Hog Profit Margin Hedging:
A Long-term Out-of-sample Evaluation

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(ABSTRACT)

This thesis is a long-term evaluation of the profit margin hedging strategy suggested by Kenyon and Clay. To implement this strategy an expected profit margin is estimated based on the amount of pork, corn price, and soybean meal price. The profit margin that can be 'locked in' by the futures market is calculated from the futures prices of live hogs, corn and soybean meal with an allowance for other cost. The hedging rule is to hedge hogs, corn and soybean meal when a profit margin of fifty percent above the expected profit margin can be 'locked-in' with the futures. In their original paper, using data from 1975-82, Kenyon and Clay found this method of hedging stabilized cash flow while increasing the overall profit level. Using out-of-sample data from 1983-98, the current research finds no difference in profits from hedging versus not hedging. The most obvious reason for the lack of success is the inability to predict the expected profit margin with the simple supply model used by Kenyon and Clay. Addition of demand shifting variables to the model failed to significantly improve the prediction of expected profit margin or the hedging results. The hedging strategy was also affected by a significant decrease in the variance in the futures market that lead to a decrease in hedging opportunities. With the failure of the Kenyon and Clay hedging strategy with out-of-sample data, this research empirically demonstrates the need for out-of-sample testing of selective hedging strategies.

Dedication

This thesis is dedicated to my late father, William D. Kee and to the late Dr. Neils W. "Doc" Robinson, Professor of Animal Science at the University of Tennessee Martin and my undergraduate advisor. Dad instilled in me the value of education. Doc pointed out that a person should pursue a career in something that he truly enjoys. Doc gave this piece of sage advice to me when I was deciding what to do with my newly minted B.S. degree but it has stayed with me. It had a major impact on my decision to return to school and retool my skills for a career in agricultural commodity pricing.

Acknowledgements

A Master's Thesis is a symbol of the culmination of a Master's education. Like so many other achievements that are considered 'personal achievements, a Master's degree cannot be earned by the sole efforts of the one receiving the degree. My degree is a result of the work of the entire faculty of the Agricultural and Applied Economics Department. I am indebted not only to those that I was privileged to take classes under, but also to those that took the time to offer advice in their specialty area and to those that were just there with a few words of encouragement when they were sorely needed. The faculty as a group combined to form an environment that is conducive to learning. However, three members of the faculty deserve individual recognition for their efforts in my pursuit of a Master's degree.

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I would be amiss if I did not mention two friends. I met Vandana Shah, now Plassmann, in Dr. Taylor's micro when we studied together. There was a natural symbiosis in our studying. If there was a concept I was having trouble with, she understood it and if she was having trouble, I understood it. From this grew a natural friendship of mutual support and encouragement.

Vandana ‘found’ Florenz and that friendship grew just as naturally. Florenz and I share a passion for economics and spent hours discussing the theories. He also deserves credit for editing early versions of this thesis and comments that were incorporated into it. Florenz is now an Assistant Professor of Economics at SUNY Binghamton. I trust they realize the asset they have.

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Chapter 1: Introduction

The current literature suggests that there are no income enhancement opportunities in the futures markets to routine (naïve) hedging strategies (futures prices follow a random walk) or to those based on price forecasts using publicly available information (semi-strong form market efficiency). However, Zulauf and Irwin (1997) found an increase in profits from corn storage between 1964-1989 based upon Working's storage hedging strategy. They term Working's strategy a market-generated forecast and identify profit-margin hedging as another form of this strategy. Profit-margin hedging is the simultaneous hedging of inputs and outputs of a production process. Prominent examples of profit-margin hedging are the soybean crush where soybeans (the input), soybean oil and soybean meal (the outputs) are hedged, cattle feeding where feeder cattle, corn (the inputs) and fed cattle (the output) are hedged and the crude oil crack where crude oil (the input), gasoline and heating oil (the outputs) are hedged. In 1987, Kenyon and Clay (KC) examined profit margin hedging in hog production where they hedged corn, soybean meal (the inputs) and live hogs (now lean hogs, the output). Their study used an in-sample test of thirty-five lots from 1975 to 1980 with an additional out-of-sample test of thirteen lots from 1980 to 1982. They found a significant reduction in variance with an increase in profits.

The first phase of the present research is an out-of-sample test of KC's "optimal" strategy using data from 1983-1998 yielding ninety-six out-of-sample test lots. The hedging methods and procedures used by KC were followed as closely as possible in order to perform a strict out-of-sample test of the KC strategy. The second phase applies knowledge gained from the out-of-sample test to develop improved strategies and recommendations for the hog producer of the 21st century.

Previous Research

The foundation for profit margin hedging was formed by Working (1949) and extended by Brennan (1956) in their seminal works on the theory of storage. Working approached storage from an inter-temporal price relationship viewpoint using empirical data from wheat futures of different maturity dates. At the time of his article, the consensus was that inter-temporal price relationships between contracts of different crop years were substantially independent. The price relationship between contracts within the same crop year were thought to be a function of the simple cost of storage which varied according to supply and demand conditions. Working included a convenience yield that varies with the aggregate amount of wheat being stored. This convenience yield successfully accounts for periods of apparent negative cost of storage and provides a link between the prices across crop years. From this, Working proposed a third order polynomial shaped storage supply curve with its relatively flat center portion that is in use today. Brennan added to Working by including a varying risk premium and a demand function for storage to explain the equilibrium condition. Brennan also mathematically derived the interrelationships of the components of the inter-temporal price differences. These two works are largely responsible for formalizing the theory of futures prices for storable commodities as it stands today:

(1.1) Futures Price = Cash Price + Cost of Carry + Convenience Yield + Risk Premium

where cost of carry includes storage cost, interest and insurance. The difference between two futures prices can be derived by substituting the nearer term futures price for the cash price and adjusting the other variables on the right-hand side by the length of time between the futures contract maturity.

Paul and Wesson (1966, 1967) related storage theory to the soybean crush and cattle feeding. Using cattle feeding as an example, in equation (1.1); the futures price would represent the futures price of live cattle which is the output, the cash price would be the input prices which in this case is the cash price of feeder cattle and corn in the proper ratio to produce live cattle, and the cost of carry would be the cost of transforming the feeder cattle and corn into live cattle. The cost of transformation would include other variable cost and general feedlot overhead. Convenience yield and risk premium remain unchanged. Additionally Paul and Wesson make the observation that storage theory can be used to relate the price of any group of unpriced services to the prices of related items for which the market price is observable.

Storage theory was first applied to hedging strategies by Working (1953) in basis hedging of grain. Hieronymus (1977) documents other hedging strategies that use these principles to hedge the profit of various processes. Prior empirical profit margin hedging or related studies include: Kenyon & Shapiro (1976), [broilers, corn, soybean meal], Shafer, et al (1978), Leuthold & Mokler (1979), Spahr & Sawaya (1981), Schroeder and Hayenga (1988), [fed (live) cattle, corn, and feeder cattle], Kenyon and Clay (1987), [hogs, corn and soybean meal], Johnson *et al*., (1991) [soybeans, soybean meal and soybean oil], Zulauf and Irwin, (1998) [corn storage].

Profit margin hedging is a selective process were hedges are placed only when prespecified rules are met. Previous research has applied two types of rules to initiate hedging based on the underlying industry structure: fixed profit levels or variable profit levels. To implement the fixed hedging rule, an implied profit margin is calculated using the futures prices for the inputs and the outputs with an allowance for other cost. For example, Leuthold and Mokler (1980) calculate the implied profit margin of feeding cattle by subtracting the cost of producing live cattle, estimated from futures prices of feeder cattle and corn with an allowance for non-feed cost, from the total income estimated from the futures price of live cattle. They analyze hedging results when the implied profit margin varies from one to fifteen dollars in one dollar increments and found the optimal trigger level to be five dollars per cwt. Returns for the five dollar trigger level were $3.11 per cwt. compared to $0.86 cwt. for cash returns with the hedge reducing variance by fifty-seven percent. They also indicate that a reverse or 'Texas hedge' was profitable when the implied profit margin was negative by one to seven dollars with the best results when the negative margin was between three and five dollars.

The structure of the pork and beef industries differ significantly. Most hogs are fed by the producer who farrows the pigs while most cattle are fed by specialized cattle feeders. Thus, the ownership of cattle is transferred from the original producer to cattle finishers. This structure implies that the demand for feeder cattle, an input, is a derived demand based on the cost of transforming feeder cattle into live or finished cattle and the expected price of live cattle four to six months in the future, the normal feeding period. Thus the cattle feeder adjusts the price he is willing to pay for feeders based on a relatively fixed and predictable supply situation at the time the feeder cattle are bought. Therefore, economic theory would suggest that cattle feeding profits are not a function of beef production levels because the effect of production levels on the price of live cattle is passed directly to the feeder cattle producer by the derived demand function for the feeder cattle. Because the ownership of hogs is not usually transferred before slaughter,[1] the hog producer receives the effect of production levels on the price of slaughter hogs. Therefore, Kenyon and Clay (KC) note that the profit level that a hog producer should expect is negatively related to the expected level of production at the time the output (hogs) is sold. They proposed a variable trigger level based on the expected profit margin determined by expected pork production and the cost of corn and soybean meal. They report the result of hedging when the implied profit margin was above the expected profit margin by zero to a hundred percent, in ten percent increments. Their best strategy was to hedge up to two quarters ahead of the sale of the market hogs if the implied profit margin was seventy percent above the expected profit margin (2/70 strategy). During their in-sample period from 1975-1980 cash profit margins were $5.50 per cwt. with a variance of $93.34 per cwt. The 2/70 strategy produced combined profits of $8.36 per cwt. with a variance of $63.43 per cwt. Thus, hedging increased profits by $2.86 per cwt. (fifty-two percent) and decreased variance by $29.91 per cwt. (thirty-two percent). In KC's out-of-sample test of thirteen lots between December of 1980 and December of 1982, cash margins averaged $0.57 per cwt. with a variance of $105.95 per cwt. The 2/70 strategy increased profits to $1.21 per cwt. and decreased variance to $43.43 per cwt. Thus, they concluded that a producer could increase profits while simultaneously reducing risk by hedging when the futures market offered an implied profit margin that exceeded the expected profit margin by seventy percent.

The Johnson *et al.*'s soybean crush research is more properly characterized as a spread trading study. They report results for the trades only and do not test if those trades would reduce the variance of the combined profits from the futures market and the crushing process for a

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[1] There are specialized feeder pig producers and hog finishers but this is a declining portion of the hog industry. These remaining specialized producers are entering into long-term contracts for the transfer of the feeder pigs by formula pricing based on slaughter hog prices. Currently the only remaining openly reported market for feeder pigs is in Missouri. Unlike feeder cattle, there is no futures market for feeder pigs, thus any profit margin study on specialized hog feeding would be limited to the feeding period.

soybean processing firm. They also place both crush spreads (long soybeans, short soyoil, short soybean meal) and reverse crush spreads (short soybeans, long soyoil, long soybean meal). However, the Johnson *et. al*. study is important because of the long sample period from 1966 to 1988 and is applicable because the basic concepts used in placing the trades are identical to those used in profit margin hedging. To implement their hedging strategy, Johnson *et al*. calculate the moving average of the gross crushing margin for the prior sixty months. The moving average serves as a proxy for all costs (excluding soybeans) of crushing soybeans. If the implied crushing/profit margin, based on the futures prices of soybeans, soyoil and soybean meal is above this moving average a crush trade is placed. If implied crushing/profit margin is below the moving average, a reverse crush trade is placed. All trades are held until the theoretical crush of the soybeans takes place. They find significant profits for trades of 5.5 months and longer after accounting for trading cost. The profits from these trades increase as the implied profit margin moves further from the moving average. For example, with a 7.5 month trade length, when the implied profit margin is more than twenty cents less than the moving average, the reverse crush trade (1 contract each, short soybeans, long soyoil, long soybean meal) has an average profit of $2,458 per trade while the same trade has an average profit of $323 per trade when the implied profit margin is between ten and twenty cents less that the moving average. Similar results for the crush spread are reported when the implied profit margin exceeds the moving average but those profits are not as pronounced.

Zulauf and Irwin simulated a storage hedging strategy for a Ohio corn producer for the 1967-96 crop years. Their study follows Working's storage hedge strategy but includes the uncertainty of basis for storage at a non-delivery point. The strategy is from the corn producer's viewpoint at harvest-time when he is faced with the decision to either sell his corn at harvest or store until some later date. The decision to store is based on the rule "Store only when the current basis minus the historical basis on the projected sell date exceeds to cost of storage." Zulauf and Irwin found that the returns to unhedged storage were not statistically different at the five percent level whether a signal to store was or was not generated. However, for hedged storage, the difference between returns from storage when a signal to store was given was statistically different from returns when a signal was not given. Variance was not considered in this study.

Zulauf and Irwin present a detailed review of the market efficiency literature. The underlying theme of the paper is that "although individuals can beat the market, few can consistently do so." They do not include producers in this group because producers do not possess either superior information or analytical skills in the Grossman and Stiglitz's sense. However, they specifically identify storage and profit margin hedging as strategies based on a market-generated forecast and as a different category of strategy that may provide opportunities for income enhancement for producers. In this category, futures prices are viewed not as a price forecast alone but as forecast that carries a signal to either encourage or discourage production or storage of the commodity.

The remaining studies are summarized in Table 1.1. These studies also imply an increase in profits from profit margin hedging. However, as a general rule, these studies are hampered by data restrictions. In particular, the cattle studies were constrained by the fact that futures for feeder cattle began trading in November 1974. With the entrance of the former Soviet Union into the world grain markets, grain experienced a structural change in 1972-73 that increased both the price level and price variance of grain. Thus, inferences drawn from prior data are questionable. For these reasons, the earlier studies lacked the possibility of rigorous statistical analysis of the hedging strategies with out-of-sample data. In fact, only the Kenyon and Clay study perform any out-of-sample test and that is with only thirteen observations. Most other studies provide split sample results, results of subperiods of the data set, as a compensation for not testing out-of-sample. While split sample results do provide some insight into the stability of the hedging strategy, the insight it provides is how well the rules fit the data over which they were developed. An appropriate analogy would be reporting the R^2 of a regression over subranges of the variables. While this might be of use, it does not prove that the regression will predict well out-of-sample and split sample results do not prove that the hedging strategy will function well out-of-sample. To truly judge the ability of a hedging strategy to function out-of-sample, it must be tested out-of-sample. Furthermore, the out-of-sample period must be of sufficient length that most of the market situations likely to be encountered are included in the

Table 1.1: Profit Margin Hedging Studies; Time Periods, Hedging Rule and Evaluation.

Authors	Commodities	Sample Period	In-Sample Observations	Out-of-Sample Observations	Results Report in Split Sample	Hedging Rule
Kenyon & Shapiro (1976)	Broilers, Corn, SBM	1970-75	72	0	Yes	Fixed
Shafer et.al (1978)	Fed Cattle, Corn, Feeder Cattle	1972-76	47	0	Yes	Fixed
Leuthold & Mokler (1980)	Fed Cattle, Corn, Feeder Cattle	1972-76	234	0	No	Fixed
Sphar & Sawaya* (1981)	Fed Cattle, Corn, Feeder Cattle	1974-78	728	0	Yes	Fixed
Kenyon & Clay (1987)	Live Hogs, Corn, SBM	1975-83	34	13	Yes	Fixed and Variable
Schroeder & Hayenga (1988)	Fed Cattle, Corn, Feeder Cattle	1978-85	90	0	Yes	Fixed
Johnson et.al* (1991)	Soybeans, Soyoil, SBM	1966-88	1266	0	Yes	Fixed
Zulauf & Irwin (1998)	Corn storage	1967-96	30	0	No	Fixed

* Overlapping observations, not distinct observations.

out-of-sample data set. An out-of-sample test of a grain strategy would be of limited use if it did not include at least one drought year. An out-of-sample test of a cattle or hog strategy would be of little use if it did not cover a complete cattle or hog cycle and preferably two cycles

Additionally, these studies suffer from a lack of proper significance testing. Of the true profit margin hedging studies in Table 1.1,[2] only the Kenyon and Shapiro and Kenyon and Clay studies perform any statistical tests. These two studies use the Dunnett's t-test of the mean but fail to test the variance. The other profit margin hedging studies only report the point estimates of the mean and variance with no significance testing. This is a common weakness of most research that uses mean/variance criteria for ranking of alternative choices. The choices are ranked according to the point estimates of the mean and variance but there is no attempt to test for a significant difference between the choices.

These statistical weaknesses, lack of data for out-of-sample testing and insufficient significance testing, are the reasons Johnson *et. al.* and Zulauf and Irwin call for additional research in the area of profit margin hedging. With the availability of additional data and the development of a joint significance test for the mean and variance, this study attempts to address those shortcomings.

Objectives

This research has two main objectives. The first objective is to determine if the KC profit margin hedging strategy increases profits and reduces variance of profits based on a true out-of-sample test. In this test, the KC hedging strategy methodology is followed as closely as possible.[3] The KC recommendations were based on thirty-five in-sample observations from 1975 to 1980 over which the models and trading rules were developed. The strategy was confirmed by KC with an additional test of thirteen out-of-sample observations from 1980 to 1982. In this study, the KC hedging strategy is applied to ninety-six out-of-sample observations beginning with February 1983 and extending through December 1998. This is the strictest form

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[2] The Johnson et. al. and Zulauf and Irwin are related studies. The statistical methods of these two studies appear appropriate for the scope of the studies. The criticism of statistical methodology is not direct at these studies.

[3] Information concerning the KC research is limited to that published in the journal article. Because the original databases are not available, the databases were reconstructed. Additionally, minor details about the methodology were not contained in the article. This required some assumptions to be made.

of out-of-sample testing possible because the hedging procedures were developed before the time period over which they are tested. The large out-of-sample size allows for true statistical significance testing of the outcome of the hedging procedure, something lacking in almost all previous hedging strategy studies.

The second objective is to improve the KC hedging methodology and trading rules. A base period of forty-eight in-sample observation from 1975 through 1982 is used to develop these changes. These changes are then tested on the same ninety-six out-of-sample observations as the KC strategy. While this appears to be a true out-of-sample test of the new strategies, it cannot be considered as such because these changes were developed with knowledge of the out-of-sample data set.

Statistical Methodology

The *a priori* hypothesis is that the hedged cash flow (cash market plus futures market cash flows) is not preferred to the unhedged or cash market cash flow. Preference is defined using the traditional mean/variance criteria. Under the mean/variance framework, the hedged cash flow is preferred if profits are increased without increasing variance or variance is reduced without decreasing profits. Mathematically, the hypothesis is stated as:

(1.2a) $H_0: \mu_H \leq \mu_C \cup \sigma^2_H \geq \sigma^2_C$

(1.2b) $H_A: \mu_H \geq \mu_C \cap \sigma^2_H \leq \sigma^2_C$

where C is the cash market cash flow and H is the hedged cash flow and one inequality in equation (1.2b) holds absolutely. This method only requires that the producer not have a risk seeking utility function. No other assumptions of risk preference are required.

The current literature does not provide a generally accepted standard for significance testing of selective hedging strategies in the mean/variance framework. There are several considerations in selecting the most efficient statistical test. The first is to recognize that the hedged flow is dependent on the cash market flow. This dependence is a result of the hedged flow being the sum of the cash market flow and the futures market flow. However, by the random walk theory of price movements, the profit or loss from the futures market is independent of the profit or loss from the cash market. Therefore, proper statistical testing must focus on the futures market flow with the hypothesis test restated in terms of the futures market flow and the cash market flow. The second consideration is the fact that the mean and variance of a given distribution are independent. This allows the joint probability in 1.2a to be calculated as the product of the probability of the two independent events. Therefore the mean condition and the variance condition in the null hypothesis are tested separately with the joint condition calculated from their respective p-values.

To test the mean condition of the hypothesis, if the hedged flow is greater than the cash market flow, it follows that the futures market flow must be greater than zero because the hedged flow is the sum of the futures and cash market flows. Therefore the mean condition in equation (1.2) is restated as:

(1.3a) H_0: $\mu_F \leq 0$

(1.3b) H_A: $\mu_F > 0$

where F is the futures market cash flow. The appropriate test of the restated hypothesis is a standard one-tailed t-test.

To devise a test for the variance condition in terms of the futures market cash flow, the component parts of the hedged cash flow, cash market plus futures market cash flows, are substituted into the variance condition of equation (1.2a) and restated as:

(1.4a) H_0: $\sigma^2_{(C+F)} \geq \sigma^2_C$

By definition, the variance of the sum of two distributions is the sum of their variances plus twice their covariance. Therefore, (1.4a) is restated as:

(1.4b) H_0: $\sigma^2_C + \sigma^2_F + 2 \text{ cov}_{(C,F)} \geq \sigma^2_C$.

Subtracting σ^2_C - 2 cov $_{(C,F)}$ from both sides of equation (1.4b) yields:

(1.4c) H_0: $\sigma^2_F \geq -2 \text{ cov}_{(C,F)}$.

Dividing equation (1.4c) by the cov $_{(C,F)}$ and then inverting produces:

(1.4d) H_0: $\text{cov}_{(C,F)} / \sigma^2_F \geq -0.5$.

The ratio of the covariance to the variance is recognized as the coefficient of an independent variable in a regression estimate. Specifically, the covariance/variance ratio is the slope coefficient in the equation:

(1.5) $C = \alpha + b_1 F$.

where C and F are defined as above, α is the intercept term and b_1 is the regression coefficient showing the effect of F on C and is the left hand side of equation (1.4d). The hypothesis is then restated as:

(1.6a) H_0: $b_1 \geq -0.5$

It follows that the alternative hypothesis is then:

(1.6b) $H_A: b_1 < -0.5$

The standard t-test statistic, as used in regression analysis, tests for a slope significantly different from zero. Subtracting -0.5 from the slope coefficient in the standard statistic alters the statistic to test for a slope significantly different from – 0.5. The test statistic is:

$$(1.7) \quad t = \frac{b_1 - (-0.5)}{\sqrt{\dfrac{\sum (C - \hat{C})^2}{(n-2)\sum (F - \overline{F})^2}}} \sim t_{n-2}$$

As with the mean condition, the appropriate test is a one-tailed significance test.

Combining the revised mean condition in equation (1.3) and the revised variance condition in equation (1.6) allows the original hypothesis in equation (1.2) to be restated without the hedged cash flow term and in terms of only the cash market and the futures market as:

(1.8a) $H_0: \mu_F \leq 0 \cup b_1 \geq -0.5$

(1.8a) $H_A: \mu_F \geq 0 \cap b_1 \leq -0.5$

where one inequality in equation (1.8b) holds absolutely.

The remainder of the thesis is divided into chapters as follows. Chapter 2 presents the original Kenyon and Clay strategy and reports the results of implementing KC's optimal strategy during a long out-of-sample test. Some of the weaknesses of the KC strategy are discussed. In Chapter 3, alternate models are formulated with the aim of improving the hedging outcome. The new models are used to evaluate strategies over the same out-of-sample period. Chapter 4 identifies changes in price movements that have occurred over the study period and discusses their ramifications to hedging. Chapter 5 summarizes the results and discusses the implications of large out-of-sample statistical testing relative to economic theory and the practical development of and evaluation of hedging strategies to be used in the business environment.

Chapter 2: Kenyon and Clay Strategy Evaluation

In KC, "a high-intensity 150 sow commercial farrow-to-finish enterprise was assumed to be located near Smithfield, Virginia" that replicates the system described in Bache and Foster (1977). The Bache and Foster system was a state-of-the-art total confinement system with realistic cost and return assumptions for efficient managers using 1975 as the base year. KC estimated cash profit margins from 1975 through 1980 with six lots of hogs sold at two month intervals each year. They used Virginia cash prices for hogs, corn and soybean meal while other production costs were estimated from the Bache and Foster budget using the *Indices of Agricultural Prices* for adjustment over time. These cash profit margins were regressed against per capita quarterly pork production, corn prices and soybean meal prices. The estimated regression coefficients were used to predict an expected profit margin using daily futures prices for corn and soybean meal and per capita pork production. Pork production was forecasted from quarterly sow farrowings intentions, pig crop, and market hog inventory estimates reported in the USDA/NASS *Hogs and Pigs* report. Implied profit margins were calculated using the Bache and Foster budget adjusted for inflation and futures prices adjusted for Virginia basis. Both the expected profit margins and the implied profit margins were calculated on a daily basis. Hedges were placed for feed and hogs when the implied profit margin exceeded the expected profit margin (EPM) by various percentage levels. Feed hedges remained in place until the feed was bought (four months prior to the sale of the hogs) while the hog hedge remained in place until the hogs were sold.

While KC reported results of hedging one, two, three and four quarters ahead of hog sales and at differing trigger levels, their best results, in terms of increased profit and reduced risk, were for the two quarters ahead forecast and the seventy percent trigger level (2/70 strategy). Specifically, the 2/70 strategy begins to place hedges up to two quarters ahead and continues until the hogs were marketed, at an implied profit margin seventy percent greater than the expected profit margins. The2/70 strategy increased the profit margins from $5.50 per cwt. to $8.36 while decreasing variance from $93.34 per cwt. to $63.43 per cwt. during the February

1975 through October 1980 in-sample period of thirty-five observations. During the December 1980 to December 1982 out-of-sample test period containing thirteen observations, profit margins increased from $0.57 per cwt. to $1.21 per cwt. while lowering variance from $105.95 per cwt. to $43.31 per cwt. In this chapter, only the two quarters ahead strategy is examined because KC found this strategy dominated all other strategies using mean/variance criteria.

This chapter follows the same concept as KC but differs in two major respects: KC assumed that the production facilities were located in Virginia. Therefore, KC's profit margin calculations were based on Virginia cash prices. This required KC to adjust futures prices by the Virginia three year moving average historical basis. No location is assumed in this study and therefore no basis is included in the calculations. Futures prices are assumed to be equivalent to cash prices. Any differences caused by the basis adjustment are assumed to be minor. Costs in KC were based on the Bache and Foster budget adjusted for inflation by the *Indices of Agricultural Prices*. Costs in this chapter are based on regularly published USDA data to eliminate known problems with simple inflation of costs over long time periods with inflation indices.[4] These changes do not alter the hedging concept of KC, but they do make this research more applicable to the industry in general. Any other minor differences between KC and the models estimated in this chapter are explained when the models are presented. Since the original data set was not available, some minor assumptions were made. No changes are made with the intent to improve the results of the hedge strategy. All changes and assumptions are consistent with a reasonable implementation of the KC strategy by a swine producer or marketing consultant.

The remainder of this chapter is divided into three sections: The Models and Data section describes the models and data sources used in the hedging process. These are based on information available in the fall of 1982 when the test period would have begun. The Hedging Results section reports the results for the hedging simulation. In the In-Sample Results subsection, the trigger level is first calibrated to the data used in this study by simulating hedging at various trigger levels from 1975 through 1982. The in-sample results of the selected trigger level are then compared against the KC hedging results to insure the outcome of the hedging

[4] Preliminary calculations with the *U.S. Production Costs Indices* and Bache and Foster budget verified this to be a problem. Cost began to become unrealistic in the 1980's.

process in this study reasonably reflects the outcome as reported by KC from 1975-1982. The Updating Procedures subsection provides a detail explanation of the procedure used to reestimate the models on a yearly basis during the out-of-sample period. 'Learning' is not allowed during the out-of-sample test. Therefore the hedging procedures and model structures are held constant. The subsection Out-of-Sample Results reports the results of the hedging process from 1983 through 1998 at the selected trigger level. The Analysis and Model Performance Through Time section provides a detailed analysis of the performance of the individual models over the out-of-sample test period as they are updated yearly. An analysis of the impact of each individual component of the model on the hedging process is conducted to investigate sources of possible improvements to the hedging process.

Models and Data

To understand the hedging process, it is critical to understand two key estimated values, Implied Profit Margin (IPM) and Expected Profit Margin (EPM). IPM is the profit margin that is implied by the futures market. IPM is calculated by subtracting the total cost of production from total revenue. Total revenue is based on the futures price of live hogs while total cost of production is based on the futures prices of corn and soybean meal with an estimated allowance for other costs. IPM is sometimes referred to as the profit that a producer can 'lock-in' by placing a hedge given no basis risk. Because this study does not assume a location and therefore no basis, IPM is in fact the actual profit that the hypothetical hog producer will receive if the hedge is placed.

EPM is the profit margin that is expected given current market conditions. In general, EPM can be any estimate of expected profit margin. KC estimated EPM from expected pork production and the futures prices of corn and soybean meal. The EPM estimate is based on the results of a regression of pork production and the prices of corn and soybean meal on past cash profit margins (CPM). The signal to hedge occurs when the IPM is greater than the EPM[5] by a prespecified premium or trigger level. The trigger can either be an absolute dollar value or a percentage above the EPM as chosen by KC. In either case, the optimal trigger level is

[5] Some studies also include the possibility of a reverse hedge when the IPM is lower than the EPM. This transaction is not considered a hedge for tax purposes by the IRS. It is in fact more appropriately considered as speculation for a hog producer because it increases his price risk exposure. Therefore, this study does not consider a reverse hedge.

determined from past outcomes of simulated hedges and depends upon the assumptions and models used to calculated the CPM, IPM and EPM.

An overall view of the KC hedging process as implemented in this study is given in Figure 2.1. The IPM and EPM are calculated on a daily basis from the closing futures prices. When a hedging signal is received, the hedge is placed by selling the live hog futures and buying both the corn and soybean meal futures on the opening futures prices of the following day. No allowance is made for slippage and futures contracts are assumed to be available in required size, i.e. 'lumpiness' of contract size is not factored into the calculations. (In practice however, two live hog contracts of 40,000 pounds, one corn contract of 5,000 bushels, and one Mid-America soybean meal contract of 20 tons[6] results in only a slight over hedging of corn and soybean meal.) Once the hedge is in place, the feed hedge (corn and soybean meal) remains in place until the feed is bought and the hog hedge remains in place until the hogs are sold. All feed is assumed to be purchased at the opening prices of corn and soybean meal on the day feeding begins which is four months prior to the sale of the hogs. No feed hedges are placed after the feed is bought and the daily IPM and EPM are calculated on the opening prices of the of corn and soybean meal on the date the feed was bought. Thus, some hedges will include hogs, corn and soybean meal while others will only include hogs.

For example, the June *Hogs and Pigs* report contains the first estimate of the March-May pig crop that is used to estimate the Quarterly Per Capita Pork production (QPKP) in the fourth quarter (October-December). When the report is released in late June, the October lot of hogs is already on feed as of June 1 which means that the feed is not hedged for this lot of hogs. Feed is assumed to have been purchased on June 1 and the EPM is calculated based on those feed prices and the estimated fourth quarter QPKP. Because feed has been purchased and its price does not change, the EPM is calculated only once for this lot. The IPM is also calculated from the June 1 feed prices but is updated daily with the change in the closing live hog price up to the time of the marketing of the hogs on October 1. The market is monitored daily for a hedge signal. If, for example, the trigger level is fifty percent and the EPM is calculated to be two dollars, if the IPM

[6] The Mid America contract originated in 1985 as 20 tons and increased to 50 tons with the August 1995 contract.

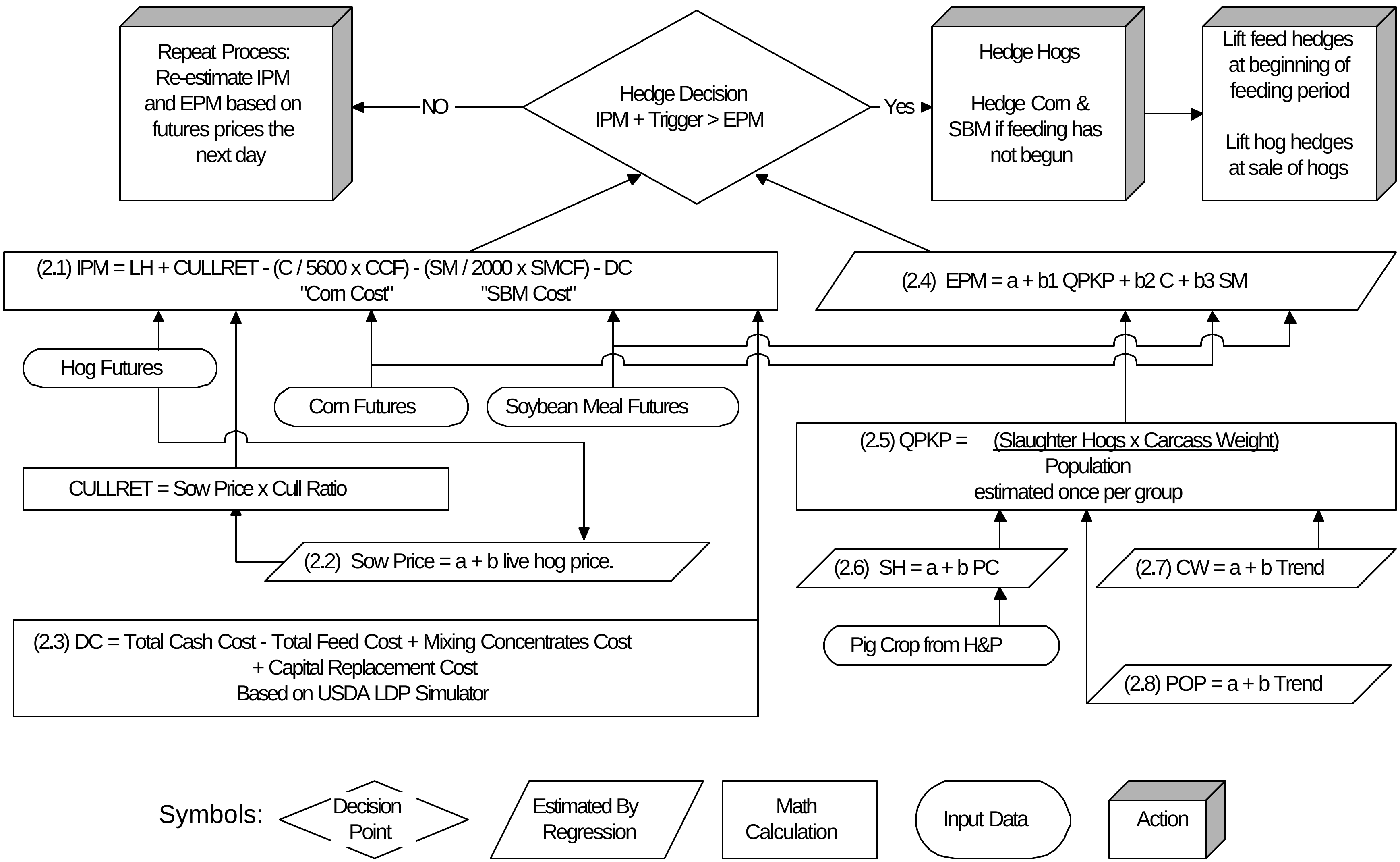

Figure 2.1: Flowchart of KC Profit Margin Hedging Process

reaches three dollars, a hedge signal is received. The hedge will be placed at the open price of the live hogs contract the following trading day. (If the hog futures are 'lock limit', which frequently happens after the release of a *Hogs and Pigs* report, no hedge is place. The hedge is placed on the first day the futures are not 'lock limit' day if the hedge signal remains valid.) The hedge remains in place until October 1, when the hogs are marketed and the hedge is closed at the opening live hogs price. The December lot hedge works similarly but this lot does not go on feed until August 1. Before August 1, the EPM is calculated daily, based on the closing price of corn and soybean meal. The trigger is monitored daily and, if met, hedges are placed on the opening prices of the next trading day for live hogs, corn and soybean meal. The feed hedges are then closed at the opening prices of feed on August 1 and the hog hedge is closed on December 1. The feed hedges can only be placed in the five week window prior to August 1 while the hog hedge can be placed for the entire twenty-two week period.

The remainder of this section provides details of the underlying models and assumptions made in estimating the IPM and EPM. However, there are two methodological points that pertain to several models. First, in all models, ten prior years of data are used to estimate the equations. Data is discarded after ten years, resulting in a ten year moving window data set if ten prior years of data was available. The ten year data window was chosen arbitrarily as a compromise between the greater accuracy of a larger data set and reduced significance of observations in the distant past, farther removed by time from the period being forecasted. The intend is to have data sets of sufficient length to provided reasonable estimates of the coefficients of the regressions while restricting the length of the data set to allow the regression estimates to respond to changes in the relationships being estimated. No attempt was made to optimize the length of the data window because there was not sufficient data available in 1982. The length of the data window was not an issue for KC because they estimated the regression equations only once with a single data set from 1975 through 1980.

The second methodological issue pertains to regressions that contain a trend variable. For each ten year window, the trend values are reassigned with each re-estimation of the regression. The intercept is always assumed to be ten years prior to the last observation in the data set. The last observation in the data set is always assigned the value of the maximum number of observations with the remaining observation numbered in reverse order. For example, a regression with ten years of quarterly data would contain forty observations. The last observation in this data set would have a trend value of forty and the first observation a value of one. However, if the first year of data is unavailable there are only nine years of data or thirty-six observations. In these cases the last trend value remains forty but the first is now five. This method of assigning trend values allows direct comparison of the intercept term across regression estimates.

Cash Profit Margin (CPM)

The first step in developing the hedging models is defining the underlying cost and revenue structure. This allows the estimation of the cash profit margin that the hypothetical producer would receive from each lot of hogs sold. Following KC, hogs are assumed to be sold on the first day of the month, beginning in February, at two-month intervals throughout the year. This results in six of the seven available live hog contracts being used to hedge with no contract being used twice. Feeding is assumed to begin four months prior to the date the hogs are sold. All feed is bought at opening prices of the corn and soybean meal futures contracts that expired nearest to but after the date feeding begins. (These are also the contracts used to place the hedges.) Table 2.1 summarizes the pertinent dates and futures contracts.

The CPM for each lot is calculated by equation (2.1):

(2.1) $CPM = LH + CULLRET - (C / 5{,}600 \times CCF) - (SM / 2{,}000 \times SMCF) - DC$

where: CPM = Cash Profit Margin, \$/cwt. of market hogs

LH = Opening Live Hog futures price,[7] \$/cwt.

Table 2.1: Pertinent Dates and Futures Contracts.

Feeding Begins Feed Purchased	Corn Contract	Soybean Meal Contract	Feeding Ends Hogs Sold	Live Hog Contract
October 1	December	October	February 1	February
December 1	December	December	April 1	April
February 1	March	March	June 1	June
April 1	May	May	August 1	August
June 1	July	July	October 1	October
August 1	September	August	December 1	December

[7] The Live Hog contract was replaced with the Lean Hog contract beginning with the Feb 1997 contract. Lean Hog prices were converted to live hog equivalent by multiplying the Lean Hog price by 0.74.

CULLRET = Cull Returns, income from cull breeding stock, \$/cwt.

C = Opening Corn futures price, cents/bu.

5,600 = Converts C into \$/lbs.

CCF = Corn Conversion Factor, lbs. of corn / cwt. market hogs

SM = Opening Soybean Meal futures price, \$/ton[8]

2,000 = Converts SM into \$/lbs.

SMCF = Soybean Meal Conversion Factor, lbs. of SM / cwt. market hogs and

DC = Direct Cost excluding feed, \$/cwt.

LH is the opening price for live hogs (later lean hogs) on the first market day of the contract month in which the hogs are sold. C and SM are the opening prices for corn and soybean meal for the nearest to expiration contracts on the day the feed is assumed to have been purchased. For example, to calculate the CPM for the August 1980 lot of hogs, the opening price on August 3, 1980 for the August 1980 live hog contract is used along with the opening price on April 1, 1980 for the May 1980 corn and soybean meal contracts.

CULLRET, CCF, SMCF and DC are derived from USDA data. In the May 1986 issue of the *Livestock and Meat Situation and Outlook* (later renamed *Livestock Dairy and Poultry Situation and Outlook* and refereed to collectively as LDP in this paper), a profit simulator was published for a 1600 head farrow to finish operation with backcasted data to 1980. These data were assumed to be available for use at the beginning of this study. Data for 1975 through 1979 were estimated from the USDA/ERS *Cost of Producing U.S Livestock* (COP) series. Because the LDP simulator is based on the COP series, the use of the COP data for 1975-79 does not represent a mixed data set.

As noted previously, this is a different data series than used by KC. KC inflated the Foster and Bache budget using *Indices of Agricultural Prices*. Over long time periods, it is extremely difficult to simply inflate costs and achieve satisfactory results. Preliminary calculations with *Indices of Agricultural Prices* and KC's inflation method proved this was a problem. By the end of their study in 1982, costs were beginning to be over estimated. Therefore, a replacement cost series was necessary that was publicly available throughout the

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[8] The CBOT Soybean Meal contract was originally based on 44 percent protein. Beginning with the September 1992 contract, it is based on 48 percent protein. Soybean meal futures prices after September 1992 are converted to 44 percent equivalent by dividing the stated price by 1.09 (48 percent ÷ 44 percent).

study period and gave accurate cost estimates to 1982 when the producer would have been choosing the coat series. The LDP budget simulator met these criteria given the use of the backcasted data. While the LDP budget simulator is also a base budget that is inflated through time, it is apparently more detailed in its methods of inflation and gave more realistic cost in the early 80's. It has the additional benefit of being easily implemented by a producer.

Table 2.2 provides annualized estimates of the CPM and costs of hog production from 1975 through 1998. All values in this table are based on one hundred pounds of markets hogs sold. The corn and soybean meal cost in Table 2.2 are based on the average cost of the six lots of hogs sold during the year. The cash cost are all other cash expenses necessary to produce hogs, i.e. hired labor, mixing concentrates, veterinary expenses, taxes, interest, etc. Capital replacement cost are based on the yearly prices for capital items and reflects the investment needed to maintain a constant production capacity over time. The sum of cash cost and capital replacement is the direct cost used in equation (2.1). Total cost is the sum of feed and direct cost. CPM is the average of the six CPM's of the year as calculated by equation (2.1).

Even though all years of the study are reported in Table 2.2, the producer selecting this data series would have only had the cost estimates through 1982 to judge the validity of the data. Through 1982, the costs appear to be reflective of actual costs experienced by typical hog producers. Deficiencies in this series after 1982 are discussed in the analysis section of this chapter. Details related to the estimation of each component of the hedging model are given below.

Cull Returns

Cull Returns (CULLRET) is an estimate of the value of cull breeding stock sold and is based on the price of live hogs. CULLRET is estimated by multiplying the cwt. of cull breeding stock sold per cwt. of market hogs by an estimated cull sow price. The cull rates in COP and LDP are 8.01 cwt. per 91.99 cwt. market hogs and 5.75 cwt. per 94.25 cwt. market hogs, respectively. Conversion to cwt. of market hogs sold produces a cull rate of 8.71 for 1975-1979 and 6.10 for 1980-1998. Following KC, the relationship between market hog price and sow price was estimated with the following equation:

(2.2) $SP = \alpha + \beta\ BG$

where: SP = Monthly sow price for U. S. 1-2, 6/7 markets and

BG = Monthly U.S. 1-3, 230-250 lbs., barrow and gilt price, Iowa/S. Minn.

Table 2.2: Yearly Hog Production Costs and CPM, $/cwt. of Market Hogs.

Year	Corn Cost*	SBM Cost*	Feed Cost	Cash Cost**	Capital Replacement	Direct Cost***	Total Cost	CPM*
1975	22.33	5.23	27.56	10.05	4.03	14.08	41.64	12.52
1976	19.36	5.58	24.94	10.41	4.84	15.25	40.19	5.59
1977	16.83	7.77	24.60	10.97	4.47	15.44	40.04	3.29
1978	16.21	6.04	22.25	12.05	4.93	16.98	39.23	14.50
1979	17.22	7.10	24.32	12.67	5.84	18.51	42.83	3.08
1980	18.61	7.00	25.61	14.24	5.37	19.61	45.22	-2.09
1981	23.52	8.53	32.05	16.31	5.92	22.23	54.28	-5.02
1982	17.69	6.91	24.60	17.96	6.13	24.09	48.69	11.44
1983	18.19	6.71	24.90	17.62	6.21	23.83	48.73	1.15
1984	22.08	7.50	29.58	17.70	6.16	23.86	53.44	-0.67
1985	17.50	5.06	22.56	16.95	6.16	23.11	45.67	3.12
1986	14.57	5.48	20.04	17.10	6.03	23.13	43.17	10.19
1987	11.12	5.75	16.87	17.14	6.09	23.23	40.10	13.45
1988	14.11	7.92	22.03	16.27	6.24	22.51	44.54	3.16
1989	17.11	8.67	25.78	16.81	6.25	23.06	48.84	-0.97
1990	16.54	6.62	23.16	17.90	6.40	24.30	47.46	11.57
1991	15.96	6.51	22.47	20.60	6.26	26.86	49.33	3.84
1992	16.40	6.79	23.19	16.38	6.28	22.66	45.85	-0.55
1993	14.53	6.59	21.13	18.10	7.05	25.15	46.28	4.26
1994	17.28	6.66	23.94	17.62	7.36	24.98	48.92	-3.75
1995	15.92	5.68	21.60	17.51	7.18	24.69	46.29	-0.74
1996	24.56	7.80	32.36	18.17	7.34	25.51	57.87	0.99
1997	18.49	9.01	27.49	18.74	7.49	26.23	53.72	3.36
1998	16.52	6.35	22.88	19.16	7.64	26.80	49.68	-11.87

* Calculated using yearly average of the six lots.

** Excluding Corn and SBM costs.

*** Cash Cost + Capital Replacement

Monthly sow price and monthly barrow and gilt price where obtained from USDA/AMS. The equation is estimated with the previous ten years of data for a total of one hundred and twenty observations. After the regression is estimated, the futures price of live hogs was used to predict the sow price.

Feed Conversion Factors

The LPD simulator uses 345.6 pounds of corn, 70.6 pounds of soybean meal and 14.3 pounds of mixing concentrate. The 1976 COP budget uses 357 pounds of corn and 83 pounds of 'protein supplements'. In the COP budget, the term 'protein supplements' includes mixing supplements. Therefore, 83 pounds of protein supplement is estimated to be equivalent to 69 pounds of soybean meal and 14 pounds of mixing supplement. These conversion factors are per cwt. of pork produced including cull breeding stock. These were converted to cwt. of market hogs yielding 388.04 pounds of corn and 75.00 pounds of soybean meal for 1975-1979. The feed usage changed to 366.68 pounds of corn and 74.91 pounds of soybean meal in 1980. LDP has not changed these conversion factors since 1980. For comparison, KC use constant feed conversion factors of 353.21 pounds of corn and 73.16 pounds of soybean meal per cwt. market hogs.

Direct Cost

Direct Cost (DC) are calculated from the LDP budgets as:

(2.3) DC = Total Cash Cost – Total Feed Cost + Mixing Concentrates Cost
+ Capital Replacement Cost

All right hand side variables are as defined in the LDP budget simulator. The May 1986 LDP contains yearly budget estimates for 1980-85. After that date, monthly budgets were published regularly and were used to obtain a yearly average. As noted above, data for 1975-1979 was estimated from the COP series. For comparison, KC's direct cost were $14.75 cwt. in 1975 and $22.02 in 1980 compared to the cost estimated for the LDP and COP budgets of $14.08 cwt. and $19.61 cwt., respectively.

Implied Profit Margin (IPM)

Equation (2.1) is also used to calculate the IPM or the profit that a producer can 'lock-in' by placing a hedge in the futures market. The difference between the IPM and the CPM is when the IPM is calculated and therefore the date of the futures prices used in the calculation. IPM is calculated daily during the hedging period with the futures prices of live hogs, corn and soybean taken at the close of the market. For example, on March 20, 1980 the IPM for the August 1980 lot of hogs is calculated from the March 20 closing futures price of the August 1980 live hogs contract and the March 20 closing futures prices of the May 1980 corn and soybean meal contracts. If a hedge is not placed, the process is repeated on March 21 in the same manner. However, on April 1, 1980, the feed is assumed to be purchased at the opening price of corn and soybean meal. Beginning on April 1, the IPM is calculated with these corn and soybean meal prices but the live hog price continues to be the daily closing price of the August contract. Because IPM is calculated daily there are many IPM's for a given lot of hogs. However, there is only one CPM for a given lot of hogs because it is calculated only once per lot, using the feed prices on the day feeding begins and the live hog price on the day the hogs were sold.

The direct costs are also a part of calculating IPM and must be estimated because cost for the current year are not known until year's end. However, no attempt was made to model and forecast costs one year ahead. The period from the beginning of the study until 1981 was a period of extremely high and volatile inflation. Because of action taken by the Federal Reserve Bank in the late 70's and early 80's, by the end of 1982, it was the consensus opinion that the period of extremely high inflation was over, at least for the foreseeable future. A forecasting model based on this high inflation period would have overestimated future costs. Therefore, for the in-sample period, the DC for the current year was used as these were known at the time of use for the in-sample period. For the out-of-sample period, the previous year's DC was used as an estimate of the current year, i.e. 1983 DC was use to calculate 1984 IPM.

Expected Profit Margins (EPM)

KC identified per capita pork production, cash corn and soybean meal prices as market conditions that are significant determinates of profit margins. Following KC, the EPM is estimated by the following equation:

(2.4) $EPM = \alpha + \beta_1 \, QPKP + \beta_2 \, C + \beta_3 \, SM$

where: EPM = Expected Profit Margin ($/cwt.)

QPKP = Quarterly per capita pork production, comm., carcass wt., (lbs/person)

C = Futures corn price, (cents/bu) and

SM= Futures soybean meal price, ($/ton).

To estimate equation (2.4), the CPM's of the past ten years, sixty observations, were used as the dependent variable.[9] The independent variables are actual quarterly per capita pork production

[9] For the first two years of the study only 8 and 9 years of historical data was available thus those estimates were limited to 48 and 54 observations respectively.

and the opening futures prices of the nearby corn and soybean meal contracts on the day the feed was bought for each lot. For example, for one observation of the regression estimation, the CPM for the August 1980 lot of hogs would correspond to the actual third quarter QPKP and the opening futures prices for the May 1980 corn and soybean meal contracts.

During the hedging period, EPM is estimated on a daily basis. To use the equation estimates to forecast a daily EPM, the estimated third quarter QPKP and the daily closing futures prices for corn and soybean meal are used. For example, on March 20, 1980 the EPM for the August 1980 lot of hogs is estimated from the March 20 closing futures prices of the May 1980 corn and soybean meal contracts. If a hedge is not placed, the process is repeated on March 21 in the same manner. However, on April 1, 1980, the feed is assumed to be purchased at the opening price of corn and soybean meal. On April 1, the EPM is calculated using these opening prices. Because the variables do not change after April 1, the EPM remains constant through the remainder of the hedging period for the August 1980 lot. [10]

Estimation of Quarterly Per Capita Pork

Quarterly per capita pork production is calculated by:

(2.5) QPKP = (SH x CW) / POP

where: QPKP = Quarterly per capita pork production, comm, carcass wt., (lbs/person)

SH = Quarterly Commercial Slaughter Hogs (# of head)

CW = Average Carcass Weight, Commercial (lbs./head) and

POP = U.S. Resident Population.

Each of the right hand side components of equation 2.5 are estimated by regression as described below. This method differs slightly from KC. The numerator in equation 2.5 is the total quarterly commercial pork production in pounds of carcass weight. KC estimated this value directly by regression from the quarterly pig crop. This study estimates the number of slaughter

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[10] The estimate of QPKP remains unchanged throughout the hedging period for a given lot. QPKP is estimated two quarters ahead by the pig crop from the *Hogs and Pigs* report. KC revised the QPKP by using the the 60-170 pound Market Hog inventory to forecast one quarter ahead. This revision was not made because the improvements are not significant and because of the extremely short period of time this estimate would be used, i.e. for the April and October lots, less than a week.

hogs by regression from the quarterly pig crop and the carcass weight by a trend regression. This change was implemented to allow a more detailed analysis of error sources.

Slaughter Hogs

Equation 2.6 is used to estimate quarterly hog slaughter:

(2.6) $SH = \alpha + \beta\ PC$

where: SH = Quarterly Commercial Hog Slaughter (# of head), and

PC = Pig Crop two quarters earlier (# of head).

Four separate regressions, one for each quarter, were estimated to allow for seasonality. Table 2.2 list the calendar quarters of hog production with the pig crop quarter used in the associated regression and prediction. Note that commercial hog slaughter is being estimated two quarters ahead by the lagged pig crop.

Final U. S. commercial hog slaughter is obtained from USDA/NASS *Livestock Slaughter* and represents the total number of barrows and gilts, sows and boars slaughtered per calendar quarter. Pig crop is the most recently revised USDA estimates as printed in *Livestock Price Outlook* published originally by Illinois Extension Service and currently by Purdue Extension Service. Pig crop estimates may be revised until the final estimates are published which may be from three to six years after the initial estimate. Using the most recent pig crop estimate and not the final estimate insures that no data were used before they were publicly available. This step was not necessary with slaughter hog numbers because they are final within two months after slaughter. Ten States[11] pig crop was used through September 1990 with ten years of data being used to estimate the equation with the exception of the first year when only nine years of data were available. Beginning with the lot of hogs sold April 1991 and corresponding to the change

Table 2.3: Pig Crop Used to Predict Hog Slaughter by Quarter.

Quarterly Commercial Hog Slaughter	Pig Crop
I (January-March)	June-August (prior year)
II (April-June)	September-November (prior year)
III (July-September)	December (prior year) - Febuary
IV (October-December)	March-May

[11] The ten states are: GA, IL, IN, IA, KS, MN, MO, NE, NC, and OH.

in January 1991 *Livestock Price Outlook*, U.S. pig crop was used. In 1991, only four years of U.S. historical data were available which reduced the number of observation to four in 1991 with the number of observations increasing by one each year until ten observations were again available for hogs slaughtered in 1997. Thus, the number of observations for each equation ranged from a minimum of four to a maximum of ten observations.

Carcass Weight

Carcass weight is estimated by equation 2.7:

(2.7) CW = $\alpha + \beta$ TREND

where: CW = Average Carcass Weight, Comm., (lbs./head) and

Trend = 1...10

Final federally inspected carcass weights for all classes of hogs, as published in USDA/NASS *Livestock Slaughter,* were used in the estimations. The equation was estimated over the prior 10 years, using a separate equation for each quarter thus providing ten observations per estimation.

Population

Population is projected by equation 2.8:

(2.8) POP = $\alpha + \beta$ Trend

Where: POP = U.S. Resident population and

Trend = 1...40

Estimates of U.S. resident population on the first day of each month were obtained from the Bureau of Census. The population of the second month of the calendar quarter was assumed to be the quarterly population. The regression was estimate over the prior ten years using a total of forty observations.

Comparison To KC

The KC article is limited in the information that is provided relating to the predictions of the underlying varibles of the hedging process. KC do provide the cash profit margins for each lot. Figure 2.2 is a direct comparison of the cash profit margins reported in KC to the cash profit margins as calculated in this study. These will differ because: 1) KC used Virginia cash prices for hogs, corn and soybean meal where this study used the futures prices, 2) KC's direct cost were based upon the Foster and Bache budget with allowances for inflation where this study is based on the LDP simulator, 3) feed conversion factors differ slightly with this study containing

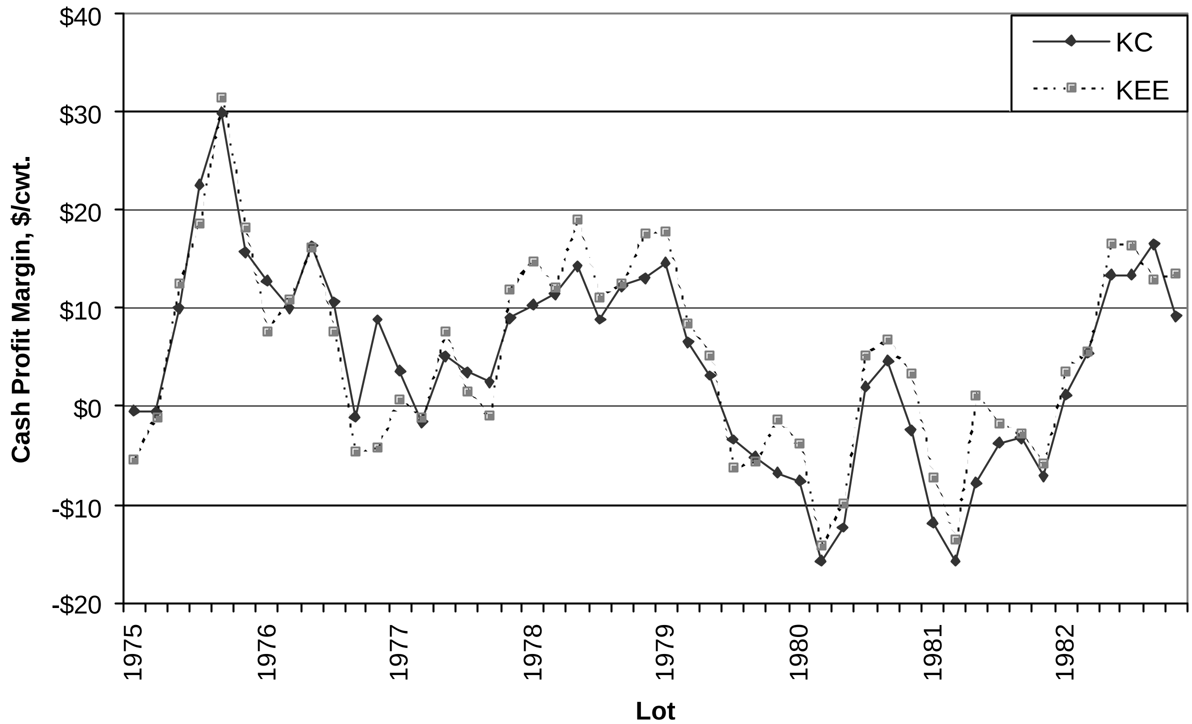

Figure 2.2: Comparison of Cash Profit Margins, KC vs Kee

a change in the factors in 1980, and 4) cull ratios differ slightly with the ratio changing in 1980 in this study. For the implementation of the hedging strategy in this study to replicate the performance reported by KC, it is not necessary that these cash profit margins be equal but they should behave similarly through time. Visual inspection of Figure 2.2 indicates that the two series do behave similar with both tending to change by approximately the same magnitude between consecutive observations. This is confirmed by a coefficient of correlation of 0.93. Most of the lack of perfect correlation can be attributed to the presence of varying basis in KC with a small amount attributable to the fact that KC updated their direct costs quarterly whereas this study updates direct costs once per year. The variance of the two series are virtually identical at 90.02 in the KC study and 90.42 in this study. There is a small shift in the overall profit level. Over the 1975-82 period the average cash profit margin for KC is $4.46 per cwt. compared to $5.42 per cwt. in this study. The two series have almost identical profit levels in 1975 and tend to drift apart through time. During 1975, the profit margins in this study average about $0.36 lower than KC while during 1982, this study averages about $1.62 higher than KC. This relative downward shift in profits by the KC series is partly attributable to the overestimation of direct cost by simple inflation of the Foster and Bache budget and the increase in feed efficiency that occurred in this study in 1980 which increased the profit margins.

KC report the results of the EPM regression equation over the time period from February 1975 through October 1980 as:

$$EPM = 102.42 - 3.242\ QPKP - 0.108\ C - 0.099\ SM$$
$$(10.31) \quad (-6.09) \qquad (-4.21) \quad (-3.31)$$
$$R^2 = .79 \qquad SER = 4.65 \qquad N = 35$$

Results for this regression estimate from the data set used in this study over the same time period are:

$$EPM = 93.81 - 2.408\ QPKP - 0.104\ C - 0.131\ SM$$
$$(8.50) \quad (-4.23) \qquad (-4.17) \quad (-3.86)$$
$$R^2 = .70 \qquad SER = 5.77 \qquad N = 35$$

The results of these two estimations will vary because the variables differ slightly. KC uses cash corn and soybean meal prices four months prior to the sale of the hogs where this study uses futures prices four months prior to the sale of the hogs. This study uses actual QPKP where KC is unclear as to whether actual or estimated QPKP was used. However, both estimations should be and are similar. KC's intercept and coefficient estimates fall within the ninety-five percent confidence interval for the estimates in this study and therefore are not significantly different in a statistical sense. From a practical standpoint, given the 'normal' price level and variation in the independent variables[12] and the fact that the KC prices are offset by Virginia basis, the corn and soybean meal estimates are very similar. However, the QPKP coefficient in KC is about thirty-five percent greater than in this study and is the cause for the shift in the intercept term. While not statistically different, the difference in the impact of the QPKP coefficients is troubling from a practical standpoint. Figure 2.3 illustrates the estimated EPM from holding corn and soybean meal price constant at 250 cents per bushel and $180 per ton, respectively, while varying the QKPK from 12 to 20 pounds, the approximate range of QPKP during 1975-82. The estimates are very similar in the mid range of QPKP but differ significantly at the ends of the range. For example, the EPM estimates differ by approximately $3.50 at twelve and twenty pounds of pork.

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[12] The mean and standard deviation for the independent variables in this study are: QPKP, 15.53 and 1.98 lbs,; C, 266 and 40 cents/bu.; SM 171 and 33 $/ton. KC do not report prices for C and SM. The mean and standard deviation for KC's QPKP is 15.8 and 2.04 lbs.

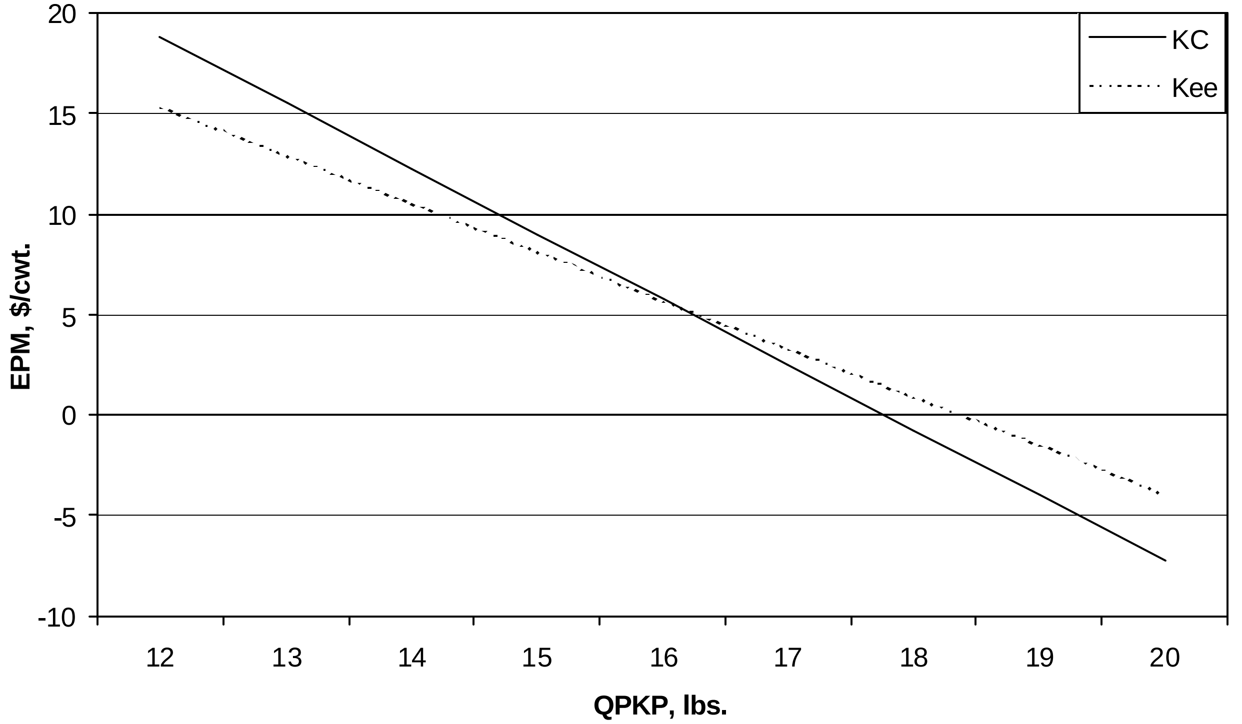

Figure 2.3: Comparison of KC vs. Kee EPM Estimates

However, the most significant difference in the equation estimate is in the accuracy of the regression. The SER of the KC regression was $4.65 per cwt. compared to a SER of $5.77 cwt. in this study, a twenty-five percent increase. Similarly, KC's R^2 was 0.79 which decreased to 0.70 in this study.

KC did not publish their estimates of QPKP and therefore no direct comparison can be made of the estimations of QPKP. However, repeated attempts were made to reproduce the quarterly commercial pork production regression equation estimates reported by KC. These attempts were unsuccessful though similar estimates were produced. Inability to reproduce journal results is a common occurrence caused by slight differences in data sets and has led many journals to require the submission of the data sets with the journal article in recent years. In this case, there are at least three sources that could cause small errors in reconstruction of the data sets that were used in the KC article. Until 1977, pork production was sometimes considered to include lard. Searching the Mann Library for pork production yields two data sets identified as having the same source, *Livestock Slaughter*. These two sets differ in years prior to 1977 by the approximate amount of lard production. KC did not indicate whether lard was included in the first two years of the study. Another source of error is the pig crop estimate. In the journal article, KC do not specify whether the estimates used for pig crop was the first, the most recent or the final estimates. This study uses the latest available estimate when the regression equation would have been estimated for use in the hedging process. Alternatively, one could logically use the first estimate or the final estimate. The third possibility is confusion over the Ten States data. In 1979, the *Hogs and Pigs* report changed from the traditional 'Corn Belt' Ten States to a new Ten States that included Georgia and North Carolina. This study uses the new Ten States. The fact of differences in the data sets is confirmed by KC's published actual QPKP from 1975-1980. The differences in KC and this study are reported in Table 2.3. These differences are a result of either a differ U.S. population series or differences in U.S commercial pork slaughter.

Hedging Results

The preferred trigger level found by KC was to hedge when IPM was seventy percent greater than the EPM. The EPM and IMP in this study differ from KC because of the different assumptions concerning direct cost, technical coefficients and the use of futures prices instead of cash prices. Additionally, this study provides results with the hedging of soybean meal that were not reported in the KC study.[13] These changes require the re-estimation of the preferred trigger level. The trigger level in this study is calibrated over the 1975-82 period whereas KC calibrated over their in-sample period of 1975-80. Hedges were simulated for various trigger levels using the predicted, in-sample QPKP estimates for estimation of the EPM. Figure 2.4 illustrates the results in a mean/variance framework.

Choosing the preferred trigger level is to a certain extent subjective as all trigger levels dominate the cash market strategy. The fifty percent trigger level appears to be a likely candidate because it dominates five of the other trigger levels, the fifty-five, sixty, sixty-five, ninety-five and one hundred, and thus they can be eliminated from further consideration. However, the fifty percent trigger level neither dominates nor is dominated by the other trigger levels. The eighty, eighty-five and ninety percent trigger levels are eliminated because their variance is very near that of the all cash market strategy and the profit improvement over the fifty percent trigger is at most, less than twenty-five cents per cwt. The variance of the seventy

[13] At the time of the KC study the Mid America SBM contract was not available. They attempted a SBM crosshedge using corn without success.

Table 2.4: Comparison of KC vs. Kee Actual QPKP, 1975-1980.

Year	Quarter	KC	KEE	Difference
1975	I	14.5	14.64	-0.14
	II	13.9	13.92	-0.02
	III	11.9	11.85	0.05
	IV	13.4	13.39	0.01
1976	I	13.6	13.65	-0.05
	II	13.1	13.11	-0.01
	III	13.9	13.84	0.06
	IV	16.8	16.80	0.00
1977	I	15.4	15.05	0.35
	II	14.9	14.52	0.38
	III	14.3	13.97	0.33
	IV	16.3	15.86	0.44
1978	I	15.0	14.66	0.34
	II	15.1	14.73	0.37
	III	14.6	14.21	0.39
	IV	16.3	15.88	0.42
1979	I	15.6	15.19	0.41
	II	16.9	16.75	0.15
	III	16.9	16.79	0.11
	IV	19.4	19.27	0.13
1980	I	18.4	18.24	0.16
	II	19.1	18.96	0.14
	III	16.6	16.51	0.09
	IV	18.8	18.69	0.11

and seventy-five percent trigger levels is about fourteen dollars per cwt. more than the fifty percent trigger with an increase in profits of only three to eight cents per cwt. This tradeoff does not appear to be justified and therefore these two trigger levels are eliminated. Of the three remaining trigger levels to consider, the forty-five percent trigger level is dominated by the forty and thirty-five percent trigger levels and can be eliminated. In comparing the thirty-five and forty percent trigger levels to the fifty, there is about a six dollar per cwt. increase in variance for about a five cent per cwt. increase in profits. This appears to be an acceptable tradeoff given the

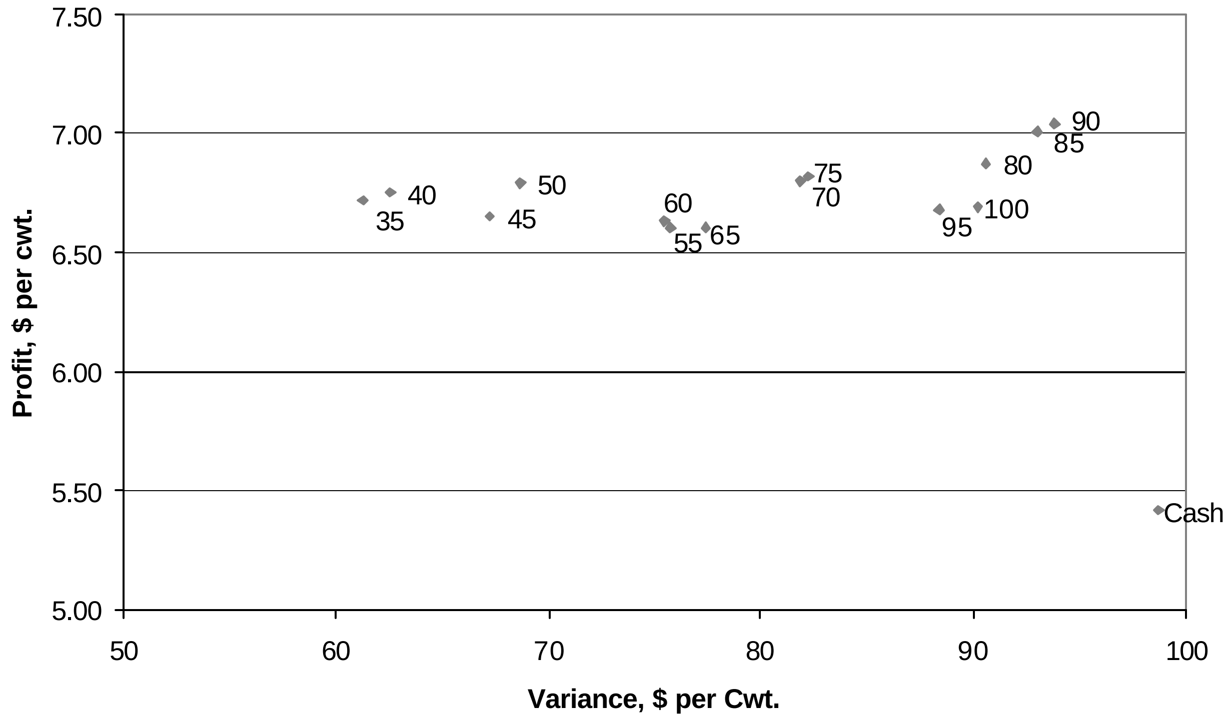

Figure 2.4: Mean/Variance Analysis of Trigger Levels, 1975-82

already large percentage decrease in variance as compared to the percentage increase in profits of these trigger levels. Therefore the fifty percent trigger level is chosen as the preferred trigger level.

In-Sample Results, 1975-1982

Table 2.4 and Table 2.5 provide a comparison of the summary statistics and significance tests of this study's fifty percent trigger hedge to KC's seventy percent trigger hedge. The full results of each individual lot of the fifty percent trigger hedge are reported in Table 2.6. The fifty percent trigger strategy resulted in thirty-two of a possible forty-eight hedges being placed during 1975-1982. As compared to cash, the strategy increased profits from $5.41 per cwt. to $6.79 per cwt. while reducing the variance from $98.75 per cwt. to $68.84 per cwt. when a three-way hedge including hogs, corn and soybean meal was implemented. The p-value for the joint hypothesis test is 0.0300 with the p-value for the mean and variance conditions 0.0243 and 0.0058, respectively. The two-way hedge of hogs and corn is basically identical to the three-way hedge with a profit of $6.83 per cwt. and a variance of $68.49 cwt. P-values for the joint, mean and variance conditions were 0.0290, 0.0230 and 0.0067, respectively. Clearly the fifty percent hedging strategy is superior to an all cash strategy based on the in-sample results.

KC's results were similar. KC reported hedge results of the in-sample period of 1975-1980 and out-of-sample period of 1981-82. For comparison to this study's in-sample results, KC's in-sample and out-of-sample results are combined. From 1975 through 1982, a total of thirty-eight hedges were placed. In comparing the individual contracts, each time this study hedged, the KC model hedged. KC's two-way hedge increased profit from $4.46 cwt. to $6.43 cwt. while reducing variance from $98.02 cwt. to $68.64 cwt. P-values for the joint, mean and variance conditions were 0.0318, 0.0109 and 0.0211, respectively. Given the strong similarities in the hedging results, this study is an accurate implementation of KC's recommended hedging strategy and implies that the KC study is not overly sensitive to data sources.

Table 2.5: Summary of In-Sample Hedge Results, 1975-82.

	Returns from futures market					Cash	Hedged**	
	Hogs	Corn	SBM	2-way*	3-way*		2-way*	3-way*
Average ($/cwt.)								
Kee	1.46	-0.05	-0.04	1.41	1.38	5.41	6.83	6.79
KC	1.97	0.00	N/A	1.97	N/A	4.46	6.43	N/A
Variance ($/cwt.)								
Kee	24.70	0.31	0.09	22.86	22.23	98.75	68.49	68.64
KC	32.01	0.44	N/A	33.20	N/A	98.02	68.64	N/A
Max Loss ($/cwt.)								
Kee	-9.95	-1.34	-1.05	-9.95	-9.95	-14.13	-14.13	-14.13
KC	-12.85	-1.66	N/A	-12.50	N/A	-15.71	-9.11	N/A
Max Profit ($/cwt.)								
Kee	13.80	2.91	1.23	14.08	14.04	31.63	24.48	24.48
KC	14.87	2.28	N/A	15.74	N/A	29.89	28.99	N/A
Hedges (#)								
Kee	32	12	12	32	32			
KC	38	24	N/A	38	N/A			
Profitable (#)								
Kee	22	4	3	20	20	31	37	36
KC	25	14	N/A	23	N/A	31	37	N/A

* 2-way is hedging both hogs and corn. 3-way is hedging hogs, corn and soybean meal.
** Hedged = Futures + Cash

Table 2.6: Significance Tests (p-values) of Hedging Strategies, 1975-82.

	$\mu_H \leq \mu_C$	$\sigma^2_H \geq \sigma^2_C$	$\mu_H \leq \mu_C \cup \sigma^2_H \geq \sigma^2_C$
Kee 3-Way Hedge	0.0243	0.0058	0.0300
Kee 2-Way Hedge	0.0230	0.0062	0.0290
KC 2-Way Hedge	0.0109	0.0211	0.0318

Table 2.7: Kee In-Sample Hedge Results 1975-82 ($ / cwt.).

Lot		Returns from futures market					Cash	Hedged**	
Year	Month	Hogs	Corn	SBM	2-way*	3-way*		2-way*	3-way*
1975	Feb	7.10			7.10	7.10	-5.31	1.79	1.79
	Apr						-1.01	-1.01	-1.01
	Jun						12.71	12.71	12.71
	Aug						18.70	18.70	18.70
	Oct	-7.15			-7.15	-7.15	31.63	24.48	24.48
	Dec	2.75			2.75	2.75	18.39	21.14	21.14
1976	Feb	13.40	-0.21	-0.04	13.19	13.15	7.76	20.95	20.91
	Apr						10.86	10.86	10.86
	Jun						16.20	16.20	16.20
	Aug						7.68	7.68	7.68
	Oct						-4.76	-4.76	-4.76
	Dec	9.70	-1.18	-1.05	8.52	7.47	-4.19	4.33	3.28
1977	Feb						0.72	0.72	0.72
	Apr						-1.08	-1.08	-1.08
	Jun	1.25			1.25	1.25	7.56	8.81	8.81
	Aug	4.95			4.95	4.95	1.50	6.45	6.45
	Oct	0.30			0.30	0.30	-0.96	-0.66	-0.66
	Dec						12.02	12.02	12.02
1978	Feb						14.70	14.70	14.70
	Apr						12.06	12.06	12.06
	Jun	-2.80			-2.80	-2.80	19.04	16.24	16.24
	Aug	5.80			5.80	5.80	11.14	16.94	16.94

continued

Table 2.7 (continued): Kee In-Sample Hedge Results 1975-82 ($ / cwt.).

Lot		Returns from futures market					Cash	Hedged**	
Year	Month	Hogs	Corn	SBM	2-way*	3-way*		2-way*	3-way*
	Oct	-2.95			-2.95	-2.95	12.42	9.47	9.47
	Dec	-1.65			-1.65	-1.65	17.64	15.99	15.99
1979	Feb	-2.70			-2.70	-2.70	17.82	15.12	15.12
	Apr	1.33			1.33	1.33	8.46	9.79	9.79
	Jun	2.85	0.21	-0.05	3.06	3.01	5.30	8.36	8.31
	Aug	13.80	0.28	-0.04	14.08	14.04	-6.11	7.97	7.93
	Oct						-5.62	-5.62	-5.62
	Dec	0.70			0.70	0.70	-1.39	-0.69	-0.69
1980	Feb	3.10			3.10	3.10	-3.91	-0.81	-0.81
	Apr						-14.13	-14.13	-14.13
	Jun	11.45	-0.80	-0.17	10.65	10.48	-9.95	0.70	0.53
	Aug						5.32	5.32	5.32
	Oct	-5.35			-5.35	-5.35	6.80	1.45	1.45
	Dec	-6.45	2.91	1.23	-3.54	-2.31	3.31	-0.23	1.00
1981	Feb	8.05	-0.46	-0.60	7.59	6.99	-7.30	0.29	-0.31
	Apr	5.60			5.60	5.60	-13.57	-7.97	-7.97
	Jun	0.45	-1.34	-0.97	-0.89	-1.86	1.12	0.23	-0.74
	Aug	0.60	0.16	0.26	0.76	1.02	-1.76	-1.00	-0.74
	Oct	5.18			5.18	5.18	-2.73	2.45	2.45
	Dec	12.50	-0.92	0.05	11.58	11.63	-5.85	5.73	5.78
1982	Feb	0.50	-0.07	-0.18	0.43	0.25	3.64	4.07	3.89
	Apr						5.55	5.55	5.55
	Jun	-9.95			-9.95	-9.95	16.59	6.64	6.64
	Aug	-1.10			-1.10	-1.10	16.32	15.22	15.22
	Oct	-1.55			-1.55	-1.55	12.97	11.42	11.42
	Dec	0.60	-0.98	-0.22	-0.38	-0.60	13.55	13.17	12.95

* 2-way is hedging both hogs and corn. 3-way is hedging hogs, corn and soybean meal.

** Hedged = Cash + Futures

Updating Procedures for Out-of-Sample Test

Great care was taken to produce an out-of-sample test using both rules and data that an actual producer would have used by following the recommended strategy. The test was conducted using data that were available at the time the hedges were placed. The models and rules developed by KC as implemented in the previous section do not change during the out-of-sample test period. The equation estimates change because they are updated on a yearly basis. The direct cost in the IPM equation was updated in December to begin hedging in January. The sow price equation and EPM equation were updated in January to begin hedging in February. The quarterly commercial pork regression equations were updated at the first hedging opportunity of that quarter, i.e. the second quarter equation was updated in December of the previous year when hedging of the second quarter begins.

The IPM equation is updated at two different times because of the availability of data, once for the direct cost and once for the sow price regression used to calculate cull returns. For the direct cost, the LDP simulator assumes all cost have been incurred for a lot of hog when they are placed on feed, hence all costs for December hogs are have been incurred by September and are not published in October or November. Thus, cost for the year can be calculated in December. The direct cost for the previous year are used in the IPM equation for the next year, i.e. 1996 cost are used as an estimate of 1997 cost, to begin hedging on the first market day of the new year, without any adjustment. The sow price regression cannot be updated in December because the average market prices for December are not compiled and published until January. Therefore, it is updated at the end of January to begin using on the first market day of February.

The EPM regression equation requires both the December cash profit margins and the actual fourth quarter QPKP to be available. Because hogs are sold on December 1, the cash profit margin would be available to update the equation before the year ended. However, in late December, the commercial pork production for both October and November have been released but the December values are not available until about the third week in January of the next year. Therefore, the EPM equation is updated in January to begin hedging on the first market day of February.

The carcass weight and slaughter hogs equations are updated at the beginning of each quarter. For example, on December 29, 1997, the December *Hogs and Pigs* report was released. This *Hogs and Pigs* report contains the 1997 September-October pig crop estimate that is used to predict slaughter hogs in the second quarter of 1998 when the April 1998 and June 1998 lots of hogs will be sold. At this time, the estimation data set for the slaughter hogs equation is updated by adding the 1996 September-November pig crop and the 1997 second quarter slaughter hogs and deleting the 1986 September-November pig crop and 1987 second quarter slaughter hogs. The second quarter slaughter hogs is available from *Livestock Slaughter* as early as July of 1997. Also, any of the September-November pig crop estimates between 1987 and 1995 that have been revised by USDA are changed in the estimation data set. The slaughter hogs equation for the second quarter is updated by this revised data set. To update the carcass weight regression equation, the carcass weights for the second quarter of 1997 must be known. This is also available from *Livestock Slaughter* as early as July of 1997. To update this equation, the 1987 second quarter carcass weight is deleted and the 1997 second quarter is added.

The third component used to estimate QPKP is the population that is estimated by a yearly regression equation updated in December of each year. In this equation, the November population estimate is used for the fourth quarter population and is available before the year ends. Population estimates are made with the newly estimated coefficients for two, three, four and five quarters ahead. For example, the regression is updated in December of 1996 and population estimates are made for the second, third and fourth quarters of 1997 plus the first quarter of 1998. Projecting five quarters ahead is necessary because the 1997 first quarter QPKP estimate is used in the fourth quarter of 1996 to hedge the February 1997 lot of hogs. While it would be possible to reestimate the 1997 first quarter population estimate, and therefore the first quarter QPKP, in December 1996 to hedge the February lot in January, this step was not taken because of the extremely high accuracy of the population estimates.

Out-of-Sample Results, 1983-1998

Table 2.7 reports lot by lot results and the summary statistics for the out-of-sample period. The three-way hedging strategy produced an average profit of $2.24 cwt. with a variance of $64.18 cwt. compared to cash profits of $2.24 per cwt. and variance of $68.46per cwt. during the 1983-1998 time period. The four cent loss by the three way hedge was definitely not an increase in profits and the small decrease in variance was not statistically less than the cash variance. The p-value for the mean condition was 0.5516, for the variance condition 0.2039 and for the joint condition 0.6431. Close examination of the summary statistics also reveals a marked change in hedging frequency and the percentage of profitable hedges. Hogs were hedged

Table 2.8: Out-of-Sample Hedging Results, 1983-98 ($ / cwt.).

Lot		Returns from futures market					Cash	Hedged**	
Year	Month	Hogs	Corn	SBM	2-way*	3-way*		2-way*	3-way*
1983	Feb						17.40	17.40	17.40
	Apr	5.90			5.90	5.90	6.05	11.95	11.95
	Jun	9.50	1.77	0.34	11.27	11.61	1.19	12.46	12.80
	Aug						-2.82	-2.82	-2.82
	Oct						-7.43	-7.43	-7.43
	Dec						-7.53	-7.53	-7.53
1984	Feb	1.35			1.35	1.35	-2.50	-1.15	-1.15
	Apr						-3.26	-3.26	-3.26
	Jun	1.10	-0.92	-1.14	0.18	-0.96	2.30	2.48	1.34
	Aug	5.90	-0.07	-0.07	5.83	5.76	0.31	6.14	6.07
	Oct	10.20			10.20	10.20	-7.68	2.52	2.52
	Dec	2.35	-2.18	-1.23	0.17	-1.06	6.79	6.96	5.73
1985	Feb						7.37	7.37	7.37
	Apr						0.86	0.86	0.86
	Jun						4.32	4.32	4.32
	Aug						-0.80	-0.80	-0.80
	Oct						-1.97	-1.97	-1.97
	Dec						8.95	8.95	8.95
1986	Feb						5.16	5.16	5.16
	Apr						-2.19	-2.19	-2.19
	Jun						8.05	8.05	8.05
	Aug	-0.70			-0.70	-0.70	19.06	18.36	18.36
	Oct						11.88	11.88	11.88
	Dec						19.21	19.21	19.21
1987	Feb						13.06	13.06	13.06
	Apr						9.61	9.61	9.61
	Jun						22.04	22.04	22.04
	Aug						20.37	20.37	20.37

continued

Table 2.8 (continued): Out-of-Sample Hedging Results, 1983-98 ($ / cwt.).

Lot		Returns from futures market					Cash	Hedged**	
Year	Month	Hogs	Corn	SBM	2-way*	3-way*		2-way*	3-way*
	Oct						10.00	10.00	10.00
	Dec						5.62	5.62	5.62
1988	Feb						9.00	9.00	9.00
	Apr						5.75	5.75	5.75
	Jun						15.50	15.50	15.50
	Aug						3.19	3.19	3.19
	Oct						-5.48	-5.48	-5.48
	Dec						-9.02	-9.02	-9.02
1989	Feb						-5.47	-5.47	-5.47
	Apr						-6.85	-6.85	-6.85
	Jun						0.16	0.16	0.16
	Aug						-0.44	-0.44	-0.44
	Oct						-1.85	-1.85	-1.85
	Dec	-3.35			-3.35	-3.35	8.58	5.23	5.23
1990	Feb	0.73			0.73	0.73	4.25	4.98	4.98
	Apr						9.58	9.58	9.58
	Jun	-8.40			-8.40	-8.40	22.81	14.41	14.41
	Aug	-4.45			-4.45	-4.45	16.25	11.80	11.80
	Oct	-2.38			-2.38	-2.38	10.08	7.70	7.70
	Dec	1.40	-2.03	-0.58	-0.63	-1.21	6.42	5.79	5.21
1991	Feb	-0.18			-0.18	-0.18	6.88	6.70	6.70
	Apr						7.02	7.02	7.02
	Jun	0.80			0.80	0.80	10.53	11.33	11.33
	Aug						6.35	6.35	6.35
	Oct						-1.10	-1.10	-1.10
	Dec						-6.66	-6.66	-6.66
1992	Feb						-3.30	-3.30	-3.30
	Apr						-2.17	-2.17	-2.17

continued

Table 2.8 (continued): Out-of-Sample Hedging Results, 1983-98 ($ / cwt.).

Lot		Returns from futures market					Cash	Hedged**	
Year	Month	Hogs	Corn	SBM	2-way*	3-way*		2-way*	3-way*
	Jun						2.93	2.93	2.93
	Aug						-1.12	-1.12	-1.12
	Oct						-2.92	-2.92	-2.92
	Dec						3.25	3.25	3.25
1993	Feb	-0.55			-0.55	-0.55	0.73	0.18	0.18
	Apr	-5.45			-5.45	-5.45	7.83	2.38	2.38
	Jun	-4.40	-0.13	-0.06	-4.53	-4.59	8.87	4.34	4.28
	Aug	1.25	0.02	0.03	1.27	1.29	4.72	5.99	6.01
	Oct	-4.73			-4.73	-4.73	4.76	0.03	0.03
	Dec	-1.70	-0.10	0.73	-1.80	-1.07	-1.37	-3.17	-2.44
1994	Feb	0.00				0.00	5.22	5.22	5.22
	Apr						-1.10	-1.10	-1.10
	Jun	4.45	-0.90	-0.30	3.55	3.25	-0.66	2.89	2.59
	Aug	5.50	-0.47	-0.09	5.03	4.94	-1.26	3.77	3.68
	Oct						-11.62	-11.62	-11.62
	Dec						-13.07	-13.07	-13.07
1995	Feb						-2.81	-2.81	-2.81
	Apr						-4.38	-4.38	-4.38
	Jun						1.06	1.06	1.06
	Aug	-1.60			-1.60	-1.60	3.68	2.08	2.08
	Oct	-1.45			-1.45	-1.45	0.27	-1.18	-1.18
	Dec	0.05	-0.10	-0.11	-0.05	-0.15	-2.30	-2.35	-2.45
1996	Feb	1.35			1.35	1.35	-3.49	-2.14	-2.14
	Apr	-3.20			-3.20	-3.20	-0.10	-3.30	-3.30
	Jun	-10.05	-0.36	-0.15	-10.41	-10.56	6.95	-3.46	-3.61
	Aug	-6.30			-6.30	-6.30	1.57	-4.73	-4.73
	Oct	-2.32			-2.32	-2.32	-4.00	-6.32	-6.32
	Dec	-5.53	-2.98	0.18	-8.51	-8.33	5.02	-3.49	-3.31

continued

Table 2.8 (continued): Out-of-Sample Hedging Results, 1983-98 ($ / cwt.).

Lot		Returns from futures market					Cash	Hedged**	
Year	Month	Hogs	Corn	SBM	2-way*	3-way*		2-way*	3-way*
1997	Feb	1.00			1.00	1.00	3.96	4.96	4.96
	Apr	2.92			2.92	2.92	4.58	7.50	7.50
	Jun	-0.85	0.72	0.56	-0.13	0.43	10.62	10.49	11.05
	Aug	-2.46			-2.46	-2.46	6.76	4.30	4.30
	Oct	4.92			4.92	4.92	-1.28	3.64	3.64
	Dec	6.73	1.90	0.76	8.63	9.39	-4.46	4.17	4.93
1998	Feb	5.64	0.16	-0.20	5.80	5.61	-6.48	-0.68	-0.87
	Apr						-11.50	-11.50	-11.50
	Jun						-3.68	-3.68	-3.68
	Aug						-11.09	-11.09	-11.09
	Oct						-14.51	-14.51	-14.51
	Dec						-23.97	-23.97	-23.97
	Average	0.03	-0.06	-0.01	-0.03	-0.04	2.28	2.25	2.24
	Variance	8.64	0.28	0.05	9.65	9.84	68.46	64.17	64.18
	Max Loss	-10.05	-2.98	-1.23	-10.41	-10.56	-23.97	-23.97	-23.97
	Max Profit	10.20	1.90	0.76	11.27	11.61	22.81	22.04	22.04
	Hedges	40	16	16	40	40			
	Profitable	20	5	6	18	17	55	56	56

* 2-way is hedging both hogs and corn. 3-way is hedging hogs, corn and soybean meal.

** Hedged = Cash + Futures

forty times with twenty profitable hedges. Feed was hedged sixteen of these forty hedges with five corn hedges profitable and six soybean meal hedges profitable. In total, forty hedges were placed out of ninety-six opportunities for a hedging percentage of about forty-two percent. Of the forty hedges placed, seventeen or about forty-two percent were profitable. This is compared to a hedging percentage of about sixty-seven percent of which about sixty-two percent were profitable for the in-sample period. For a more direct comparison, twenty profitable hedges were made during the eight year in-sample period versus only seventeen for the sixteen year out-of-sample period.

Examination of the hedge results suggests that for the first two years, 1983 and 1984, the strategy behaved similarly to the 1975-82 in-sample period in terms of hedging frequency and increased profits. During this period of twelve lots, five of seven three-way hedges placed were profitable and increased profit from $0.24 cwt. to $2.97 cwt. However, variance increased from $53.40 cwt. to $64.87 cwt. But from February 1985 through October 1989, only one hedge was placed. During the in-sample period some hedges occurred each year. From December 1989 through December 1998, when hedges were again being placed, cash profits were $0.92 cwt. while the three-way hedge profits were $0.27 cwt. The variance decreased from $62.81 cwt. with the cash strategy to $51.88 cwt. with the three-way hedge.

A producer implementing this strategy would have profited only during the first two years of the out-of-sample period. Most producers would have abandoned the strategy during the inactive hedging period of 1985-89 as 'not worth their time'. Had the producer still been following the strategy after 1989, their results would have been virtually identical to the cash market. The obvious conclusion is that the hedging strategy is ineffective during the out-of-sample test period having failed to outperform an all-cash strategy starting in 1985. In the following section, the individual models are investigated in detail to determine the cause of the ineffectiveness during the out-of-sample period.

Analysis and Model Performance Through Time

The out-of-sample hedging results do not show the increase in profit and the reduction in variance that the in-sample results report. The obvious question is why. There are three basic components of the model: 1) the estimation of feed cost and returns, 2) the prediction of QPKP, and 3) the estimation of the expected profit margin (EPM). To determine why the strategy failed, each of the model components are examined through the hedging period. Attention is paid to the statistical soundness of the models, changes that occur through time and to the relative impact of errors in the individual components to errors in the final results.

Estimation of Costs

Though not strictly a model, the underlying cost structure is an important consideration in the performance of the hedging strategy. A limitation of any study estimating cost over an extended period of time is updating costs in an appropriate fashion and taking into account technological improvements. The LDP 1,600-head simulator was chosen because it is both publicly available and extends throughout the out-of-sample period. However, the production technology in the simulator is based on 1980 data from the COP budgets. The LDP simulator has not been updated to reflect either the known increase in feed efficiency or the dramatic shift to larger and presumably more cost efficient hog operations. As a result, both feed cost and direct cost are over estimated. For example, the cost of producing hogs in August 1998 was estimated at $49.42 cwt. including replacement cost with 250 cent per bushel corn and $165 per ton soybean meal. Industry sources place current operating costs of the mega producers, which now constitute a significant portion of the industry, at around $36-38 per cwt. Therefore, the cost estimates in this study appear high and the returns low.

However, these high cost estimates effect both the IPM calculation and the EPM regression estimates. IPM and CPM are direct functions of the direct cost and feed efficiency which form total cost. The EPM is a direct function of the CPM and therefore an indirect function of the direct cost and feed efficiency. Thus, these high costs do not cause an offset between the IPM and the EPM (causing either no lots being hedge or all lots being hedged) because the IPM and EPM have similar errors. However, these higher costs would effect the trigger level in two possible ways. First, the error in cost is trending higher which would directly effect the optimal trigger level. Second, because the trigger is proportional, these higher costs effect the absolute amount the IPM must exceed the EPM to trigger the hedge. For example, suppose that for a given set of market conditions and these higher costs, the EPM is estimated to be $2.00 per cwt.. At the fifty percent trigger, IPM must exceed $3.00, an absolute difference of $1.00 per cwt., to trigger a hedge. However, given the same set of conditions but more realistic costs, the EPM for the same market conditions would be about $10.00 per cwt. and the IPM must exceeded $15.00 per cwt. to trigger a hedge, an absolute difference of $5.00 per cwt.. Thus, the higher costs would cause too many hedges to be placed at small premiums to the EPM during times of relative low production and high profits. The reverse effect would be true during periods of relative high production and negative profits. The higher costs would result in the estimated EPM being even more negative, requiring a larger absolute premium and no hedges being placed. While there are not enough observations in these extremes to statistically test this hypothesis, visual inspection of the in-sample hedging pattern between 1975-80 and the hedging results in the 90's tend to support this hypothesis.

Changes in the *Indices of Agricultural Prices* in the early nineties adversely affected the direct cost for that period by decreasing the stability as shown in Figure 2.5.[14] While the U.S. Production Costs Indices is not directly used in this study, it is used by LDP for their simulator. Direct cost were relatively stable from 1982 through 1989 with yearly changes of less than $1.00 per cwt. But between 1990 and 1993, direct cost first increased by $1.24 and $2.56 cwt. in 1990 and 1991 and then decreased by $4.20 cwt. in 1992, followed by an increase of $2.49 per cwt. in 1993. From 1993 through 1998, direct cost were again relatively stable with a slight upward trend. Clearly, the instability of the direct costs from 1990 through 1993 is not consistent with the relatively stable economic conditions of the period. This artificial instability leads to difficulties in the prediction of the IPM. Because the previous year's direct cost is the estimate for the current year, the error in IPM is the yearly change in direct cost. Taking the extreme example of 1992, the IPM was over estimated by $4.20 per cwt. which is equivalent to a $6.30 per cwt. ($4.20 x 1.55 trigger) error in the EPM estimated. The instability also effects the EPM equation estimates because it adds noise to CPM and therefore decreases the accuracy of the EPM regression estimates when these years are included in the estimation data set.

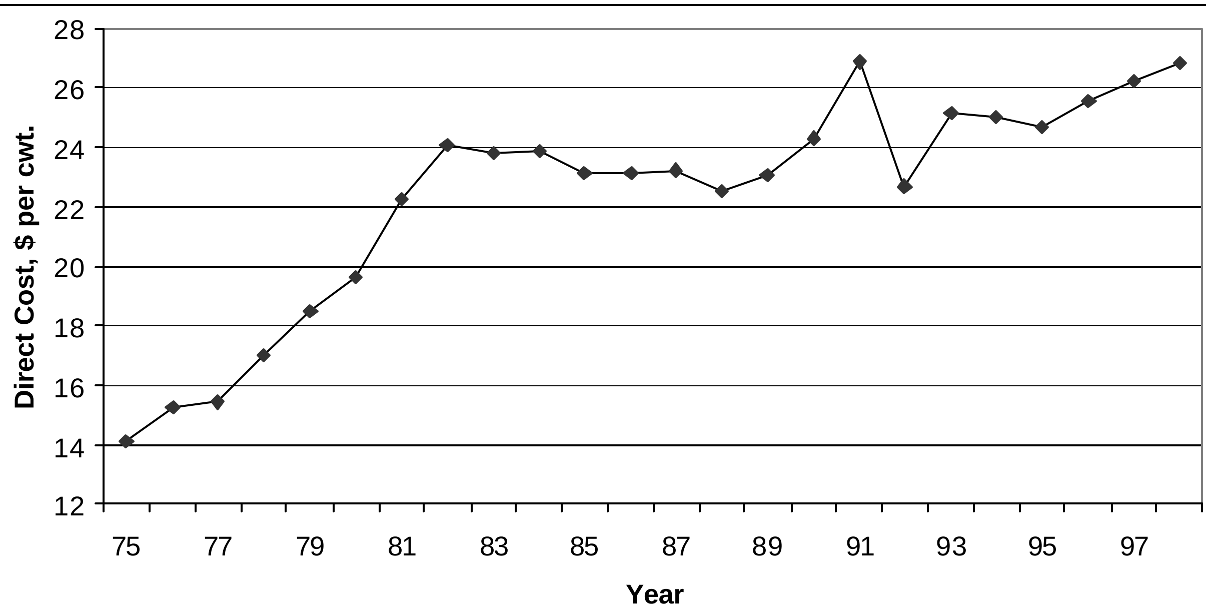

Figure 2.5: Direct Cost by Year

[14] Personal contact with Leland Southard of the Economic Research Service of USDA confirmed this was the source of the instability in the LDP simulator.

Sow Price Regressions

Yearly estimates of the sow price regression are reported in Table 2.8. The predictive power of the regression, as defined by R^2, declines from greater than ninety percent to near eighty percent in the 1990's while the SER increases from approximately $2.00 per cwt. to $3.00 per cwt.. However the effect of the error on the IPM is minor. At the minimum SER during the study of $1.83 per cwt., the effect of a one standard deviation error is $0.11 per cwt. (1.83 x 6.10 / 100). At the maximum SER of $3.29 per cwt. the effect on IPM is $0.20 per cwt. More importantly, cull returns in the both the CPM and IPM are calculated using the hog futures prices instead of actual sow prices.[15] Therefore, the real effect of including cull returns in the profit equations is the scaling up of the income portion of both the IPM and the CPM (and therefore the EPM) by about five percent. This in turn would effect the choice of trigger level but not the profit margin hedging concept or outcome.

The Durbin-Watson tests in this and most of the equations to follow, all show positive autocorrelation. The nature of this correlation remains relatively constant through time. Because the purpose of this and the other equations is to forecast out-of-sample and the sample sizes of some of the equations are small, this statistical problem was not addressed in this equation or the other equations. In many cases, the remedies for autocorrelation may lead to greater problems with out-of-sample forecast, especially with small sample size.

There is evidence of a downward shift in sow price relative to market hogs. This can be seen in the "Sow Price: $42 Mkt Hogs" column of Table 2.8 where sow price was calculated given a $42 market hog price. Up to and including the regression equation estimated by the 78-87 data set, the estimated sow price is relatively constant at about $37.50 though there are some offsetting changes in the intercept and slope coefficient. Beginning with the 78-87 data set, the estimates of the sow price decreases with each sequential estimate with the regression equation estimated by the 87-96 data set estimating a sow price of $33.58 or about a four dollar reduction in the relative price of sows during the study.

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[15] While it is not clear in the KC paper, it appears that this may have been the case in their research also because no source of sow prices is cited and published sow prices in Virginia are not readily available.

Table 2.9: Yearly Sow Price Regression Results with Monthly Data.

Data Set	R^2	SER	DW	Intercept	Slope*	Sow Price:** $42 Mkt Hogs
73-82	0.94	1.83	0.81	-3.26	0.97	$37.43
74-83	0.92	2.07	0.78	-3.35	0.97	$37.29
75-84	0.90	2.18	0.77	-1.67	0.93	$37.47
76-85	0.88	2.28	0.80	-2.10	0.94	$37.41
77-86	0.87	2.29	0.80	0.02	0.90	$37.65
78-87	0.85	2.54	0.75	1.96	0.85	$37.69
79-88	0.80	3.14	0.53	0.11	0.88	$36.90
80-89	0.76	3.28	0.51	0.62	0.86	$36.70
81-90	0.75	3.29	0.58	-0.07	0.87	$36.48
82-91	0.76	3.29	0.64	-2.20	0.91	$35.85
83-92	0.75	3.25	0.64	-2.38	0.90	$35.36
84-93	0.75	3.14	0.62	-2.49	0.89	$35.05
85-94	0.80	3.08	0.69	-4.63	0.93	$34.49
86-95	0.82	3.08	0.76	-5.86	0.95	$33.93
87-96	0.82	3.10	0.76	-6.48	0.95	$33.58

* All values statistically significant at 5% level in each data set.

** Sow price is calculated assuming a market hog price of $42 per cwt.

Population

The results of the yearly population regression estimations are reported in Table 2.9 The estimates are extremely stable and well behaved. R^2 is above .99 for each time period. SER ranges from 227 to 500 thousand people. This model appears more than sufficient for the application at hand.

Table 2.10: Yearly Population Regression Results with Quarterly Data.

Data Set	R^2	SER	DW	Intercept	Trend*
73-82	0.999	251	0.74	209530	567
74-83	0.999	227	1.21	211649	572
75-84	0.999	247	1.24	213896	571
76-85	0.998	286	1.09	216237	566
77-86	0.998	304	1.14	218624	559
78-87	0.998	293	1.40	221049	550
79-88	0.998	257	2.06	223442	541
80-89	0.999	243	2.58	225712	538
81-90	0.998	288	1.90	227811	544
82-91	0.997	358	1.26	229796	557
83-92	0.996	453	0.85	231689	579
84-93	0.995	500	0.75	233590	602
85-94	0.996	482	0.83	235613	623
86-95	0.997	431	1.05	237786	638
87-96	0.998	370	1.45	240090	647
89-97	0.998	345	1.69	242551	651

* All values statistically significant at 5% level in each data set.

Carcass Weight

The results of the carcass weight regression estimations are given in Table 2.10. The first two sets of four quarterly equations, estimated by the ten year windows of 73-82 and 74-83, indicate an increase in carcass weight of about 0.25 pounds per year but have relatively low R^2s of about 0.25. The trend variable was statistically significant in predicting Quarter IV carcass weights and insignificant at the 5% level in the other three quarters. The insignificance of the trend variable is caused by abnormally high carcass weight between Quarter III of 1973 and Quarter III of 1974. During this period price controls were in effect but it was widely anticipated that they would soon be removed without a pre-announcement. Producers held hogs longer than normal which lead to heavier weights in anticipation of the removal of price controls and presumed higher hog prices. The trend to heavier carcass weights is evident in the data from 1975 through 1982 and most people associated with the industry in 1982 would have had the

Table 2.11: Yearly Carcass Weight Regression Results by Quarters.

Quarter I

Data Set	R^2	SER	DW	Intercept	Trend
73-82	0.09	2.15	2.31	168.13	0.21*
74-83	0.11	2.20	1.64	168.42	0.25*
75-84	0.62	1.34	2.31	166.73	0.53
76-85	0.65	1.36	2.16	167.05	0.58
77-86	0.86	1.04	2.15	166.30	0.81
78-87	0.85	1.23	1.70	166.89	0.90
79-88	0.85	1.22	1.66	167.98	0.89
80-89	0.86	1.20	1.75	168.68	0.92
81-90	0.87	1.18	1.73	169.37	0.94
82-91	0.94	0.92	1.98	169.14	1.15
83-92	0.94	0.92	1.95	170.43	1.12
84-93	0.95	0.88	1.48	171.29	1.15
85-94	0.95	0.76	1.90	172.93	1.08
86-95	0.96	0.71	2.05	174.28	1.04
87-96	0.96	0.71	1.62	175.35	1.04
88-97	0.97	0.67	2.10	175.52	1.22

* Not significant at 5% level.

Quarter II

Data Set	R^2	SER	DW	Intercept	Trend
73-82	0.02	1.91	2.21	170.74	0.09*
74-83	0.11	2.02	1.74	170.34	0.22*
75-84	0.80	0.90	1.53	168.41	0.55
76-85	0.80	0.89	1.69	169.16	0.55
77-86	0.80	0.89	1.71	169.81	0.54
78-87	0.79	0.88	1.61	170.49	0.53
79-88	0.82	1.03	1.58	170.34	0.68
80-89	0.93	0.76	2.34	170.00	0.86
81-90	0.96	0.66	2.87	170.35	0.95
82-91	0.96	0.63	2.61	170.98	1.00
83-92	0.96	0.59	2.15	172.30	0.95
84-93	0.98	0.48	2.59	172.79	1.03
85-94	0.98	0.50	2.29	173.74	1.05
86-95	0.98	0.45	2.42	174.37	1.13
87-96	0.96	0.69	2.05	175.80	1.04
88-97	0.95	0.75	2.74	176.97	1.06

Table 2.11 continued: Yearly Carcass Weight Regression Results by Quarters.

Quarter III

Data Set	R^2	SER	DW	Intercept	Trend
73-82	0.05	1.63	1.69	168.95	0.12*
74-83	0.19	1.58	1.72	168.40	0.24*
75-84	0.77	0.87	1.46	167.01	0.50
76-85	0.77	0.85	1.55	167.71	0.48
77-86	0.76	0.92	1.44	168.17	0.51
78-87	0.76	0.91	1.04	168.84	0.51
79-88	0.84	0.96	1.31	168.43	0.70
80-89	0.95	0.56	3.03	168.31	0.80
81-90	0.95	0.72	3.01	168.56	0.93
82-91	0.95	0.72	3.19	169.49	0.93
83-92	0.96	0.67	3.51	170.15	0.96
84-93	0.95	0.73	3.33	170.88	1.02
85-94	0.96	0.73	3.27	171.69	1.07
86-95	0.95	0.77	3.19	172.87	1.03
87-96	0.90	1.00	2.08	174.18	0.94
88-97	0.89	1.08	2.62	175.14	0.97

*Not significant at 5% level.

Quarter IV

Data Set	R^2	SER	DW	Intercept	Trend
73-82	0.50	1.13	2.48	170.29	0.35
74-83	0.43	1.18	2.65	170.62	0.32
75-84	0.41	1.18	2.61	171.02	0.30
76-85	0.60	1.14	2.37	170.64	0.44
77-86	0.60	1.39	1.85	170.90	0.53
78-87	0.61	1.41	1.28	171.56	0.54
79-88	0.85	1.06	1.57	170.76	0.78
80-89	0.85	1.06	1.82	171.37	0.77
81-90	0.87	1.11	2.18	171.61	0.89
82-91	0.89	1.10	2.16	172.17	0.95
83-92	0.92	0.96	2.00	172.59	1.01
84-93	0.92	0.96	2.47	173.77	1.00
85-94	0.91	1.07	2.03	174.75	1.05
86-95	0.90	1.07	2.05	175.95	1.02
87-96	0.93	0.93	2.45	176.42	1.10
88-97	0.93	1.04	2.50	176.98	1.22

opinion that carcass weights were trending higher. These abnormal observations would have effect the in-sample estimations and the first two years of the out-of-sample test but not the remaining years.

Beginning with the 75-84 data set, when these abnormal observations are not in the ten year data window, the estimated trend coefficients increased steadily until 1991 at which time the equations indicate that the carcass weights are increasing approximately one pound per year. Subsequent equations continue to indicated that carcass weights are increasing at about one pound per year. Beginning with 75-84 data set, the R^2s values ranged between sixty to eighty and began increasing. By the 1990's, they generally ranged between ninety and ninety-five. A similar pattern of increased accuracy is seen in the SER's where, by the 1990's, the SER's were generally from 0.70 to 1.00 pounds. In evaluating the SER, the average carcass weight was 170 pounds at the beginning of the study and has increased to its present value of 190 pounds. Thus, a one pound SER is equivalent to an error of approximately half a percent in the carcass weight.

Slaughter Hog Regression

The slaughter hog regression equation estimates are reported in Table 2.11. Caution should be used in interpreting these results as the independent variable was changed from Ten States Pig Crop to U.S. Pig Crop with the Quarter II, 87-90 data set. (This change is indicated by a dashed dividing line in the table.) The dependent variable does not change and is all classes of Commercial U.S. Slaughter Hogs throughout the study. R^2s with Ten States pig crop were generally between seventy and ninety and increased to the mid nineties using U.S. pig crop. The SER's show a similar improvement generally ranging between 500-900 thousand head (excluding 1974-82 and 1974-83 data sets) with the Ten States pig crop and decreasing to the 200-350 thousand head range with U.S. pig crop. One SER is approximately four percent and one percent, respectively, of the twenty to twenty-four million head per quarter slaughter. Overall, there is a marked improvement in the R^2 and SER of the regressions when using U.S. pig crop with the notable exception of the Quarter IV equation estimates. The R^2 and SER of the Quarter IV U.S. pig crop equations were actually worse than the Ten States pig crop equations, especially for the first two years with limited data sets and again in the last year of the study.

The Quarter I regression estimates after the change to U.S. data deserve additional attention. The Quarter I coefficient estimates using the 1987-92 data set are substantially different from the 1987-93 estimates. The latest estimates of prior pig crops are used with each

Table 2.12: Yearly Slaughter Hog Regression Results by Quarters.

Quarter I

Data Set	R^2	SER	DW	Intercept	PigCrop
74-82	0.81	1051	1.88	2664	1.069
74-83	0.81	984	1.90	2727	1.066
75-84	0.83	950	1.87	2043	1.104
76-85	0.87	771	1.90	2056	1.109
77-86	0.84	699	2.63	-2008	1.337
78-87	0.82	737	2.25	-535	1.255
79-88	0.81	687	2.51	605	1.193
80-89	0.82	643	2.56	1543	1.143
81-90	0.68	654	1.64	688	1.186
87-91	0.97	147	0.98	1167	0.888
87-92	0.94	342	1.16	-4156	1.127
87-93	0.82	583	2.30	3322	0.795
87-94	0.95	292	2.32	-2836	1.065
87-95	0.96	272	2.21	-2299	1.042
87-96	0.97	257	2.25	-2505	1.051
88-97	0.94	253	2.15	-3212	1.080

Quarter II

Data Set	R^2	SER	DW	Intercept	PigCrop
74-82	0.76	1335	1.45	1609	1.126
74-83	0.77	1254	1.57	1512	1.134
75-84	0.88	897	2.01	-106	1.223
76-85	0.87	873	2.13	-1160	1.282
77-86	0.86	710	2.33	-8840	1.711
78-87	0.84	740	2.08	-12228	1.897
79-88	0.82	727	2.17	-14051	1.997
80-89	0.80	762	2.02	-11443	1.856
87-90	0.99	112	3.08	-16619	1.704
87-91	0.98	161	1.86	-15606	1.655
87-92	0.94	330	1.32	-8519	1.327
87-93	0.93	366	1.38	-4914	1.162
87-94	0.94	347	1.60	-4560	1.146
87-95	0.96	324	1.54	-4921	1.162
87-96	0.96	307	1.60	-4738	1.153
88-97	0.95	257	2.16	-2242	1.046

* Not significant at 5% level.

Note: Dashed line indicates the change from Ten States to U.S. Pig Crop.

Table 2.12 continued: Yearly Slaughter Hog Regression Results by Quarters.

Quarter III

Data Set	R^2	SER	DW	Intercept	PigCrop
73-82	0.84	934	2.43	4914	0.978
74-83	0.90	736	1.71	5207	0.979
75-84	0.97	426	2.97	2264	1.184
76-85	0.90	541	1.94	3439	1.114
77-86	0.80	722	2.32	2837	1.144
78-87	0.75	749	2.19	3575	1.093
79-88	0.70	764	2.25	3972	1.073
80-89	0.76	663	2.23	5131	0.990
87-90	0.99	111	1.75	-5111	1.257
87-91	0.97	177	1.04	-3396	1.171
87-92	0.99	166	1.44	-2459	1.125
87-93	0.98	205	1.91	-1414	1.074
87-94	0.98	222	2.52	-1329	1.069
87-95	0.95	354	2.23	735	0.970
87-96	0.95	353	2.08	1135	0.950
88-97	0.89	390	1.80	3115	0.860

Quarter IV

Data Set	R^2	SER	DW	Intercept	PigCrop
73-82	0.77	1287	0.46	440	1.079
74-83	0.92	789	0.99	-1894	1.218
75-84	0.94	687	1.07	-1615	1.220
76-85	0.89	661	1.18	475	1.119
77-86	0.88	707	0.93	2405	1.026
78-87	0.89	660	1.41	4171	0.950
79-88	0.90	570	1.39	5370	0.900
80-89	0.91	490	1.94	4983	0.916
87-90	0.42	636	1.51	11714	0.458*
87-91	0.54	610	1.89	8130	0.604*
87-92	0.74	557	1.50	4895	0.734
87-93	0.71	553	1.29	4323	0.759
87-94	0.83	541	1.18	689	0.902
87-95	0.85	501	1.25	591	0.906
87-96	0.80	545	0.92	1186	0.888
88-97	0.61	703	0.74	1337	0.886

Not significant at 5% level.

Note: Dashed line indicates the change from Ten States to U.S. Pig Crop.

regression estimate and therefore when data is later revised, the revised estimates are used with later regression estimates. In this case two of the six data points were increased from the 1987-92 data set to the 1987-93 data set (from the September 1992 to the September 1993 *Hogs and Pigs* report). The 1986 June-August pig crop estimate increased from 21,158 thousand to 21,280 thousand while the 1991 June-August pig crop estimate increased from 24,432 thousand to 24,499 thousand. A more significant pig crop estimation revision took place the following year with the 87-94 data set (from the September 1993 to the September 1994 *Hogs and Pigs* report). The 1992 June-August pig crop was estimated at 25,751 thousand. By the following year, this number was reduced by 1,144 thousand to 24,607 thousand.[16] With this correction in pig crop, the equation estimates for the reminder of the study, beginning with the 87-94 data set, are reasonably stable. These early regression estimates clearly demonstrates the fragility of estimates made with small data sets, especially where the variables are estimates and are subject to revision at a later date.

To better evaluate the out-of-sample performance of the regression equations, the errors in the predicted slaughter hogs (predicted – actual) were calculated using both the first estimate and final estimates of pig crop.[17] The errors in estimates of slaughter hogs using the first estimates are the actual errors encountered in the hedging process and are the sum of the errors from the equation estimate and USDA's error in estimating the pig crop. Slaughter hog estimates made from the final pig crop estimate are not used in the hedging process. Errors in slaughter hogs estimates made by final pig crop are a result of the equations estimate alone. Thus, by comparing the differences in the errors made by these two estimates of pig crop, the errors associated with the first estimates of pig crop can be differentiated from the errors inherent to the equation estimates. The results are given in Table 2.12 with the mean error and standard deviation for each quarter. The mean error is an indication of bias in the estimates. By definition, the mean error of the regression equation estimates is zero and the estimated coefficients are not biased. The standard deviation indicates the consistency of the estimates. Both are important measures in evaluating the errors because they effect the hedging frequency. Caution is in order in interpreting these statistics because of the small number of observations in

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[16] This estimate was again revised downward the following year but by only seventeen thousand.

[17] Final estimates of the 1998 pig crop have not been released. Pig Crop estimates for 1998 are as given in the December 1999 *Hogs and Pigs* report were assumed final.

Table 2.13: Errors in Slaughter Hog Estimation (Thousands of Head).*

		Qt. I		Qt. II		Qt. III		Qt. IV	
	Year	1st Est.	Final	1st Est.	Final	1st Est.	Final	1st Est.	Final
Ten States Data	1983	-250	48	-334	-5	-1338	779	-1171	-1030
	1984	-234	-62	363	466	-1043	307	-1886	-1719
	1985	-169	115	-141	-141	-1085	905	-438	-438
	1986	459	459	650	659	1434	-763	-969	-873
	1987	-760	-211	874	414	775	-580	-1457	-1152
	1988	98	314	79	81	-564	-235	-1040	-770
	1989	65	212	-1689	-1004	-82	-90	-18	386
	1990	917	283	-351	-279	463	-492	320	268
	1991	445	163						
	Mean Error	63	147	-69	24	-180	-21	-832	-666
	Std. Dev.	466	203	793	525	999	626	739	713
U. S. Data	1991			12	213	-123	-296	-671	-704
	1992	-877	-882	596	933	7	-95	-598	-569
	1993	1801	491	1601	790	1644	-527	154	-451
	1994	-569	-276	-1264	154	-784	52	-1367	-818
	1995	103	137	-446	134	795	-802	-45	-753
	1996	95	-120	1826	708	1370	-391	-148	-743
	1997	43	-384	143	336	381	-472	-1280	-1563
	1998**	-766	-240	605	806	-284	12	-2591	-2350
	Mean Error	-24	-182	384	509	376	-315	-818	-994
	Std. Dev.	908	429	1018	332	840	293	904	641

*Error is defined as Predicted – Actual Slaughter Hogs.

** 1998 final pig crop estimates have not been released. 1998 pig crop estimates were as published in the December 1999 *Hogs and Pigs* report.

each sample. However, the individual errors that resulted from predictions with the first estimate of pig crop are the actual errors that were encountered in the hedging process. Therefore, these individual errors did impact the hedging process and inferences can be drawn from them.

There are three major findings in Table 2.12. First, the standard deviations of the errors of the estimates made by the final U.S. pig crop are smaller than the standard deviation of the errors made by the final Ten States pig crop with the exception of the first quarter. This is expected because the SER of the U.S. pig crop equation estimates are smaller and supports the proposition that the equation estimates of the U.S. data are more consistent. However, using the first estimate of pig crop, the standard deviations of the errors made by the Ten States pig crop are smaller than with the U.S. pig crop with the exception of the third quarter. This is unexpected and implies that the errors in USDA's first estimates of pig crop are more than proportionally larger with the U.S. estimates versus the Ten States estimates. To test this hypothesis, the standard deviation of the error, in percentage terms, between first and final estimates for the Ten States and the U.S. pig crop was calculated. The standard deviations are 1.85 percent and 2.38 percent for the Ten States and U.S. data respectively. Thus the conclusion is drawn that the improved consistency of the slaughter hog equation estimates using U.S. data is more than offset by the less accurate first estimate of U.S. pig crop. However, from a hedging standpoint, there is little difference in the consistency of the estimates by first estimates of pig crop using either the Ten States or U.S. data with the exception of the first quarter.[18] Thus, the change from Ten States to U.S. pig crop had little effect on the hedging process and did not significantly contribute to the increase in the hedging frequency in the last half of the out-of-sample period when hedging frequency returned to the levels of the in-sample period.

The second and third findings concerns the relative performance of the fourth quarter compared to the other three quarters. As previously mentioned, with U.S. data the fourth quarter regression estimates were not as accurate as the other three quarters in terms of the R^2 and SER. Using the first estimates of pig crop, the errors in the slaughter hog estimates in the fourth quarter of 1991 and 1992 were –671 and –598 thousand head, respectively. Comparatively, the second quarter errors were 12 and 596 thousand head and the third quarter's were –123 and 7 thousand head for the same years. The error for the first quarter of 1992 was –877 thousand head. Errors above 600 thousand head are not uncommon during other periods of the study. Thus, while the errors for the fourth quarter for 1991 and 1992 are large, they are not unreasonably large. Therefore, these equation estimates did not have a significant impact on the hedging process.

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[18] Factoring out the large error in the first quarter of 1993, that can be at least partially attributed to the small data set and revision to the pig crop discussed above, the standard deviation of the error for the first quarter with U.S. pig crop would be 459 thousand head which is approximately the same as the 466 thousand head with the Ten States pig crop.

The other problem equation estimate for the fourth quarter is the 88-97 data set estimate that is used to predict the 1998 fourth quarter slaughter hogs. This equation estimation had an R^2 of sixty-one and a SER of 703 thousand head. The other three quarters during 1988-97 had R^2s 0.89 or higher and SERs between 250 and 400 thousand head (Table 2.11). In the 1998 fourth quarter, the forecast error in slaughter hogs was –2591 thousand head, by far the largest single error during the sixteen year out-of sample period (Table 2.12). This error resulted in an estimated QPKP of 17.55 pounds versus an actual QPKP of 19.39 pounds or an under estimation of 1.84 pounds. Multiplying the QPKP error by the QPKP coefficient of –4.50 from the EPM equation for 1988-97 data set yields an overestimation of EPM by $8.28 per cwt. With a fifty percent trigger level, this implies the IPM must be $12.42 per cwt. above the level required to trigger a hedge assuming no error in QPKP. Such a large error virtually eliminates all possibility of a hedge being placed. In the particular case of the fourth quarter of 1998, had the estimation error been no larger than the next largest error of 1800 thousand head, hedges would have been placed for the October and December lots at profits of about seven and fourteen dollars. Adding these profits to the overall hedging results would result in a profit of about seventeen cents per cwt. instead of the loss of four cents. The variance of the hedged cash flow would have also decreased substantially. Thus, this equation estimation did effect the hedging results.

The third finding is the apparent negatively biased slaughter hog estimates in the fourth quarter from both the Ten States and U.S. pig crop. With the Ten States data, using the final estimates of pig crop, the mean error is –666 thousand head while with U.S. data it is –994 thousand head. (On a percentage basis, these mean errors represent about four percent of the total hog slaughter.) Statistically, these mean errors do not significantly differ from zero. However, with Ten States pig crop six of the eight estimates are less than actual slaughter hogs while with the U.S. pig crop all eight estimates are less than actual slaughter hogs. This is a strong indication of biased estimates, particularly with U.S. pig crop. Because the negative mean errors are found using final estimates of pig crop, the bias is a result of the equation estimates and not a bias in USDA's first estimates of pig crop. In fact, the mean errors with USDA's first estimates of pig crop are of the same magnitude as the mean errors with final estimates indicating that USDA's first estimates are not biased.

The mean errors of the other three quarters using Ten States data are all approaching zero and thus show no indication of bias. The mean errors of the first and third quarters using U.S. pig crop also approach zero. The mean error for the second quarter, using final estimates of U.S. pig crop, is 509 thousand head and is not statistically different from zero. However, all eight estimates of slaughter hogs are overestimated. With an increase in observations, the second quarter equation estimates may prove to be biased. However, the 509 thousand head mean error represents only about two percent of slaughter hogs or about half the error of the fourth quarter. Subjectively, any bias in the second quarter using U.S. pig crop is not of sufficient magnitude to have a major impact on the hedging results. Only the fourth quarter is of concern.

EPM Regression

EPM regression estimate results are reported in Table 2.13. The coefficients of the independent variables behave as economic theory suggests. There is a decrease in profit margin with an increase in quarterly pork production, corn prices or soybean meal prices. The pork coefficient is generally decreasing (becoming more negative) through time indicating that profit margins are becoming more sensitive to the quantity of pork produced. For example, with the 75-84 data set, the pork coefficient was -2.42 meaning that the profit margins decreased by $2.42 for each additional per capita pound of pork while with the 88-97 data set, profit margins decreased by $4.50 per pound of pork.[19] The corn price coefficient averages approximately -0.06 indicating that for each cent per bushel increase in the price of corn, profit margins decrease by $0.06 per cwt. Similarly, the soybean meal coefficient averages approximately -0.05, indicating a one dollar per ton increase in price of soybean meal decreases profits by $0.05. These average impacts on profit margins are of the same magnitude as the impact calculated from the feed conversion factors. The corn conversion factor of 366.68 pounds per cwt. is equivalent to approximately 6.5 bushels per cwt. of pork. Thus, an increase of one cent per bushel decreases profits by $0.065 per cwt. The soybean meal conversion factor of 74.91 pounds per cwt. is equivalent to approximately 0.037 tons per cwt. pork. Thus, an increase of one dollar per ton in the price of soybean meal decreases profits by $0.037 per cwt. At the five

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[19] While the EPM regression is strongly related to the demand for pork and would behave similarly, it cannot be strictly interpreted as such because income and substitutes are not included in the regression. The QPKP coefficient, in particular, consists primarily of the elasticity of demand for market hogs.

Table 2.14: Yearly EPM Regression Results with Bimonthly Data.

				Coefficients				Projected
Data Set	R^2	SER	DW	Intercept	Pork	Corn	SBM	EPM**
75-82	0.63	6.22	0.91	75.76	-2.29	-0.0633	-0.0907	5.57
75-83	0.65	6.02	0.90	78.68	-2.45	-0.0683	-0.0873	5.23
75-84	0.66	5.74	0.94	78.89	-2.42	-0.0698	-0.0883	5.34
76-85	0.58	5.60	0.94	69.71	-2.37	-0.0764	-0.0377*	4.57
77-86	0.57	5.82	0.97	68.24	-2.32	-0.0761	-0.0335*	4.76
78-87	0.65	5.55	1.26	71.06	-2.87	-0.0858	0.0163*	5.42
79-88	0.64	5.54	1.19	70.36	-2.75	-0.0598	-0.0344*	4.15
80-89	0.63	5.48	1.12	69.77	-2.59	-0.0541	-0.0555	3.73
81-90	0.64	5.38	1.15	77.80	-3.08	-0.0555	-0.0532	3.97
82-91	0.62	5.22	1.18	87.60	-3.68	-0.0621	-0.0489	3.22
83-92	0.68	4.71	1.29	82.53	-3.22	-0.0696	-0.0545	2.48
84-93	0.64	4.70	1.34	78.97	-3.02	-0.0694	-0.0525	2.55
85-94	0.67	4.72	1.34	88.37	-3.64	-0.0785	-0.0404*	1.85
86-95	0.68	4.73	1.23	88.50	-3.83	-0.0518	-0.0579	2.78
87-96	0.66	4.53	1.37	90.50	-4.34	-0.0091*	-0.0767	4.46
88-97	0.56	4.55	1.30	86.07	-4.50	-0.0141*	-0.0325*	4.32

* Not significant at 5% level.

** Projected EPM is calculated assuming 16 pounds QPKP, 265 cents per bushel corn and $185 per ton soybean meal.

percent significance level, pork is significant in each regression, corn is significant in all but the last two regressions while soybean meal is significant in only ten of the sixteen years. The reason for the insignificance of corn price variable with the 85-96 and 86-97 data sets is not readily apparent. Insignificance of the soybean meal price variable is effected by the fact that corn cost typically represent over two-thirds of feed cost and is therefore the dominate cost factor in the EPM equation.

The estimated coefficients change substantially over time, sometimes abruptly. In some cases changes in one coefficient are offset by changes in another coefficient. For example, the change in the pork coefficient from –3.08 to –3.68 when the estimates are based on the 81-90 data set versus the 82-91 data set is partially offset by the change in the intercept from 77.80 to 87.60. Similarly, between the estimations using the 78-87 and 79-89 data sets, the corn coefficient changes from –0.0858 to –0.0598 while the soybean meal coefficient changes from 0.0163 to –0.0344. To evaluate the effect of these changes in the estimated coefficients, Table 2.12 includes the projected EPM assuming 16 pounds of pork, 265 cents per bushel corn and $185 per ton soybean meal. The most obvious pattern is the somewhat jagged downward trending of the EPM from the 78-87 through the 85-94 data set estimations. Trending should not be considered a problem as it may well reflect changes through time. However, the magnitude of the changes coupled with reversals in the trend and sharp temporary departures in times of no trending are causes for concern. These shifts, increasing or decreasing by as much as $1.00 cwt. or more with constant levels of QPKP, C and SBM, occur as the ten year window is moved by one year with six old observations being deleted and six new observations being added. These large changes in coefficient estimates and EPM estimates indicate that the equation is quite sensitive to the time period. An estimation period longer than ten years would reduce the year to year variations but would also not be as sensitive to changes through time. Thus, it appears that the ten year window is an appropriate compromise though it does present some problems. Depending upon the ten year window, the regression explains 56-68 percent of the variation in actual cash margins as indicated by the R^2 with no apparent trend through time. However, the SER's are constantly decreasing through time, beginning at $6.22 per cwt. and ending at $4.55 per cwt. These two facts indicates that the variance in profit margin is decreasing. In Table 2.12, the entire twenty-four year data set is divided into three eight year subperiods with the averages and variances for CPM and QPKP calculated for each subperiod. These calculations verify a strong decrease in the variance of the CPM in each of the subperiods with the variance of the 1991-98 subperiod being about one half of the variance in 1972-83 subperiod. The decrease in the variance of the CPM from the 1975-82 to the 1983-90 subperiod may be at least

Table 2.15: Average and Variance of CPM and QPKP by Subperiods.

	CPM		QPKP	
Subperiod	Average	Variance	Average	Variance
1975-82	5.41	98.75	15.79	3.52
1983-90	5.12	72.72	15.65	1.15
1991-98	-0.35	48.85	16.73	1.24

partially caused by a corresponding decrease in variance of QPKP, the independent variable with the strongest effect on the EPM equation. However, the variance of QPKP did not decrease from the 1983-90 to the 1991-98 subperiod while the variance of the CPM decreased substantially. The variance of corn and soybean meal prices, the other independent variables in the EPM equation, did not change substantially during the study period. The fact that the variance of the CPM has decreased may be an indication that the variance of the IPM during hedging period has decreased thus decreasing hedging opportunities. This hypothesis is explored in Chapter 4.

Effect of QPKP Prediction Errors on EPM Predictions

The EPM prediction is based upon the accuracy of the EPM regression itself and the error in the QPKP estimate. Errors in the QPKP are from the three regression estimates that are used to calculate the QPKP, the population, carcass weight and slaughter hogs regressions, and of course the error in the *Hogs and Pigs* first estimate of pig crop. To better evaluate the impact of errors in each of the regression equations that form the QPKP on the EPM prediction, the partial derivative of the EPM equation with respect to variables is taken:

$$EPM = \alpha + \beta_1 (SH * CW / POP) + \beta_2 C + \beta_3 SM$$

$$\delta EPM / \delta SH = \beta_1 (CW / POP)$$

$$\delta EPM / \delta CW = \beta_1 (SH / POP)$$

$$\delta EPM / \delta POP = - \beta_1 (SH * CW / POP^2)$$

To quantify the effects of a one SER error[20] of one of the three equations that form QPKP, the actual values for the variables are substituted into the partial derivatives and multiplied by one SER of the subject equation. For example, to estimate the impact of the error in estimating the carcass weight on the EPM, the actual values for slaughter hogs a divided by the population with the resulting value multiplied by the QPKP coefficient. The result is then multiplied by one SER of the carcass weight equation to determine the error that one SER in the carcass weight equation causes in the EPM estimation. These error estimates are on an equivalent basis and can be directly compared to each other as well as the SER of the EPM equation. Because the EPM regression estimates changed substantially from the beginning to the end of the study, the error

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[20] Statistically, the SER of a regression is the equivalent of the standard deviation of the errors in estimation. Therefore, approximately sixty-seven percent of the errors in the estimation would be expected to be between plus or minus one SER and ninety-five percent would be expected to be between two SERs.

contributions were evaluated with the regression estimations made using the 75-84 and 86-95 data sets. The Quarter 3 quarterly regression for carcass weight and slaughter hogs for those years were arbitrarily chosen for the evaluation. The results are reported in Table 2.15.

Individually, each of the three regressions used to compute QPKP contribute relatively little error to the EPM as compared to the SER of the EPM equation that was $5.74 and $4.73 per cwt. for the 75-84 and 86-95 data sets respectively. From a practical viewpoint, a one SER error in the population or the carcass weight regression effects profits by $0.25 per cwt. or less than the equivalent of one tick in the futures price of live hogs. The slaughter hog regression is the major source of error in estimating QPKP by at least a factor of four with equivalent EPM errors of $0.75 and $0.93 per cwt. However, comparatively, the EPM regression introduces an error that is eight times greater than the slaughter hog regression in the 75-84 data set and five times greater in the 86-95 data set.

Because of the possibility of interrelationships in the regressions and varying levels of the factors that produced QPKP, it is not possible to directly estimate the overall effect of the QPKP estimate on the EPM estimate. Therefore, potential problems associated with estimating QPKP were tested by replacing the predicted QPKP with the actual QPKP in the hedging process. Using the actual QPKP assumes perfect foresight of QPKP, eliminating both the errors in estimating QPKP from the regressions and errors in the *Hogs and Pigs* report's estimate of pig crop. These pig crop estimation errors would include the first estimate error that is used to project the slaughter hogs from the regression estimates as well as those that are used to estimate the regression equation that are subsequently changed.

The results in Table 2.16 indicate that hedging during the out-of-sample period with the actual QPKP did improve the hedging results but they were still highly statistically insignificant with a p-value of 0.4563 for the joint condition versus a p-value of 0.6431 for the hedges with

Table 2.16: Errors in EPM Contributed by QPKP Component Regressions.

	75-84 Data Set			86-95 Data Set		
Model	Actual	SER	EPM Error ($ / cwt.)	Actual	SER	EPM Error ($ / cwt.)
Population (thou.)	238139	247	0.04	265425	431	0.10
Carcass Weight (lbs.)	172.86	0.87	0.18	182.00	0.77	0.25
Slaughter Hogs (thou.)	20556	426	0.75	22714	354	0.93

Table 2.17: Significance Tests of 3-way Hedging Strategies: Predicted vs. Actual QPKP.

	Hedged Mean ($ / cwt.)	$\mu_H \leq \mu_C$ (p-value)	Hedged Variance ($ / cwt.)	$\sigma^2_H \geq \sigma^2_C$ (p-value)	$\mu_H \leq \mu_C \cup \sigma^2_H \geq \sigma^2_C$ (p-value)
1983-98					
Cash	$2.28		$68.46		
Predicted QPKP	$2.24	0.5516	$64.18	0.2039	0.6431
Actual QPKP	$2.52	0.2258	$65.74	0.2978	0.4563

predicted QPKP. The improvement is a result of the increase in profit to $2.65 per cwt. versus cash profits of $2.28 per cwt. and hedging with predicted QPKP of $2.24. This change in profits deceased the p-value of the mean condition from 0.5516 with the predicted QPKP to 0.2258 with the actual QPKP. However, there was a small increase in the variance. The variance for cash, predicted and actual QPKP being $68.50, $64.18 and $65.74 per cwt. respectively. This change in variance resulted in a p-value of 0.2978 for the actual QPKP versus 0.2039 for the predicted QPKP hedges. While the errors in predicting QPKP do contribute to the hedging failure in the out-of-sample period, hedging with the actual QPKP confirms that these errors are not the major factor.

Figure 2.6 compares the actual CPM to the predicted EPM using the actual QPKP, corn and soybean meal prices for both the in-sample and out-of-sample years. The errors in the prediction are illustrated in Figure 2.7. The in-sample years, 1975-82 demonstrate a randomness in the errors that continues through 1985. At that point, the EPM begins to consistently over estimate the CPM and continues to do so until 1990. For the period 1985-89, the EPM over estimated the actual CPM by an average of $4.53 per cwt. with seventy-five percent of the forecasts being greater than the actual cash profit margin received by the producer. This is consistent with the lack of hedges being placed in the 1985-89 time period. For the 1990-98 time period, the EPM over estimated the actual CPM by an average of $0.41 per cwt. with only forty-five percent being over estimated. This is consistent with the return of the hedging frequency after 1990 to levels similar to those prior to 1985 but it does not explain the lack of profitability in the hedging strategy after 1990. However, these tests support the proposition that, in general, predicting the EPM is the source of the change in the in-sample versus the out-of-sample results and that predicting QPKP is a relatively minor source of the change.

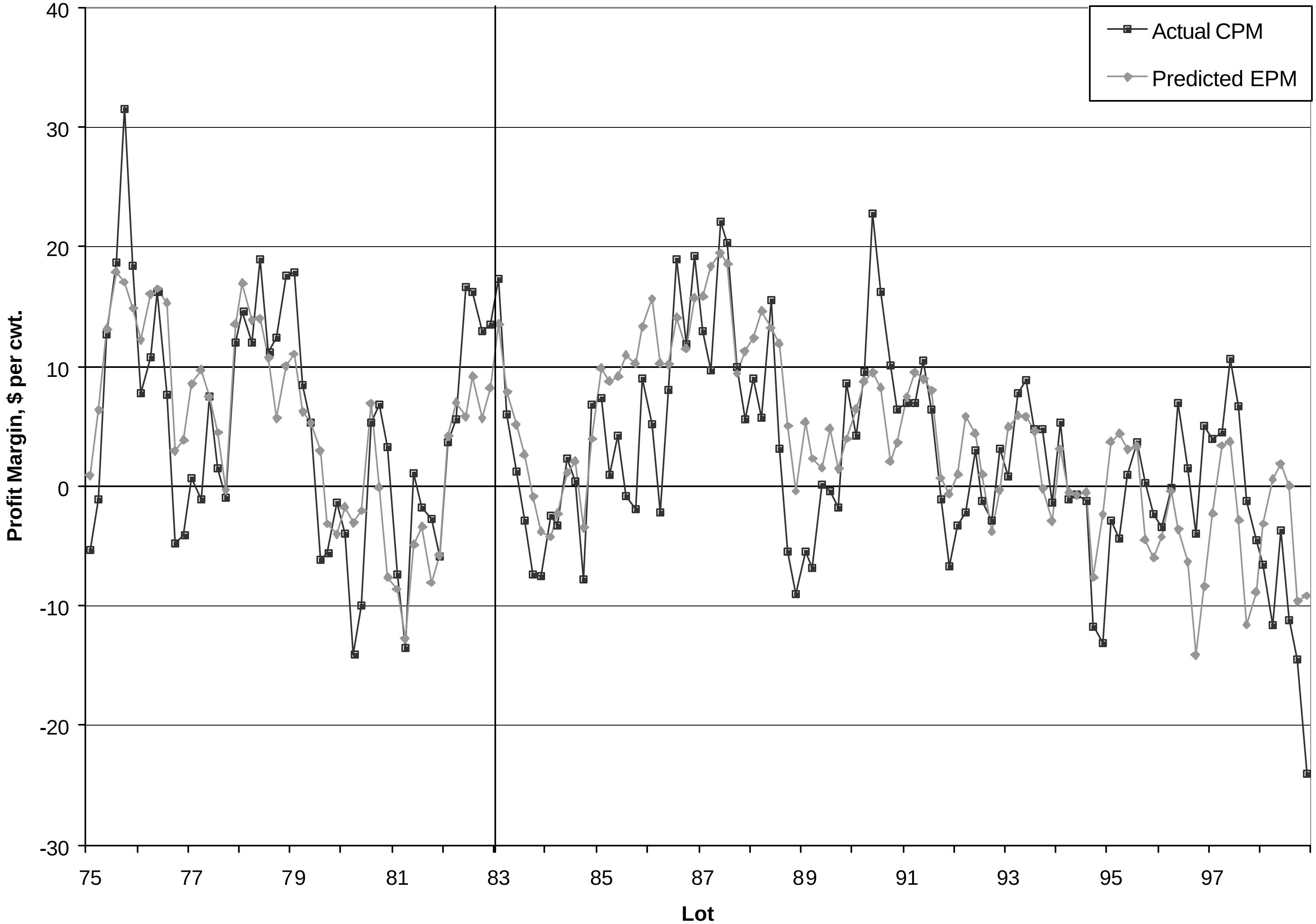

Figure 2.6: Comparison of CPM and EPM, 1975-98

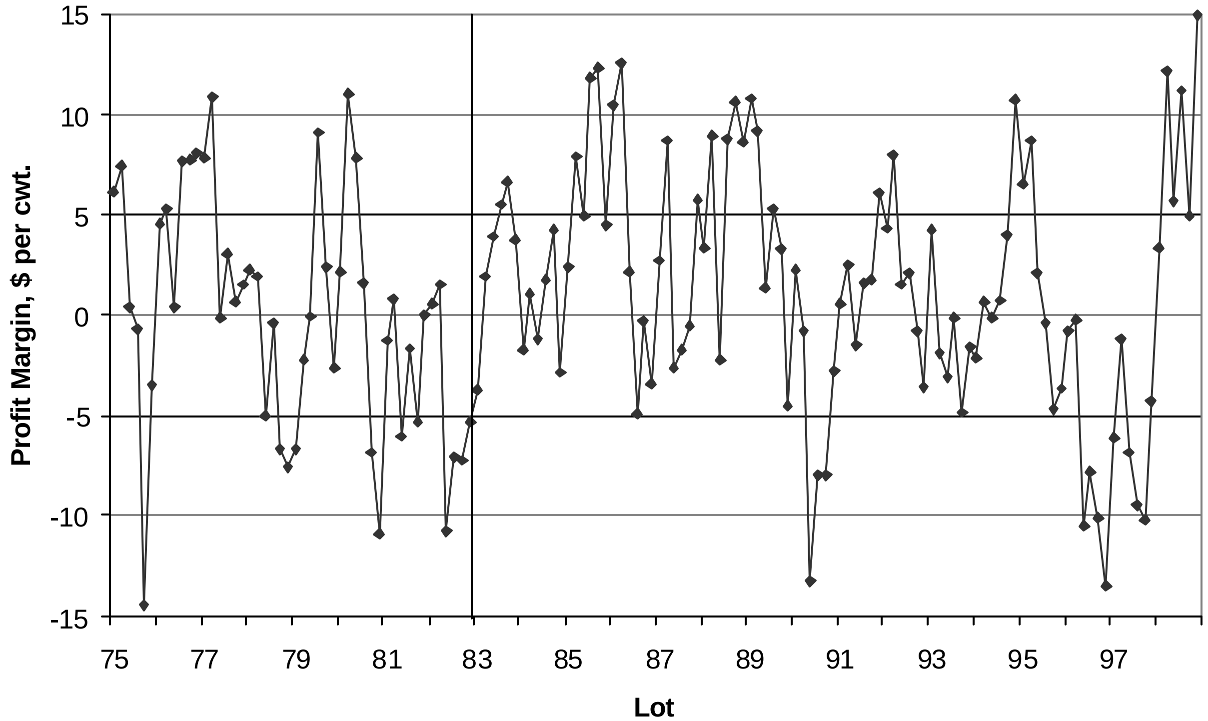

Figure 2.7: Errors in Estimation, EPM - CPM, 1975-98

Conclusions

In the analysis of the individual models, it is clear that any improvements to the hedging strategy must focus on improvements to the EPM model because it is the major source of error. The EPM equation was particularly troublesome in the 1985-89 time period when no hedges were placed. The estimation of feed cost and returns are not completely realistic with known changes in technology, especially as these changes began increasing rapidly in the early 1990's. The cost structure could be effecting the hedging results, especially in the later periods of the research. These changes are the focus of the next chapter. There are also possibilities of improving the estimation of QPKP but errors in QPKP are relative minor in comparison to the EPM equation. Therefore, unless a significant improvement is made in the hedging results by better EPM estimations or an improved cost structure, alternative models for QPKP will not be tested.

Chapter 3: Alternative Models

The basic KC strategy was not successful in the out-of-sample period because the EPM equation could not accurately predict the expected profit margin. Without an accurate prediction of the EPM, the trigger mechanism frequently failed to hedge at the appropriate time. The main goal of this chapter is to improve upon the accuracy of the EPM estimates. Chapter 2 identified two potential areas of improvement by examining the performance of the models from 1975 through 1998. The cost structure based on the LDP simulator became unrealistic. These unrealistic costs are embedded in the EPM equation and may have contributed to its failure. An additional problem with the EPM equation is that it only includes variables related to the supply of pork and cost of production. KC assumed the demand for pork was constant citing then current literature. A more recent study (Purcell, 1998) indicates a possible change in demand. Additionally, even if demand was constant, this does not imply that the profit margin for a given supply of pork and given costs remains constant because demand studies typically compensate for changes in observable 'demand shifters' such as supply of competing products, inflation and disposable income. To more accurately predict EPM, these observable demand shifters and possible changes in demand must be taken into consideration. These two specific areas are addressed in this chapter.

First, a more realistic cost structure is developed based on producer data that takes into account the technological changes that have occurred in the industry. Hedging results are given for the new cost structure to determine any changes in the hedging results as compared to the LDP cost structure. Second, additional variables are identified that may be significant market factors in determining EPM. The EPM equations with these variables are tested individually and in combination to evaluate their forecasting ability. From a statistical evaluation of these changes over the entire data set, a final set of changes will be selected to rerun the hedging strategy. This new model will be tested in the same matter as the KC model. The new model will be re-calibrated with a base period of 1975 through 1982. The equations will be updated on a regular basis from 1983 through 1998. No rules or models are changed during the 1983-98 period or data used before it is publicly available. On the surface, this would also appear to be an out-of-sample test. However, in making revisions to the models through knowledge gained by previous tests, the remainder of this research cannot be considered a true out-of-sample test. Any relationships that are uncovered are subject to change over time and while there is no intentional 'curve fitting', all research that is conducted on an existing data set is subject to unintentional 'curve-fitting'.

The remainder of this research retains KC's original goal of developing a hedging strategy that is useful and widely acceptable to hog producers or market advisors that operate in the 'real world'. For a strategy to be accepted in the 'real world' it must meet three criteria: 1) understandable, 2) easily implemented, and 3) profitable. The first two criteria can be achieved by similar methods. First, only basic statistics with OLS regressions and linear relationships are used. The models are easily implemented in standard spreadsheet software. Secondly, a conscious attempt is made to simplify the data sets used by limiting the number and requiring that the data be easily available. For an independent variable to be included in a model, it must have a clearly explainable impact on the predicted variable. If a variable is used in a model, it is used in each year of the study. Thus, each variable is not required to be statistically significant in each year of the model. Additionally, the liberty is taken to include variables that are generally accepted in the industry to have an impact. In some cases, this may lead to models that are not considered to be the most superior in a statistical sense being accepted. This approach is justified in that the goal is to develop a system of models that will forecast into the future by anticipating possible changes without including superfluous variables. The third criterion, profitable, is included as a reminder of the goals of a producer in choosing to implement a hedging strategy. It is a generally accepted paradox that producers will not consistently engage in a hedging strategy that is superior to the cash market in a mean/variance framework if the superiority is a result of reduced variance. In Parcell *et. al.*, less than twenty-five percent of the agricultural research marketing economists surveyed agreed with the statement "The primary goal of a marketing strategy should be to reduce risk." Therefore, the primary emphasis of this research is to increase income without increasing variance with a secondary emphasis of reducing variance.

Revised Budget

The LDP simulator budgets used in the previous chapter do not effectively reflect the changes in technology that have occurred during the study period. Iowa State University collects and analyzes data from actual hog farms in Iowa that voluntarily participated in the Iowa Swine Enterprise Records program. This information is available from Iowa State University (ISU) beginning with 1982 data and has been regularly published in the popular press in recent years. The number of farms participating began with 147 farms in 1982, reached a peak of 353 in 1991 and declined to 102 in 1997. The top one-third, by profit margin, of these farms is reported separately.[21] For this top third of the farms, the number of market hogs sold per year was relatively constant at 1,500 hogs per year until 1992 when it began moving upward to a high of over 2,500 in 1995. Figure 3.1 illustrates these two trends. The top third was chosen as being more representative of producers who are adapting new technology, increasing in size and willing to consider implementing a hedging strategy. The ISU data should captures at least part of the cost structure changes in the industry that have been brought about by the mega producers.

The ISU budgets were adapted to the framework used in this study. As in the COP budgets, the ISU term 'supplement' includes mixing concentrates. This study assumes that eighty-three percent of supplement is soybean meal and calculated the soybean meal conversion

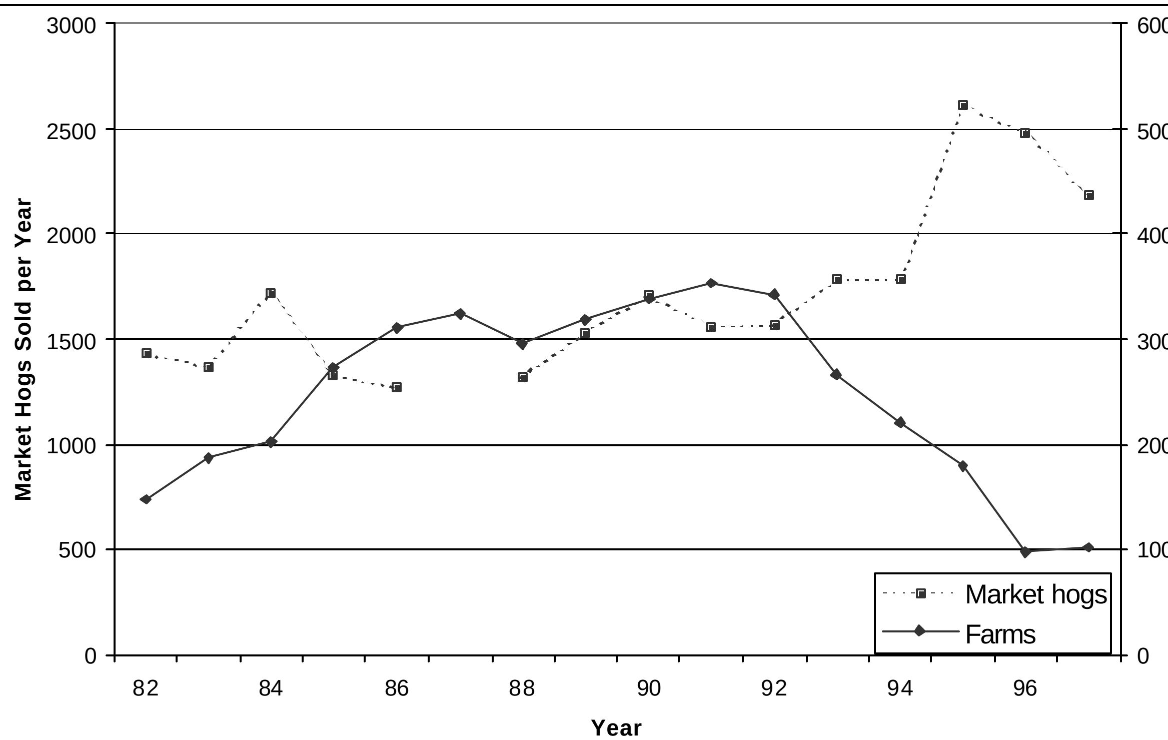

Figure 3.1: Characteristic of ISU Enterprise Data

[21] In 1987, data was only published for the average farm. Cost data was extrapolated from 1986 top third data based on changes between the 1986 and 1987 average producer data.

as eighty-three percent of the published supplement usage. The direct costs were estimated by subtracting corn cost and soybean meal cost from the ISU published total cost of production. The corn cost is based on the ISU published corn conversion and the ISU published grain price paid by the producers. The soybean meal cost are estimated by the calculated soybean meal conversion and Decatur Illinois soybean meal price.[22]

The ISU data are in terms of pounds of pork produced and, like the LDP budgets in Chapter 2, is converted into cwt. of market hogs by the same method. For the years before the data are available, 1975-81, the direct cost, corn and soybean conversion factors used by KC in 1975 were assumed to have changed constantly from 1975 until 1982. Using this method from 1975-81, direct cost increased by $1.35 per cwt. per year, the corn conversion factor decreased by 4.2 pounds per cwt. per year and the soybean meal conversion factor decreased by 0.6 pounds per cwt. per year. The ISU data are not generally available to the public until mid-year of the following year when it appears in the popular press, i.e. 1996 data are published in May or June of 1997. To estimate 1997 direct cost and conversion factors for use beginning the first market day of 1998, the average change in these factors over the past three years was used to adjust the 1996 value.

The ISU data do not contain an estimate of pounds of cull breeding stock sold. Following KC, a constant 6.1 pounds of cull breeding stock per cwt. of market hogs was assumed to have been produced. Other than these changes, the CPM and IPM are calculated in the same manner as in Chapter 2. Several regressions were estimated to predict sow price using a trend variable with and without dummy monthly variables to test for seasonality. The improvements in accuracy of these test regressions were only slightly better than the original regression and would have at best a minimal impact on the hedging results as discussed in Chapter 2. Therefore, because of the added complexity, neither the trend or seasonality variables are included. ISU conversion factors, cost factors and CPM are reported in Table 3.2 with

[22] Three assumptions were made due to missing data. 1) The grain price was published from 1985 through 1994 and had an average basis of $0.10 below USDA/AMS Central Illinois corn price. Corn prices for years not published were estimated to be Central Illinois minus $0.10 basis. 2) Top third was not published in 1987 and was estimated by multiplying the 1986 top third total cost and conversion factors the percentage change in these factor between 1986 and 1987 by the average producer. 3) Only total feed conversion is given in 1996 and 1997. 80% is assumed corn and 20 % soybean meal which is the ratio in 1995.

Table 3.1: ISU Top 1/3 and LDP Cost Factors , $/cwt., 1975-98.

Year	Conversion Factors lbs. / cwt.*		Feed Cost $ / cwt.**		Direct Cost		CPM $ / cwt.**	
	Corn	SBM	ISU	LDP	ISU	LDP	ISU	LDP
1975	353	73.2	25.43	27.56	14.75	14.08	12.80	12.52
1976	349	72.6	22.81	24.94	16.10	15.25	5.88	5.59
1977	345	72.0	22.42	24.60	17.45	15.44	2.54	3.29
1978	341	71.4	19.98	22.25	18.80	16.98	13.78	14.50
1979	336	70.8	21.62	24.32	20.14	18.51	3.15	3.08
1980	332	70.2	23.42	25.61	21.49	19.61	-1.78	-2.09
1981	328	69.6	28.96	32.05	22.84	22.23	-2.53	-5.02
1982	324	69.0	21.98	24.60	24.19	24.09	13.97	11.44
1983	320	68.3	21.98	24.90	24.19	23.83	3.71	1.15
1984	317	62.7	25.34	29.58	22.22	23.86	5.20	-0.67
1985	314	62.9	19.23	22.56	22.69	23.11	6.88	3.12
1986	312	64.2	17.11	20.04	18.52	23.13	17.75	10.19
1987	321	65.7	14.77	16.87	19.45	23.23	19.33	13.45
1988	308	63.5	18.56	22.03	19.14	22.51	10.00	3.16
1989	311	61.9	21.67	25.78	18.90	23.06	7.29	-0.97
1990	302	60.7	18.99	23.16	19.75	24.30	20.29	11.57
1991	311	60.1	18.76	22.47	20.39	26.86	14.01	3.84
1992	298	60.4	18.79	23.19	20.48	22.66	6.02	-0.55
1993	297	60.7	17.11	21.13	19.57	25.15	13.86	4.26
1994	297	63.3	19.62	23.94	20.90	24.98	4.65	-3.75
1995	299	64.5	17.85	21.60	20.86	24.69	6.83	-0.74
1996	292	61.0	25.92	32.36	20.48	25.51	12.45	0.99
1997	278	57.5	20.92	27.49	21.32	26.23	14.84	4.37
1998	289	59.4	18.05	22.88	20.49	26.80	-0.73	-11.23

* Feed conversion factor for LDP budgets were 388.04 lbs./cwt. for corn and 75 lbs./cwt. for soybean meal prior to 1980 and 366.68 and 74.91 lbs./cwt. after that year.

** Calculated using the yearly average of the six lots.

comparison data from the LDP budgets. The conversion factors in the ISU data are steadily decreasing which reflects the changes in the industry. The direct cost escalated from $14.75 cwt. in 1975 to a high in 1982-83 of $24.19 cwt. as a result of the inflation in those years. Since 1987, direct cost have fluctuated by $1.50 around the $20.00 level whereas the LDP direct cost continued to escalate. The ISU data appear to be more representative of the changes brought about by consolidation in the industry that have lowered cost. Total cost of production averaged $38.54 per cwt. of market hog in 1998 is a much more realistic cost than the $49.68 cwt. of the LDP budget and is generally in line with industry sources of $36-38.00 cwt. for the mega producers.

In making these changes to the cost structure, the dependent variable of EPM equation, CPM, has been changed while the independent variables, QPKP, corn price and soybean meal price, remain unchanged. The re-estimated EPM equations by time period are reported in Table 3.2 and are directly comparable to Table 2.13. The most striking difference is the large increase in projected EPM during the later part of the study (calculated by assuming 16 pounds. QPKP, 265 cents per bushel corn and $185 per ton soybean meal). These high EPM's are a result of the lower cost structure of the ISU data.[23] In general, the profit margin for the LDP cost series was slightly easier to predict with higher R^2s and lower SER's than the ISU cost series. This problem is at least partially caused by the ISU cost data being more variable due the fact that they are composite of actual producer data for a particular year. Actual cost data include variance from both the Iowa weather and changes in the individual producers who participate in the program. The corn and soybean meal price coefficients have more instances were they are insignificant. In fact, in only three instances are they both significant in an equation estimate and there is one instance where both are insignificant. From a statistical standpoint, the LDP costs regressions are preferred to the ISU costs regressions.

The real test of a forecasting model's performance is its ability to forecast out of the sample period over which it was estimated. To test forecasting ability, the EPM was calculated for each lot of the following year, using the actual QPKP, corn and soybean meal prices for each

[23] These high EPM's are not reflective of the actual profit margin currently being received by hog producer because, while average QPKP over the study period averaged 16 pounds, the actual QPKP is now averaging about 18-19 pounds.

Table 3.2: Yearly EPM Regression Results with Bimonthly Data, ISU Costs.

				Coefficients				Projected
Data Set	R^2	SER	DW	Intercept	Pork	Corn	SBM	EPM**
75-82	0.57	6.56	0.80	70.28	-2.25	-0.0483	-0.0848	$5.87
75-83	0.59	6.28	0.80	73.14	-2.35	-0.0541	-0.0832	$5.84
75-84	0.58	6.11	0.84	71.78	-2.40	-0.0465	-0.0806	$6.09
76-85	0.51	5.77	0.87	66.04	-2.48	-0.0381*	-0.0570	$5.66
77-86	0.58	5.91	0.90	78.18	-2.95	-0.0388*	-0.0763	$6.64
78-87	0.72	5.24	1.43	86.19	-3.61	-0.0757	0.0007*	$8.42
79-88	0.74	5.19	1.47	89.14	-3.73	-0.0679	-0.0176*	$8.26
80-89	0.73	5.09	1.39	87.48	-3.52	-0.0723	-0.0193*	$8.37
81-90	0.68	5.44	1.16	90.73	-3.56	-0.0750	-0.0249*	$9.28
82-91	0.61	5.41	1.09	94.37	-3.77	-0.0777	-0.0220*	$9.40
83-92	0.63	5.31	1.04	91.27	-3.50	-0.0810	-0.0256*	$8.99
84-93	0.56	5.31	1.01	83.19	-2.96	-0.0797	-0.0268*	$9.76
85-94	0.57	5.38	1.00	91.06	-3.65	-0.0774	-0.0132*	$9.63
86-95	0.62	5.05	1.05	92.25	-3.87	-0.0320*	-0.0572	$11.31
87-96	0.60	4.84	1.18	94.80	-4.43	0.0139*	-0.0775	$13.23
88-97	0.50	5.08	1.02	91.54	-4.73	0.0032*	-0.0188*	$13.15

* Not significant at 5% level.

** Projected EPM is calculated assuming 16 lbs QPKP, 265 cents per bu. corn and $185 per ton soybean meal.

lot. Thus, any error is generated by the EPM equation and not by errors in estimated QPKP or changes in feed costs. To find the errors in the forecast, the actual CPM's are subtracted from the estimated EPM's. Table 3.3 provides the statistics for these error terms for the EPM estimates using both the LDP and ISU cost structure. Figure 3.2 is a graphical representation of the same distributions. The absolute mean deviation and the standard deviations are almost identical for the ISU and LDP cost data, $4.80 versus $4.75 per cwt. and $6.01 versus $6.04 cwt., respectively. The ISU error distribution is slightly flatter than the LDP error distribution as seen by a kurtosis of -0.33 versus –0.15 with both being flatter than the normal distribution. However, in calculating the percentage of observations within ± $5.00 per cwt., the ISU

Table 3.3: Distributional Statistics of EPM Errors, ISU vs. LDP Cost Structures.*

Statistic	ISU Cost	LDP Cost
Average Error, $ / cwt.	-1.75	1.22
Absolute Mean Deviation, $ / cwt.	4.80	4.75
Standard Deviation, $ / cwt.	6.01	6.04
Kurtosis	-0.33	-0.15
Skewness	-0.08	-0.19
Minimum, $ / cwt.	-15.93	-13.45
Maximum, $ / cwt.	11.21	14.54

* Error = EPM - CPM

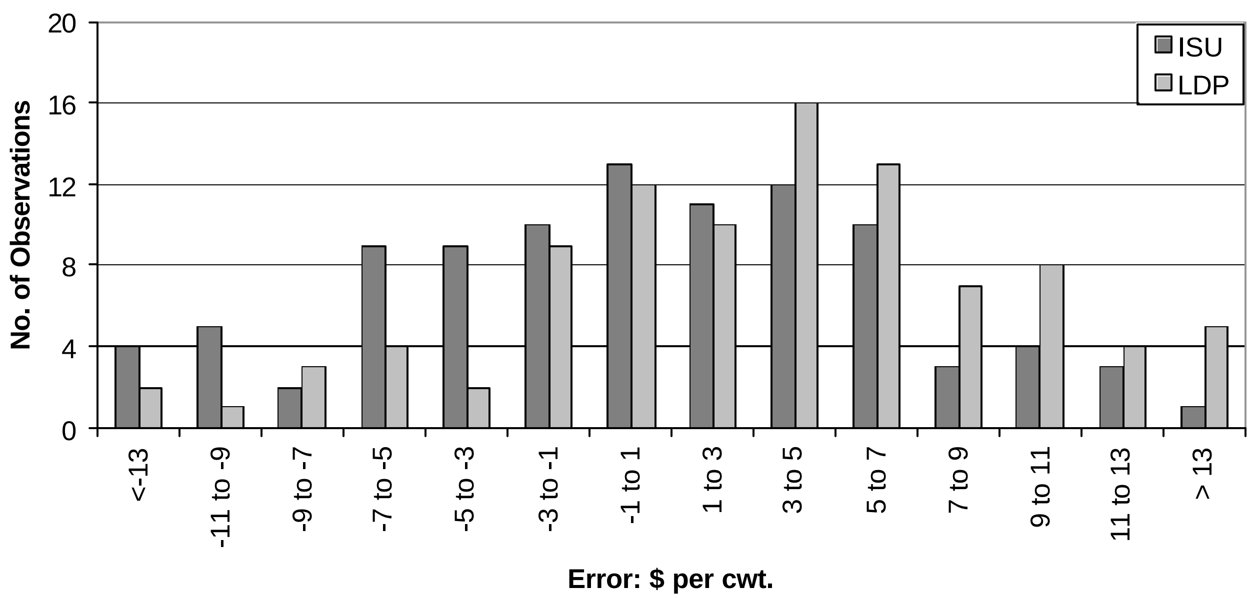

Figure 3.2: Errors in EPM, ISU vs. LDP

distribution had fifty-seven percent versus fifty-one percent for the LDP distribution. This indicates that the ISU kurtosis is more strongly effected by extreme errors than the LDP and that the ISU regressions may in fact have a stronger central tendency in the midrange of errors. The ISU distribution is also slightly less skewed with a skewness of –0.08 versus –0.19. This indicates that the ISU regressions do not tend to overestimate as much as the LDP regressions which appear to be a problem in chapter 2. Taken overall, the regression equations based on the ISU cost data are, at best, only slightly better than those based on the LDP data.

Following the re-calibration process in Chapter 2, hedges were simulated with the ISU cost data for various trigger levels over the 1972-82 time period using the predicted, in-sample

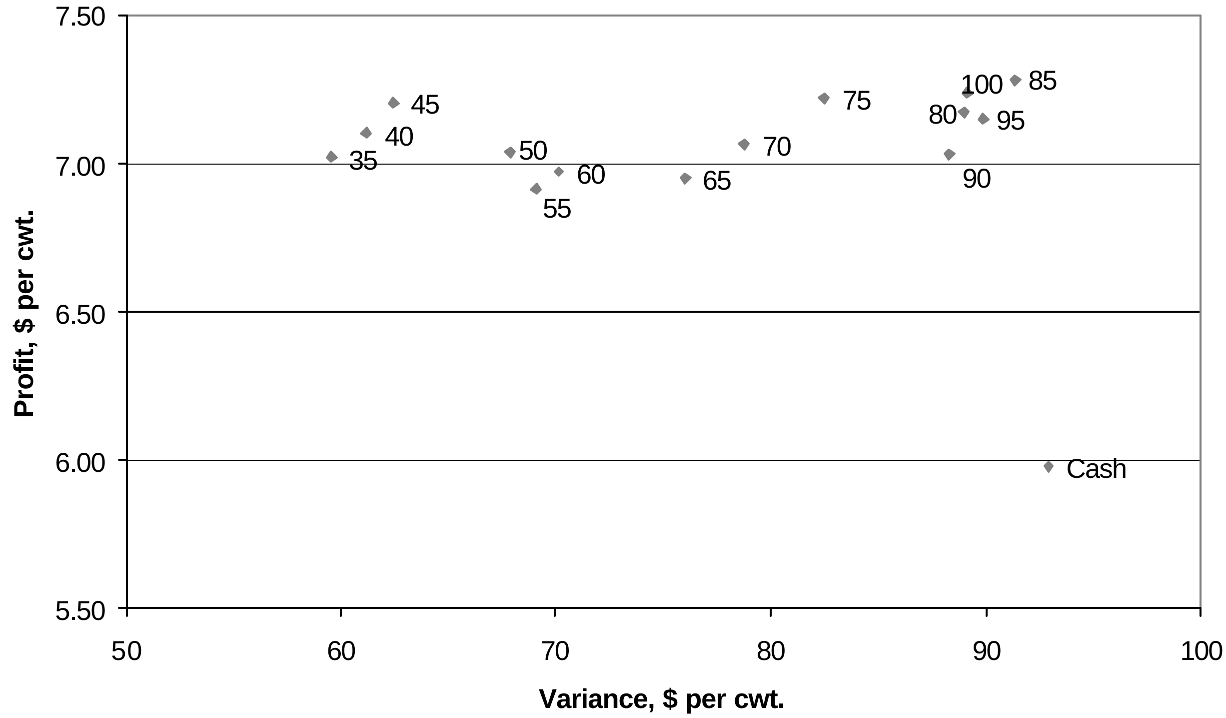

Figure 3.3: Mean/Variance Analysis of Trigger Levels, ISU Cost Series, 1975-82

QPKP estimates for estimation of the EPM. Figure 3.3 illustrates the results in a mean/variance framework and is comparable to Figure 2.3. The forty-five percent trigger has a profit of $7.20 per cwt. with variance of $62.41 per cwt. This trigger dominates the higher trigger levels except the seventy-five, eighty-five and one hundred trigger levels that have profits of $7.22, $7.28 and $7.23 per cwt., respectively. However, these small gains in profit are more than offset by large increases in the variance. The $82.51, $91.33 and $89.14 per cwt. variances of these trigger levels are very near the $92.92 per cwt. variance of the all cash strategy. The forty-five percent trigger does not dominate the thirty-five and forty percent trigger levels. The forty-five percent trigger was chosen for analysis because it had a higher average return with only a small increase in variance over lower trigger levels.

Tables 3.4 provides the summary statistics for the ISU cost hedge for both 1975-82 and 1983-1998 periods while Table 3.5 gives the results of the significance tests for both periods. The LDP hedge data are provided in both tables for comparison. During the 1975-82 time period, the ISU hedge increased the hedged cash flow by $1.23 per cwt. while the LDP hedge increased the hedged cash flow by $1.38 per cwt. Therefore the LDP hedge does have a slight advantage of fifteen cents per cwt. in increasing profits. This difference is reflected in

Table 3.4: Summary of Hedge Results, ISU vs. LDP Costs.

		Returns from Futures Market					
		Hogs	Corn	SBM	Total	Cash	Hedged*
1975-82							
Average ($/cwt.)	LDP	1.46	-0.05	-0.04	1.38	5.41	6.79
	ISU	1.31	-0.04	-0.04	1.23	5.97	7.20
Variance ($/cwt.)	LDP	24.70	0.31	0.09	22.23	98.75	68.64
	ISU	25.66	0.27	0.08	23.32	92.92	62.41
Max Loss ($/cwt.)	LDP	-9.95	-1.34	-1.05	-9.95	-14.13	-14.13
	ISU	-10.85	-1.42	-0.97	-10.82	-13.86	-13.86
Max Profit ($/cwt.)	LDP	13.8	2.91	1.23	14.04	31.63	24.48
	ISU	13.80	2.58	1.12	14.00	31.22	24.22
Hedges (#)	LDP	32	12	12	32		
	ISU	32	14	13	32		
Profitable (#)	LDP	22	4	3	20	31	36
	ISU	21	6	4	20	32	40
1983-98							
Average ($/cwt.)	LDP	0.03	-0.06	-0.01	-0.04	2.28	2.24
	ISU	0.14	-0.06	-0.02	0.07	10.15	10.22
Variance ($/cwt.)	LDP	8.64	0.28	0.05	9.84	68.46	64.18
	ISU	10.16	0.20	0.04	11.10	67.59	62.05
Max Loss ($/cwt.)	LDP	-10.05	-2.98	-1.23	-10.56	-23.97	-23.97
	ISU	-10.05	-2.43	-1.12	-10.48	-13.59	-13.59
Max Profit ($/cwt.)	LDP	10.20	1.90	0.76	11.61	22.81	22.04
	ISU	10.20	1.58	0.62	11.39	31.31	27.93
Hedges (#)	LDP	40	16	16	40		
	ISU	50	18	18	50		
Profitable (#)	LDP	20	5	6	17	55	56
	ISU	28	7	8	25	87	88

* Hedged = Futures + Cash

Table 3.5: Significance Tests (p-values) of Hedging Results; LDP vs. ISU Costs.

	$\mu_H \leq \mu_C$	$\sigma^2_H \geq \sigma^2_C$	$\mu_H \leq \mu_C \cup \sigma^2_H \geq \sigma^2_C$
1975-82			
LDP Costs	0.0243	0.0058	0.0300
ISU Costs	0.0424	0.0045	0.0467
1983-98			
LDP Costs	0.5516	0.2039	0.6431
ISU Costs	0.4209	0.1528	0.5094

the p-values for the mean condition of the ISU and LDP hedges being 0.0424 and 0.0243 respectively. Even though the LDP hedge appears to perform better at increasing profits, both the LDP and ISU hedges are statistically significant at the five percent confidence level. During the same period, the ISU hedge decreased variance by $30.51 per cwt. or thirty-three percent while the LDP hedge had a variance of $30.11 per cwt. or about a thirty percent decrease. While the ISU hedge has a slight advantage in decreasing variance, the variance condition for both are highly significant with p-values of 0.0045 and 0.0058 respectively. The p-value of the joint condition for the ISU hedge is 0.0467 compared to 0.0300 for the LDP hedge. If a producer were choosing between these two cost series, based upon the in-sample results in 1982, he would have most likely chosen the LDP cost structure. However, if a producer had not conducted the hedge with the LDP cost series, he would have logically accepted the ISU cost series because it is both statistically significant and is comparable to KC's original two way hedge results (p-values of 0.0109, 0.0211, and 0.0318 respectively). Thus, it is appropriate to simulate hedging during the 1983-98 period with the ISU cost series.

During the 1983-98 period, the ISU cost series hedges produced marginally improved results. The ISU hedge resulted in a profit of $0.07 per cwt. whereas the LDP hedge produced a loss of $0.04 per cwt. However, the mean condition is still highly insignificant with a p-value of 0.4209 compared to the LDP hedge p-value of 0.5516. The ISU hedge also decreased variance slightly more than the LDP hedge, $5.54 per cwt. or about eight percent versus $4.28 per cwt. or about six percent. This small change in variance decreased the p-value of the ISU hedge to 0.1528 as compared to 0.2039 for the LDP hedge. While improved, it is still insignificant at either the five or ten percent significance level. The joint condition p-values were extremely high for both series at 0.6431 and 0.5094 for the LDP and ISU series, respectively.

Table 3.6 gives the results of the individual hedges for each lot for the ISU hedge and is comparable to Table 2.6 for the LDP hedge. There is a significant difference in the hedging frequency. In the period from February 1985 through October 1989 where the LDP series placed only one hedge, the ISU series placed seven hedges. However, there was still a two year period from December 1987 through October 1989 were no hedges were placed by the ISU series. Overall, the ISU series placed eleven hedges when the LDP series did not hedge whereas the LDP series placed one hedge where the ISU series did not hedge. Thus, in total, the ISU series placed fifty hedges and the LDP forty or a fifty-two and forty-two percent hedging frequency. Half of the hedges placed by the ISU series were profitable compared to about forty-two percent for the LDP series. Still, the ISU series only had twenty-five profitable hedges in the sixteen year out-of-sample period versus twenty in the eight year in-sample period.

In general, the hedging results do not appear to be overly sensitive to the choice of cost series. In both the in-sample and out-of-sample periods the ISU cost series was more successful at reducing variance. Profits for the ISU hedge were slightly less during the in-sample period but they were slightly higher than the LDP hedge in the troublesome out-of-sample period. In favor of the ISU cost series is that it generated hedges more consistently during the out-of-sample period. However, the most important factor in favor of the ISU series is that it more accurately reflects the actual cost of production. Therefore, only the ISU cost series will be used in developing EPM models with additional variables.

EPM Models with Additional Variables

A key limitation of the EPM model is that it does not incorporate demand factors. If the demand for pork is relatively stable over time, it should be possible to develop a model that improves the accuracy of the EPM estimates by incorporating other demand shifters. Three specific areas are focused upon: 1) trending over time, 2) seasonality of demand and 3) competing products. These are tested individually to evaluate the impact of each and then in combination to select a final model.

Table 3.6: Out-of-Sample Hedging Results of ISU Cost Structure, 1983-98 ($ / cwt.).

Lots		Returns from Futures Market				Cash	Hedged
Year	Month	Hogs	Corn	SBM	Total		
1983	Feb	2.00	-0.26	-0.08	1.66	19.41	21.07
	Apr	5.90			5.90	8.24	14.14
	Jun	9.50	1.58	0.31	11.39	3.70	15.09
	Aug					0.10	0.10
	Oct					-4.65	-4.65
	Dec					-4.53	-4.53
1984	Feb	-1.15			-1.15	3.71	2.56
	Apr	0.35			0.35	2.79	3.14
	Jun	1.10	-0.81	-1.05	-0.76	8.07	7.31
	Aug	5.90	-0.06	-0.07	5.77	6.34	12.11
	Oct	10.20			10.20	-1.70	8.50
	Dec	2.35	-1.90	-1.12	-0.67	12.02	11.35
1985	Feb					11.28	11.28
	Apr					4.71	4.71
	Jun	6.80	0.04	-0.08	6.76	8.16	14.92
	Aug					3.11	3.11
	Oct					1.76	1.76
	Dec					12.28	12.28
1986	Feb					12.64	12.64
	Apr					5.57	5.57
	Jun					15.83	15.83
	Aug	-4.10			-4.10	26.77	22.67
	Oct	5.10			5.10	19.43	24.53
	Dec	1.70			1.70	26.23	27.93
1987	Feb					18.98	18.98
	Apr					15.47	15.47
	Jun	-1.33			-1.33	27.78	26.45
	Aug	0.15			0.15	26.14	26.29

continued

Table 3.6 (continued): Out-of-Sample Hedging Results of ISU Cost Structure, 1983-98 ($ / cwt.).

Lots		Returns from Futures Market				Cash	Hedged
Year	Month	Hogs	Corn	SBM	Total		
	Oct	1.43			1.43	16.09	17.52
	Dec					11.50	11.50
1988	Feb					15.29	15.29
	Apr					12.36	12.36
	Jun					21.95	21.95
	Aug					9.91	9.91
	Oct					1.62	1.62
	Dec					-1.14	-1.14
1989	Feb					3.21	3.21
	Apr					1.53	1.53
	Jun					8.68	8.68
	Aug					7.79	7.79
	Oct					6.25	6.25
	Dec	-4.15			-4.15	16.25	12.10
1990	Feb	-0.80			-0.80	12.89	12.09
	Apr					18.18	18.18
	Jun	-6.95			-6.95	31.31	24.36
	Aug	-4.45			-4.45	25.05	20.60
	Oct	-2.38			-2.38	19.12	16.74
	Dec	1.40	-1.72	-0.48	-0.80	15.18	14.38
1991	Feb	-0.18			-0.18	16.90	16.72
	Apr					17.03	17.03
	Jun	-0.95	0.28	0.05	-0.62	20.65	20.03
	Aug					16.60	16.60
	Oct	0.90			0.90	9.11	10.01
	Dec	4.40			4.40	3.76	8.16
1992	Feb					3.39	3.39
	Apr					4.23	4.23

continued

Table 3.6 (continued): Out-of-Sample Hedging Results of ISU Cost Structure, 1983-98 ($ / cwt.).

Lots		Returns from Futures Market				Cash	Hedged
Year	Month	Hogs	Corn	SBM	Total		
	Jun					9.61	9.61
	Aug					5.62	5.62
	Oct					3.88	3.88
	Dec					9.40	9.40
1993	Feb	0.75			0.75	10.20	10.95
	Apr	-1.20			-1.20	17.23	16.03
	Jun	-4.40	-0.11	-0.05	-4.55	18.29	13.74
	Aug	1.25	0.01	0.02	1.29	14.39	15.68
	Oct	-3.53			-3.53	14.38	10.85
	Dec	0.05	-0.74	0.16	-0.53	8.64	8.11
1994	Feb					13.36	13.36
	Apr	4.85			4.85	7.55	12.40
	Jun	4.45	-0.73	-0.24	3.47	8.09	11.56
	Aug	5.50	-0.38	-0.07	5.05	7.30	12.35
	Oct					-3.04	-3.04
	Dec					-5.33	-5.33
1995	Feb					4.40	4.40
	Apr					2.79	2.79
	Jun					8.43	8.43
	Aug	0.35			0.35	11.35	11.70
	Oct	-4.05			-4.05	8.17	4.12
	Dec	-1.70	0.16	0.17	-1.38	5.82	4.44
1996	Feb	1.35			1.35	6.90	8.25
	Apr	-5.95			-5.95	10.69	4.74
	Jun	-10.05	-0.29	-0.13	-10.48	18.36	7.88
	Aug	-7.50			-7.50	13.56	6.06
	Oct	-6.40			-6.40	8.84	2.44
	Dec	-5.53	-2.43	0.15	-7.80	16.37	8.57

continued

Table 3.6 (continued): Out-of-Sample Hedging Results of ISU Cost Structure, 1983-98 ($ / cwt.).

Lots		Returns from Futures Market				Cash	Hedged
Year	Month	Hogs	Corn	SBM	Total		
1997	Feb	1.00			1.00	15.68	16.68
	Apr	2.92			2.92	15.66	18.58
	Jun	-0.85	0.57	0.45	0.18	21.66	21.84
	Aug	-2.46			-2.46	19.05	16.59
	Oct	4.92			4.92	10.29	15.21
	Dec	6.73	1.51	0.62	8.86	6.73	15.59
1998	Feb					4.89	4.89
	Apr					0.28	0.28
	Jun					7.82	7.82
	Aug					-0.01	-0.01
	Oct					-3.78	-3.78
	Dec					-13.59	-13.59

Trending Over Time

The EPM regression results in Table 3.2 show evidence of an upward trend over time. The trending appears to be relatively constant and the inclusion of a trend variable may improve the accuracy of the regressions. There are two obvious causes for a trend in the EPM regressions: the demand function for market hogs and costs of production that are closely associated with the long-run supply function.[24] While the EPM regression does not directly estimate either the demand or the supply functions, these functions are the underlying relationships that determine profits.

The EPM equation (Eq. 2.4) is a function of quantity of pork, corn price and soybean meal price. The demand for pork is embedded in the QPKP coefficient and the intercept term. KC explicitly assume that the demand for pork is constant, citing supporting literature of the period. Purcell (1998), referring to the demand for pork at the retail level through 1997, argues that “The demand surface is substantially lower than earlier in the decade and in the 1980s,

[24] The very short run supply is fixed and the prices of hogs are dependent solely on the current demand.

especially the early 1980s." Industry sources that are involved in market hog price forecasting also indicate that the elasticity of demand for pork may have shifted over time which would imply a change in the demand functions.[25] The EPM is also a function of the costs of production. The dependent variable in the EPM regression is the cash profit margin as defined by Equation 2.1. From this equation, CPM is a function of live hog price, feed cost and direct cost. Live hog prices are a function of demand and associated with the quantity of pork as discussed above. Feed costs are accounted for by the corn and soybean meal price coefficients but feed requirements are trending downward in the ISU budget. The direct costs are embedded in the intercept term and therefore, as direct cost change, so will the intercept. However, the direct cost does not include a return to management nor capital in the form of opportunity cost. The changing structure of the hog industry will affect these costs. The trend variable should capture the sum of these effects. The trend will also capture effects from other unspecified factors of the supply and demand structure that trend over time. These could include changes in income and supply of competing products.

The results of the addition of a trend variable to the EPM equation are given in Table 3.6. The trend is expressed in terms of change in EPM per lot or the change in EPM per two months because the lots are sold two months apart. To better judge the impact of the trend, the trend coefficient can be multiplied by six to transform it to a yearly change in EPM. For example, the 75-84 trend coefficient of $0.18 represents a yearly increase of $1.08 per cwt. in profit. Trend is significant in about half the estimates at the five percent level of confidence. All significant trend coefficients are positive indicating an increase in profits. Where the trend coefficient is significant, it is accompanied by an increase in R^2 and an associated decrease in SER. For example, with the 75-84 data set, the R^2 increased from 0.58 to 0.67 while the SER decreased from $6.11 to $5.47 per cwt. Whether the increase in the accuracy is significant is an arbitrary decision. The average SER in of the equation estimates with ISU cost data (Table 3.2) is $5.50 per cwt. A five percent increase in accuracy would be a reduction in the SER of about $0.27 per cwt. The average decrease in the SER is $0.26 per cwt. but the majority of the improvement came in the first three equation estimations; $1.24, $0.58 and $0.63 per cwt. respectively. A total

[25] Traditional supply change forecasting models have used a rule of thumb of a one percent change in supply causes a two percent change in the price of market hogs. More recently, the change in hog price is more on the level of three percent.

Table 3.7: Yearly EPM Regression with Trend Results with Bimonthly Data.

				Coefficients				
Data Set	R^2	SER	DW	Intercept	QPKP	Corn	SBM	Trend
75-82	0.72	5.32	1.39	81.22	-3.39	-0.0389	-0.1318	0.36
75-83	0.67	5.70	1.06	81.31	-3.16	-0.0476	-0.1064	0.21
75-84	0.67	5.47	1.08	82.01	-3.01	-0.0529	-0.1045	0.18
76-85	0.56	5.56	0.99	68.59	-2.70	-0.0598	-0.0365*	0.11
77-86	0.61	5.79	0.99	71.00	-2.73	-0.0641	-0.0353*	0.10*
78-87	0.72	5.27	1.44	83.24	-3.53	-0.0767	0.0065*	0.03*
79-88	0.74	5.23	1.47	89.83	-3.75	-0.0685	-0.0172*	-0.01*
80-89	0.73	5.12	1.43	91.07	-3.66	-0.0791	-0.0119*	-0.03*
81-90	0.70	5.36	1.21	85.21	-3.51	-0.0572	-0.0382*	0.08*
82-91	0.65	5.20	1.23	92.69	-3.99	-0.0583	-0.0382*	0.11
83-92	0.68	5.01	1.23	92.56	-3.94	-0.0610	-0.0428*	0.12
84-93	0.61	5.00	1.27	90.81	-3.86	-0.0573	-0.0429*	0.13
85-94	0.64	4.97	1.32	106.71	-4.69	-0.0782	-0.0333*	0.15
86-95	0.62	5.07	1.11	97.03	-4.22	-0.0387*	-0.0507*	0.04*
87-96	0.60	4.88	1.17	93.29	-4.31	0.0190*	-0.0831	-0.02*
88-97	0.54	4.92	1.17	99.95	-5.17	-0.0139*	-0.0174*	0.10

* Not significant at 5% level.

of six regression estimations had at least a $0.27 increase in SER but five of the estimations actual had an increase in the SER.[26] Clearly, the trend variable did not have as great an influence on the regression results as may have been initially expected by examination of the trending in projected EPM in Table 3.2. Any improvements in hedging results by including the trend variable alone would likely to be marginal at best.

[26] This is a result of the estimation formula of SER where degrees of freedom is the denominator. The inclusion of an additional variable decreases the degrees of freedom and therefore increases the SER estimate. Inclusion of an additional variable cannot actually decrease the accuracy of the equation.

Seasonality

There are well documented changes in the seasonal demand for pork with the holiday season in the fourth quarter representing the strongest demand. Therefore, a higher profit level would be expected for the October and December lots given all other factors remain constant. To test the effect of changing seasonal demand on EPM, dummy variables are added to the EPM equation for each lot of the year. April is chosen as the base lot because it is the lot with the lowest relative profit margins. In addition to demand seasonality, there is a secondary production effect that may also be captured. Pork production is estimated on a quarterly basis whereas the price used to calculate profit margin is the price at the first of the month when the hogs are sold. The hog price is more strongly correlated with the nearby supply than the quarterly supply because live hogs are a non-storable commodity. Production varies significantly from month to month within some quarters. Using dummy variables for each lot may capture some of these monthly production variations.

The results of the equation estimates including seasonality are reported in Table 3.8. The addition of the seasonal variables provides an increase of 0.07 to 0.19 in R^2 while reducing SER by about $0.60 per cwt. on average when compared to the original model (with ISU cost) statistics in Table 3.2. More importantly, there appears to be a greater improvement in the mid and later period estimation where hedging results were generally not as profitable. As expected, because of the holiday season, October and December provided the largest increases of about $9 per cwt. greater profit margins when compared to the April base lot. June also had an average gain of about $6.50 cwt. Only one of the October and one of the June estimations were not significant at the five percent level. The February coefficients averaged about $3.90 with six of the estimated coefficients being significant. However, at the ten percent level, ten estimations are significant. The August seasonal variable is generally insignificant even at the ten percent level. Significance of the corn price coefficient is relatively unchanged from the original equation but the soybean meal price coefficient is significant only once and six of the coefficients are of the incorrect, positive sign.

The results in Table 3.8 indicate that seasonality is a factor in predicting EPM and should be included in the equation. However, the exact method of inclusion of the dummy variables is, to a large extent, a subjective matter that must be decided by the modeler. Some seasonal

Table 3.8: Yearly EPM Regressions with Bimonthly Seasonal Variables.

				Coefficients								
Data Set	R^2	SER	DW	Intercept	QPKP	Corn	SBM	Feb	Jun	Aug	Oct	Dec
75-82	0.67	6.08	0.54	72.36	-2.98	-0.0450	-0.0638*	2.81*	6.52	2.60*	9.02	8.24
75-83	0.67	5.97	0.53	76.96	-3.10	-0.0552	-0.0604*	3.21*	5.52*	1.71*	7.75	7.30
75-84	0.65	5.81	0.63	76.25	-3.22	-0.0488	-0.0523*	3.23*	5.37	1.27*	6.90	7.47
76-85	0.60	5.50	0.58	71.00	-3.25	-0.0368	-0.0365*	3.77*	4.92*	-0.10*	4.06*	7.00
77-86	0.69	5.38	0.68	85.20	-4.01	-0.0314	-0.0554	3.96*	5.32	0.82*	6.15	9.43
78-87	0.85	4.09	1.36	97.10	-5.18	-0.0781	0.0528*	5.26	6.56	1.62*	9.47	11.20
79-88	0.84	4.27	1.24	100.22	-5.15	-0.0653	0.0153*	5.22	6.54	1.40*	8.38	10.15
80-89	0.84	4.09	1.13	97.91	-4.94	-0.0656	0.0057*	5.20	7.46	3.05*	8.77	10.77
81-90	0.80	4.57	0.88	118.39	-6.44	-0.0611	0.0179*	4.92	8.51	2.27*	10.07	11.65
82-91	0.73	4.69	0.75	123.44	-6.53	-0.0699	0.0131*	4.27	7.71	2.27*	9.64	11.00
83-92	0.73	4.72	0.69	113.25	-5.68	-0.0759	0.0051*	4.34	7.19	3.21*	8.76	10.39
84-93	0.66	4.86	0.67	96.11	-4.36	-0.0802	-0.0022*	2.94*	7.46	3.93*	7.06	7.97
85-94	0.67	4.96	0.66	102.47	-4.99	-0.0741	0.0099*	3.10*	7.24	4.10*	7.96	7.36
86-95	0.75	4.30	0.83	108.38	-5.45	-0.0311*	-0.0370*	3.12*	6.83	4.46	9.71	8.89
87-96	0.76	3.96	1.08	124.05	-6.63	0.0100*	-0.0675	3.22*	6.09	2.78*	10.32	10.23
88-97	0.70	4.15	0.87	142.05	-7.98	-0.0102*	-0.0188*	3.36*	6.00	3.03*	12.35	11.85

* Not significant at 5% level.

variables can be excluded as not being significant, which depends on the chosen significance level, and some seasonal variables can be combined. For example, seasonal variables for October and December could be combined into one fourth quarter variable because the two variables have coefficients that are not significantly different. The February and August seasonal coefficients are mostly insignificant and could be removed from the model. Removing February and August may adversely effect the significance level of the other seasonal variables, particularly the June lot that could possibly become insignificant. The fact that the study uses a series of regression estimates over an extended period of time to select one model further complicates model selection. For example, the February seasonal is insignificant in the first five equations, then significant in the next six, and then insignificant in the remaining five equations. Is this a data aberration or was it a true shift in seasonality? If it was a true shift, will it repeat itself? The answers are not clear. To avoid making these subjective decisions, this study includes seasonal variables for all lots. This allows for the possibility of changing seasonality and has the additional advantage of being extremely clear for presentation to a producer. The sole disadvantage of either including insignificant seasonal variables or not combining those that are similar is that the accuracy of the equation as estimated by the R^2 is slightly overestimated and as estimated by the SER is slightly underestimated.

Competing Products

Both chicken and beef are generally accepted to be the strongest substitutes for pork. Of the three major components of the meat sector, the biology and structure of the poultry industry is significantly different than that of either the pork or beef industry. Visual inspection of a simple scatter chart of yearly per capita production versus inflation-adjusted prices for broilers reveals a relatively stable increase in production and decrease in price.[27] The stability of the changes in the broilers allows most of the effects of chicken to be captured by a trend variable. Therefore, no attempt is made to model chicken directly. The impact of beef on the profit margin is modeled by including the quarterly per capita beef production, QPKB, in the original EPM equation. Economic theory suggests that as the amount of beef that must clear the market increases, the price of market hogs and thus profit margin will decrease.

[27] Scatter charts were published for pork, beef and broilers for the period 1960-97 in Purcell (1999)

Table 3.9 reports the results of the equation estimations using the actual QPKP as the dependent variable. The results indicate that the QPKB has little effect on the original EPM equation. Six of the sixteen coefficient estimates were insignificant a five percent level of confidence and three have an incorrect positive sign. There is no meaningful change is the significance of either the corn or soybean variable. The average SER decreased only about $0.20 with the inclusion of the QPKB variable which is less than a five percent improvement. This small amount of improvement must be weighted against the fact that in a hedging strategy, the QPKB must be estimated. Thus estimation errors will be introduced that will at least partially offset these small gains. Therefore, QPKB alone is not an improvement to the EPM equation.

Table 3.9: Yearly EPM Regressions with QPKB.

				Coefficients				
Data Set	R^2	SER	DW	Intercept	QPKP	Corn	SBM	QPKB
75-82	0.61	6.26	1.05	116.57	-3.07	-0.0513	-0.0935	-1.19
75-83	0.64	5.96	1.05	117.81	-3.14	-0.0535	-0.0923	-1.18
75-84	0.63	5.75	1.08	119.47	-3.20	-0.0482	-0.0928	-1.26
76-85	0.59	5.37	1.14	113.04	-3.33	-0.0414	-0.0586	-1.27
77-86	0.61	5.76	1.07	115.03	-3.51	-0.0476	-0.0624	-1.11*
78-87	0.73	5.26	1.43	71.09	-3.48	-0.0800	0.0085*	0.52*
79-88	0.74	5.20	1.51	66.15	-3.57	-0.0748	-0.0082*	0.85*
80-89	0.73	5.13	1.42	74.29	-3.45	-0.0762	-0.0131*	0.49*
81-90	0.72	5.15	1.31	146.19	-3.71	-0.0586	-0.0527	-2.16
82-91	0.67	5.04	1.28	150.70	-4.15	-0.0584	-0.0462*	-2.12
83-92	0.68	4.99	1.20	144.12	-4.09	-0.0623	-0.0448*	-1.88
84-93	0.60	5.09	1.18	133.16	-3.73	-0.0651	-0.0412*	-1.64
85-94	0.63	5.02	1.20	151.40	-4.35	-0.0701	-0.0328*	-2.03
86-95	0.65	4.89	1.14	132.90	-4.25	-0.0304*	-0.0679	-1.41
87-96	0.61	4.80	1.20	119.30	-4.62	0.0154*	-0.0773	-0.94*
88-97	0.52	5.05	1.04	115.46	-4.89	0.0063*	-0.0145*	-0.99*

* Not significant at 5% level.

Combinations of Variables

In the previous sections, QPKB, trend and seasonal variables were each added to the original EPM equation independently. Only the seasonal variables had a significant improvement although the trend variable caused a marginal improvement. In some cases, a combination of variables may remove variance that is adversely effecting one variable, and improve the significance of several variables. For instance, if there is seasonality in beef demand, an equation that included both of these variables would be expected to perform better than the individual equation results would indicate. Conversely, if the variables are correlated, the equation may perform worse than expected. Therefore, to test the possible interactions of these variables, each possible combination is tested in this section.

When QPKB and trend are combined with the original EPM equation (Table 3.10), both are generally insignificant: QPKB thirteen times and trend twelve out of the sixteen regressions. More troubling is that four of the QPKB coefficients are of the incorrect positive sign. As would be expected from this insignificance, the accuracy of the regression estimates is basically unchanged from the trend only equation. Therefore, the QPKB and trend combination would not improve EPM forecasts.

The results of combining the QPKB and seasonality variables with the original EPM equation are reported in Table 3.11. The R^2s range from 0.70 to 0.84 with a decrease in the SER's of $1.35 on average from the original equation or about twice the improvement seen by adding seasonality alone. The significance of the QPKB coefficient is slightly improved with five estimates insignificant versus six estimates insignificant with QPKB alone. More importantly, there is only one QPKB coefficient estimate with an incorrect sign compared to three with beef alone. The major change in the QPKB coefficient estimates are in the magnitude. With seasonality included, they average about $1.90 per cwt. increase in EPM per pound of beef decrease with all significant estimates ranging from $2.00 to $3.00 per cwt. Without seasonality, the significant beef coefficients ranged for $1.08 to $2.16. Thus, the model is more sensitive to changes in beef supply. Overall, eighteen of the seasonality variables are insignificant compared to twenty-seven when seasonality is added alone. The February, October and December seasonal coefficients have major increases compared to the first five data sets with seasonality alone. The performance of the soybean meal coefficient estimates is between the performance of QPKB alone and seasonality alone and not significantly different than the original equation

Table 3.10: Yearly EPM Regression with QPKB and Trend.

				Coefficients					
Data Set	R^2	SER	DW	Intercept	QPKP	Corn	SBM	QPKB	Trend
75-82	0.72	5.36	1.35	69.32	-3.27	-0.0371	-0.1340	0.33*	0.39
75-83	0.67	5.72	1.13	96.76	-3.32	-0.0485	-0.1058	-0.45*	0.17
75-84	0.67	5.47	1.15	100.07	-3.23	-0.0525	-0.1053	-0.53*	0.15
76-85	0.59	5.41	1.13	108.41	-3.28	-0.0455	-0.0542*	-1.13*	0.02*
77-86	0.62	5.76	1.08	100.44	-3.22	-0.0615	-0.0398*	-0.81*	0.07*
78-87	0.73	5.27	1.46	59.12	-3.28	-0.0836	0.0218*	0.76*	0.05*
79-88	0.74	5.23	1.56	63.76	-3.67	-0.0799	-0.0039*	1.07*	-0.03*
80-89	0.73	5.15	1.49	74.08	-3.59	-0.0862	-0.0016*	0.66*	-0.04*
81-90	0.72	5.17	1.31	137.37	-3.67	-0.0509	-0.0567	-1.93	0.04*
82-91	0.68	5.04	1.30	138.99	-4.18	-0.0530	-0.0492	-1.71	0.05*
83-92	0.69	4.98	1.23	125.39	-4.11	-0.0583	-0.0470	-1.19*	0.06*
84-93	0.62	5.03	1.26	107.08	-3.93	-0.0572	-0.0445*	-0.59*	0.10*
85-94	0.66	4.91	1.32	138.00	-4.77	-0.0735	-0.0386*	-1.22*	0.10*
86-95	0.65	4.93	1.14	132.89	-4.27	-0.0307*	-0.0675	-1.40	0.00*
87-96	0.61	4.85	1.20	117.91	-4.53	0.0191*	-0.0815	-0.93*	-0.01*
88-97	0.57	4.81	1.24	134.69	-5.46	-0.0126*	-0.0113*	-1.38*	0.11

* Not significant at 5% level.

except there are now three estimates of the incorrect sign. Corn is much the same as in the other equations with three insignificant estimates with one of those having an incorrect sign. As compared to the original EPM equation, the QPKP coefficient are from about $2.00 to $3.00 more negative and therefore the model is more sensitive to change in the quantity of pork.

Table 3.12 reports the results of the combination of trend and seasonality variables. This combination exhibits a significant improvement over the original EPM equation as well as the regressions with either of the variables alone. In general, the R^2s of this equation range from 0.70 to 0.87 and are significantly higher and much more consistent through time. The average decrease in SER over the original EPM equation is $1.27 per cwt. The improvement in SER is greater than the sum of the improvements when the two variables are added alone ($0.66 + $0.26 = $0.92) and is approximately twice the improvement seen when seasonality is added alone. By

Table 3.11: Yearly EPM Regressions with QPKB and Seasonality.

Data Set	R^2	RMSE	DW	Coefficients: Int	QPKP	Corn	SBM	QBKB	Feb	Jun	Aug	Oct	Dec
75-82	0.84	4.24	1.09	186.38	-5.69	-0.0525	-0.0631	-2.77	5.85	6.48	2.55*	15.68	14.86
75-83	0.84	4.18	1.18	187.92	-5.79	-0.0559	-0.0592	-2.75	5.46	5.53	2.11*	14.68	14.23
75-84	0.83	4.13	1.26	187.62	-5.83	-0.0557	-0.0532	-2.74	5.25	5.33	1.50*	13.48	13.98
76-85	0.76	4.30	1.04	159.55	-5.45	-0.0425	-0.0260*	-2.17	4.75	5.02	0.17*	8.84	11.84
77-86	0.78	4.58	1.09	163.46	-5.64	-0.0457	-0.0208*	-2.22	4.45	5.61	0.89*	9.27	12.72
78-87	0.85	4.11	1.39	109.38	-5.34	-0.0749	0.0484*	-0.40*	5.23	6.51	1.70*	9.81	11.59
79-88	0.84	4.31	1.24	98.93	-5.14	-0.0656	0.0157*	0.05*	5.22	6.54	1.37*	8.35	10.12
80-89	0.84	4.13	1.13	100.85	-4.96	-0.0648	0.0044*	-0.11*	5.15	7.44	3.10*	8.81	10.82
81-90	0.83	4.23	1.21	170.86	-6.16	-0.0479	-0.0142*	-2.25	3.56*	8.05	3.91*	9.54	11.24
82-91	0.80	4.06	1.19	189.48	-6.82	-0.0496	-0.0160*	-2.55	2.51*	7.32	3.98	9.68	11.32
83-92	0.80	4.12	1.14	182.19	-6.60	-0.0539	-0.0154*	-2.37	2.78*	6.83	4.47	9.32	11.30
84-93	0.75	4.23	1.13	181.63	-6.13	-0.0574	-0.0164*	-2.58	1.42*	7.21	5.20	8.74	10.06
85-94	0.78	4.07	1.21	197.48	-6.27	-0.0653	-0.0148*	-3.09	0.73*	6.97	6.52	9.06	8.64
86-95	0.82	3.62	1.33	184.40	-6.16	-0.0356	-0.0526	-2.61	0.90*	6.75	6.83	10.42	9.56
87-96	0.77	3.87	1.22	153.07	-6.72	0.0095*	-0.0649	-1.19*	2.22*	6.11	3.81	10.10	10.00
88-97	0.70	4.17	0.89	153.29	-7.85	-0.0090*	-0.0154*	-0.60*	2.69*	6.00	3.45*	11.79	11.31

* Not significant at 5% level.

Table 3.12: Yearly EPM Regression with Trend and Seasonality.

Data Set	R^2	SER	DW	Coefficients									
				Int	QPKP	Corn	SBM	Trend	Feb	Jun	Aug	Oct	Dec
75-82	0.84	4.24	0.87	87.17	-4.43	-0.0358	-0.1094	0.39	2.89*	5.72	0.40*	9.71	8.02
75-83	0.77	5.06	0.65	88.63	-4.22	-0.0478	-0.0816	0.24	3.15*	5.12	0.18*	8.45	7.59
75-84	0.75	4.97	0.75	88.81	-3.99	-0.0559	-0.0750	0.20	3.30*	4.90	0.15*	7.32	7.34
76-85	0.65	5.19	0.66	74.26	-3.55	-0.0607	-0.0126*	0.12	4.24*	5.06	-0.22*	4.50*	7.28
77-86	0.70	5.28	0.73	77.66	-3.73	-0.0546	-0.0199*	0.09*	4.54*	5.56	1.24*	6.02	9.21
78-87	0.85	4.13	1.36	98.97	-5.25	-0.0775	0.0503*	-0.01	5.21	6.55	1.56*	9.57	11.32
79-88	0.86	4.03	1.43	119.52	-6.11	-0.0779	0.0296*	-0.12	5.19	6.85	1.07*	10.24	12.03
80-89	0.87	3.66	1.45	120.35	-6.07	-0.0964	0.0485	-0.16	5.61	8.24	3.19*	11.37	13.12
81-90	0.80	4.58	0.91	114.23	-6.29	-0.0520	0.0090*	0.04*	4.84	8.33	2.06*	9.53	11.21
82-91	0.77	4.43	0.90	123.53	-6.86	-0.0497	-0.0024*	0.10	4.26	7.34	1.39*	9.34	10.90
83-92	0.79	4.24	0.97	120.10	-6.59	-0.0502	-0.0113*	0.13	4.57	6.70	2.00*	9.23	11.15
84-93	0.76	4.10	1.18	126.84	-7.25	-0.0410	-0.0119*	0.20	4.11	6.98	2.03*	10.39	11.83
85-94	0.80	3.85	1.32	146.75	-8.40	-0.0589	-0.0041*	0.25	4.46	6.77	2.83*	12.82	12.27
86-95	0.84	3.50	1.46	160.91	-9.55	-0.0572	0.0136*	0.26	5.21	7.17	4.07	16.59	15.08
87-96	0.82	3.43	1.44	164.12	-9.58	-0.0544	0.0058*	0.24	5.14	7.04	4.11	16.99	15.31
88-97	0.85	3.00	1.87	185.69	-10.49	-0.0518	-0.0185*	0.21	4.82	6.33	3.90	17.73	16.31

* Not significant at 5% level.

adding seasonality to the equation, the insignificance of the trend variable is reduced from seven to two occurrences. Thus, removal of the variation caused by seasonality allowed for the variation of the trend to be more clearly expressed. The seasonal variables also had an increase in significance. Of a total of eighty seasonal variable estimates, the occurrence of insignificant coefficients dropped for twenty-seven to nineteen. The greatest change occurred in the February variable that decreased from fifteen to ten insignificant estimates. The soybean meal variable continues to be problematic with twelve insignificant estimations with six being of the incorrect, positive sign. Corn however, is now significant and of the correct negative sign in all estimations. While the seasonality variables, and to a lesser extent the trend variable alone, increased the absolute value of the QPKP coefficient, the combination of the two shows an additional increase in the QPKP coefficients. In the equation estimation with the 1988-97 data set, a one pound increase in the amount of pork produced would decrease the profit margin by about $10.50 per cwt. The change in the QPKP coefficients is also accompanied by an offsetting change in the intercept term. For the last three equation estimations, the coefficients for the October and December seasonal variables increased significantly.

The last model is a combination of QPKB, trend and seasonality variables. These results are given in Table 3.13. The R^2s are consistently in the upper 70's to upper 80's with the SER's averaging $1.58 per cwt. lower than the original equation. Estimates of the QPKB coefficients are insignificant five times with two of these having the incorrect sign. This is comparable to the estimations of the QPKB and trend model. The trend coefficient has nine insignificant estimates. This demonstrates again that when a model contains both trend and QPKB, QPKB overshadows the trend variable and its significance becomes troublesome. This suggests a problem with multicollinearity. Correlation matrices for the three eight year subperiods were calculated. Only the correlation between beef and trend was above 0.70 in absolute value at –0.77 for the 1975-82 period. The 1983-90 and 1991-98 correlations were –0.66 and 0.59. The correlation of all other variables in each subperiod was below 0.70 in absolute value. Of eighty seasonality coefficient estimates, nineteen are insignificant which is comparable to the results when either trend or QPKB are regressed with the seasonality variables and is superior to the seasonality variables alone. In general, the magnitude of the seasonality coefficients are similar to the equation with trend and seasonality. There are twelve insignificant estimations of the soybean variable with four of these having an incorrect sign. Only two of the corn variables are insignificant. There is

Table 3.13: Yearly EPM Regression with QPKB, Trend and Seasonality.

Data Set	R^2	SER	DW	Coefficients: Int	QPKP	Corn	SBM	QPKB	Trend	Feb	Jun	Aug	Oct	Dec
75-82	0.87	3.88	1.12	147.46	-5.41	-0.0440	-0.0901	-1.61	0.23	4.63	6.02	1.28*	13.31	11.97
75-83	0.84	4.18	1.14	176.89	-5.74	-0.0538	-0.0649	-2.40	0.06*	5.16	5.42	1.66*	13.98	13.43
75-84	0.83	4.12	1.22	176.84	-5.71	-0.0567	-0.0593	-2.39	0.05*	5.01	5.21	1.17*	12.75	13.11
76-85	0.77	4.21	1.22	187.92	-5.98	-0.0250*	-0.0418*	-2.94	-0.10*	4.72	4.95	0.35*	10.15	13.30
77-86	0.78	4.59	1.13	178.14	-6.01	-0.0352*	-0.0351*	-2.53	-0.05*	4.20*	5.53	0.67*	9.76	13.28
78-87	0.85	4.13	1.41	122.59	-5.64	-0.0712	0.0395*	-0.68*	-0.04*	5.09	6.46	1.60*	10.29	12.15
79-88	0.86	4.04	1.44	97.22	-5.99	-0.0864	0.0395*	0.88*	-0.13	5.33	7.00	0.58*	9.85	11.59
80-89	0.87	3.69	1.44	110.49	-6.02	-0.0999	0.0537	0.38*	-0.17	5.79	8.32	3.01*	11.28	12.99
81-90	0.83	4.27	1.21	174.16	-6.19	-0.0500	-0.0130*	-2.34	-0.01*	3.53*	8.08	4.03*	9.68	11.35
82-91	0.81	4.10	1.18	185.90	-6.85	-0.0482	-0.0163	-2.41	0.01*	2.61*	7.29	3.78*	9.64	11.29
83-92	0.80	4.14	1.12	169.01	-6.66	-0.0511	-0.0157*	-1.85*	0.04*	3.19*	6.76	3.83*	9.33	11.33
84-93	0.77	4.14	1.20	139.47	-7.13	-0.0429	-0.0132*	-0.54*	0.17*	3.59*	7.01	2.62*	10.18	11.61
85-94	0.81	3.81	1.41	173.34	-7.98	-0.0595	-0.0103*	-1.27	0.18	3.11*	6.79	4.17	11.92	11.43
86-95	0.86	3.31	1.71	190.63	-8.75	-0.0521	-0.0108*	-1.56	0.18	3.26*	7.02	5.60	14.95	13.63
87-96	0.84	3.29	1.76	197.11	-9.76	-0.0567	0.0106*	-1.32	0.25	4.10	7.09	5.28	16.92	15.19
88-97	0.86	2.91	2.05	208.24	-10.35	-0.0509	-0.0120*	-1.13*	0.21	3.63	6.35	4.72	16.87	15.46

* Not significant at 5% level.

a marked increase in the absolute value of the QPKP variable over the original EPM equation. Overall, this equation is the most sensitive to change in the quantity of pork having slightly higher sensitive in the earlier estimates as compared to the equation with trend and seasonality.

Model Selection

Selecting a model from a group of models is, to some extent, a subjective decision even when those models are only estimated over a single data set. The researcher must decide, usually through the choice of significance level, if the coefficient estimates are a true reflection of the 'real world' relationships. Alternatively, he may decide that a model with additional variables is a result of excessive 'curve fitting' and reject that model, even though it a superior model in terms of estimated accuracy. The current research is unique in that the model is selected from a series of sixteen estimation periods through time. While this may help in identifying excessive 'curve fitting', it adds to the complexity and subjectivity because there are no established guidelines for model selection across multiple time periods. There are two main selection criteria used in this study: expected out-of-sample accuracy of the equation based on the SER's and ease of implementation for a pork producer.

Four of the models with additional variables deserve consideration by having improved the in-sample accuracy as indicated by the average SER's: 1) seasonality with SER of $4.84 per cwt., 2) trend and seasonality with SER of $4.23 per cwt., 3) QPKB and seasonality with SER of $4.15 per cwt., and 4) QPKB, trend and seasonality with SER of $3.92 per cwt. (The average SER of the original equation is $5.50 per cwt.) Two of these models include QPKB. The actual QPKB was used to estimate the regressions but it must be forecasted in order to use in the hedging process. These forecasts of QPKB will have a prediction error. To estimate the impact of this error, assume the standard deviation is equal to that of QPKP, 0.7 pounds. Multiply the standard deviation by the derivative of the EPM equation with respect to QPKB, the negative of the QPKB coefficient. For a QPKB coefficient of 1.5, the additional error induced by the estimation of QPKB is approximately $1. For a QPKB coefficient of 2.5 the error in EPM increases to about $1.75. Thus it is highly possible that the additional error from the QPKB estimate will result in a less accurate EPM estimate than is given by the original EPM equation. Therefore, the models that include QPKB are rejected.

There are two remaining models to consider: seasonality and seasonality with trend. There is often a question when trend is included in a model as to whether it represents true change through time or whether it is merely a ‘curve fitter.’ There are real economic factors that have been trending during the period of this research that would effect the profit margin. Namely, the poultry production has been increasing on a per capita basis which would decrease profit margins through lower demand for pork. On the other hand, income has been rising which should increase profit margins through higher demand for pork. The sum of these and other unspecified effects cannot be stated with certainty. These considerations support the inclusion of trend with the seasonality variables given that there are only two insignificant trend coefficient estimates in the model. However, the level of the trend variable is not stable over time. Only the estimates of the trend coefficients made with the last five data set exhibit the stability that would be preferred to be confident that the trend variable is useful in producing a more accurate forecast of EPM. Therefore, the forecasting ability of these two models is tested as described in the Revised Budget section of this chapter.

Table 3.14 reports statistics of the errors in the estimated EPM by the original model and the two alternative models. The key statistic in determining accuracy of the estimates is the standard deviation. With a standard deviation of $6.42 per cwt., the model with seasonality and trend is clearly inferior to either the original model or the model with seasonality that have standard deviations of $6.01 and $5.50 per cwt. respectively. The average error of $1.60 cwt. indicates that the seasonality and trend model has a tendency to overestimate the profit margin while the skewness statistic indicates that large errors are more apt to be underestimations. The kurtosis statistic indicates that the distribution is ‘fat-tailed’ or that the model is prone to large errors. The range of the minimum and maximum errors supports the kurtosis statistic. (A large overestimation of EPM would cause the hedge not to be placed even if conditions were favorable whereas a large underestimation would cause the hedge to be placed even if conditions were unfavorable.) It is evident from the statistics in Table 3.14 that adding trend to the seasonal model does not improve the prediction of the EPM.

The model with seasonality is an improvement over the original model. The standard deviation decreased from $6.01 to $5.50 per cwt. which is similar to the improvements seen in the SER’s of $0.66 per cwt. The kurtosis statistic more closely approaches the normal (normal = 0) than either of the other models. The seasonality model’s distribution is positively skewed indicating that large errors tend to be overestimations whereas the original model’s distribution

Table 3.14: Distributional Statistics of EPM Errors: Original EPM Model, Original with Seasonality, and Original with Seasonality and Trend.*

Statistic	Original	Seasonality	Seasonality and Trend
Average Error, $ / cwt.	-1.75	-2.25	1.60
Absolute Mean Deviation, $ / cwt.	4.80	4.48	4.71
Standard Deviation, $ / cwt.	6.01	5.50	6.42
Kurtosis	-0.33	-0.02	1.30
Skewness	-0.08	0.30	-0.34
Minimum, $ / cwt.	-15.93	-13.90	-17.55
Maximum, $ / cwt.	11.21	13.59	18.89

* Error = EPM - CPM

was more nearly symmetrical. On average, the seasonality model underestimates the EPM slightly more than the original model. While this model is not a great improvement in the original model, there is a demonstrable improvement in the accuracy of about eight percent. Seasonality is easily implemented and does not require either an additional estimation or additional data to be collected. Therefore, this model will be tested in the simulated hedge program.

Hedge Results with Seasonality

The hedge trigger is recalibrated as described previously with Figure 3.4 illustrating the results in the mean/variance framework. The pattern exhibited in this graph is strikingly different from earlier mean/variance graphs in Figures 2.3 and 3.3. Most noticeably, the range of the variances is compacted with the higher trigger levels having a generally lower variance and the lower trigger levels having a generally higher variance. Less apparent is the wider range of profit margins. Figure 3.3, the graph for the original model using ISU data, has a profit range of about $0.30 per cwt. whereas with the seasonality added, the profit range of the hedges is about $0.50. These changes imply that the choice of the preferred trigger level is more critical to profit level and less critical to variance when seasonality is added to the EPM equation. These changes also make the choice of the preferred profit level more difficult. The most dominate trigger level is the forty percent trigger level because it dominates all trigger levels of sixty-five percent or more. The remainder of the trigger levels, thirty-five to sixty percent, fall on an almost straight line and the choice of tradeoffs between increasing profits and decreasing variance is not a clear

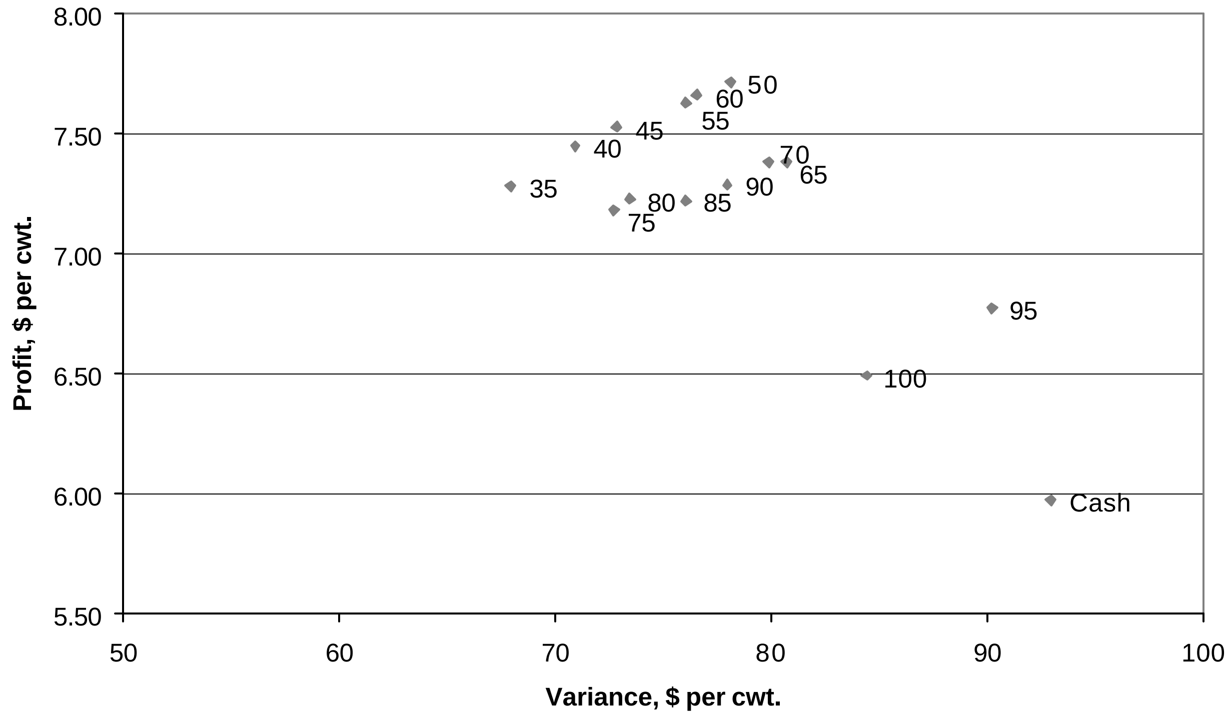

Figure 3.4: Mean/Variance Analysis of Trigger Levels, Orig. EPM with Seasonality, 1975-82

choice. The forty percent trigger level is chosen as the preferred trigger level because it has the lowest joint p-value and thus would be more likely to have better overall performance in the out-of-sample period.

Tables 3.15 and 3.16 presents a summary of the hedge results and the significance tests for both the 1975-82 and 1983-98 periods with the results of the original EPM model with ISU costs restated for comparison. For the 1975-82 period, the profit from hedging increased from $1.23 to $1.47 per cwt. or about a twenty percent increase. The respective p-values for the mean condition decreased from .0424 to .0246. However, the variance of the hedged cash flow increased from $62.41 to $70.95. per cwt. with p-values of 0.0045 and 0.0434 respectively. While both the mean and variance conditions for the seasonality model are significant, because the variance condition is approaching 0.05, the joint condition is not significant at the five percent level of confidence with a p-value of 0.0669 whereas the original EPM model was significant with a p-value of 0.0467.

Table 3.15: Summary of Hedge Results, Original EPM Model vs. Original EPM Model with Seasonality.

		Returns from Futures Market					
		Hogs	Corn	SBM	Total	Cash	Hedged*
1975-82							
Average	Original	1.31	-0.04	-0.04	1.23	5.97	7.20
($/cwt.)	Seasonality	1.49	0.00	-0.01	1.47	5.97	7.45
Variance	Original	25.66	0.27	0.08	23.32	92.92	62.41
($/cwt.)	Seasonality	27.11	0.16	0.04	25.58	92.92	70.95
Max Loss	Original	-10.85	-1.42	-0.97	-10.82	-13.86	-13.86
($/cwt.)	Seasonality	-9.95	-1.20	-0.97	-9.95	-13.86	-5.20
Max Profit)	Original	13.80	2.58	1.12	14.00	31.22	24.22
($/cwt.)	Seasonality	13.80	2.11	0.80	14.00	31.22	29.37
Hedges	Original	32	14	14	32		
(#)	Seasonality	31	12	12	31		
Profitable	Original	21	6	4	20	32	40
(#)	Seasonality	20	6	5	19	32	38
1983-98							
Average	Original	0.14	-0.06	-0.02	0.07	10.15	10.22
($/cwt.)	Seasonality	-0.01	-0.04	-0.01	-0.05	10.15	10.09
Variance	Original	10.16	0.20	0.04	11.10	67.59	62.05
($/cwt.)	Seasonality	10.33	0.18	0.02	11.28	67.59	61.17
Max Loss	Original	-10.05	-2.43	-1.12	-10.48	-13.59	-13.59
($/cwt.)	Seasonality	-10.05	-2.61	-1.05	-10.48	-13.59	-13.59
Max Profit)	Original	10.20	1.58	0.62	11.39	31.31	27.93
($/cwt.)	Seasonality	9.50	1.58	0.62	11.39	31.31	27.91
Hedges	Original	50	18	18	50		
(#)	Seasonality	59	20	20	59		
Profitable	Original	28	7	8	25	87	88
(#)	Seasonality	27	9	8	25	87	88

* Hedged = Futures + Cash

Table 3.16: Significance Tests (p-values) of Hedging Results; Original EPM Model vs. Original with Seasonality.

	$\mu_H \leq \mu_C$	$\sigma^2_H \geq \sigma^2_C$	$\mu_H \leq \mu_C \cup \sigma^2_H \geq \sigma^2_C$
1975-82			
Original EPM	0.0424	0.0045	0.0467
with Seasonality	0.0246	0.0434	0.0669
1983-98			
Original EPM	0.4209	0.1528	0.5094
with Seasonality	0.5631	0.1185	0.6149

During the 1983-98 period, the EPM model with seasonality had a loss of $0.05 per cwt. as compared to the original EPM with a profit of $0.07 resulting in p-values of 0.5631 versus 0.4209 for the mean condition. Variance was reduced by $6.42 per cwt. with seasonality which is slightly more than the $5.54 per cwt. reduction of the original EPM model. The p-value for the variance condition decreased from 0.1528 to 0.1185. This is approaching significance at the ten percent level. The joint condition still remains highly insignificant with a p-value of 0.6149 as compared to the original EPM model's 0.5094. The seasonality model did increase the hedging frequency by placing fifty-nine hedges in the out-of-sample period which is comparable to the thirty-one placed during the in-sample period. However, only twenty-five were profitable compared to nineteen in the in-sample period. The individual lots result are reported in Table 3.17. During the troublesome period from February 1985 through October 1989, the seasonality model placed nine hedges compared to seven by the original model with ISU costs.

Because of the failure of the forty percent trigger level hedge and the stated main emphasis of this chapter to increase the profits, hedging with seasonality at the fifty percent trigger was also simulated. During the 1975-82 time period, profits increased from $5.97 to $7.71 per cwt. or a total of $1.74 per cwt. over cash. This was accompanied by a decrease in variance from $67.59 to $78.11. These changes resulted in p-values of 0.0110, 0.1329 and 0.1425 respectively for the mean, variance and joint conditions. For the 1983-98 time period, the loss of $0.12 per cwt. was actually more than that of $0.05 per cwt. of the forty percent trigger. Variance was reduced to $60.27 which is comparable to the $61.17 of the forty percent trigger. The p-values for the fifty percent trigger level was 0.6648, 0.0748 and 0.6713 for the mean, variance and joint conditions respectively. While the variance condition is not significant at the

Table 3.17: Out-of-Sample Hedging Results of Seasonality, 1983-98 ($ / cwt.).

Lots		Returns from Futures Market				Cash	Hedged
Year	Month	Hogs	Corn	SBM	Total		
1983	Feb	2.00	-0.26	-0.08	1.66	19.41	21.07
	Apr	5.90			5.90	8.24	14.14
	Jun	9.50	1.58	0.31	11.39	3.70	15.09
	Aug					0.10	0.10
	Oct					-4.65	-4.65
	Dec					-4.53	-4.53
1984	Feb	-1.55			-1.55	3.71	2.16
	Apr	0.20			0.20	2.79	2.99
	Jun	1.10	-0.81	-1.05	-0.76	8.07	7.31
	Aug	5.00	0.10	0.00	5.10	6.34	11.44
	Oct					-1.70	-1.70
	Dec					12.02	12.02
1985	Feb	2.25			2.25	11.28	13.53
	Apr	5.75			5.75	4.71	10.46
	Jun	6.80	0.04	-0.08	6.76	8.16	14.92
	Aug					3.11	3.11
	Oct					1.76	1.76
	Dec					12.28	12.28
1986	Feb					12.64	12.64
	Apr					5.57	5.57
	Jun					15.83	15.83
	Aug	-4.10			-4.10	26.77	22.67
	Oct	6.40			6.40	19.43	25.83
	Dec					26.23	26.23
1987	Feb					18.98	18.98
	Apr					15.47	15.47
	Jun	-0.95			-0.95	27.78	26.83
	Aug	-5.65			-5.65	26.14	20.49

continued

Table 3.17 (continued): Out-of-Sample Hedging Results of Seasonality, 1983-98 ($ / cwt.).

Lots		Returns from Futures Market				Cash	Hedged
Year	Month	Hogs	Corn	SBM	Total		
	Oct	1.93			1.93	16.09	18.02
	Dec					11.50	11.50
1988	Feb					15.29	15.29
	Apr	-1.45			-1.45	12.36	10.91
	Jun					21.95	21.95
	Aug					9.91	9.91
	Oct					1.62	1.62
	Dec					-1.14	-1.14
1989	Feb					3.21	3.21
	Apr					1.53	1.53
	Jun					8.68	8.68
	Aug					7.79	7.79
	Oct					6.25	6.25
	Dec					16.25	16.25
1990	Feb	-1.20			-1.20	12.89	11.69
	Apr	-0.60			-0.60	18.18	17.58
	Jun	-3.40			-3.40	31.31	27.91
	Aug	-5.15			-5.15	25.05	19.90
	Oct	-2.38			-2.38	19.12	16.74
	Dec	1.40	-1.72	-0.48	-0.80	15.18	14.38
1991	Feb	-0.18			-0.18	16.90	16.72
	Apr	-2.95			-2.95	17.03	14.08
	Jun					20.65	20.65
	Aug	0.90			0.90	16.60	17.50
	Oct	-0.80			-0.80	9.11	8.31
	Dec					3.76	3.76
1992	Feb	2.90	0.32	0.14	3.36	3.39	6.75
	Apr	-1.45			-1.45	4.23	2.78

continued

Table 3.17 (continued): Out-of-Sample Hedging Results of Seasonality, 1983-98 ($ / cwt.).

Lots		Returns from Futures Market				Cash	Hedged
Year	Month	Hogs	Corn	SBM	Total		
	Jun					9.61	9.61
	Aug	-1.05	-0.29	0.03	-1.31	5.62	4.31
	Oct	-2.20			-2.20	3.88	1.68
	Dec	-0.75			-0.75	9.40	8.65
1993	Feb	-3.05			-3.05	10.20	7.15
	Apr	-8.10			-8.10	17.23	9.13
	Jun	-4.65	-0.14	-0.14	-4.93	18.29	13.36
	Aug	1.25	0.01	0.02	1.29	14.39	15.68
	Oct	-4.73			-4.73	14.38	9.65
	Dec	1.10	-0.35	-0.20	0.55	8.64	9.19
1994	Feb	0.00			0.00	13.36	13.36
	Apr	-0.30			-0.30	7.55	7.25
	Jun	4.55	-0.73	-0.21	3.61	8.09	11.70
	Aug	5.50	-0.38	-0.07	5.05	7.30	12.35
	Oct					-3.04	-3.04
	Dec					-5.33	-5.33
1995	Feb					4.40	4.40
	Apr					2.79	2.79
	Jun					8.43	8.43
	Aug	-3.25			-3.25	11.35	8.10
	Oct	-4.05			-4.05	8.17	4.12
	Dec	-1.70	0.16	0.17	-1.38	5.82	4.44
1996	Feb	1.35	0.00	0.00	1.35	6.90	8.25
	Apr	-5.95			-5.95	10.69	4.74
	Jun	-10.05	-0.29	-0.13	-10.48	18.36	7.88
	Aug	-7.50			-7.50	13.56	6.06
	Oct	-0.95			-0.95	8.84	7.89
	Dec	-3.90	-2.61	0.12	-6.39	16.37	9.98

continued

Table 3.17 (continued): Out-of-Sample Hedging Results of Seasonality, 1983-98 ($ / cwt.).

Lots		Returns from Futures Market				Cash	Hedged
Year	Month	Hogs	Corn	SBM	Total		
1997	Feb	1.00	0.00	0.00	1.00	15.68	16.68
	Apr	2.92			2.92	15.66	18.58
	Jun	-1.07	0.59	0.36	-0.12	21.66	21.54
	Aug	-2.46	0.00	0.00	-2.46	19.05	16.59
	Oct	4.92			4.92	10.29	15.21
	Dec	6.73	1.51	0.62	8.86	6.73	15.59
1998	Feb	5.64	0.13	-0.16	5.61	4.89	10.50
	Apr	2.78			2.78	0.28	3.06
	Jun	1.85			1.85	7.82	9.67
	Aug	5.11	-0.37	-0.10	4.64	-0.01	4.63
	Oct					-3.78	-3.78
	Dec					-13.59	-13.59

five percent level, it would be significant at the ten percent significance level. However, this reduction in variance came at the expense of profits.

Conclusion

In this chapter a more realistic cost structure was developed and additional variables in the EPM equation were investigated. These changes provide virtually the same results as in Chapter 2 statistically significant results during the 1975-82 insample test and non-significant results during the 1983-98 out-of-sample period. Given the consistency of the results between cost structures and alternate EPM models, the question must be asked “Has there been a significant change in the futures market?” The next chapter investigates changes in the price movements in the futures market that would effect a profit margin hedging strategy.

Chapter 4: Market Changes and Routine Hedging

Chapter 2 discussed the fact that the variance of cash profit margins has decreased over time. The variance decrease from the 1975-82 subperiod to the 1983-90 subperiod may be partially explained by the decrease in variance of QPKP that took place between those periods (Table 2.14). However, the variance of QPKP did not decline in the 1991-98 subperiod while the variance of the cash profit margin continued to decline. Other factors may be contributing to this decline. The pork industry has undergone significant structural changes since the mid-seventies. Certainly, hogs are not grown or marketed in the same manner today as they were in the mid-seventies. Because of the strong link between the cash price and futures price, the theory of futures prices suggests that factors effecting the cash market also effect the futures market. This chapter investigates the price action in the futures market to determine if the changes in the cash market have been incorporated into the futures market and the implication of those changes to profit margin hedging.

In the previous chapters a selective hedging process was implemented based on the IPM and the trigger mechanism. In this chapter, routine hedges of hogs, corn and soybean meal are placed with the results reported in the profit margin framework of the previous chapters. Except for the profit margin framework, this chapter has similarities to numerous efficient market studies of individual commodities. However, the results in this chapter are not subjected to the rigorous statistical testing of a true market efficiency study. The results should be used as indications of trends within the futures markets as they relate to hog production and as a springboard for additional research.

Methodology

The routine hedging process in this chapter, as compared to the selective hedging process of the previous chapters, greatly simplifies the methodology. Broadly defined, routine hedging is the placing of hedges without regard to expected price movements or market conditions. Specifically, in this chapter, routine hedging is the placing of a hedge a specific number of market days before the hogs are sold. Therefore, it is not necessary to calculate the quarterly pork production, expected profit margins or implied profit margins to monitor for a hedge to be triggered. However, the basic assumptions of the previous chapters apply to this chapter as well. Six lots of hogs are assumed to be produced each year with the dates and contracts used in Table 2.1 applicable. Hedges are placed using hogs and corn and soybean meal if the feeding period has not begun. After the feeding period begins, only hog hedges are placed. Hedges for the feed are offset four months prior to the sale of the hogs when all feed is assumed to have been purchased and hogs are offset on the day of the sale. Hedges are placed and closed on the opening prices of the futures market without allowance for basis. The hedge ratio of corn and soybean meal are the ISU feed conversion factors given in Table 3.1 and are assumed known for a given year, i.e. 1996 conversion factors are used as the hedge ratio to hedge the 1996 lots. Contracts are assumed available in the required size.

In order to demonstrate changes over time in the market, the entire twenty-four year data set is divided into three, eight year subsets of forty-eight observation each; 1975-82 which is the original in-sample period, 1983-90 that includes the period where the hedging frequency decreased dramatically and 1991-98. To form a continuous series, results for a hypothetical routine hedge for each market day are calculated beginning one hundred and ninety market days before the hogs are sold[28]. All results are reported in market days with approximately twenty market days per month.

For comparison to the selective hedges in the previous chapters, hedging opportunities were sought beginning at about seventy markets days for the April and October lots, about ninety for the February and August lots and about one hundred and ten for the June and December lots. Most hedges were placed soon after hedging opportunities were sought with a large percentage being placed the day after the *Hogs and Pigs* report was released. Related to the production cycle, hogs are placed on feed at approximately eighty market days, pigs are farrowed at about one hundred and twenty market days and sows are bred at a little less than two hundred market days.

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[28] There were a total of six contracts between October 1988 and October 1992 where data wer only available for 186 to 189 market days. These contracts were backfilled to 190 days by assuming the first available futures prices would have been the prices of the one to four prior days. Any missing data point within the data set was assumed to be the average of the prior and following day.

The remainder of the chapter is divided into four sections. The first two sections report the results for the average returns and variance from the futures market alone. Both have a major impact on the profit margin hedging process. These results are not effected by the cash profit margin. The third section incorporates the results of the futures market and the cash market by reporting the combined cash flows from the futures and cash markets that a producer would have receive by placing routine hedges. The fourth section draws conclusions from the previous sections.

Average Futures Market Returns

The average futures returns is the difference between the futures prices when the hedges are placed and the offsetting prices when the hedges are closed, averaged over the eight year subperiod. From Equation 1.1, factors such as cost of carry, convenience yield and risk premium can combine to produce an average other than zero and the market still be efficient. These factors can and do vary across years and within years. From a simplistic view, the market can be said to be either underestimating or overestimating the final realized cash price.[29] From a practical standpoint, the hog producer would prefer the profit margins to be overestimated because he would, on average, profit from placing a hedge. Unfortunately for the hog producer, most research has found little or no difference in the corn and soybean futures market and only slight underestimation, if any, in the hog futures market. The results vary according to the time period and statistical techniques of the research (Kolb, 1995).

Figure 4.1, a graph of the average returns from the routine hedges of the three subperiods, indicates trending in the returns. To better evaluate these trends, equation 4.1 was estimated by simple OLS regression:[30]

(4.1) $RET = b_1 \, DAYS$

where: RET = returns from the futures market, $ per cwt. market hogs, and

DAYS = Length of hedge, 0 to 190 Market Days.

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[29] There is a rich volume of literature concerning normal backwardization and cartango markets, the terms applied to what is simplified into under and over estimation in this chapter. These terms are usually applied to a single commodity market and not to a portfolio of markets.

[30] The equations were estimated with an intercept term of zero. By definition, returns from hedging are zero on day zero.

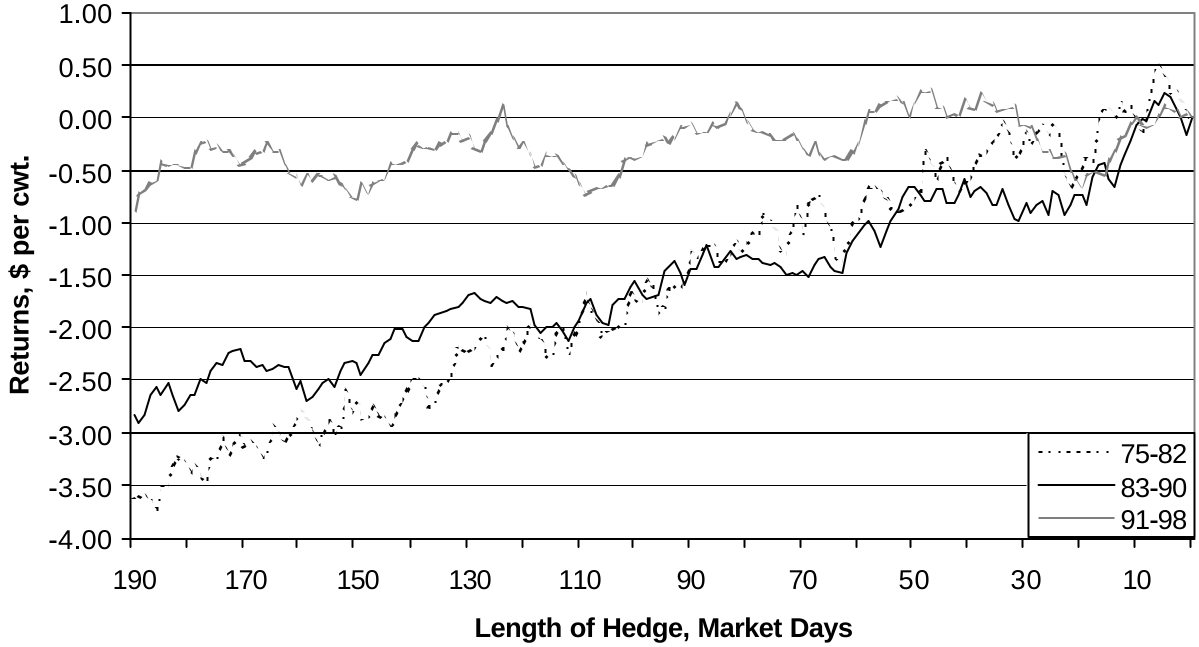

Figure 4.1: Average Futures Market Returns

The graph suggest that the first two subperiods, 1975-82 and 1983-90, behaved similarly with the combination (or portfolio) of hog, corn and soybean meal futures underestimating the final prices. The equation estimates of the market days coefficient or slope of the these two periods confirm this fact. The slopes of the 1975-82 and 1983-90 subperiods are $0.0180 and $0.0153 per day, respectively, with each being highly significant. To the producer this means that a typical hedge placed at one hundred days before the hogs are sold would have 'cost' $1.80 and $1.53 for the respective subperiods because of the underestimation in the market. From the standpoint of the profit margin hedging strategy, the futures market can be considered to be underestimating the cash profit margin by the amount of the underestimation. This underestimation must be overcome before a hedge can be placed. For example, suppose the expected profit margin is estimated to be $3.00 per cwt. and the trigger level is fifty percent. Therefore, the IPM must be $4.50 per cwt. for a hedge to be placed. However, the underestimation of about $1.50 must be added to the IPM for a true estimate of the cash profit that is implied by the futures market. Thus the futures market would actually be implying a $6.00 per cwt. profit margin or one hundred percent trigger level for the hedge to be placed. Since the hedging strategy is calibrated over the 1975-82 subperiod and the 1983-90 subperiod contains essentially the same degree of underestimation, this underestimation is accounted for in the optimization of the trigger level. Therefore the underestimation was not a factor in hedges not being consistently placed in the 1985-90 period.

The 1991-98 subperiod in Figure 4.1 clearly does not exhibit the same degree of underestimation as the other two subperiods. The slope of the regression is $0.0027 per market day and is highly significant. This implies a 'cost' of $0.27 per cwt. for hedges placed at one hundred days prior to the marketing of the hogs. The much smaller underestimation of returns is a contributing factor in the hedges in Chapter 2 and 3 being placed more frequently after 1990 as compared to the 1985-90 period. using the same example from the previous paragraph, an underestimation of $0.27 per cwt. is added to the IPM and results in a $4.75 per cwt. cash profit, or a fifty-eight percent premium to the EPM. The lower premium is actually implied by the futures market means the trigger level is more easily reached.

Variance of Futures Market Returns

The variance of the futures market returns is the variance of the returns from the futures market on any given day prior to the marketing of the hogs for the subperiod. For example, the forty-eight returns for hedges placed at one hundred days are calculated for the 1991-98 subperiod. The variance of these forty-eight returns is defined as the variance of the returns for the one hundredth day. This variance has two important effects on profit margin hedging that must be considered. First, in order for hedges to be placed, the IPM must move above the EPM, which is an estimate of the CPM and therefore, by implication, the IPM must move above the final CPM. Because the variance of the futures market returns is the variance of the IPM, a larger variance in the futures market returns implies more hedging opportunities while less variance implies fewer opportunities to hedge. Any hedges placed that are not a result of the variance of the futures market returns are a result of an error in the estimation of the EPM and are not related to the price action in the futures market.

The second effect is related to the timing of the hedges. Most of the selective hedges were placed on the first day after the release of the *Hogs and Pigs* report when the futures market was not locked limit up or down. These hedges were often placed at levels substantially above the trigger level. A large variance in the futures market returns implies that on any given day the returns from the futures market will have a wider range. Thus, the higher variance implies that these hedges will have higher returns because hedges are placed only on the right tail of the distribution.

Figure 4.2 gives the variance of the three subperiods. The trend is unmistakable and parallels that of the cash profit margins.[31] Each successive subperiod has less variance than the previous. For example, at eighty days, when the hogs are placed on feed, the respective variances for the successive subperiods are $65.38, $44.20 and $25.13 per cwt. Using the $3.00 per cwt. EPM and fifty percent trigger level of the previous example, the percentage of times the IPM would be expected to exceed the trigger level of $4.50 per cwt. is about twenty-nine, twenty-two and eighteen percent. Stated in this form, the decrease in hedging opportunities does not appear to have a large influence on the hedging process. However, these percentages lead to fifty-six percent more hedging opportunities in the in-sample period than in the last half of the out-of-sample period that is due to the change in variance. This is a major difference in the hedging opportunities.

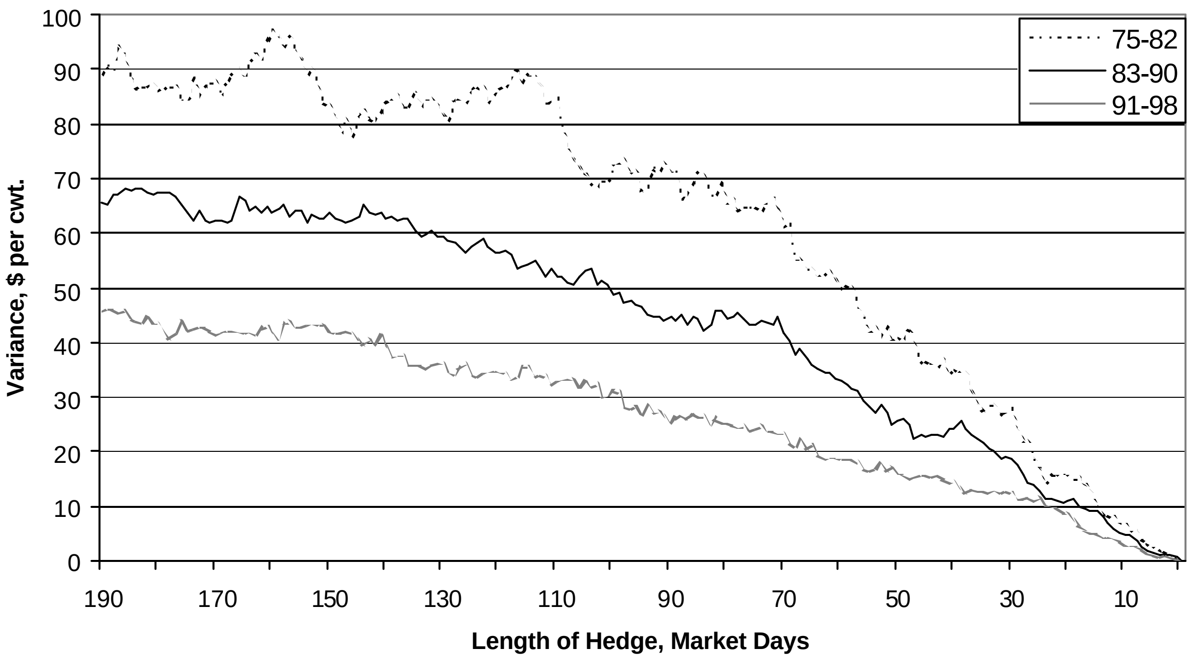

Figure 4.2: Variance of Futures Market Returns

[31] Cash profit margin variances for the LDP cost series are $98.75, $72.72 and $48.85 per cwt., respectively for the three subperiods (Table 2.14). In Table 4.1, cash profit margin variances for the ISU cost series are $94.01, $81.09 and $52.82 per cwt., respectively.

Routine Hedging Results

The results from the futures market can be considered the results of trading the market. In order to truly evaluate the outcome of a hedge, those results must be combined with the cash market results to calculate the variance of the hedged cash flow as in the previous chapters. The cash profit in this section is calculated similar to those in the previous chapters with some minor simplification. Equation 2.1, repeated here for reference, remains the basis for the calculation.

(2.1) CPM = LH + CULLRET – (C / 5,600 x CCF) – (SM / 2,000 x SMCF) – DC

where: CPM = Cash Profit Margin, $/cwt. of market hogs

LH = Opening Live Hog futures price, $/cwt.

CULLRET = Cull Returns, income from cull breeding stock, $/cwt.

C = Opening Corn futures price, cents/bu.

5,600 = Converts C into $/lbs.

CCF = Corn Conversion Factor, lbs. of corn / cwt. market hogs

SM = Opening Soybean Meal futures price, $/ton

2,000 = Converts SM into $/lbs.

SMCF = Soybean Meal Conversion Factor, lbs. of SM / cwt. market hogs, and

DC = Direct Cost excluding feed, $/cwt.

The ISU cost structure as it appears in Table 3.1 is assumed known for the given year. For example, the direct cost and feed conversion for 1996 is used to calculate the profits for all groups in 1996. The cull returns are calculated by the previous year's sow regression estimates in Table 2.7. For example, the regression estimates for the 1987-96 data set are used to calculate the 1997 lots.

The results of routine hedging (Cash + Futures) are reported in Table 4.1 in intervals of twenty market days for hedges beginning at one hundred and eighty days. These results are useful as a benchmark against the hedges in Chapter 3 and for evaluating routine hedging as a possible hedging strategy. In Chapter 3, the seasonality model during the 1983-98 out-of-sample period was near the point of being statistically significant at the ten percent significance level when the variance was reduced from a cash variance of $67.59 to $61.17 for the hedged variance or about a ten percent reduction. A ten percent or more reduction in variance can be achieved in the two later subperiods by routine hedging about one month before the hogs are sold. In the 1975-83 subperiod, both the original and seasonality models were highly significant in reducing

Table 4.1: Results of Routine Hedging; 1975-82, 1983-90 and 1991-98.

Length of Hedge	75-82		83-90		91-98	
	Avg Profit ($ / cwt.)	Variance ($ / cwt.)	Avg Profit ($ / cwt.)	Variance ($ / cwt.)	Avg Profit ($ / cwt.)	Variance ($ / cwt.)
180 days	2.68	23.69	8.66	10.78	8.51	13.35
160 days	3.26	28.92	8.79	14.57	8.34	13.79
140 days	3.57	29.19	9.18	20.30	8.67	18.47
120 days	3.91	37.62	9.50	23.04	8.75	17.09
100 days	4.31	37.36	9.75	36.55	8.59	24.82
80 days	4.85	55.21	10.00	33.15	8.94	27.88
60 days	5.09	48.40	10.20	50.04	8.72	33.10
40 days	5.48	76.94	10.54	55.15	9.08	39.97
20 days	5.56	69.45	10.57	66.89	8.33	48.09
Cash	6.06	94.01	11.31	81.09	8.98	52.82

variance but here again, the twenty day routine hedge produced the same magnitude of variance reduction. The inference drawn is that any variance reduction in the in-sample period or perceived reduction in the out-of sample period is from the act of placing hedges and not the timing of the hedges by the hedging rules. However, the hedges in Chapter 3 did provide more profits, in each case, than the routine hedges and therefore the twenty day routine hedge could not be considered superior in a mean-variance framework.

Of more interest in terms of using routine hedging as a strategy is the tremendous variance reduction of the longer term hedges and the apparent shift in the futures market that decreases the ‘cost’ of this reduction. Hedges placed before pigs are farrowed, before one hundred and twenty days, reduce variance by seventy to ninety percent across all periods. This did come at a significant reduction in profits of between $2.00-3.50 per cwt. during the first two periods. However, in the later 1991-98 period the average profit reduction was less than fifty cents per cwt. Figure 4.3 further illustrates the impact on profits from a one hundred and eighty day routine hedging strategy. Clearly, the producer would not have fully participated in the relatively good markets in June of 1996 and June of 1997, receiving six to seven dollars less than the cash market. However, he would have scarcely noticed the down turn in December of 1994 and would have broke even instead of losing about $13.50 per cwt. in December of 1998. While

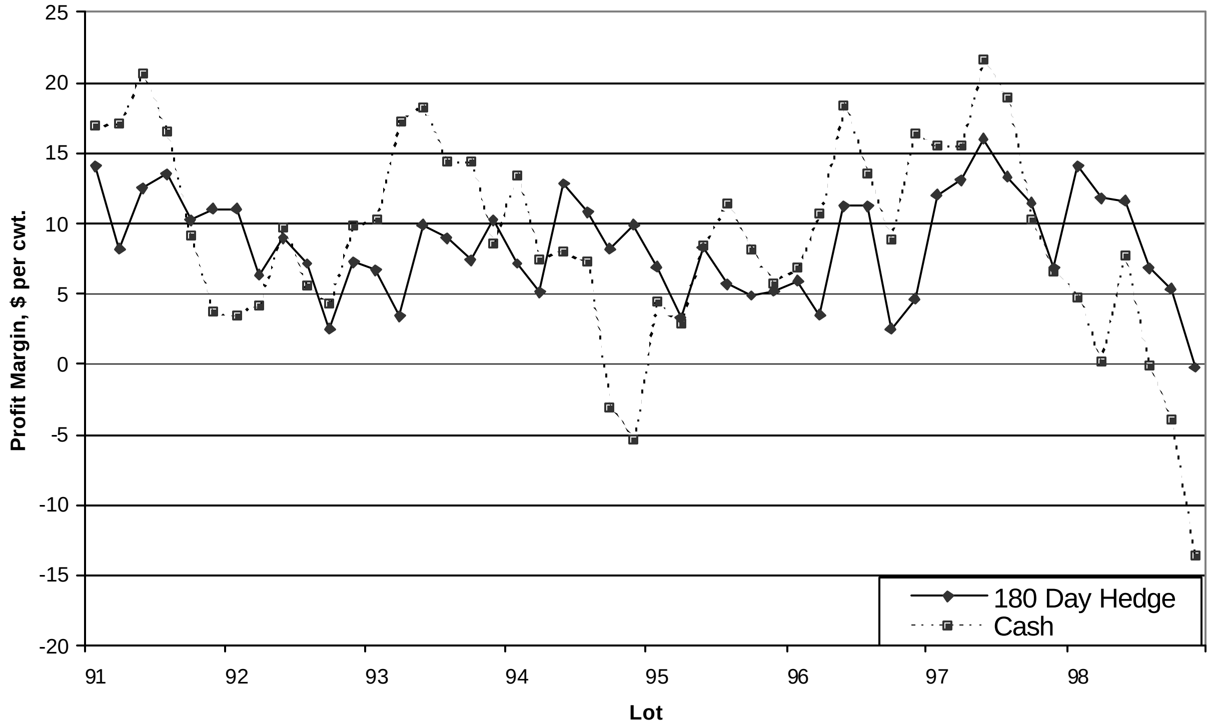

Figure 3.3: Profit Margins, Cash vs. 180 Day Hedge, 1991-98

this type of strategy may not be for all producers, it should be of interest to those considering 'window price contracts' or to those considering outright contract production.

The reduction in the variance of the cash market in the later subperiods may lead to a false conclusion about the need for risk management. The simple inference is that the variance facing the hog producer at the end of this study is about half that facing the producer when the KC study was conducted. Thus, the need for hedging programs or other forms of risk management is not as critical now. However, this inference cannot be drawn. The cash market returns are in terms of profit per cwt. It does not consider the return to capital or the leverage of the hog enterprise. Today's hogs are increasingly raised in high tech specialized single purpose facilities compared to the farrowing huts and open feeding floors of the seventies. Capital requirements on a per cwt. basis have increased tremendously and by inference, most producers would be more leveraged especially if they are expanding or modernizing. Both of these factors lead to an increased exposure to risk.

Another critical point is that the variance does not contain the total risk profile in terms of short terms cash flow and being able to keep the hog enterprise financed as an ongoing operation. The kurtosis and the skewness statistics contain additional information that must be considered. Comparing cash market of the 1975-82 period to the 1991-98 period, the kurtosis changed for –0.43 to 0.84 that implies the tails have become 'fatter' meaning there are more extreme observations. The skewness changed from 0.13 to -0.63 which means that in the 1975-82 period larger deviations from the mean were more apt to be in the direction of increased profits where in the 1991-98 period larger deviations were more apt to be in the direction of decreased profits or losses. A successful risk management program is aimed at protection from these observations in the left tail or reducing the chance of large losses. Thus, because these observations in the left tail have increased, the need for risk management has increased. From a producer's viewpoint, these statistical concepts may be viewed with a bit of skepticism and he may not be convinced of the need for risk protection. Returning to Figure 3.3, a producer enjoying the high profits of the first half of 1997 would not have seen the need for a risk management program. To see the need for a risk management program for an ongoing hog production enterprise, take the viewpoint of a banker in 1999 deciding whether to extend operating credit to two hog producers, one with cash flows from the cash market and one with the flows from the hedging. Which producer is more likely to receive the credit he needs?

Conclusions

There have been significant changes in the futures market during the period of this study. The most significant is the reduced variance exhibited in the returns from the futures market in the 1983-90 and 1991-98 subperiods. With the reduction in variance, fewer hedging opportunities present themselves and those that are present at the release of the *Hogs and Pigs* report are at a lower profit level. Both of these factors have a negative impact on profit margin hedging. On the positive side is that the amount of underestimation in the market is less in the 1991-98 period than in the two prior periods which has the opposite effect. The broader implication of the reduction in underestimation is that long term routine hedging may now be an attractive alternative to other forms of risk management.

Chapter 5: Conclusions and Implications

The purpose of this research was to evaluate the Kenyon and Clay profit margin hedging strategy with a long-term out-of-sample test. Improvements or refinements to the strategy were to be made based on the results of the initial test. From that work, recommendations were to be made for the pork producer of the 21st century. The failure the out-of-sample test to reproduce the earlier results, even with improvements to the model, leaves no clear profit margin hedging strategy that can be recommended to the pork producer. However, the investigation of the failure does provide useful information that leads to direct and strong implications to the 21st century pork producer. For researchers, the difficulties encountered in this research are used to draw inferences and conclusions concerning the conduct of future research, especially the use of out-of-sample testing. These findings are primarily directed to researchers but they also serve as a guideline to a producer evaluating research.

Kenyon and Clay found a significant increase in profits with an accompanying reduction in variance during their in-sample period of 1975-80. The findings were verified by a short out-of-sample test of thirteen observations from 1980-82. The research presented in this thesis successfully replicated those results over an in-sample period of 1975-82 with different cost structures and extensions of the central model of the hedging strategy, the expected profit margin model. The in-sample results of this research were subjected to a more stringent statistical testing method and Kenyon and Clay's strategy proved to be statistically significant in simultaneously reducing variance and increasing profits. For example, using Kenyon and Clay's original expected profit margin model with Iowa State University costs, the profits increased from \$5.97 per cwt. to \$7.20 per cwt. while from \$92.92 per cwt. to \$62.41 per cwt. The p-value for the joint condition was 0.0467. Thus, Kenyon and Clay's findings were repeatable and robust to a variety of assumptions. They were an accurate representation of the possibilities offered in the futures market for the 1975-80 period over which the models were developed and the for the small 1980-82 out-of-sample test period of thirteen observations. However, the conclusions drawn and recommendations made by Kenyon and Clay from their research were overstated and proved to be false by the long out-of-sample test of this research. During the out-of-sample test from 1983-98, no profit margin hedging strategy tested in this thesis proved to be statistically significant in either reducing variance or increasing profits. During the out-of-sample test for Kenyon and Clay's original expected profit margin model with Iowa State University costs, the profits only increased from $10.15 per cwt. to $10.22 per cwt. while variance was reduced from $67.59 per cwt. to $62.05 per cwt. The p-value for the joint condition was 0.5094.

The false conclusions and recommendations made by Kenyon and Clay were a result of insufficient testing of the strategy with out-of-sample data. Unfortunately, the Kenyon and Clay paper is not an exception to the rule but represents the standard in terms of lack of out-of-sample testing. In fact their small out-of-sample test was more than conducted in most studies. The other profit margin hedging papers reviewed (Table 1.1) did no out-of-sample testing and except for the Leuthold and Mokler paper, appear in peer reviewed journals. Therefore, the need for long-term out-of-sample testing put forth in this chapter is not a condemnation of the Kenyon and Clay research but a call to raise the standard of research of all those engaged in hedging strategy research designed for use by producers.

The need for out-of-sample testing of sufficient length to provide statistically reliable results is not a new revelation. The fact that the statistics that indicate the accuracy of an equation estimate are only reliable indicators over the data range or time frame over which the equation was estimated is a widely accepted principle of statistics. They should be viewed as the maximum accuracy obtainable when the model is used as a forecasting model. The empirical focus of this research gives 'real world' examples of the deterioration of the accuracy when models are used for forecasting.

The central model to the hedging strategy and major cause of the out-of-sample failure is the expected profit margin equation. From the data presented in Figures 2.6 and 2.7, had Kenyon and Clay conducted sufficient out-of-sample testing they would have seen the estimates of expected profit margin were biased beginning in 1985 and continuing through 1989.[32] By definition, in-sample estimates are not biased because the errors sum to zero. Why the bias occurred is not clear. It might be from the significantly reduced feed prices, the generally

[32] Kenyon and Clay's research was published in 1987. They, nor the other papers cited. did not have access to data of sufficient length to both develop a strategy in-sample and test out-of-sample because of the major structural change in agricultural commodities that took place in 1972-73. This example and the others that follow are hypothetical examples and are used to illustrate the need for out-of-sample testing now that sufficient data exists.

depressed farm economy, the previous period of high inflation or other macro conditions. The argument could be made that any of these possible causes were one time events and forecasting models cannot be expected to predict a one time event. But out-of-sample testing increases the chance that a one time occurrence is encountered and provides at least some indication of the robustness to unexpected occurrences.

To illustrate a second point, assume that this period of overestimation did not occur and the performance of the EPM model during the 1983-90 period out-of-sample was relatively similar to the 1991-98 period forecasts. The SER of the last eight EPM equations used to predict the 1991-98 period average about $4.80 per cwt. The standard deviation of the actual errors in the estimates is $6.22 per cwt. or about thirty percent larger than the SER would have predicted. The increase in error expected based on the SER to that realized by the actual forecasts is a result of the equations not predicting as well out-of-sample as in-sample. The average SER of the EPM equations used to predict the 1983-90 period was about $5.75 per cwt. Adding thirty percent to $5.75 per cwt. to account for out-of-sample forecasting error, the expected standard deviation of the EPM errors would be about $7.50 per cwt. The in-sample standard deviation of the errors in EPM was $6.01 per cwt. The increase from the 1975-82 in-sample to 1983-90 out-of-sample period would have likely produced the same failure in the hedging strategy as seen in the 1991-98 period. Had Kenyon and Clay conducted sufficient out-of-sample testing they would have encounter these additional forecasting errors. Carrying the argument one step farther back in time, adding the thirty percent forecasting error to the $6.22 per cwt. SER of the EPM equation used to forecast the 1975-82 in-sample period would produce an expected standard deviation about $8.00 per cwt. This raises the question as to whether the hedging strategy would have been successful in the in-sample period if a proper allowance had been made for the forecasting errors.

In addition to the problems associated with estimating expected profit margin, the trigger mechanism implicitly assumes the average cash profit margin and the variance of the futures market remains constant. The average profit level is a function of the cost structure. The estimation of cost over any length of time is a problem because of technological changes. Other structural changes in the market have reduced the variance of both the cash and futures market as discussed in chapter 4. It is difficult to estimate the effects of these changes on the trigger mechanism because of the more serious problems above. However, the rules may have been too rigid to function effectively in a rapidly changing market structure. These problems might have been uncovered with a longer out-of sample test if the other problems were not present.

Out-of-sample testing of hedging strategy research directed to producers has the additional benefits concerning implementing and updating the strategy. For example, in Kenyon and Clay's research, costs of producing hogs were estimated by simple inflation of the costs from a base year, 1975. This method works well for short time periods but their costs were beginning to be overestimated by the end of their study period in 1982. A longer out-of-sample test period would have forced Kenyon and Clay to deal with these overestimations as they became more serious. This would have made the Kenyon and Clay strategy more easily and confidently implemented by the producer. Out-of-sample testing also provides the opportunity to 'stress test' the models in regard to updating frequency. For example, in this research models were updated on a yearly basis. Had the strategy proved successful, would it have been necessary to update on a yearly basis? Would updating every two or four years been as successful as updating yearly? Without the guidance of the researcher, the producer is left with no insight into the updating procedure and similar questions.

Out-of-sample testing is not a total solution to the problems encountered in forecasting. However, it is a critical tool that enhances the believability of the results. Research results that are not tested out-of-sample to estimate the forecasting errors and robustness to changes in a dynamic marketplace should be viewed very skeptically.

Future Research and Concluding Remarks

The failure of the profit margin hedging strategy is this study should not be considered as proof that profit margin hedging does not work. The scope of this study is limited to the hog market and simple models that could be implemented by a hog producer. Of the profit margin hedging papers reviewed, hogs are by far the most complex because ownership of a major input, the feeder pig, is not transferred and therefore not priced. This implies that profits are effected by and must be estimated in relation to the supply of pork. In cattle feeding and the soybean crush, all major inputs are priced and profits are not effected, or at least not to a major extend, by supply. Possibly more complex models, beyond the scope of a producer, could prove successful. However, for them to be successful, they must be able to properly account for the structural changes taking place in the pork industry. In fact, research concerning these structural changes and their effects appears to be a much more productive area of research and of more value to the independent hog producer. If he is to survive, he must be able to understand and cope with these changes.

In a broader context, there is a need for more applied market research in the context of 'real world' situations. There is a great deal of literature that deals with single commodities with comparatively little dealing with groups of associated commodities. In the meat sector in particular, commodities are dealt with in groups. Single commodity research fails to account for interrelationship with the group. Profit margin hedging is just one example of capturing the interrelationship of commodities. Additionally, most research on price movements is from a short term perspective but producers are also concerned with longer term price movements. Daily price movements tend to be a random walk. Are longer term price movements random walks? Economic theory suggest that prices tend to converge to the long run average cost of production in a competitive market. This question has important implications in the pricing of window contracts. While these are specific cases and applications, the greater worth of applied research that deals more directly with real world situations is that it may uncover 'abnormalities' that are not explainable by current theory and knowledge of the market. The uncovering of these abnormalities leads to a more efficient market and a deeper understanding of the marketplace.

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Vita

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