Using the Hog Futures Market to Quantify Threat of Injury

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Executive Summary

The main purpose of this study is to address the question of the threat of injury to the domestic U.S. hog industry. To address this question we turn to the Chicago futures markets, a reliable indicator of how the hog market will unfold for the remainder of 2005. We explain the workings of the lean hog futures market, its relationship to the cash market for slaughter hogs, and why the futures market is so critical to this case. Most hog producers use the futures market directly, or through forward contracting. The futures market is central to the industry and central to this case.

Using price quotes from the Chicago hog and corn futures markets, the Iowa State University *Estimated Livestock Returns* model predicts that U.S. hog producers will earn near record profits in 2005. Given the extraordinarily high-expected profits, there is no imminent threat of injury from imports from Canada.

We came to this conclusion after performing a careful study of the performance of the Chicago Mercantile Exchange (CME) hog futures market. Our conclusion is based on a series of key empirical findings with regard to the lean hog futures and cash markets, and implications for threat of injury from subject imports from Canada. The findings are as follows:

- The Chicago Mercantile Exchange lean hog futures market is the primary price discovery point for hogs in North America. In other words, hog futures prices lead hog cash prices.

- The hog futures market is a good and unbiased predictor of forthcoming hog cash prices, except for very distant forecasts.

- A recent study by Boessen, Lawrence, and Grimes (2004) indicates that a large fraction of the hog industry uses futures prices.[1]

- The unique characteristics of hog and grain futures markets allows hog producers to hedge both their revenue and costs throughout 2005, at attractive levels. The combination of the two futures markets allow us to make precise statements regarding expected hog industry profits over the next 10 months.

- We use actual values of lean hog and corn futures (as of January 31, 2005)[2] to project industry profitability using the Iowa State University *Estimated Livestock Returns* model.[3]

- The lean hog futures market indicates that 2005 will be a very profitable year for U.S. hog producers. Hence, there is no imminent threat of injury from imports from Canada. If all hog farmers choose to hedge with futures or forward contracts, the implication is that the U.S. hog industry will earn about $2.7 billion in 2005.[4]

- Use of the hog futures to forecast cash prices allows us to determine with very high certainty that those farmers who go unhedged and bet on the cash market instead will also earn large profits. We place statistical confidence intervals around current futures price forecasts for 2005 and the prices in these confidence intervals lie well above the breakeven price

[1] See appendix I. Data is taken from Christian Boessen, John D. Lawrence, and Glenn Grimes, "Production and Marketing Characteristics of U.S. Pork Producers - 2003," Agricultural Economics Working Paper 2004-4. Available at http://www.econ.iastate.edu/faculty/lawrence/Final%20Draft%20Survey%20Article%202004.pdf .

[2] We used 2005 futures prices as of January 31st. If instead, we had used 2005 futures as of February 28th, our results would be virtually identical as there was little change in 2005 futures from January 31st to February 28th 2005.

[3] See http://www.econ.iastate.edu/faculty/lawrence/EstRet/Index.html for detailed information on the ISU model.

[4] As an alternative to the direct use of the futures market, it is common in this industry for producers to use forward contracts for both hogs and corn. Forward contracts are typically based on futures prices and they are offered by middlemen, processors or feed companies. Those companies often use the futures market to offset the risk associated with offering the forward contracts to farmers. In principle, forward and futures contracts offer hog producers similar hedging opportunities.

for hog producers. In particular, we are 95% confident that profits for farmers in the cash market will lie between $1.7 and $3.7 billion for 2005.

- The results indicate the industry is economically healthy. We find that the hog industry's expected profits in 2005 are higher than any other comparable year in the past decade.

- The approach we take in the brief is well grounded in the literature and our results are very consistent with earlier published results on the hog market.

1. Introduction

This case is somewhat unique in that there is an active futures market for the industry's major output (hogs) and major input (grain). So we can look into the future with a higher degree of confidence than in many other cases. These futures markets are the predominant price discovery mechanisms for North American hog and grain prices. Furthermore, the hog futures market is a good and unbiased predictor of forthcoming hog cash prices, except for very distant forecasts. So the futures market is an excellent yardstick for measuring threat of injury.

We place statistical confidence intervals around current futures price forecasts for 2005 and the prices in these confidence intervals lie well above the breakeven price for hog producers. Using price quotes from the Chicago hog and corn futures markets, the Iowa State University *Estimated Livestock Returns* model predicts that U.S. hog producers will earn near record profits in 2005.

The existence of hog and grain futures markets allows hog producers to hedge both their revenue and costs throughout 2005, at attractive levels. This can be accomplished through the use of futures or forward contracts. Statistically speaking, it will also be a very profitable year for those producers who do not take advantage of hedging opportunities but instead remain in the cash market.

2. The Lean Hog Futures Market

2.1. Description of the Market

Commodity futures contracts are a type of (standardized) forward contract where one party agrees to buy a commodity from another party at a future date for a specific price. Everything about a futures contract is standardized except its price. All of the terms of the contract are established before active trading begins; neither side is hampered by ambiguity. The price for a futures contract is what's determined in the trading pit of a futures exchange and it is public information

In general the buyer of the futures contract agrees on a fixed purchase price to buy the underlying commodity (e.g., hogs) from the seller at the expiration of the contract. The seller of the futures contract agrees to sell the underlying commodity to the buyer at expiration, at the agreed upon price.

The lean hog futures contract is just one specific type of futures contract. As a result a lean hog futures contract shares all the common characteristics of commodity futures contracts for nonstorables. Each hog contract is based on 40,000 pounds of lean value hog carcasses, the quantity of meat produced from slightly more than 200 hogs. Lean hog futures and options are traded on the Chicago Mercantile Exchange (CME).

The CME's hog futures contract is based on a lean weight because most finished hogs are sold based on carcass weight, not live weight. So the lean weight contract is a post slaughter price. This means that the futures contract

price can be multiplied by about 0.74 to infer the equivalent live hog price per hundredweight. 0.74 is an approximation of the live hog weight to the lean carcass weight (i.e., a 250-265 pound live hog yields a dressed carcass of approximately 185-195 pounds).

To trade in hog futures, one must specify the maturity month. Trading in lean hog futures takes place for eight different contract months: February, April, May, June, July, August, October, and December.[5] Each hog futures contract expires on the tenth business day of the contract (i.e., maturity) month.

In contrast with many commodity futures markets, CME lean hog futures contracts are not settled through physical delivery of hogs. Instead, any contract open at time of expiry is cash settled at the CME Lean Hog Index (what is often referred to as the "CME cash price").[6] The buy or sell position can be reversed at any time before the contract expires and the reversal is made by simply taking an opposite position.

The CME Lean Hog Index (CME cash price) is based on a sample of cash and formula price transactions at packinghouses, and is a two-day weighted average of these prices. The sample consists of hogs purchased on a lean value cost basis by cooperating packers located within the Mid-South, Eastern Corn Belt and Western Corn Belt areas, as reported by the USDA.[7]

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[5] The May contract for lean hog futures is fairly new. This maturity month was not included in the analysis because this contract did not trade for the entire period of study, 1998-2004. May futures trading only started in 2001 for 2002 delivery. Moreover, the trading volume is relatively thin compared to the other contracts.

[6] The CME also trades futures and options contracts on frozen pork bellies (i.e., bacon) and the contract size is 40,000 pounds. The contract for frozen pork bellies is physically deliverable.

[7] See http://www.cme.com/trading/prd/ag/lhindex3423.html

While we recognize that some of the following discussion about market efficiency and statistical tests can be difficulty to follow for someone not familiar with futures markets, the essential efficiency of the hog futures market is fundamentally related to how the market was designed – the hog futures market was deliberately organized so the futures price converges to a representative cash price. Hence, all participants have a financial stake in having the futures market accurately predict what the market price will be in the maturity month.

In the hog futures market there is a daily price move limit of 2 cents per pound above or below the previous day's hog settlement price, with no limits in the delivery month during the last two days of trading.

In recent years, the annual volume of trading in lean hog futures on the CME has exceeded 2 million contracts. This is equivalent to 80 billion pounds of lean hogs, or about 4 times the annual production of pork in the U.S. In 2004, the volume of trading in CME lean hog futures surged to 3.2 million contracts, a 48% increase over 2003 volume.[8] This large and growing volume of trade is indicative of the strong endorsement that the hog industry provides to the futures market.

2.2. Price Determination and the Futures Market

Hog prices fluctuate, as do the prices of all agricultural commodities. The price of a product or a commodity depends on the relationship between supply

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8 http://www.cme.com/dta/hist/monthly_volume_action.html?theyear=2004&themonth=11&submit=Search&pageOption=0

and demand. If the supply and demand curves are placed on the same graph, the point where they intersect is the product's market price. Based on all the supply and demand factors, this is the price “discovered” as market participants buy and sell the commodity and/or trade futures. As time passes, the contract's price changes as new supply and demand information comes into the market.

2.2.1. Supply

The supply of hogs slaughtered in any given week or month depends on decisions made by hog producers several months earlier. Sows are generally bred twice per year. From the time a hog producer decides whether to breed sows and gilts it takes about 10 months to get pigs to market. This includes time for breeding, gestation, and feeding to finish. The gestation period is 3½ months and the time from birth to slaughter is about 6 months. Hogs are slaughtered when they weigh 250-265 pounds, producing a dressed carcass weight of around 185-195 pounds.

The main concept to grasp is that biology dictates that there is limited scope for the hog farmer to affect the timing of when his product is brought to market. The supply of slaughter hogs in any given week was determined at least 10 months previous and is perfectly inelastic with respect to the market price of slaughter hogs that week.[9]

[9] The time lag issue and the short-run inelasticity of supply are emphasized by Bullock (2003). Bullock, J.B. 2003, “Performance Evaluation of the U.S. Hog Slaughter Industry,” Department of Agricultural Economics Working Paper No. AEWP 2003-1, University of Missouri-Columbia.

The price of feed plays an important role in any hog producer supply decision as feed makes up about 65% of feeder pig-to-finish production costs.[10] Feed is also the most volatile component of input costs. Hog feed is mainly comprised of grains such as corn, barley, milo, oats and wheat. Oilseed meals are also used in feed rations for protein.

2.2.2. Demand

The price of slaughter hogs depends heavily on the demand for pork and meat substitutes. Changes in demand depend on the price of various pork products (e.g., pork chops, ham, bacon (pork bellies), sausage, etc.), changes in tastes and preferences, income and population growth, and the price of various substitutes for pork, such as beef, chicken, and fish. Other relevant factors include changes in exchange rates, world pork trade, and seasonal factors.

There are stocks of frozen pork in the U.S. of about 475 to 500 million pounds at any given time, but this amounts to less than 3% of annual pork production (of about 20 billion pounds) and so stocks have little influence on the current cash or futures price for hogs. It is also the case that frozen stocks are of lower quality than fresh pork.

2.2.3. The Role of Imports

Hogs are sold for slaughter within a rather narrow weight and age span. Once they reach market weight, producers cannot easily hold these animals back

[10] See http://www.porkboard.org/publications/pubIssues.asp?id=65

from the market. Because hogs are a nonstorable commodity, the cash price is determined by current supply and demand. So we would not expect that imports of isowean and feeder pigs would directly affect cash prices for slaughter hogs. Rather, we expect that if imports have any impact on the market, their effect would be via the futures price.

2.3. Price Discovery and Transference of Risk

Futures and options markets have many economic functions but two of the key functions are the discovery of prices and the transference of price risk. Supply and demand factors are transformed into price levels on the futures exchange, and this is the price discovery process. Futures markets are also useful economic institutions because they provide hedgers (such as hog producers and packers) with a mechanism for managing price risk (through hedging) and thus lowering the cost of doing business.

The hog futures market is the predominant price discovery mechanism for North American hog prices. Yang, Bessler, and Leatham[11] (2001) found that nearby hog futures prices are the primary informational source for cash prices. In other words, nearby hog futures prices lead cash prices.[12] As we explain

[11] Jian Yang, David Bessler, and David J. Leatham, "Asset Storability and Price Discovery in Commodity Futures Markets: A New Look" *Journal of Futures Markets.* March 2001; 21(3): 279-300.
[12] Yang, Bessler, and Leatham found this result for the 1996 to 1998 time period.

elsewhere, imports of isoweans do not impact nearby futures prices; rather they have a very minor impact on distant futures prices.[13]

The Yang, Bessler, and Leatham finding is consistent with the earlier result by Fama and French (1987)[14] that hog futures prices have strong forecast power. The results in this brief confirm the validity of this existing academic work and we provide new empirical evidence (using data from 1988-2004) supporting the conclusion that hog futures prices lead cash prices and that hog futures have power to forecast cash prices.

Price risk for agricultural commodities arises from demand and supply shocks that can occur for a number of reasons, including weather, disease, political developments, and other global events. Commodity futures markets provide a means to transfer risk between traders. Futures exchanges exist and are successful based on the principle that hedgers may forgo some upside profit potential in exchange for less risk and that speculators will have access to increased profit potential from assuming this risk. Trading in futures (or through forward contracts) is the only way for hog producers to purchase price insurance. A recent study by Boessen, Lawrence, and Grimes (2004) indicates that a large share of hog producers use the futures market (directly or indirectly) to hedge their price risk. [15]

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[13] See Exhibit 1 for a detailed econometric analysis of this point.
[14] Eugene F. Fama and Kenneth R. French, "Commodity Futures Prices: Some Evidence on Forecast Power, Premiums, and the Theory of Storage" *Journal of Business.* January 1987; 60(1): 55-73.
[15] See appendix I. Data is taken from Christian Boessen, John D. Lawrence, and Glenn Grimes, "Production and Marketing Characteristics of U.S. Pork Producers - 2003," Agricultural Economics Working Paper 2004-4. Available at http://www.econ.iastate.edu/faculty/lawrence/Final%20Draft%20Survey%20Article%202004.pdf .

2.4. Are Canadian Markets Organized Similarly?

There is no central price determination mechanism in Canada for hogs, such as a futures market. Instead, all spot and forward transactions in Canada are based on U.S. markets. Canadian hog farmers and packers who want to use futures to hedge risk must trade directly on the CME or indirectly through forward contracting. This situation reflects that fact that the continental hog market is integrated. For an example of how closely the Manitoba hog market is tied to the U.S. market see http://www.farmcentre.com/english/updates/reports/hog_report.htm. In the case of Ontario, for an example of base pricing off the U.S. market, see http://www.ontariopork.on.ca/ProducerInfo/Contracts/priceformula.htm.

2.5. Why Is the Hog Futures Market Relevant for this Case?

There are several reasons why the hog futures market is highly relevant for this case. First, if isowean and feeder pig imports have any price impact in the U.S., such imports will impact futures prices rather than current cash prices.[16] Second, the futures market has a direct impact on realized cash prices. The futures market is the central market, by which we mean that cash and formula slaughter hog prices paid by packers are typically based on the nearby futures market as a principal reference price. Furthermore, isowean prices are by and

[16] In Exhibit 1, we measure the impact of feeder pig imports from Canada on Chicago Mercantile Exchange (CME) futures prices and find these imports have a *de minimis* impact on U.S. prices.

large based on hog futures contracts that mature in approximately six months time. Third, if the futures market has forecast power, then it provides a good barometer of likely industry profitability in 2005. So current futures prices are a vital source of information, sufficient for addressing the issue of threat of injury. Simply said, through hedging with futures or forward contracts, hog producers can take advantage of the large expected profits for 2005.[17]

3. Market Efficiency

3.1. Background

Futures prices swiftly reveal new information, and the substantial trading volume helps ensure that futures prices accurately represent market conditions. The financial term for this is an efficient market. An "efficient" futures market is one in which prices fully reflect available information at any point in time. In an "efficient" market, competition among traders leads to a situation where, at any point in time, futures (and cash) prices reflect both the effects of current information and events that are expected to occur in the future. In statistics, this is characterized as a "fair game" and in an "efficient" market the current price will be an accurate estimate of the commodity's true intrinsic value. This means it would be difficult to come up with a better price forecast to “beat” the Chicago futures market. If a trader did come up with a system to beat the market then, in

[17] As we will discuss below this also requires hedging the feed price, and possibly locking in a basis (i.e., the difference between the futures and cash price) for both hogs and feed. This is routine practice for many hog producers.

theory, other traders would soon exploit that profit opportunity and the inefficiency would quickly disappear.

Prices quickly adjust to new supply and demand information, as it becomes available, in an "efficient" market. Price changes from day-to-day are random because news events come into the market in a random fashion. Today the news might suggest the market is going higher (i.e., bullish news that U.S. pork exports are rising) and tomorrow the news might be negative and suggest the market price is going lower (i.e., bearish news that the price of beef is falling). The more market participants there are and the faster the dissemination of information, the more "efficient" a market should be. An efficient market does a superior job of using current information to determine prices.

3.2. What Is Known About the Efficiency of the Hog Futures Market?

Markets can be tested for efficiency. Carter and Galopin (1993)[18], and others such as Yang Bessler and Leatham (2001) found that hog futures prices are "efficient." Carter and Galopin found that most of the supply and demand "news" that the government may release in the quarterly *Hogs and Pigs Reports* (HPRs) is already in the market price. Traders also have an incentive to gather this supply and demand information and often times the hog futures market correctly anticipates the content of government news reports.

[18] Carter, C. A., and Galopin, C. A. 1993, 'Informational Content of Government Hogs and Pigs Reports', *American Journal of Agricultural Economics*, vol. 75, no. 3, pp. 711-18.

The volume of imported isoweans and feeder pigs from Canada will have little or no effect on the current cash price of slaughter hogs. Any impact of increased imports of pigs from Canada on the price of hogs should be reflected in the futures market, as the futures market reflects all expectations regarding supply and demand fundamentals in the continental market. If additional volume of imported isoweans and feeder pigs from Canada influences the futures market, the impact will be concentrated on those futures contracts that expire 4 to 6 months hence.

Day-to-day changes in nearby hog futures prices affect day-to-day changes in cash prices. This means that firms or individuals affected by price activity in the underlying cash market are indirectly affected by price activity in the nearby futures market. This is true whether or not these firms or individuals use the futures and options market directly.

Not only are prices discovered in an absolute sense in the futures market, but prices are also discovered for a number of future points in time, and this is called a set of intertemporal prices. The hog price is set at any point in time for different contract months. For instance, on January 31, 2005 we could look forward and see the futures price for February (the nearby price), April (2 months out), June (4 months out), August (6 months out), and December (10 months out).

Hog futures prices are determined by anticipated supply and demand, so the futures market has a forward pricing role. The hog futures price is equal to the expected cash price in the contract month and reflects what traders expect

supply and demand to be at that future date. For a nonstorable commodity like hogs there is little or no arbitrage between cash prices and medium to distant futures prices. The difference between cash and futures prices reflects what the market participants believe will happen to cash prices between now and the futures contract maturity date.

Forward pricing is an important economic justification for futures prices for a nonstorable commodity such as hogs as emphasize by Peck (1985).[19] Tomek (1997) stressed that futures prices can provide poor price forecasts, but still be efficient as long as their forecasts are better than any alternative.[20] Previous literature has also found that hog futures provide reliable estimates of forthcoming cash prices.[21]

3.3. Future Prices Lead Cash Prices

Yang, Bessler, and Leatham (2001) found that hog futures prices were the primary informational source for cash prices, for the 1996 to 1998 time period. This means that hog futures prices lead movements in hog cash prices.

We adopt the Yang, Bessler, and Leatham econometric procedure, using updated data from 1998-2004. This involves the use of a vector autoregression error correction model to represent the relationship between hog cash prices and futures prices. We determine the lag structure of the model by using Akaike's

[19] Peck, A. E. 1985, 'The economic role of traditional commodity futures markets'. *In Futures markets: their economic role* (A. E. Peck, ed.) American Enterprise Institute for Public Policy Research, Washington, D.C., pp. 1-81.
[20] Tomek, W. G. 1997, 'Commodity Futures Prices as Forecasts', *Review of Agricultural Economics*, vol. 19, no. 1, pp. 23-44.
[21] Larry Martin and Philip Garcia 'The Price- Forecasting Performance of Futures Markets for Live Cattle and Hogs: A Disaggregated Analysis' *American Journal of Agricultural-Economics.* May 1981; 63(2): 209-15.

information criterion and Final Prediction Error criterion. The error correction model has differenced vector autoregressive terms (that represent short term adjustment coefficients for disequilibrium in the two markets) and an error correction term (which represents long run adjustment mechanism that corrects for disequilibrium).[22]

We then restrict the parameters of this time series model to test for whether futures markets lead cash markets, or vice versa. The results are shown in Table 1. The results strongly confirm the earlier findings of Yang, Bessler, and Leatham (2001). The estimated p-value for the null hypothesis that futures lead cash is equal to 0.39, while the p-value for the null hypothesis that cash lead futures is equal to 0.0. These results demonstrate that the null hypothesis that futures lead cash is likely true and that the alternative (cash lead futures) is likely untrue. The smaller the p-value, the more convincing is the rejection of the null hypothesis. Normally any p-value greater than 0.05 would lead us to accept the null hypothesis. But our estimated p-value is 0.39 for the hypothesis that futures prices lead cash prices. Stated differently, we find strong statistical evidence that hog futures prices are the primary point of price discovery, and that they lead cash prices.

[22] All data used in this exhibit are public. An electronic version of the data will be made available for the USTIC Office of Economics.

Table 1. Test for Long Run Causality Between Hog Futures and Cash Prices

Null Hypothesis	χ^2	p Value	Comment
Futures Lead Cash	0.71	0.39	Accept Null Hypothesis
Cash Lead Futures	46.5	0.00	Reject Null Hypothesis

Note: vector autoregressive error correction model estimated with 1998-2004 data, nearby futures and CME cash prices. χ^2 (Chi-square) is the test statistic for our test of goodness-of-fit.

3.4. Testing the Efficiency of the Hog Futures Market

3.4.1. Futures Prices Are <u>Unbiased</u> Forecasts of Eventual Cash Prices

The economics literature has tested the forecasting ability of the futures market.[23] Using ordinary least square (OLS, or least squares), we estimate the coefficients of the following linear regression equation:

$$CP_t = \alpha + \beta FP_{t-i} + e \qquad (1)$$

[23] For instance, see W.G. Tomek and R.W.Gray. 1970, 'Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles', *American Journal of Agricultural Economics*, vol. 52, no. 3, pp. 372-80; R.M.Leuthold. 1972, 'Random Walk and Price Trends: The Live Cattle Futures Market', *Journal of Finance*, vol. 27, pp. 879-889; T. Kofi, T. 1973, 'A Framework for Comparing the Efficiency of Futures Markets', *American Journal of Agricultural Markets*, vol. 55, pp. 584-594; and D. Kenyon, E. Jones, and A. McGuirk. 1993, 'Forecasting Performance of Corn and Soybean Harvest Futures Contracts', *American Journal of Agricultural Economics*, vol. 75, no. 2, pp. 399-407. .

where CP_t = cash price at time t when the futures contract matures, FP_{t-1} is the futures price quotation for contract t, i months before maturity, and e = error term, representing the forecast error. A "perfect forecast" is one for which α and β are estimated to be zero and unity, respectively. The *R-squared* (R^2) from equation (1) will lie between zero and one and it is an indication of forecast power of the least squares equation. In this equation, R-squared is the percent of variation in the forecasted cash price explained by the futures price. So the R-squared measures the (in-sample) forecast success of the least squares regression equation.

To judge the forecasting performance of futures prices, two criteria need to be satisfied. First, futures prices should be unbiased forecasts of cash prices. This is the test for $\alpha = 0$ in the above equation (1). Second, futures prices should explain movements in cash prices when cash prices are either rising or falling. This is the test for $\beta = 1$ in the above equation.

Martin and Garcia (1981) found that live hog futures perform the forecasting function well. We update their study using 1998-2004 data and come to an identical conclusion. The forward pricing function of live hog futures markets is reliable for contracts that mature within a six-month time period. This underscores our belief that the futures market is the primary price discovery mechanism for hogs.

Figures 1 through 4 show lean hog futures prices as a forecast of maturity month cash prices. These figures show our data used to test for the forecast

power of hog futures. In each of the figures 1 through 4, the futures maturity month actual cash price (CP_t) is plotted as a solid circle. For each cash price, the earlier futures market forecast (FP_{t-i}) of that cash price is plotted as a hollow circle, directly above or below the cash price. The cash prices used are the CME cash indexes for the first day of the relevant maturity month and we obtained these data from the CME. The futures prices are for the maturity months of February, April, June, July, August, October and December each year, and we obtained the futures data from the *Commodity Research Bureau* in Chicago.[24] In Figures 1 through 4, we report the closing futures price for the first business day in the lagged month. [25]

Figure 1 displays futures market forecasts 2 months prior to the realized cash price. Figure 2 is for forecasts 4 months prior, and so on. Visual inspection of these four figures indicates that futures prices are a reasonable forecast of maturity month cash prices for 2, 4, and 6 month lagged futures prices. In other words, for Figures 1 through 3, the vertical gap between the forecast and the realized cash price is relatively small. The average size of the gap widens as we move from Figure 1 through to Figure 4. For the 2 month ahead forecast, the average of the absolute value of the forecast error was $5.42 per cwt. This average forecast error (in absolute value) increased to $6.32, $8.05, and $9.91 for the 4, 6, and 10-month ahead forecasts, respectively.

[24] www.crbtrader.com
[25] May futures were not included in the analysis because this contract did not trade for the entire period of study, 1998-2004. CME May futures were introduced in 2001.

Figure 1. Lean Hogs: Maturity Month Cash Price and 2-Month Lagged Futures Price, 1998-2004

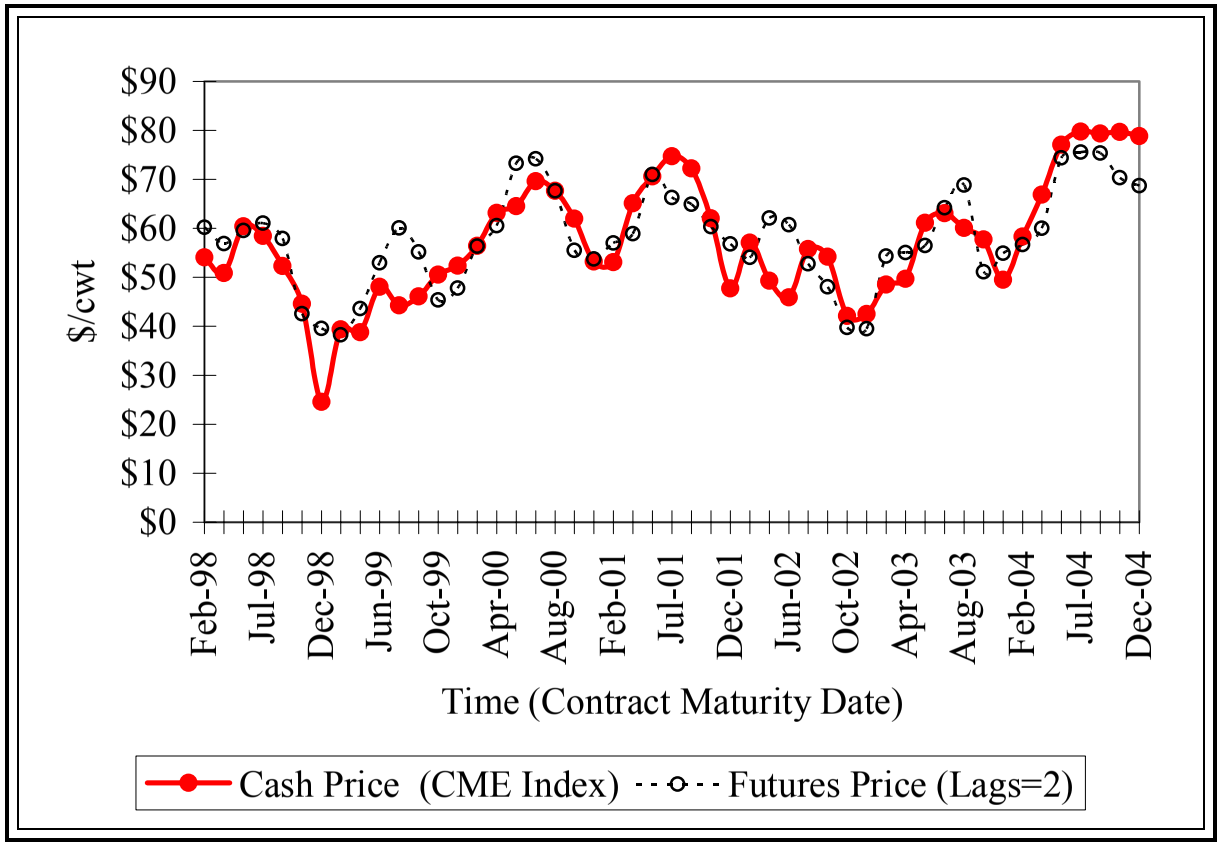


Figure 2. Lean Hogs: Maturity Month Cash Price and 4-Month Lagged Futures Price, 1998-2004

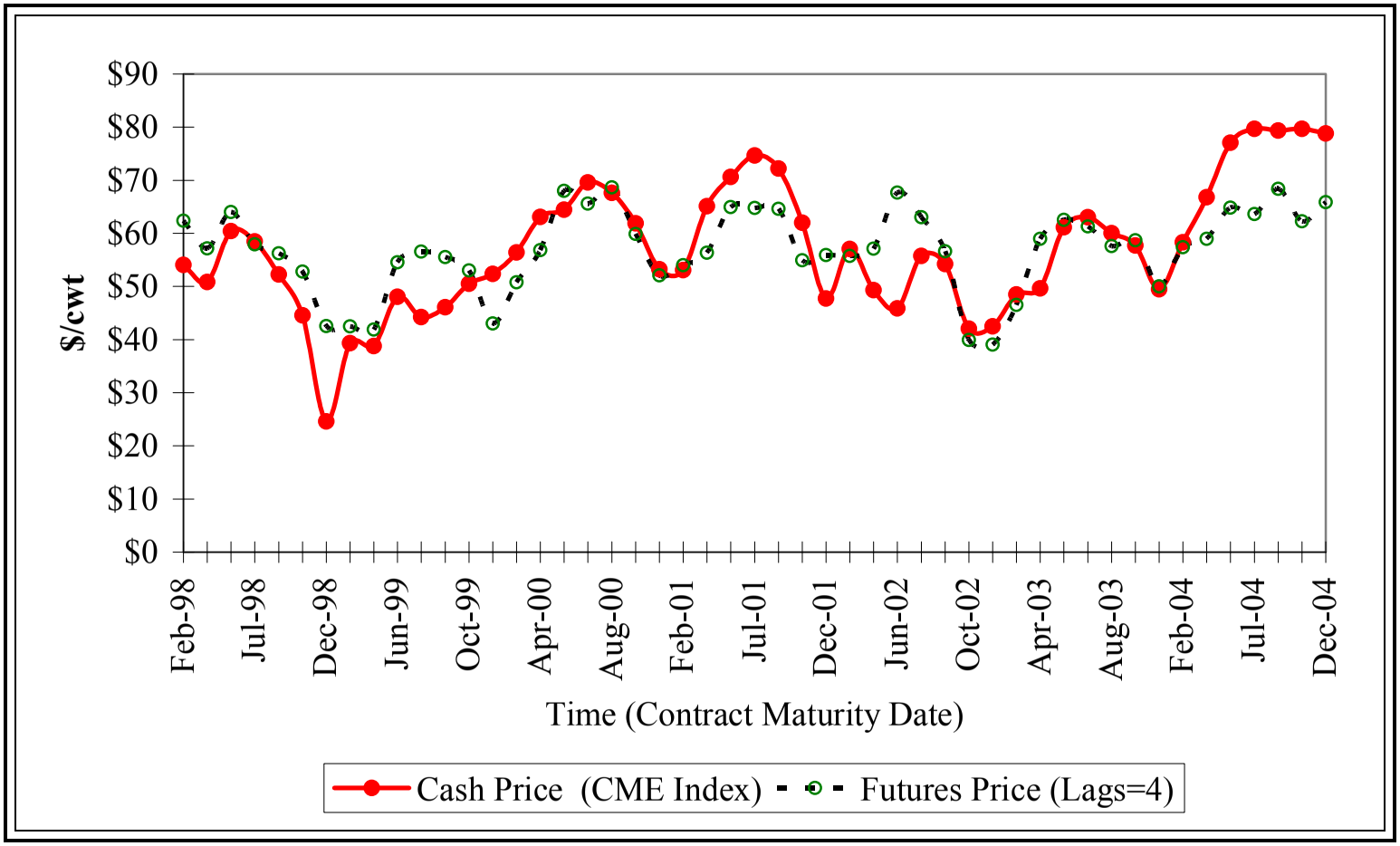


Figure 3. Lean Hogs: Maturity Month Cash Price and 6-Month Lagged Futures Price, 1998-2004

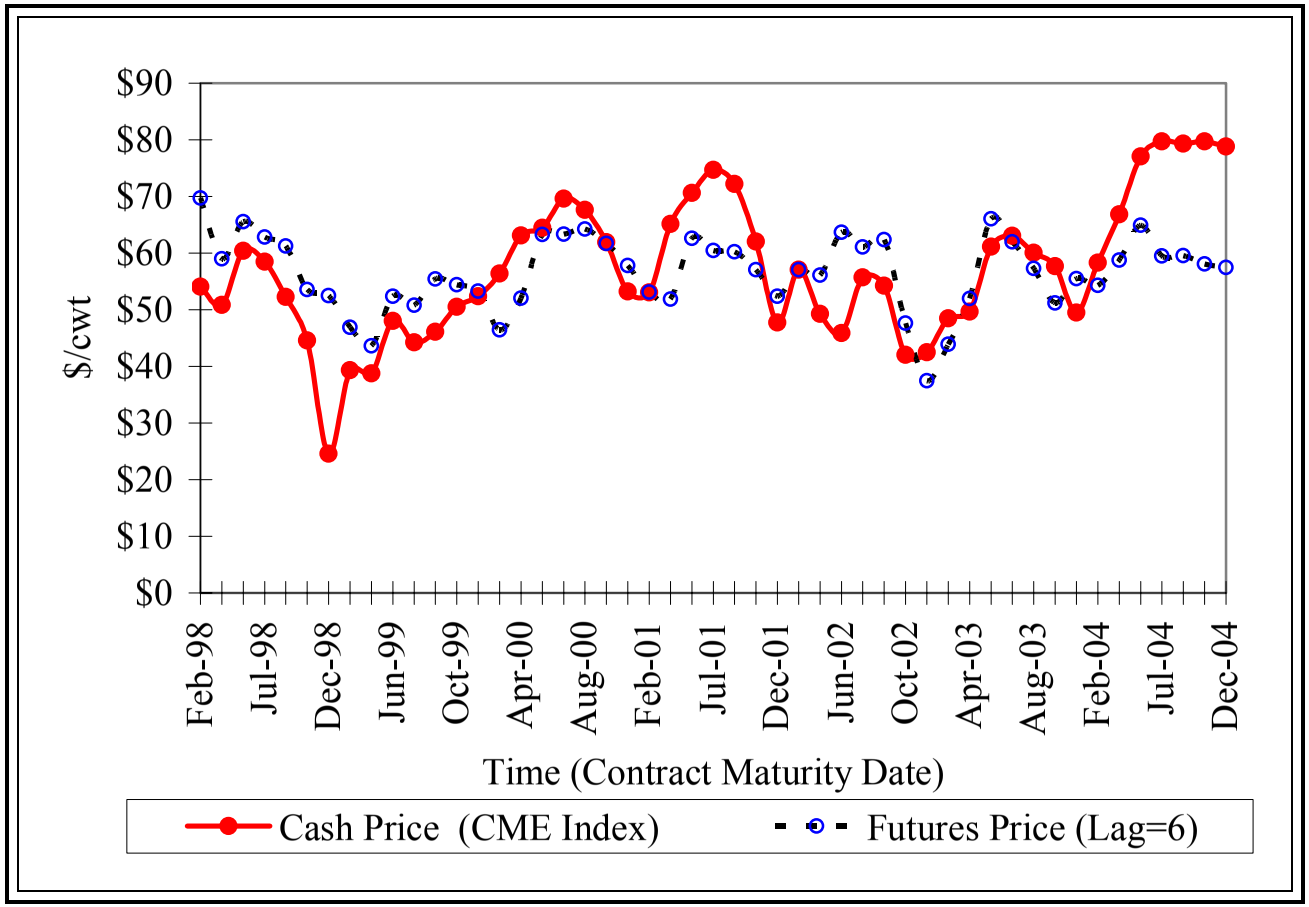


Figure 4. Lean Hogs: Maturity Month Cash Price and 10-Month Lagged Futures Price, 1998-2004

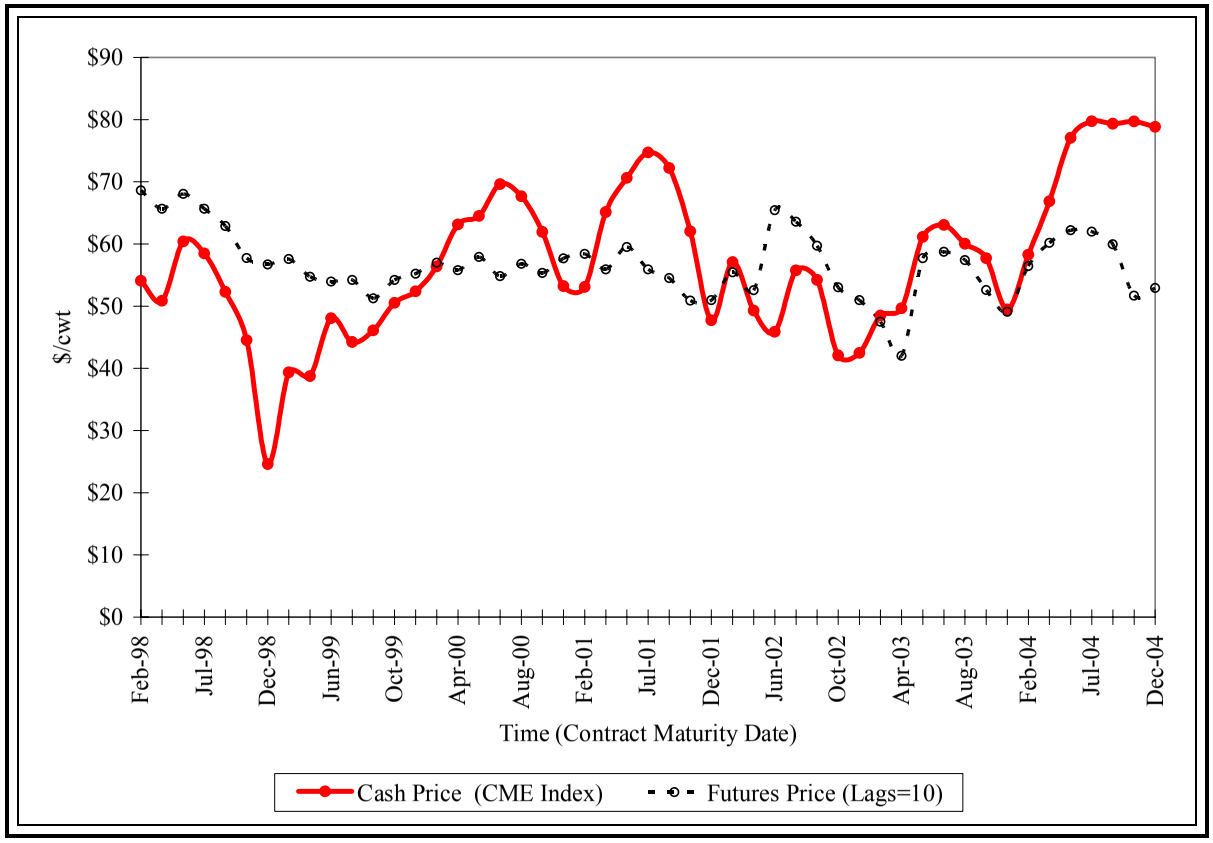


Table 2 below provides detailed regression results based on our estimates of the forecast power equation (1). If the estimated β=1 and α=0, this suggests that futures are good forecasts of forthcoming cash prices. We found that for the 2, 4, and 6-month forecasting models, the regression slope coefficients (i.e., the β's) are not statistically different from 1.0, and the intercepts (i.e., the α's) are not statistically different from 0.0. So the hog futures market provides a good forecast 6 months out. However, for forecasts 10 months away, the regression coefficient is different from one and the intercept is different from zero.

The R-squared's for the 2, 4, and 6 month ahead forecasts are 0.70, 0.56, and 0.28, respectively (see Table 2). This indicates that the forecast power declines the more distant the forecast (as we would expect), but even the 6 month ahead forecast has reasonably good explanatory power. But the forecast power breaks down if we ask the futures market to forecast cash prices 10 months out.[26]

Brenner and Kroner[27] (1995) argue that the test results that we report in Table 2 could be inappropriate for commodity markets if cash and futures prices are not cointegrated. However, Yang, Bessler, and Leatham (2001) find that hog cash and futures are cointegrated. Using nearby lean hog futures and CME cash prices for the 1998-2004 time period, we update the Yang, Bessler, and Leatham

[26] For each of the four forecasting models in Table 2 additional specifications using a dummy variable to represent falling and rising price regimes were estimated. The results are not reported here but they were qualitatively equivalent to the results shown in Table 2.

[27] Brenner, R. J., and Kroner, K. F. 1995, 'Arbitrage, Cointegration, and Testing the Unbiasedness Hypothesis in Financial Markets', *Journal of Financial and Quantitative Analysis*, vol. 30, no. 1, pp. 23-42.

finding and we conclude that hog cash and futures prices are indeed cointegrated, based on the Johansen test for cointegration.[28]

Table 2. Forecasting Models of Cash Prices Using Futures Prices

Martin and Garcia Regression Based Forecasting Models				
	(2 month lag model)	(4 month lag model)	(6 month lag model)	(10 month lag model)
Dependent Variable	Cash Price	Cash Price	Cash Price	Cash Price
Explanatory Variables				
Futures Price (Lags)				
2	1.032 (0.099)***			
4		1.169 (0.151)***		
6			0.984 (0.228)***	
10				0.385 (0.333)
Constant	-2.617 (5.790)	-9.482 (8.698)	1.518 (12.972)	35.360 (18.972)*
Observations	49	49	49	49
Hypothesis-Futures Prices are Unbiased Forecasts	Accept	Accept	Accept	Reject
Hypothesis-Futures Prices have Explanatory Power	Accept	Accept	Accept	Reject
R-squared	0.70	0.56	0.28	0.03

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

[28] Johansen, S. 1995. *Likelihood Based Inference in Cointegrated Vector Autoregressive Models*. Oxford: Oxford University Press.

3.4.2. Today's Cash Price Is A Poor Predictor of Eventual Cash Prices

We performed similar tests of forecasting power using cash prices instead of futures prices. See Table 3 for detailed results. We found that current cash prices for hogs are biased forecasts of forthcoming cash prices (i.e., $\alpha \neq 0$ in the regression equation) and relatively poor forecasts (i.e., $\beta \neq 1$). Using the Diebold-Mariano forecast comparison test, we found that futures prices provide much better forecasts than cash prices do. The results comparing cash versus futures forecasts are reported in Appendix VII.

Given the actual series of cash prices and two competing predictions (i.e., cash and futures), we calculate a measure of predictive accuracy (e.g., mean squared error) that allows the null hypothesis of equal accuracy to be tested. To compare the predictive accuracy of the two alternative forecasts, first we compare the difference in MSEs. The forecast with the lowest MSE is better. Second, a hypothesis test is conducted to see if the MSEs are indeed statistically different from each other. The S(1) measure tests that the mean difference between the MSE for the two predictions is zero (see Appendix VII).

Table 3. Forecasting Models of Cash Prices Using Lagged Cash Prices

Martin and Garcia Regression Based Forecasting Models

	(2 month lag model)	(4 month lag model)	(6 month lag model)	(10 month lag model)
Dependent Variable	Cash Price	Cash Price	Cash Price	Cash Price
Explanatory Variables				
Cash Price (Lags)				
2	.636842 (0.129)***			
4		0.239 (0.17)		
6			0.193 (0.152)	
10				-0.493 (0.165)**
Constant	21.55 (7.435)**	44.064 (10.102)***	47.557 (8.427)***	55.703 (8.777)***
Observations	49	49	49	49
Hypothesis-Unbiased	Reject	Reject	Reject	Reject
Hypothesis-Explanatory Power	Reject	Reject	Reject	Reject
R-squared	0.34	0.24	0.05	0.00

Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

4. Using the Hog Futures Market to Forecast Cash Prices in 2005

4.1. Market Efficiency and Predicting Prices

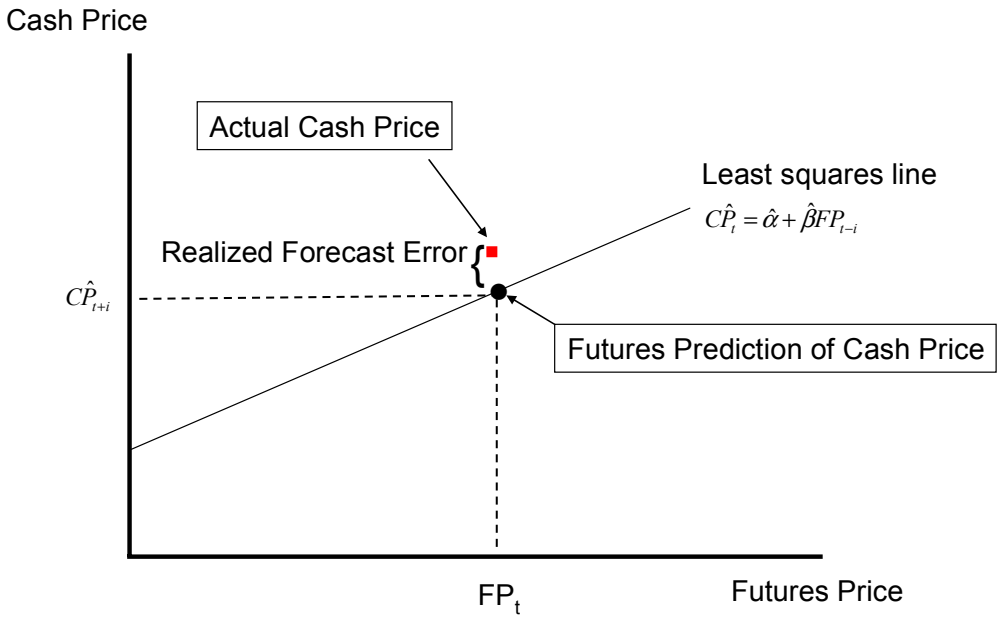
We have demonstrated that the forecast power of equation (1) can be used to predict (with confidence) the dependent variable, the CME cash hog price. In order to generate a forecast of the cash price we replace α and β in equation (1) with their estimators $\hat{\alpha}$ and $\hat{\beta}$, and we replace e with its expectation, zero. This gives us the following prediction equation for CP, the cash price for 2005:

$$\hat{CP}_t = \hat{\alpha} + \hat{\beta} FP_{t-i} \qquad (2)$$

Given the strong regression results in Table 2, we have confidence that equation (2) will provide good price predictions for 2005. Figure 5 illustrates the concept of how we use the least squares fitted line (above in equation 2) to predict 2005 cash prices. The least squares line is the straight upward sloping line in Figure 5. Futures prices are represented on the horizontal axis. For a given futures price at time t-i (FP_{t-i}), we plug this price into the regression equation and generate a corresponding cash price forecast for time period t, $\hat{CP}_t$.

The strength of this prediction procedure can be evaluated by the forecast error, e = CP_t - $\hat{CP}_{t+i}$, where CP_t is the realized cash price, $\hat{CP}_t$ is a forecast of that price, and e is the error term as in equation (1). See Figure 5 for a graphical illustration of the forecast error, the gap between the actual realized cash price

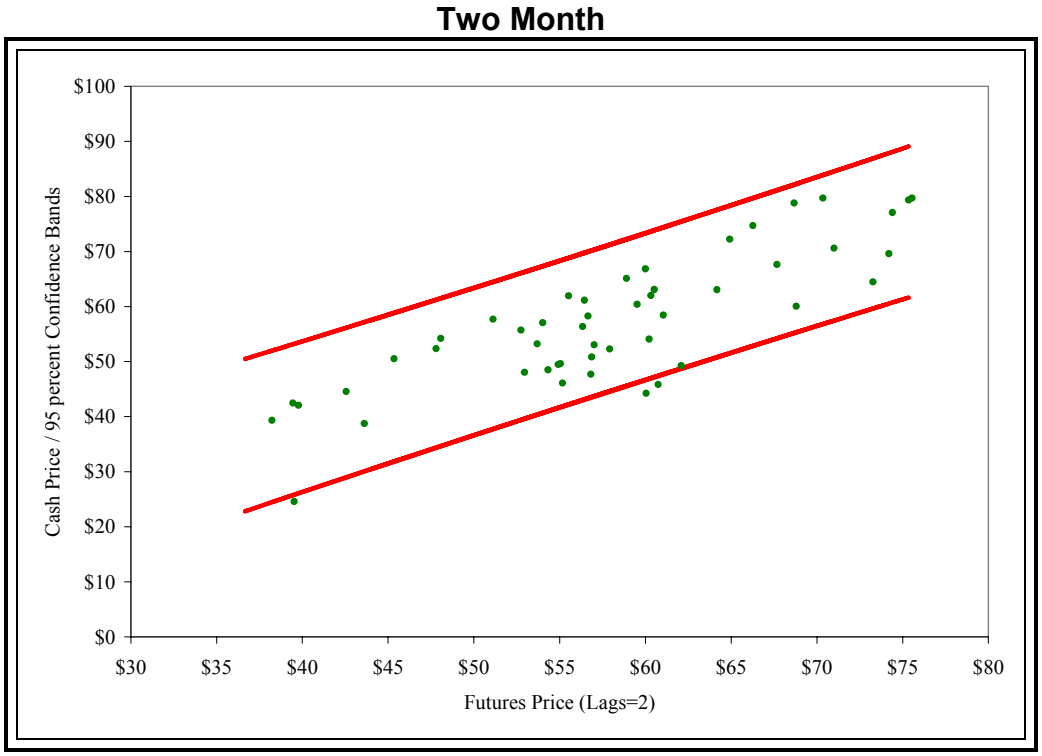
Figure 5. Illustration of Futures Price Predictor

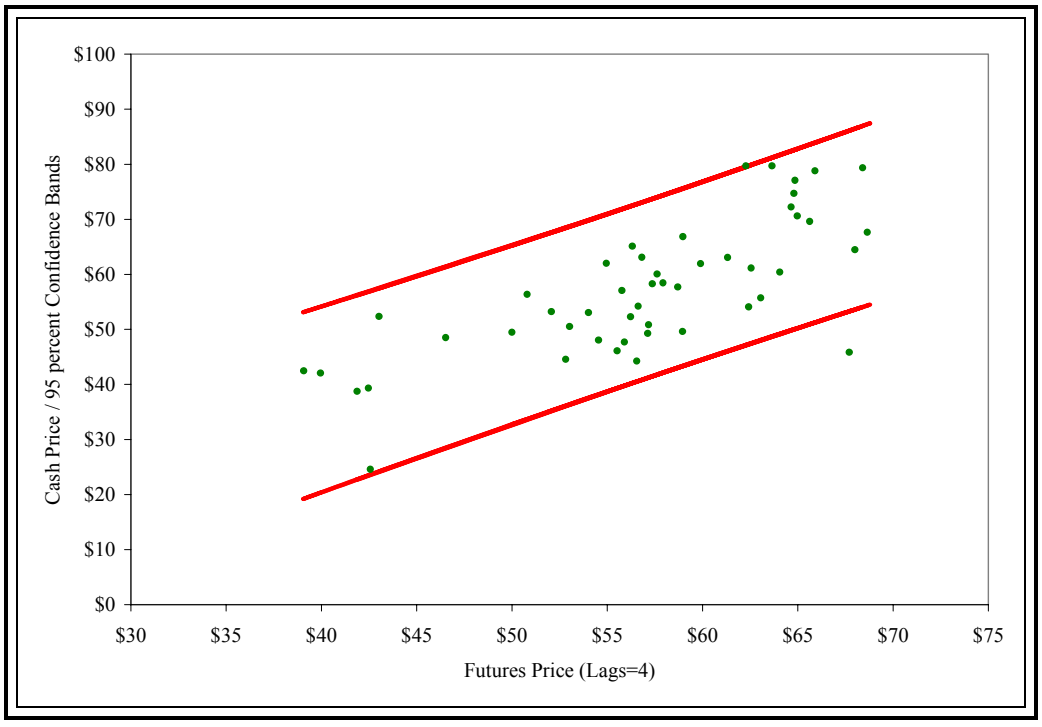


and the predicted cash price. The least squares estimator is an unbiased predictor if the forecast error is zero, on average.

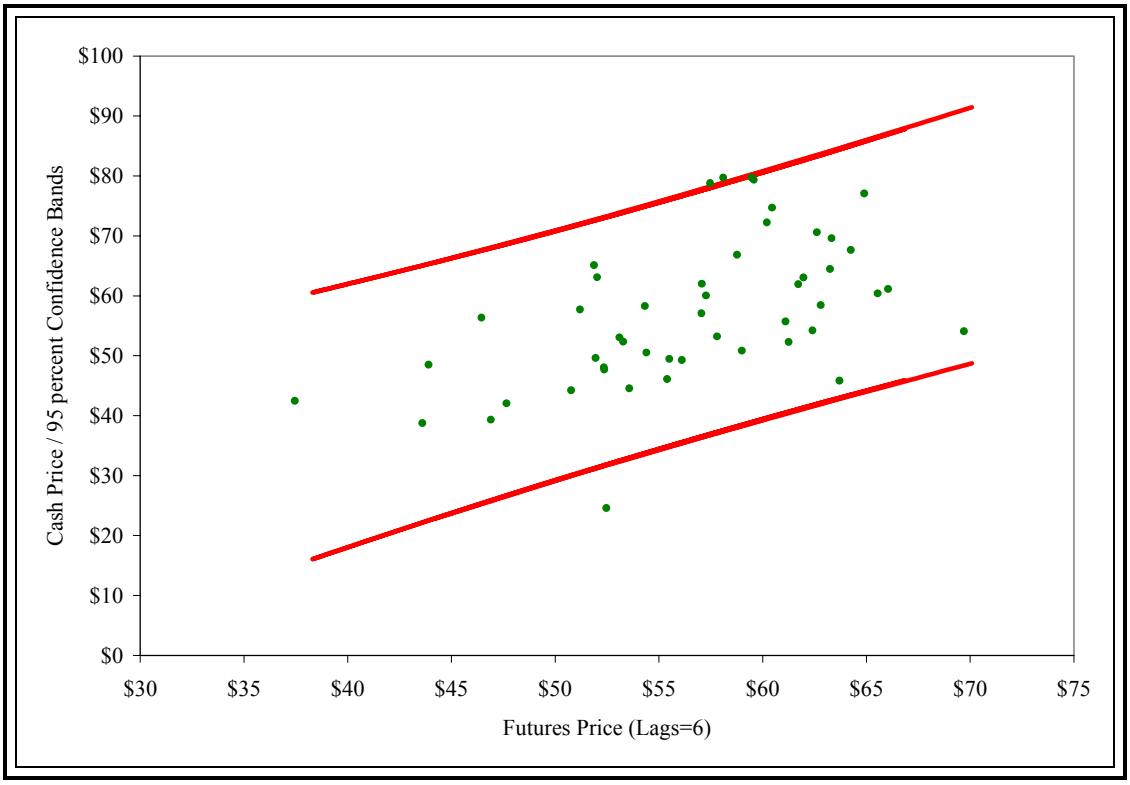
Figure 6 shows the least squares fitted line for 2, 4, 6 and 10th month ahead forecasts, using 1998-2004 data. These are all in-sample forecasts in Figure 6. Using our four forecasting models, we first predicted the Cash Price ($C\hat{P}_t$). Then, 95% confidence intervals were calculated for the forecast

Figure 6: In-Sample Futures Price Forecasts of Lean Hog Cash Prices (with 95% confidence intervals)

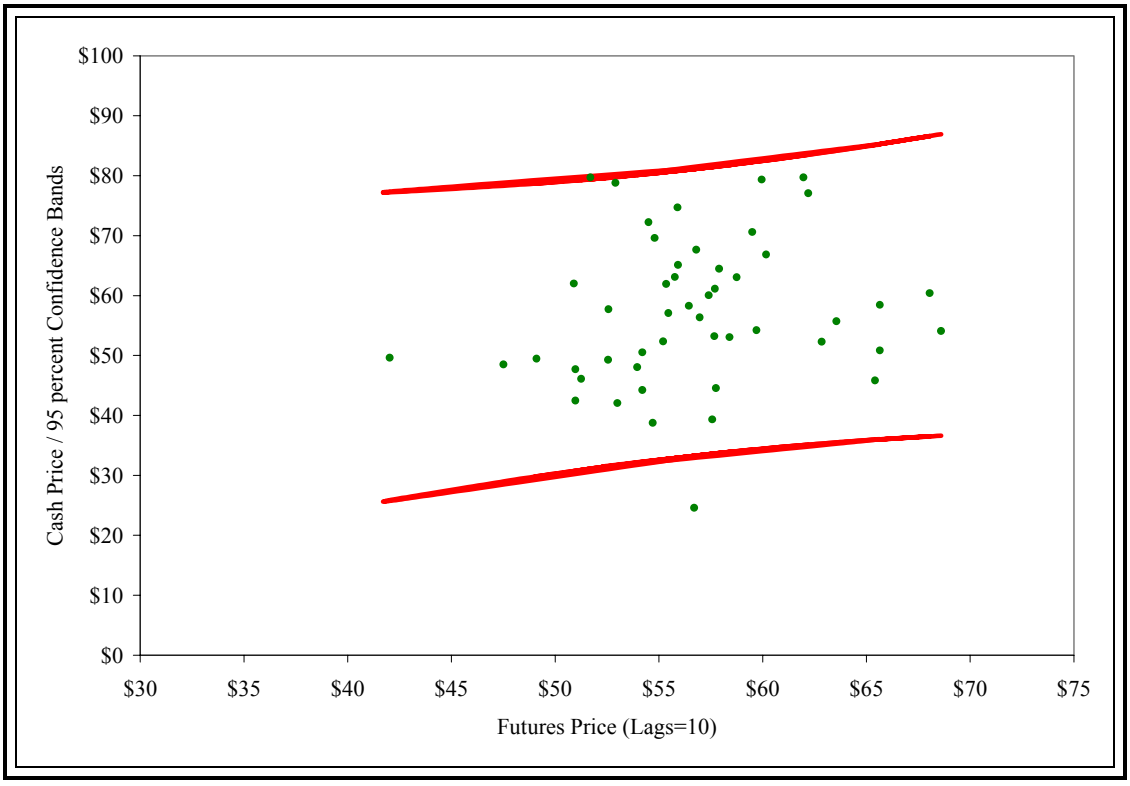




Six Month



Ten Month



estimates, and these confidence intervals are shown in Figure 6 as the light upward sloping lines.[29]

A point on any of the four least squares solid lines shown in Figure 6 gives each prediction of the cash price. The forecast errors are shown by the vertical distance between the square dots and the least squares line. As we see from Figure 6, the forecast errors are relatively small for 2, 4, and 6-month ahead forecasts. In other words, the dots are closely clustered around the least squares prediction equation.

Note that the forecast standard errors used to calculate the confidence intervals in Figure 6 capture both the uncertainty about β (so a component of the forecast error is due to the variance of the estimated slope coefficient) and the uncertainty about the regression model (that is, a component of the forecast error is due to the variance of the dependent variable). This is the most general form of calculating a confidence interval and usually leads to the widest confidence interval; less conservative methods will yield narrower confidence intervals.

Our regression model is $CP_t = \alpha + \beta FP_{t-i} + e$, where the error variance is assumed to be constant Var (e) = δ^2. We estimate $\hat{\alpha}, \hat{\beta}, \hat{\delta}^2$ using OLS

$$\text{Where } Var(\hat{\beta}) = \frac{\hat{\delta}^2}{\sum (FP_{t-i} - \overline{FP})^2} \qquad (3)$$

We then forecast the cash price with the OLS equation, $\hat{CP_t} = \hat{\alpha} + \hat{\beta} FP_{t-i}$

Our forecast error is

[29] For a discussion of how to construct these confidence intervals, see William. H. Greene. 1993. *Econometric Analysis*. New York: Macmillan Publishing Company. p. 195.

$$CP_t - \hat{CP}_t = \beta FP_{t-i} + e - \hat{\beta} FP_{t-i} = e + (\beta - \hat{\beta}) FP_{t-i} \qquad (4)$$

So the forecast error variance is equal to

$$\text{Var}(e) + \text{Var}((\beta - \hat{\beta}) FP_{t-i}) = \hat{\delta}^2 + FP_{t-i}^2 \frac{\hat{\delta}^2}{\sum (FP_{t-i} - \overline{FP})^2} = \hat{\delta}^2 \left(1 + \frac{FP_{t-i}^2}{\sum (FP_{t-i} - \overline{FP})^2} \right) \qquad (5)$$

since

$$Var(e) = \hat{\delta}^2, Var(\beta) = 0 \text{ and, } Var(\hat{\beta} FP_{t-i}) = FP_{t-i}^2 Var(\hat{\beta}) = FP_{t-i}^2 \left(\frac{\hat{\delta}^2}{\sum (FP_{t-i} - \overline{FP})^2} \right)$$

The more reliable the forecast, the smaller will be the variance of the forecast error.

The 95% forecast error confidence interval equals

$$\hat{CP}_t \pm t_{.025} \sqrt{\text{Forecast Variance}} \qquad (7)$$

We use this equation (7) to put confidence intervals around the forecasts of the cash prices for 2005.

4.2. Expected Price in 2005

In order to evaluate the likely profitability of U.S. hog production in 2005, we use the forecast confidence interval for out-of-sample forecasts for April, June, August, and December 2005. We converted the CME cash price into a price comparable with the Iowa-Southern Minnesota cash price by using the Iowa State's historical basis table over the 2002-04 period.[30] The basis adjustment is

[30] Basis table available at http://www.econ.iastate.edu/faculty/lawrence/HOGS_files/Car-Hog%2004.pdf .

attached as Appendix III to this exhibit and calculations underlying the conversion is in Appendix IV.[31] In making the 2005 profitability projections for each month we assumed a basis equal to the monthly average over the 2002-04 time period. We also note that it is common practice in the hog industry to hedge with forward contracts or to use futures with fixed basis. The packers play a key role in providing these forward and basis contracts to producers.

The January 31, 2005 futures price forecasts for these four maturity month cash prices (April, June, August and December) along with their corresponding confidence intervals for each cash price forecast are displayed in Figure 7.

The advantage of converting the CME price to the Iowa-Southern Minnesota cash price is that it allows us put expected prices in 2005 into an appropriate context for this particular case. For comparison, in Figure 7 we also plot the average monthly Iowa-Southern Minnesota hog price over the 1993-2001 period.[32] The comparison is important because as shown, hog prices usually decline late in the calendar year. Hence, the fact that hog prices are projected to be lower late in 2005 is not evidence of injury – it simply reflects normal seasonal price variation.

We show the typical seasonal variation with the seasonal index plotted in Figure 8. This index was computed by expressing the average price for each month as a percentage of the overall average price for the entire ten year period (1994-2004). From Figure 8 we see that cash hog prices typically peak during the spring and summer months. The price in June and July is more than 10

[31] Details of the calculations are given in section 5.2.
[32] We use the 1993-2001 period because that is the time period that ISU reports monthly profits.

percent above the yearly average, in a normal year. The index in November and December is less than 90, indicating that the price at the end of the calendar year is more than 10 percent below the yearly average price.

Two striking results emerge from Figure 7. First, in every month for 2005 the expected cash price lies above the historical average. Recall, this is the price that a hog producer can now establish for his/her hogs for 2005. This means that as of January 31, 2005 a hog producer could essentially guarantee themselves $13-22/cwt higher prices above normal levels.

Second, in every month the 95% lower bound on the expected price lies above the historical average. What exactly does this mean? Suppose a hog producer does not hedge and instead is willing to maintain an open cash position. This may be because she feels cash prices will be higher than the futures market now predicts and she is willing to "trade off" guaranteed profits for the chance of even larger profits. As a result, suppose this producer simply sells her hogs for the realized cash price on the marketing date. Obviously prices could be higher or lower than what she could have locked-in today. Our statistical analysis tells us that in every month even if prices end up being lower; we are 95% confident that the cash price will still be higher than the historical average hog price for that month. In other words, even if her guess is incorrect and prices are not higher (as she had hoped), the extent that they end up lower than the futures price prediction will still yield her a healthy return by historical standards.

Figure 7. January 31 2005 Futures Prices and Forecasts of Maturity Month Cash Prices (with 95% Confidence Intervals) Relative to Historical Monthly Average Prices

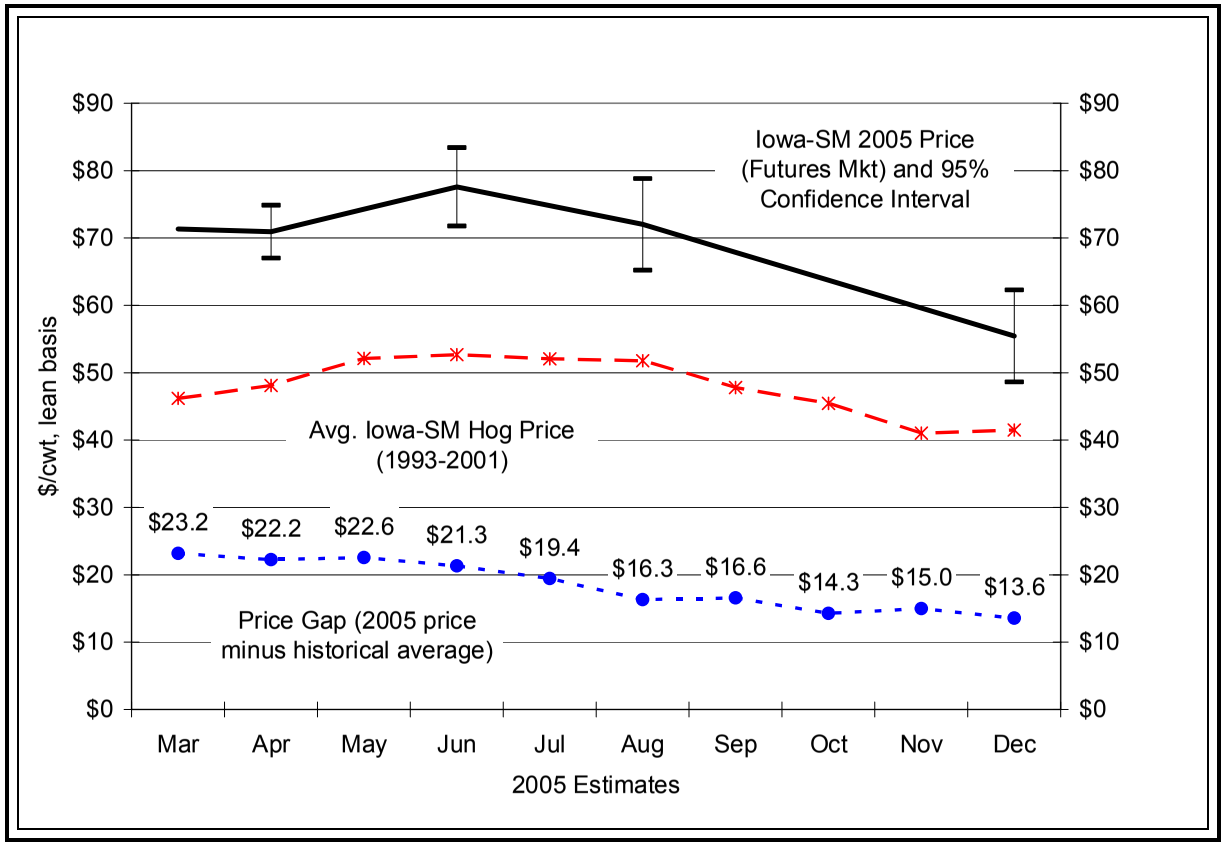
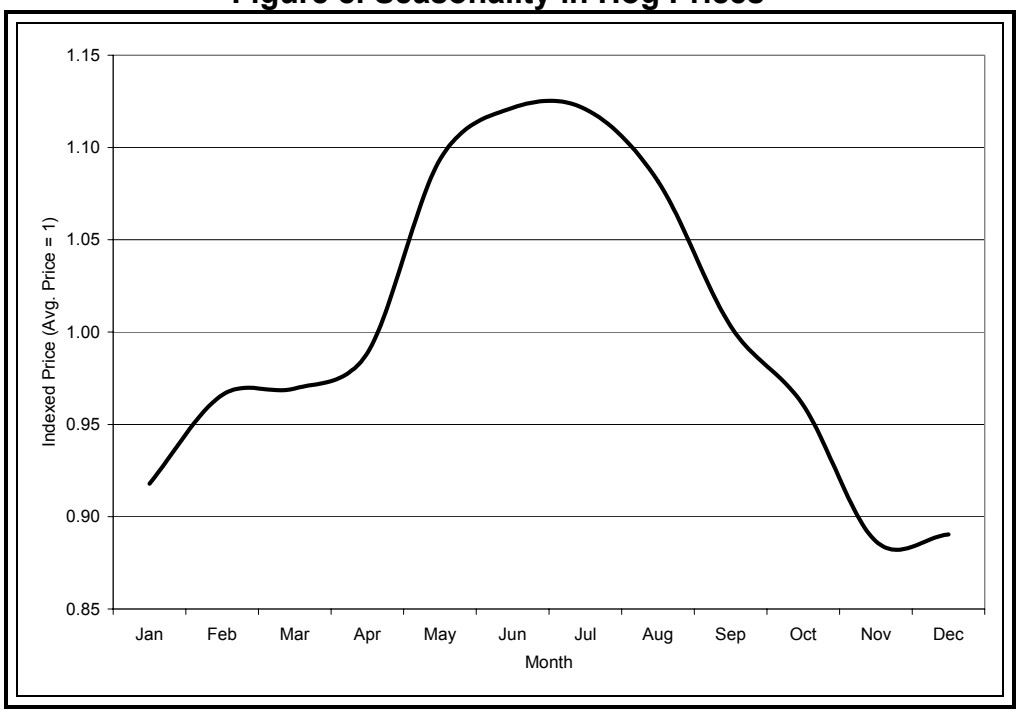


Figure 8. Seasonality in Hog Prices[33]



5. Futures Market Predicts 2005 Will be Highly Profitable for U.S. Hog Farmers

The above analysis indicates that hog farmers can use the futures or forward contracts to establish prices in every month during 2005 that are well above the comparable historical average. Even if hog farmers opt to stay in the cash market, the futures market allows us to predict with 95% confidence that eventual cash prices will be well above the average hog price.

We now use the futures market predictions in conjunction with the Iowa State University *Estimated Livestock Returns* model to calculate what current market prices imply for the overall profit level of the industry.

[33] Seasonality chart produced by averaging monthly Iowa-Southern Minnesota Barrow & Gilt Price, 1994-2004. Dividing by the annual average yields the indexed price series.

5.1. Using Corn Future Prices to Predict Costs of Production

In order to determine how much profit a farmer makes when selling a hog, we need to have an idea what it costs to raise the hog. One way to obtain a measure of costs is to use the responses to the *Producer Questionnaires* sent out by the USITC. Even with a large response rate, however, this sample will represent only a small fraction of producers. Moreover, the *Producer Questionnaires* will not allow the ITC to put the current situation into the proper historical context.

The Iowa State University (ISU) *Estimated Livestock Returns* model resolves both problems.[34] This publication contains estimates of production costs for common livestock enterprises in Iowa. Estimates are intended to reflect average or above-average levels of management using common technology. The model is explicitly designed to help producers plan their hog operation decisions. For individual farms, expected costs and input requirements can be substituted into the model. The model breaks down the total costs of production into fixed and variable costs along with a measure of labor costs.

The ISU model provides a detailed breakdown of the costs of producing a hog from farrow-to-finish. While we are concerned that the ISU model understates actual profits because there are some issues with the cost components of the ISU model,[35] the model has two tremendous virtues. First, it

[34] Available at http://www.extension.iastate.edu/Publications/FM1815.pdf .
[35] The model's single biggest shortcoming is that only a small share of hogs are produced in farrow-to-finish farms. Most hogs are produced in multi-site hog operations. In addition, the

is periodically updated to account for improvements in production efficiency. Thus, it attempts to reflect the costs of a representative Midwestern hog producer. Second, it allows the user of the model to project expected costs fairly simply by using spreadsheet style tables.

In Appendix II, we provide details of how the ISU model can be used for the purposes of this case. In brief, we used the table indicating how total costs per hog vary with the price of corn (the main grain used to feed hogs). We assume that a producer establishes her grain costs for the year by using Chicago corn futures contracts or forward contracts. We report the corn futures price as of January 31, 2005 in Appendix II. We then plug the futures price into the ISU table and project costs for each month throughout 2005.[36] For months where corn futures prices are not available, we interpolated (averaged) adjacent months for which corn futures prices are available.

5.2. Using Futures Markets to Predict Hog Cash Prices

We next turned to calculating what price a producer could expect to receive in each month. As described above, we use the January 31, 2005 futures prices in conjunction with the ISU basis table to determine the expected Iowa-Southern Minnesota hog price. Our calculations are given in appendix 4. Several explanatory comments are in order. First, in months without a futures

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model understates production efficiency in a number of dimensions. For instance, in comparison with reports by pigchamp (http://www.pigchamp.com/) the ISU model understates current farrowing efficiencies. The model also assumes the producer does not change the feed mix ratio as relative prices of alternative feeds change. By gearing its report to represent a small producer, the ISU model understates actual industry profits.

[36] ISU has released its monthly profit calculation for January 2005. We use the actual costs reported by ISU for January. See http://www.econ.iastate.edu/faculty/lawrence/EstRet/FA/FA05.pdf .

price (e.g., May) we interpolated (averaged) adjacent months for which hog futures prices are available. Second, since we only have estimates for the 2-, 4-, 6-, and 10-month standard errors, we also interpolated our standard errors for the other months. Third, the futures prices are quoted in $/cwt lean. As a result, we multiplied by 1.95 to convert to a lean hog price, assuming a slaughtered hog produces a dressed carcass weight of 195 pounds.

5.3. Hedged Profits in 2005

Combining projected prices and costs, it is straightforward to compute expected 2005 total revenue and total costs for each month:

Profit per hog = (P-C), where P = per unit price and C = unit costs

Industry profits = (Profit per hog) x (Estimated Commercial Slaughter)

For the estimated 2005 commercial slaughter, we used monthly slaughter projected for 2005 by informa economics.[37,38]

5.3.1. Billions of Profits To Be Earned in 2005

In Appendix V we report the actual 2005 profits hog producers could have been established as of January 31, 2005. The result is rather striking. For 2005, is all hog producers were to hedge both their grain costs and hog revenue, they

[37] Livestock & Meat Reference Tables, January 26, 2005, Informa Economics, Inc., page LV-49.
[38] Informa's 2005 slaughter projections are similar to the actual 2004 slaughter. Using actual 2004 slaughter data does not materially change our projections.

could essentially guarantee industry profits equal to an estimated $2.7 billion (according to the ISU model and the futures market).

Are these significant profits compared to most years? Yes, they are phenomenal. For perspective, these numbers mean that the ISU model projects that the industry could establish higher profits than what the ISU model estimated was actually earned by the industry in 2004. Two banner years back-to-back. This is hardly evidence of imminent threat of injury.

Are these unrealistically large profits? We don't think so. For example, our estimated profits for 2005 closely match the profit projection made by Chris Hurt, an agricultural economist at Purdue University.[39]

The recent Smithfield Foods SEC report also suggests our profit projections are accurate. Smithfield is one of the few large hog companies that actually break out the profit from its hog production from the rest of its activities. Smithfield Foods SEC filings indicate[40] its Hog Production Group reports almost $200 million profit over the six-month period ending October 31, 2004, which projects to $400 million profit over a twelve-month period. As it turns out, however, this projection is likely an understatement. Smithfield's February 14, 2005 press release indicates they expect to announce a 125% increase in quarterly profit on March 1, 2005![41] According to Pork Powerhouse Smithfield

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[39] Hurt states
"For the year, hog prices are expected to average around $51.50 which is just $1.00 lower than in 2004. My estimates are that 2005 will be the most profitable hog production year since 1990. Costs of production are estimated at $38.50 per live hundredweight and hog prices at $51.50. This would provide a profit of $13 per live hundredweight the best annual return since 1990 at $11.50 per live hundredweight." Chris Hurt "2005: Another Great Hog Year?", January 5, 2005. Available at http://www.agecon.purdue.edu/extension/prices/hogs/HogRptJan05.pdf .

[40] Available at http://www.smithfieldfoods.com/Investor/Sec/ .

[41] Available at http://www.smithfieldfoods.com/Investor/Press/press_view.asp?ID=261 .

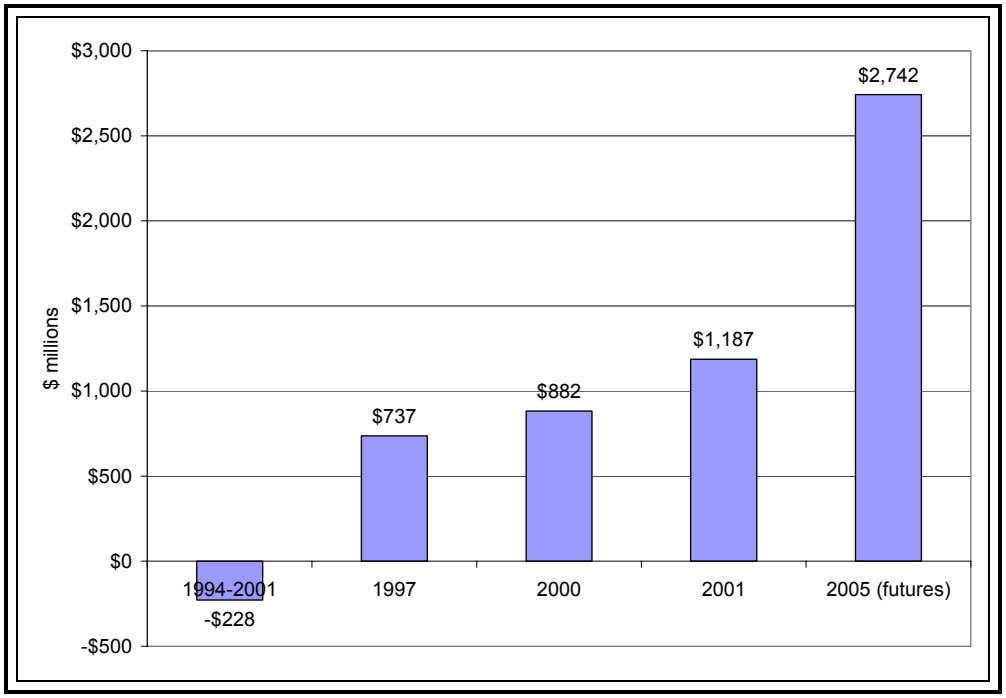
owns about 16% of US hogs production.[42] If Smithfield is an accurate barometer, billions of dollars in profits will be earned by the U.S. hog industry this year.

5.3.2. 2005 Profits Far Larger Than Any Comparable Year

As impressive as the industry's performance in 2005 will be, it is possible the petitioner's will argue that profits could be theoretically higher at this point in the pricing cycle. To get a sense of whether there is any merit to this possible claim, we used the ISU reported profits per head over the past decade and compared the hedgeable profits in 2005 with previous years.[43] The full table is reported in Appendix V. Here we simply summarize the bottom line finding.

[42] Pork Powerhouse (published by Successful Farming) reports that Smithfield has 808,000 sows in 2004. The USDA estimates the 2004 pig crop was 102,305,000. Assuming the USDA average statistics of 8.935 pigs per litter and 2.32 litters/mated female/yr, USDA figures imply a total domestic sow base of 4,935,309. See Exhibit 18 for more details on Pork Powerhouse reports.
[43] Reported profits per head available at http://www.econ.iastate.edu/faculty/lawrence/EstRet/FA/FarFin00.pdf .

Figure 9. Comparison of Projected 2005 Hog Industry Profits vs. Actual Profits in Other Recent Years



These results on profitability are nothing short of incredible. Compared with any benchmark, the US hog industry will do far, far better in 2005. How much better?

- Compared to 2001, the hog industry will earn 2.3 times as much profit in 2005;
- Compared to either 1997 or 2000, the hog industry will earn more three times as much profit in 2005;
- Compared to the average year during 1993-2001, the industry will earn $3 billion more profit in 2005!

5.4. Large Expected Cash Market Profits in 2005

Not all producers will use the futures market and guarantee themselves a highly profitable 2005. It seems hard to believe that there is an imminent threat of injury when a simply futures market transaction would eliminate the threat. Nevertheless, what does the profit look like for those produces that remain in the cash market?

In appendix 6 we report the results using the 95% confidence intervals derived earlier. While we cannot predict whether producers pass up the futures market lock will do better or worse than those who use the futures market, we can say with a high degree of certainty that large profits will still be earned.

If events break right, producers in the cash market could earn $36/head profit (95% upper bound). This translates into almost $4 billion of industry-wide profit. If the cash price falls below the futures prediction, producers in the cash market will still earn $16/head profit, or $1.7 billion of profit (industry-wide).

6. Conclusion

To summarize, the Chicago Mercantile Exchange hog futures market is the central price discovery mechanism in North America because hog futures prices lead cash prices. This means that supply and demand information is first picked up by the hog futures market and then there is feedback to the cash market from the nearby futures contracts. Furthermore, hog futures prices are

powerful predictors of forthcoming cash prices, and we can use this reliable source of information to forecast hog industry profits for 2005.

We have established a confidence interval around hog profitability for the remainder of 2005. There is little doubt that U.S. hog farmers will have a profitable year in 2005. U.S. hog producers are rolling in cash. There is no compelling evidence of threat of injury.

Appendix I – Use of Hog Futures Market by U.S. Hog Producers

Information from Boessen et al (2004)

	Table 2	Table 23	
Firm Size	**% of marketings**	**% using contracts tied to futures (e.g., packer contracts)**	**% using futures at times**
<1	1%		
1 - 3	8%	19%	17%
3 - 5	4%	28%	27%
5 - 10	9%	33%	33%
10 - 50	19%	28%	44%
50 - 500	19%	4%	83%
500+	40%	14%	67%

Data is taken from Christian Boessen, John D. Lawrence, and Glenn Grimes, "Production and Marketing Characteristics of U.S. Pork Producers - 2003," Agricultural Economics Working Paper 2004-4. Available at http://www.econ.iastate.edu/faculty/lawrence/Final%20Draft%20Survey%20Article%202004.pdf .

Appendix II – Using ISU Model to Predict Costs of Hog Production

(Cost schedule from ISU)*

Break-even selling price for farrow-to-finish if corn price is:

Corn Price ($ per bushel)	Supplement Price ($ per pound)	Total Costs $/cwt.
$1.75	$0.12	$36.97
$2.00	$0.14	$39.85
$2.25	$0.16	$42.74
$2.50	$0.18	$45.62
$2.75	$0.20	$48.51
$3.00	$0.22	$51.39
$3.25	$0.24	$54.28

*Table 6, page 5 from http://www.extension.iastate.edu/Publications/FM1815.pdf .

Corn futures price (as of Jan-31-05)

	Corn Futures Price	Interpolate parameter (between adjacent ISU corn prices)	Implied Total Costs ($/cwt)	Implied Total Costs ($/hog)
Mar-05	$1.97	88%	$39.50	$104.10
May-05	$2.05	18%	$40.37	$106.38
Jul-05	$2.12	47%	$41.21	$108.59
Sep-05	$2.19	77%	$42.08	$110.87
Dec-05	$2.29	15%	$43.17	$113.76

ISU costs Month-by-Month ($/hog)		
Jan-05	$101.89	<-- actual from ISU
Feb-05	$102.99	
Mar-05	$104.10	
Apr-05	$105.24	
May-05	$106.38	
Jun-05	$107.49	
Jul-05	$108.59	
Aug-05	$109.73	
Sep-05	$110.87	
Oct-05	$110.72	
Nov-05	$111.67	
Dec-05	$113.76	

Costs for months without corn futures contracts are the average of the adjacent months.
January costs are actual (as reported by ISU)

Appendix III – ISU Hog Basis Calculations

WESTERN CORNBELT LEAN HOG BASIS, 2002-2004 FOR THE 51-52% LEAN CARCASS CONTRACT ($/CWT/ CARCASS) -- IOWA STATE UNIVERSITY

Market Period	Contract for Basis	Expected Basis	Monthly Avg		
Jan- 1st half	February	($6.49)			
Jan- 2nd half	February	($2.12)			
Feb- 1st half	February	($2.31)			
Feb- 2nd half	April	($5.36)			
Mar- 1st half	April	($4.39)	($3.82)	March	($3.82)
Mar- 2nd half	April	($3.24)		April	($4.61)
Apr-1st half	April	($3.21)	($4.61)	May	($2.07)
Apr- 2nd half	June	($6.01)		June	($0.77)
May-1st half	June	($2.13)	($2.07)	July	($0.33)
May- 2nd half	June	($2.01)		August	$1.27
Jun- 1st half	June	($2.46)	($0.77)	September	$0.94
Jun- 2nd half	July	$0.93		October	($2.31)
Jul- 1st half	July	($1.96)	($0.33)	November	($4.61)
Jul- 2nd half	August	$1.30		December	($5.25)
Aug- 1st half	August	($1.28)	$1.27		
Aug- 2nd half	October	$3.81			
Sep- 1st half	October	($0.50)	$0.94		
Sep- 2nd half	October	$2.38			
Oct- 1st half	October	($0.96)	($2.31)		
Oct- 2nd half	December	($3.66)			
Nov- 1st half	December	($4.73)	($4.61)		
Nov- 2nd half	December	($4.48)			
Dec- 1st half	December	($2.20)	($5.25)		
Dec- 2nd half	February	($8.29)			

Table from

http://www.econ.iastate.edu/faculty/lawrence/HOGS_files/Car-Hog%2004.pdf .

Appendix IV – Using ISU Model to Predict 2005 Cash Prices for Hogs

Future Prices as of Jan-31-2005 (from CME)	
Apr-05	$75.550
Jun-05	$78.350
Jul-05	$74.625
Aug-05	$70.750
Oct-05	$63.375
Nov-05	$60.700
Dec-05	$59.900

Regression Estimates and Standard Errors	($/cwt)	95 % confidence interval limits	
	Futures Price	Lower Limit	Upper Limit
Apr-05	$75.55	$71.63	$79.47
Jun-05	$78.35	$72.53	$84.17
Aug-05	$70.75	$63.95	$77.55
Dec-05	$60.70	$53.86	$67.54

Expected Basis (calculated by ISU)	
April	-$4.61
May	-$2.07
June	-$0.77
July	-$0.33
August	$1.27
September	$0.94
October	-$2.31
November	-$4.61
December	-$5.25

(Appendix IV continued)

Implied Iowa-SM Price (via futures market), basis adjusted			
$/cwt lean		95 % confidence interval limits	
	Futures Price	Lower Limit	Upper Limit
Jan-05	$72.08	$72.08	$72.08
Feb-05	$71.69	$70.36	$73.03
Mar-05	$71.33	$68.74	$73.92
Apr-05	$70.94	$67.02	$74.86
May-05	$74.26	$69.39	$79.13
Jun-05	$77.59	$71.77	$83.41
Jul-05	$74.80	$68.49	$81.11
Aug-05	$72.02	$65.22	$78.82
Sep-05	$67.88	$61.07	$74.69
Oct-05	$63.74	$56.92	$70.56
Nov-05	$59.60	$52.77	$66.43
Dec-05	$55.46	$48.62	$62.30

* January hog price is actual (as reported by ISU)

Implied Iowa-SM Price (via futures market), basis adjusted			
$/hog		95 % confidence interval limits	
	Predicted Hog Price	Lower Limit	Upper Limit
Jan-05	$140.56	$140.56	$140.56
Feb-05	$139.80	$137.20	$142.40
Mar-05	$139.09	$134.05	$144.14
Apr-05	$138.33	$130.69	$145.98
May-05	$144.81	$135.32	$154.31
Jun-05	$151.29	$139.94	$162.64
Jul-05	$145.86	$133.56	$158.16
Aug-05	$140.43	$127.17	$153.69
Sep-05	$132.36	$119.08	$145.64
Oct-05	$124.28	$110.98	$137.58
Nov-05	$116.21	$102.89	$129.53
Dec-05	$108.14	$94.80	$121.48

Appendix V – Using Futures to Establish 2005 Profits

	US Commercial Hog Slaughter (000 Head)*	Hedgeable Profit per head	Industry Profit ($000)
Jan-05	8,459	$38.67	$327,110
Feb-05	7,925	$36.81	$291,704
Mar-05	8,925	$34.99	$312,292
Apr-05	8,325	$33.09	$275,498
May-05	8,000	$38.43	$307,448
Jun-05	8,475	$43.81	$371,252
Jul-05	7,250	$37.27	$270,212
Aug-05	9,100	$30.70	$279,347
Sep-05	8,975	$21.48	$192,802
Oct-05	9,125	$13.56	$123,773
Nov-05	9,175	$4.54	$41,632
Dec-05	9,075	-$5.63	-$51,063
	Avg. profit per head (simple monthly average)	$27.31	
	Total profit (full year, $000)		$2,742,006
	Total profit (Mar-Dec, $000)		$2,123,193

* Estimated by Informa Economics. Livestock & Meat Reference Tables, January 26, 2005, Informa Economics, Inc., page LV-49. Informa's 2005 slaughter projections are similar to the actual 2004 slaughter. Using actual 2004 slaughter data does not materially change our projections.

Appendix V – (Continued)
Comparing 2005 Profit with Other Periods of Time

	Avg. profit per head (ISU)	Industry profit (full year, $000,000)	Industry profit (Mar-Dec, $000,000)
2005 (futures)	$27.31	$2,742	$2,123
1994-2001	-$1.82	-$228	-$106
1997	$9.25	$737	$623
2000	$9.76	$882	$904
2001	$13.67	$1,187	$1,195

Appendix VI – 95% Confidence Interval for Cash Market

Using Cost and Price to Predict Profits – 95% Confidence Interval for Cash Market

	Estimated by informa economics				
	US Commercial Hog Slaughter (000 Head)	**95% Lower Bound Profit per head**	**95% Lower Bound Industry Profit ($000)**	**95% Upper Bound Profit Per Head**	**95% Upper Bound Industry Profit ($000)**
Jan-05	8,459	$38.67	$327,110	$38.67	$327,110
Feb-05	7,925	$34.21	$271,107	$39.41	$312,301
Mar-05	8,925	$29.95	$267,265	$40.04	$357,319
Apr-05	8,325	$25.45	$211,861	$40.74	$339,134
May-05	8,000	$28.93	$231,476	$47.93	$383,420
Jun-05	8,475	$32.46	$275,069	$55.15	$467,435
Jul-05	7,250	$24.97	$181,004	$49.58	$359,419
Aug-05	9,100	$17.44	$158,681	$43.96	$400,013
Sep-05	8,975	$8.20	$73,619	$34.76	$311,986
Oct-05	9,125	$0.27	$2,420	$26.86	$245,127
Nov-05	9,175	-$8.78	-$80,565	$17.86	$163,829
Dec-05	9,075	-$18.96	-$172,106	$7.71	$69,979
	Avg. profit per head	$17.73		$36.89	
	Total profit (full year, $000)		$1,746,941		$3,737,071
	Total profit (Mar-Dec, $000)		$1,148,724		$3,097,661

Appendix VII – Diebold-Mariano Econometric Tests of Forecast Accuracy: Futures Versus Cash Forecast of Forthcoming Prices

Futures and Cash Market Forecasting Performance (Lags=2)

Diebold-Mariano forecast comparison test for actual : cashprice
Competing forecasts: cashatl2 versus futhatl2
Criterion: MSE over 47 observations
Maxlag = 2 Kernel : uniform

Series	MSE
cashatl2	97.04
futhatl2	43.86
Difference	53.19

By the MSE criterion, futhatl2 is the better forecast

H0: difference is not significant
S(1) = 2.099 p-value = 0.0358

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Futures and Cash Market Forecasting Performance (Lags=4)

Diebold-Mariano forecast comparison test for actual : cashprice
Competing forecasts: cashatl4 versus futhatl4
Criterion: MSE over 45 observations
Maxlag = 2 Kernel : uniform

Series	MSE
cashatl4	149.3
futhatl4	65.58
Difference	83.72

By the MSE criterion, futhatl4 is the better forecast

H0: difference is not significant
S(1) = 2.089 p-value = 0.0367

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Futures and Cash Market Forecasting Performance (Lags=6)

Diebold-Mariano forecast comparison test for actual : cashprice
Competing forecasts: cashatl6 versus futhatl6
Criterion: MSE over 43 observations
Maxlag = 2 Kernel : uniform

Series	MSE
cashatl6	154.5
futhatl6	104.3
Difference	50.22

By the MSE criterion, futhatl6 is the better forecast

H0: difference is not significant
S(1) = 2.347 p-value = 0.0189

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Futures and Cash Market Forecasting Performance (Lags=10)

Diebold-Mariano forecast comparison test for actual : cashprice
Competing forecasts: cashatl10 versus futhatl10
Criterion: MSE over 39 observations
Maxlag = 2 Kernel : uniform

Series	MSE
cashatl10	104.1
futhatl10	120.9
Difference	-16.81

By the MSE criterion, cashatl10 is the better forecast

H0: difference is not significant
S(1) = -1.18 p-value = 0.2378

Appendix VIII – Data Listing