during October. Thus, an October forward month swap and a November previous month swap are identical.[6]

Exchange-cleared basis swaps for New York Harbor, Los Angeles Harbor and the Gulf Coast were introduced by the GME Group in October of 2007. These contracts are settled in their final

---

[5] The December contract settles on the third business day of December making the November average of the December futures price more useful than the December average of the three available December futures prices.

[6] Though trivial in this case, this distinction is less so when a futures contract maturity is not available for each calendar month as common in the grain markets.

months at the cumulative monthly average basis (location specific spot price minus futures price). Thus far, volume and open interest in basis swaps has been small.

An exchange-cleared swap transaction works as follows. An ethanol broker negotiates terms with the counterparties in an ethanol transaction. Once the broker has contracts with both parties, the offsetting contracts are submitted to the Chicago Mercantile Exchange for clearing through CME ClearPort. Contracts submitted for clearing have standardized margin requirements, positions are marked-to-market daily at the ethanol futures settlement price except during the final month when the cumulative average of the spot futures contract is used, margin calls to bring margin accounts up to initial levels are made as necessary, and the contracts contain an exchange for risk provision which allows the swap contracts to be converted to futures contracts any time before futures contract maturity. Futures contracts also have an exchange for risk settlement provisions so that futures-swap conversion rights are bi-directional. Because the contracts are entered into off exchange, prices are not available. However, daily volume and open interest are available through the exchange clearing process.

Figure 5 shows volume and open interest for ethanol futures and exchange-cleared swaps from January 2007 through January 2010. Note that the vertical scales are logarithmic and that the swaps market is roughly ten times as large as the futures market in terms of contracts and roughly five times the size of the futures market in terms of gallons of product.[7] This figure shows the steady growth of both markets.

To analyze price discovery relationships between the futures and the swaps markets, we would ideally use a vector error correction model of the form,

(6a) $\Delta x_t = \Pi\, x_{t-1} + \sum_{i=1}^{p} \Gamma_i\; \Delta x_{t-i} + e_t$

where x is a vector of futures and swap prices at time t. In this ideal scenario, we could reach conclusions about the source of price discovery based on the rank of Π and the values of π_{ij}. The model cannot be estimated because swap transaction prices are not observable.

As an alternative, we resort to Telser's (1958) net-hedging/net-speculation model of the simultaneous determination of futures prices and open interest so (6a) is formulated in open interest rather than prices. Also, because open interest does not display the random walk behavior that characterizes prices,[8] the error correction and cointegration aspects of the model are unnecessary. Hence (6a) reduces to a causality model of the form

(6b) $x_t = \gamma + \sum_{i=1}^{p} \Gamma_i\; x_{t-i} + e_t,$

where x_t is a 2 x1 vector of futures and swaps open interest. This specification allows us to estimate and test the process of futures and swaps market equilibration in that, if $\Gamma_{k,1,2} = 0$ for k = 1, 2, … p, then swaps adjustments do not "Granger" cause futures adjustments and if the effects of $\Gamma_{k,2,1} = 0$ for k = 1, 2, … p, then futures adjustments do not "Granger" cause swaps adjustments.

---

[7]   An exchange-cleared swap contract is half the size of a futures contract.
[8]   We will test for and verify this claim.

Before estimating (6b) we incorporate the mean behavior of open interest. Assuming a given maturity and all else held constant except for the passage of time, open interest begins small, builds over the life of the contract, then declines rapidly as the contract expires. To represent this behavior we use a gamma function

(7a) $\gamma(\tau) = \gamma_0\, \tau^{(\alpha-1)} \exp(-\tau/\beta)$

where $\gamma(\tau)$ represents mean open interest τ days before contract maturity, and $\tau = T(m) - t$ (i.e., the time of maturity less the current time). The derivative of a logarithmic transformation of (7) with respect to time is

(7b) $d \ln \gamma(\tau) / dt = -(\alpha-1)/\tau + \beta^{-1}$.

Replacing $\gamma(\tau)$ with the 2 x 1 column vector $x_{m,t}$ which contains futures and swaps open interest for contract maturity m at time t, and relaxing the ceteris paribus assumption results in the causality model

(7c) $\Delta \ln x_{m,t} / \Delta t = a_m + b_m\, \tau_{m,t}^{-1} + \sum_{i=1}^{p} \Gamma_i\, \Delta \ln x_{m,t-i} / \Delta t_{t-i} + e_{m,t}$

where $x_{m,t}$ is a vector of futures and swaps open interests matched by maturity and day.[9]

Table 3 shows the results of estimating (7c) with p equal 3. While the model explains a significant amount of variation in the change in open interest for both futures and swaps, it explains more of the variation in swaps adjustments than in futures adjustments. As these markets have grown, the effects of contract maturities (a_m, m=1,2, … M) are not expected to be constant and the statistical results indicate significant differences. The time to maturity effects (b_m, m=1,2, … M) are also significant.

Before considering additional effects, we tested for unit root in the errors about the maturity and time to maturity effects. The unit root hypothesis was rejected with the probability of a greater Dickey-Fuller statistic of < 0.0001 for futures and 0.0173 for swaps.

Table 3 next shows the effects on futures and swaps open interest of lagged values of futures and swaps open interest. Statistically significant causality is found in three of these four blocks. Specifically, these results indicate that ethanol futures open interest is related to lagged futures open interest and lagged swaps open interest. As it appears that adjustments in swaps equilibrium open interest precede adjustments in futures equilibrium open interest, then swaps market equilibrium Granger causes futures market equilibrium. More simply stated, the futures market adjusts to the swaps market.

Ethanol swaps open interest adjustments are related to lagged swaps open interest adjustments, but not related to lagged futures open interest adjustments. This result implies that the swaps market does not adjust to futures market equilibrium so futures market equilibrium does not Granger cause swaps market equilibrium.

---

[9]   All open interest differences are with respect to time while holding the contract maturity constant. Differences are never computed across maturities.

Table 3. Futures-swaps causality estimation results.

Dependent Variable:	$\Delta \, \mathbf{dln(x_{f,t})} \, / \, \Delta \, \mathbf{t}$ (Futures)		$\Delta \, \mathbf{dln(x_{sw,t})} \, / \, \Delta \, \mathbf{t}$ (Swaps)	
N	10,222		10,222	
R-Sq	0.082		0.488	
RMSE	0.07014		0.04604	
F_{10125}^{96}	9.40***		100.42***	
Maturity Effects	DF	F Value	DF	F Value
a_m, m=1,2, M	44	1.92***	44	7.97***
b_m, m=1,2, M	45	13.03***	45	208.57***
Parameter on	Estimate	Std Err	Estimate	Std Err
$\Delta \, dln(x_{f,t-1}) \, / \Delta \, t_{t-1}$	0.0258*	0.0101	0.0014	0.0066
$\Delta \, dln(x_{f,t-2}) \, / \Delta \, t_{t-2}$	0.0442***	0.0098	-0.0010	0.0064
$\Delta \, dln(x_{f,t-3}) \, / \Delta \, t_{t-3}$	0.0111	0.0098	0.0071	0.0064
$\Delta \, dln(x_{sw,t-1}) \, / \Delta \, t_{t-1}$	0.0796***	0.0160	-0.0356***	0.0105
$\Delta \, dln(x_{sw,t-2}) \, / \Delta \, t_{t-2}$	0.0738***	0.0151	0.0596***	0.0099
$\Delta \, dln(x_{sw,t-3}) \, / \Delta \, t_{t-3}$	0.0176	0.0154	-0.0331***	0.0101

Summary and Conclusions

To summarize, we set out to understand the paradox where ethanol price risk managers were saying in personal interviews, "We don't use ethanol futures … The market is too thin … bid ask spread are too wide ," yet hedging studies indicate that the ethanol futures market can provide hypothetical hedging effectiveness. We first reviewed the effectiveness levels the hypothetical ethanol hedges and observed that the price risk protection that was available from hedging with the ethanol futures contract was statistically significant and commercially attractive.

We then examined ethanol futures market efficiency and observed that during the month prior to contract maturity, the futures contract did not display pricing efficiency while contracts with more than a month to maturity did display pricing efficiency.

Finally we examined the exchange-cleared ethanol swaps market. Exchange-cleared swaps have some unique features, such as exchange for risk, exclusive cash settlement, and settlement at the cumulative average of the settlement price of the nearby futures contact during the swap maturity month. Our results indicate that futures market equilibrium is significantly influenced by recent swaps market adjustments but that the converse does not hold.

The implications of these findings are as follows.

- The notion that risk managers don't use futures because the bid ask spreads are too wide is discredited by the observation that these risk managers instead either directly or indirectly through brokers, use swaps and derivatives where prices are not reported and hence the bid ask spread is unknown. This leaves only thinness as the argument for not using the futures market. We have seen that the futures market is indeed small relative to the amount of hedging that a risk manager for an individual refinery might undertake.

- Our empirical results indicate that futures open interest adjusts to swaps open interest but not vice versa. In a simultaneously determined system, this means that the publicly available futures prices reflect swaps market equilibrium. This finding has two practical implications. First, futures prices reflect equilibrium in the much deeper swaps market rather than just equilibrium in the thinly traded futures market. The exchange for risk provision helps to insure that equilibrium in the swaps market is reflected in the futures market. The second implication of this finding is that swaps are marked to market at relevant valuations so that margin accounts serve as effective performance bonds.

- Our empirical results indicate a consistent break from market efficiency in the ethanol futures contract's final month. This break may be due to the departure of swaps settlement pricing from futures settlement pricing during this period. Specifically, during the final month swaps are settled at the cumulative average of the futures price during the month. Because the futures price reacts to the swaps market, it too should more reflect the cumulative average futures price rather than the expected future spot price.

- We would expect that the exchange for risk provision that allows the conversion of futures to swaps positions and vice versa should create a single equilibration process between both markets. While our results do not indicate a bidirectional causal relationship, they do indicate that the futures price reflects conditions in the much deeper swaps market.

References

Bigman, D., D. Goldfarb, and E. Schectman. "Futures Market Efficiency and the Time Content of Information Sets." *Journal of Futures Markets* 3(1983):321-334.

Bessler, D., and T. Covey. "Cointegration: Some Results on U.S. Cattle Prices." *Journal of Futures Markets* 11(1991):461-474.

Chowdhury, A.R. "Futures Market Efficiency: Evidence from Cointegration Tests." *Journal of Futures Markets* 11(1991):577-589.

CME Group (2009). "An Introduction to Grain Calendar and Basis Swaps" Available online at: http://www.cmegroup.com/trading/commodities/files/AgSwapsWhitePaper.pdf. [Accessed May 18, 2010].

Dahlgran, R.A. "Transaction Frequency and Hedging in Commodity Processing." *Journal of Agricultural and Resource Economics* 30(2005):411-430.

Dahlgran, R.A. "Inventory and Transformation Hedging Effectiveness in Corn Crushing." *Journal of Agricultural and Resource Economics*, 34(2009): 154-171.

Enders, W. *Applied Econometric Time Series.* John Wiley and Sons, New York, NY, 1995.

Fackler, P.L., and K.P. McNew. "Multiproduct Hedging: Theory, Estimation, and an Application*." Review of Agricultural Economics* 15(1993):521-535.

Fama, E. "Efficient Capital Markets: Theory and Empirical Work." *Journal of Finance* 25(1970):383-417

Franken, J.R.V., and J.L. Parcell. "Cash Ethanol Cross-Hedging Opportunities." *Journal of Agricultural and Applied Economics* 35(2003):509-516.

Garcia, P., J.S. Roh, and R.M. Leuthold. "Simultaneously Determined, Time-Varying Hedge Ratios in the Soybean Complex." *Applied Economics* 27(1995):1127-1134.

Lai, K.S., and M. Lai. "A Cointegration Test for Market Efficiency." *Journal of Futures Markets* 11(1991):567-575.

MacDonald, S.S., and S.E. Hein. An Empirical Evaluation of Treasury Bill Futures Market Efficiency: Evidence from Forecast Efficiency Tests." *Journal of Futures Markets* 13(1993):199-211.

Nelson, R., and S. Turner. Experimental Examination of a Thin Market: Price Behavior in a Declining Terminal Market Revisited. *Journal of Agricultural and Applied Economics*, *27*(1995), 149-160.

Pennings, Joost M. E., and Matthew T. G. Meulenberg. "The Hedging Performance in New Agricultural Futures Markets: A Note." *Agribusiness* 13(1997):295-300.

Renewable Fuels Association. "Ethanol Industry Statistics." Available at http://www.ethanolrfa.org/pages/statistics. [Retrieved May 29, 2010.]

Schroeder T.C., and B.K. Goodwin. "Price Discovery and Cointegration for Live Hogs." *Journal of Futures Markets* 11(1991):685-696.

Telser, L.G. (1958). "Futrues Trading and the Storage of Cotton and Wheat." *Journal of Political Economy*, 66(1958):233-255.

The White House. 2007. "State of the Union – Twenty in Ten: Strengthening America's Energy Security" The White House, Washington, DC. Available at http://www.whitehouse.gov/stateoftheunion/2007/initiatives/energy.html. [Retrieved March 25, 2007].