AN ABSTRACT OF THE THESIS OF

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in the Department of Agricultural and Resource Economics presented

on November 10, 1986

TITLE: An Analysis of Pacific Northwest Live Hog Futures Basis

Redacted for Privacy

Abstract approved: Carl O'Connor

Unstable prices have been a chronic problem in the U.S. hog industry during the past 15 years, and several studies illustrate the need for price risk avoidance tools for hog producers. One such price risk management tool is the use of live hog futures markets. This study explores if Pacific Northwest hog producer's could selectively utilize the live hog futures market and receive a return higher than the average cash price for barrows and gilts during the 1980 to 1986 time period. And, the study also explores whether these producers could reduce the related price uncertainty by utilizing these same selective hedging strategies.

These strategies combine readily available price forecasts with localized futures market prices. A producer was assumed to hedge if the current futures market price adjusted for the appropriate basis was higher than the forecast cash price for a specific forecast time horizon.

The lack of statistically different outcomes when different forecasts were utilized make it difficult to draw strong, definitive

conclusions and subsequent marketing guidelines. However, the findings of this study are consistent with the findings of other studies which have shown that the combination of cash price forecasts and futures market quotations can be effective in increasing revenue while reducing price risk. This appears to be as true for hog producers in the Pacific Northwest as for producers located in the major Midwest Corn Belt.

An important conclusion of this study is the fact that Pacific Northwest hog producers can utilize U.S.D.A.'s quarterly Midwest based seven market, barrow and gilt price forecasts, by making a simple average price adjustment.

An Analysis of Pacific Northwest Live Hog Futures Basis

by

Juan Mendez

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed November 10, 1986

Commencement June 1987

APPROVED:

Redacted for Privacy

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Date Thesis Presented November 10, 1986

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CHAPTER I

INTRODUCTION

The Problem

The pork production sector of the agricultural economy supplies about 30 percent of the red meat consumed annually in the U.S. (Hayenga et al., 1985). The pork industry is also an important customer for many productive resources such as feed grains, capital, and labor. At the farm gate, hog production accounted for roughly $9.7 billion in sales during 1984; 6.85 percent of total U.S. farm income in that year (USDA, **Economic Indicators**, 1984).

Rhodes and Grimes (1983) estimate that in 1982 about 78 percent of the U.S. hog production was located in the midwest region known as the Corn Belt area. Although the Washington-Oregon, Pacific Northwest (PNW) region is not an important hog producing area in the national context, this region accounts for the majority of hog production on the Pacific coast of the United States. In 1985, the number of hogs in Oregon totaled 125,000 head, and Washington totaled 51,000 head. These hogs were pro-duced on 6,900 hog operations in the two-state region in the same year.[1]

The hog industry has been characterized by highly variable farm level prices. This instability may create serious adverse effects on producers' incomes and unfavorable impacts on producers' investments. Although a mix of commodity enterprises may reduce variability in farm income, the trend in hog production has been

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[1]An operation is any place having one or more hogs on hand during the year.

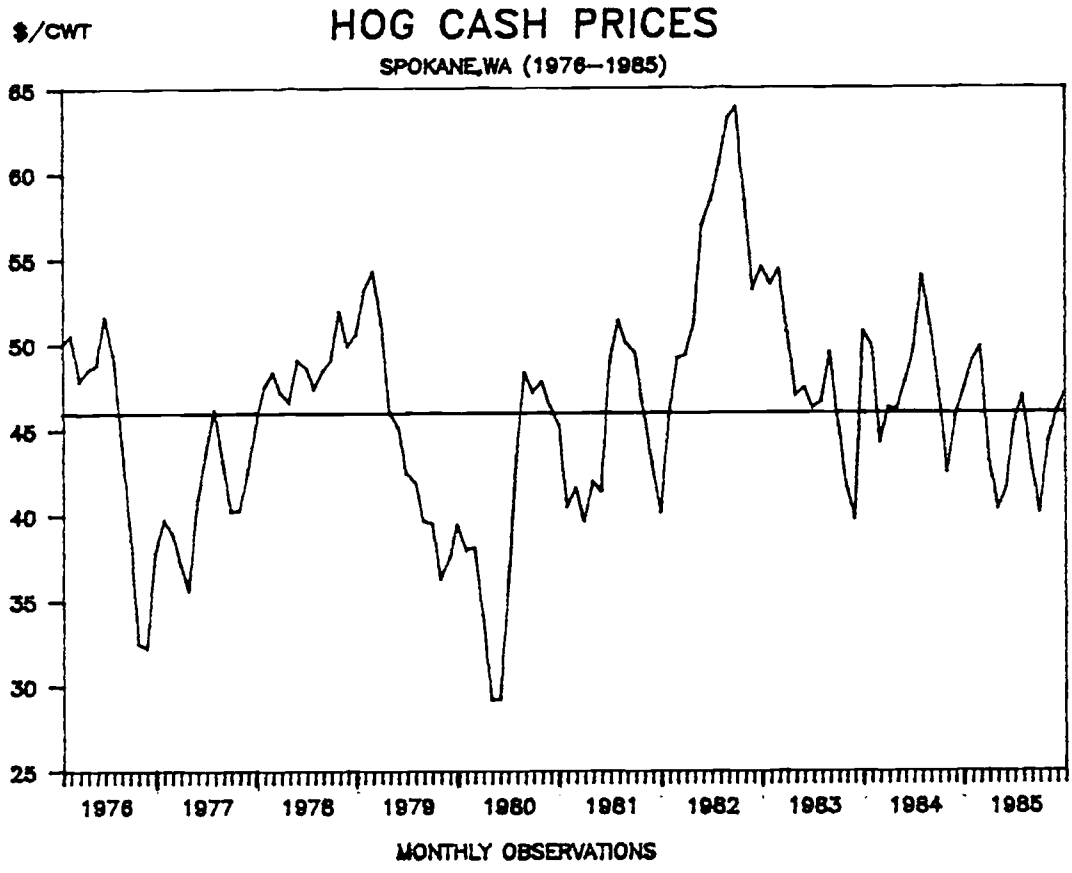
toward increased specialization. Unstable prices have been seen as a chronic problem in the hog industry during the past 15 years. Hayenga et al. (1985) point out that hog prices in the U.S. have experienced changes of about 50 percent over the last 10 years in the extreme cases.

This same variability has been present in Pacific Northwest hog prices. Monthly barrow and gilt prices at the Spokane-Washington auction for 1976 through 1985 are shown in Figure 1. Over this time, prices ranged from a low of $28 per hundred weight to a high of $64 per hundred weight. Some seasonal and cyclical price trends, as described by Hayenga et al. (1985), are apparent. However, the ability to forecast prices accurately, which will be explored in more detail later, is difficult at best.

Skadberg et al. (1984) indicates that about 70 percent of the nation's hogs are sold by producers themselves. That is, the producer negotiates directly with a buyer and the price is established through direct negotiation. Marketing hogs in the Pacific Northwest is very similar. Public markets such as auctions are another alternative method to market hogs. However, few of these auctions move a large enough volume of hogs to warrant public market price reporting. One exception is the Spokane-Washington auction which is reported by U.S.D.A.'s Agricultural Market News Service. This auction is used in this study as a representative market of hogs sold in the Pacific Northwest.

The author acknowledges that the majority of hogs in the Northwest move by private price treaty, with much of the volume

Figure 1. Live Barrow and Gilt Average Cash Price, Spokane, Washington, 1976-1985.



using a "basing point" pricing system. That is, hogs in the Pacific Northwest are sold to meat packers based upon the average price of hogs in major Midwest markets. The price may be adjusted by a negotiated premium or discount, depending upon local supply and demand conditions. However, the price for locally processed pork is usually a premium, since the retail shelf life is extended as a result of decreasing the shipping time from the packer to the retail store.

Brown and Purcell (1978) point out that a hog producers' need for price risk avoidance tools is well illustrated by the fact that the biggest impact on producers' income comes from price instability. One such price risk management tool is the use of futures markets.

Futures Market

Gold (1975) indicates that commodity futures exchanges were created to meet specific needs of the business community. The need for protection against inventory price losses and an initial attempt to avoid the price risk involved in producing and trading agricultural commodities were the principal objectives of the futures exchanges.

Live hog futures are traded by the Chicago Mercantile Exchange. Trading of live hog futures began in 1966, following the successful introduction of trading live cattle futures the previous year. The delivery point for live hog futures contracts is Peoria, Illinois. However, deliveries may also be made in Omaha, Nebraska; East St.

Louis, Illinois; Sioux City, Iowa; and St. Paul, Minnesota; at varying discounts per hundred weight. Hogs at or close to the delivery points mentioned above are said to be "in position to delivery," and those delivery points are known as in position to delivery markets (in position markets). Commodities in position to deliver would not be penalized if actual delivery occurred. A market would be "out of position to delivery" (out of position market), if the seller incurred excess transportation costs, or any other cost, not incurred at an in position market.

Hedging

The procedure used by producers to attempt to transfer price risk is known as "hedging." Ikerd (1979) indicates that there are two basis objectives of hedging in futures markets. The most common objective is to get a higher price. But an equally important objective is to get a more certain price. Sometimes a hedger may achieve both objectives at the same time. However, stable prices which offer a reasonable rate of return may be the more advantageous goal of hedging.

Kohls and Uhl (1985) indicate that a hedge involves the temporary substitution of a futures market transaction for a cash transaction which will occur in the future. In other words, the mechanics of hedging consists of making opposite transactions in the cash and futures markets. An example may illustrate this concept. If a farrow-to-finish hog producer wants to evaluate if hedging in

the future market may reduce price risk, the producer could go through the following steps:

1. Determine the most likely time period that the anticipated cash sales will occur. For example, if the hedging decision is being made in April, October 1 may be the expected sales date.
2. Determine the current price that an October live hog futures contract is currently trading. For example, the producers' local commodity futures broker could be contacted, and may indicate that the Chicago Mercantile's October contract is currently (on April 1) trading for $47 per hundred weight.
3. Determine the expected price relationship between the cash price and October futures contract price, at the time the hogs will be sold (October 1). This will have to be an estimate, and is usually obtained by observing this price relationship during the same period of time during past years. The producer may determine, based upon the average of the past 5 years, that the October futures contract price is usually $1 per hundred weight higher than the cash price on October 1. This relationship between the cash and futures contract price, at any point in time, is referred to as the "basis."
4. By adjusting the October futures contract quote of $47 per hundred weight, by the $1 expected basis, the producer determines that a hedge (selling the October futures contract now) could result in an expected return of $46 per hundred

weight in October. This process is also illustrated in the top portion in Table 1, corresponding to the April 1 date. The producer must then compare the expected return of $46 per hundred weight to his/her price objective, which may be the variable costs of production or some other objective, which will vary for each producer. If the expected return of $46 meets the producers' objective, and the producer does not care to take additional price risk, the producer will sell an October futures contract on April 1.

5. Once the hedge is established, the outcome of the hedge will solely depend upon the actual basis when the hedge is lifted, relative to the expected basis on April 1, when the hedge was set. For example, in Table 1, it is assumed that on October 1, when the hogs were sold, and the hedge terminated, that the cash price for hogs was $44 per hundred weight. On that same day, the producer bought back an October futures contract for $45 per hundred weight. This represented a $2 per hundred weight (ignoring transaction costs) profit in the futures market. This profit, ordinary income into the business, may be added to the $44 per hundred weight the producer received for the hogs in the cash market, resulting in net revenue from the hedge transactions of $46 per hundred weight.

Please note that net revenue was exactly the same as expected when the hedge was placed. The reason for this outcome is that the realized basis ($1) on October 1 was exactly the same as the

producer had forecast on April 1. Had the price relationship been different, the net revenue would have varied exactly by this difference. Therefore, the key factor for the producer is, "How accurately can the basis be forecast?"

If the basis can be forecast with an acceptable level of accuracy, then the hog producer can use the futures market in conjunction with his usual cash merchandising method to reduce price risk. However, the results described in step 4 above, comparing the

Table 1. Illustration of a Hypothetical Perfect Hedge (100 Percent Predictable Basis) for a Farrow-to-Finish Operation

Date	Cash Market	Futures Market	Oct. Basis
Apr. 1	Oct. price objective: Futures $47/cwt Expected Basis $ 1/cwt Expected Revenue $46/cwt	Sell Oct. Futures @ $47/cwt	$1/cwt (expected)
Oct. 1	Sell locally @ $44/cwt	Buy back futures @ .....$45/cwt Futures gain $ 2/cwt	Futures $45/cwt Cash $44/cwt Basis $ 1/cwt

Hedge Performance: October 1

Cash Price = $44
+ Futures Gain = $ 2
Net Revenue = $46

expected return to an already established price objective may not yield an acceptable economic result. That is, a hedge may "lock in" a net return which would be less than the price objective. In this

case, the producer may not hedge. However, this decision will depend upon the producers' price expectations of the cash market. In fact, even if the calculations in step 4 do yield an expected hedge return above the established price objective, the producer will compare this economic outcome to not hedging and speculating with the economic outcome based entirely upon the cash price on October 1. The economic outcome of the producers' decision to hedge, or not hedge, will depend upon how well the producer can estimate the basis relative to how well the producer can estimate the cash price.

Objectives

The overall objective of this study is to evaluate whether Pacific Northwest (PNW) hog producers could receive a higher price than the average cash market price, and whether they could reduce the uncertainty associated with price instability by using a selective hedging strategy in the live hog futures market. To accomplish the overall objective, two specific objectives are addressed:

1. To determine the applicability of U.S.D.A.'s nationally oriented quarterly price forecast for the aggregated seven major hog markets to the Spokane-Washington cash market.
2. To determine if a Pacific Northwest hog producer could combine price forecasts with hedging to reduce price variability.

CHAPTER II

METHODOLOGY

The purpose of this chapter is to present the theory and methodology supporting the analysis of selective hedging of live hogs in the Pacific Northwest.

Economic theory suggests at least two types of benefits that may arise through futures trading. First futures trading provides for shifting risk from producers to others willing to bear the risks at lower costs. It is an alternative to other types of capital markets such as forward cash contracting which is prevalent in the hog industry.

Another type of benefit arises when forward prices generated by futures trading enable producers to better plan the efficient use of their resources. Trading in futures can serve as an alternative to other market coordinating arrangements such as vertical integration, cooperatives, or various forms of government control.

Risk Analysis

This study focuses upon the risk-shifting aspect of futures trading. In particular, the study attempts to measure the potential for selective hedging as a means to shifting the price risks associated with feeding barrows and gilts in the Pacific Northwest. With this goal in mind, the general framework for decision making under risk, provided by portfolio theory is utilized.

Numerous studies of futures trading have focused upon the effect of hedging on both risk and expected returns. Heifner (1966) analyzed the impact of hedging on the mean and variance of returns from grain storage. Tomek and Grey (1970) studied the effectiveness of hedging on reducing the variance of income from crop reduction. Gum and Wildermuth (1970) measured the effect of hedging in reducing price risk variability in cattle feeding. In each of these studies, the measure of profit variability employed was the variance or standard deviations of profit about its means.

Peck (1975) in her review of these studies points out that this conceptual framework is relatively "long-run" in nature, and these measures do not reflect the uncertainty or risk actually confronting producers. Peck continues;

> "Futures markets operate with an essentially short-run horizon. Contracts are traded for at most a year in advance of their expiration, often for shorter periods. This is long enough to be useful to producers as it is to the commercial trade. But, for most commodities, it is certainly not long enough to stabilize incomes in the sense used by the above authors." p. 238.

This paper focuses on the relative short run risks associated with the price variability which a producer incurs after the initial decision has been made to feed hogs. That is, the only relevant price variability, at this point in time, is that which makes the producers' price forecast differ from the actual market price for the hogs. It is from this point of view, using portfolio analysis, that this study explores the economic implication of hedging hogs in the Pacific Northwest.

Several studies of hedging behavior have made use of portfolio theory, and in particular of the "mean variance" formulation due to Markowitz (1959). The hedger is regarded as being able to hold one or more of several alternative assets. For example, in the case of the short hedger, there could be, (1) unhedged product; (2) product hedged in the futures market; or (3) product hedged by forward cash contracts.

Grey and Rutledge (1978) review the theory developed by Markowitz as follows:

> "The return on each "asset" is a random variable and it is assumed that each (potential) hedger has a subjective probability distribution over these variables. The hedger is assigned a cardinal utility function whose argument in the net value of his assets at the end of the period under consideration. If this utility function is concave he is said to be 'risk averse'. It is further assumed that the hedger will act in such a way as to maximize the expected value of his utility function.
>
> In the Markowitz framework the hedger chooses among alternative portfolios on the basis of their means and variances--this implies the existence of mean-variance indifference curves. If μ and V are respectively the mean vector and variance-covariance matrix of the hedger's subjective probability distribution, any portfolio X will have an expected return $X'\mu$ and risk X'VX. The hedger is assumed to select a portfolio which maximizes $X'\mu$ for a fixed value of X'VX. This gives rise to an "efficient" set of portfolios and the hedger chooses that which allows him to attain his "highest" mean-variance indifference curve." p. 30

The primary theoretical studies of hedging viewed as portfolio selection were reported by Tesler (1955-56) Stein (1961) and Johnson (1960). Johnson and Stein consider a grain merchant who holds a predetermined level of stocks and has to decide what proportion of these stocks should be hedged. Tesler, on the other hand, takes a look at the merchant before acquiring the stocks, and goes through the

decision of what quantity of stocks to hold hedged and what quantity to hold unhedged.

As discussed earlier, Peck (1975) takes this theory into a short run setting, and with the use of available price forecasts, develops a hedging strategy which stablized income (reduced risk) by lowering producers' exposure to unpredictable price variation. Brandt (1985) specifically applies Peck's theoretical concepts to the hog industry. He shows that hog producers can reduce risk of unfavorable price fluctuations by combining the information from price forecasting models with a selective hedging strategy.

This study of hedging strategies of Pacific Northwest hog producers follows the theoretical and problem solving format utilized by Peck and Brandt. In particular, the study explores if a Pacific Northwest producer can utilize U.S.D.A.'s quarterly barrow and gilt price forecasts with hedging to reduce price variability.

Alternative Forecasting Approaches

Large variations in the livestock product prices in the 1970s have increased the need for designing better price forecasting approaches to serve as accurate information sources to decision makers (Brandt, 1985). Since forecasting livestock prices over the past several years has been increasingly affected by outside influences, the analyst must consider an increasing amount of available information to include in the models (Stillman, 1985).

This research utilizes hog price forecasts generated by the World Agricultural Outlook Board, of the United States Department of

Agriculture. These forecasts are composite forecasts representing a committee of professionals consensus. This committee is composed of members from the Foreign Agricultural Service, Economic Research Service, Agricultural Marketing Service, Agricultural Stabilization and Conservation Service and the World Agricultural Outlook Board. Brandt and Bressler (1981) evaluated performances of several forecasting techniques, many of which are used by the U.S.D.A. group listed above, and found that composite forecasts offer some promise in improving forecasting accuracy.

The U.S.D.A. forecast price series represents the market price that farmers receive for barrows and gilts in the seven major Midwest hog markets. In turn these forecasts were adjusted for the average price differential between Spokane, Washington and the seven major markets.

In order to establish the degree of correlation between hog prices in the Midwest and the Pacific Northwest, quarterly average hog cash prices for the seven major Midwest markets were regressed on cash prices reported for the Spokane, Washington market.

Another price forecast utilized is the naive or "no change" approach. This technique assumes that the decision maker views the current price as an acceptable forecast of the market price in the future.

Price Forecast Evaluation

From the first quarter of 1980 to the second quarter of 1986, twenty-six cash price forecasts were generated by each forecast

approach for two different forecast horizons, three and six months respectively. The mean and standard deviations of the forecast and actual price series were compared. In order to evaluate the performance of the forecasts, the root mean squared error (RMSE) was used as a parameter to measure the reliability of the approach.[2]

Combining Forecasts with a Hedging Strategy

The goal of the hedger, generally, is to determine an optimal level of hedging (Peck, 1975). However, in this analysis the decision maker either hedges or does not hedge, based on the signal provided by the price forecast. This deviates from much of the portfolio theory that provides information on the quantity to hedge as well as this hedging decision itself. However, it is unlikely that serious harm is done by enforcing this hedge or no hedge decision, because of the small quantity of finished hogs that most Northwest producers have available for sale at any given period of time. Nelson (1985) provides an interesting discussion of the economic consequences of the "lumpiness" of hedging in futures contracts versus hedging utilizing forward cash contracts.

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[2] Mean = $\sum_{n} P^{F}n$ and $\sum_{n} P^{A}/n$

Standard derivation = $[\sum_{n}(P^{F}\text{-mean})^{2}/n\text{-}1]^{1/2}$

Root Mean Squared Error = $[(\sum_{n}(P^{A} - P^{F})_{2})/n\ ]^{1/2}$

Where P^{F} = forecast price and P^{A} = actual price.

A simple rule for hedging was followed: A producer will hedge if the current futures market price adjusted for the expected basis, at the time of delivery is higher than the forecast cash price for that same delivery time. On the other hand, a producer will not hedge if the adjusted futures market price is lower than the forecast cash price.

Of the seven live hog futures contract months, the February, June, August and December contract months were selected for the quarterly analysis. The current futures market prices were evaluated averaging the daily futures prices of the last week of the quarter when the forecasts are generated. The futures contract expiration price was calculated averaging daily futures prices of the first week of the contract month. Finally, in order to adjust the current futures market prices, the predicted basis was calculated by averaging the previous basis values in each corresponding marketing period for the past two years.

Forecast Model Performance

The number of times over the period in which the producer chose to hedge based on the forecast price signal were calculated for each forecasting approach and for each forecast horizon. The mean price and standard deviations of the actual prices received by producers were also calculated. Efforts were extended to calculate the number of times the forecast price signal to hedge was correct or incorrect and the magnitude of the price increase opportunity or the foregone opportunity, respectively. The foregone opportunity implies that

prices moved adversely against the hedge position, and the opportunity to get a higher cash market price is lost.

Risk Reduction Evaluation

Peck (1975) indicates that, traditionally risk evaluations have simply compared variation in the hedge series with that of the unhedged series to evaluate risk reduction. However, in this study, efforts were extended to measure risk reduction by comparing the root mean squared errors (RMSE) of the forecast series with the corresponding RMSE presented by the combined forecasting-hedging approach. In other words, this analysis examines only that portion of variation in prices which was not predictable. For the unhedged position, the forecast error was used to calculate the RMSE, and for the hedge position the forecast error was replaced with the basis error to calculate the RMSE. This was done, since once a hedge position is established, only basis risk remains. Since the two error series are likely to be cross correlated a specific procedure (Ashley, 1980) was used to test if the mean square error (MSE) of the combined forecasting-hedging approach is statistically smaller than the MSE of the respective forecasting approach.

The composition of the variance of the hedged and unhedged series may give better insights into the various factors affecting the producer's outcome. The following equation indicates the components of the price received by producers:

$$P_t = CP_t + h(FPS_{t-1} - FPB_t) \qquad (1)$$

Where, P is price received by producers, CP is the cash price, h takes a value of zero if an unhedged position, and value of one if a hedged position is taken, FPS is the futures price at the time the contract is sold, FPB is the futures price at the time the contract is repurchased, and t is the time period.

Rearranging terms, equation (1) can be rewritten as follows:

$$P_t = CP_t + hFPS_{t-1} - hFPB_t \qquad (2)$$

Finally, the following equation defines the variance of P_t (Gujarati, 1978).

$$\begin{aligned} \text{Var } P_t = {} & \text{Var } CP_t + \text{Var}(hFPS_{t-1}) + \text{Var}(hFPB_t \\ & + 2\text{Cov}(hCP_t, FPS_{t-1}) - 2\text{Cov}(hCP_t, FPB_t) \\ & - 2\text{Cov}(hFPS_{t-1}, FPB_t) \end{aligned} \qquad (3)$$

Equation (3) indicates that the total variation in prices (Var P_t) is equal to the variance in the cash prices (Var CP_t) plus the variance in the selling futures price [$(hFPS_{t-1})$] plus the variance in the buying futures price [$(hFPB_t)$] plus two times the covariance between the cash price and the selling futures price [$2\text{Cov}(hCP_t, FPS_{t-1})$] minus two times the covariance between the cash price and the buying futures price [$-2\text{Cov}(hCP_t, FPB_t)$] minus two times the covariance between the futures prices sell and buy [$-2\text{Cov}(hFPS_{t-1}, FPB_t)$]. Where h equals zero or one, if an unhedged or hedged position is taken, respectively.

CHAPTER III

DATA

This chapter presents the procedures employed in generating data, and a review of the reference sources from which the data were obtained.

The data used for this study are quarterly data for the 1980(1) - 1986(2) period.

Cash Prices

Cash prices were obtained from the United States Department of Agriculture (USDA) annual publication, Livestock and Meat Situation for the period 1980(1)-1986(2). Prices represent $/cwt for USDA No. 1 and No. 2 Barrows and Gilts, as reported for the average at the seven major Midwest markets.

Pacific Northwest (PNW) cash prices were obtained from the Federal State Market News Information Service, Oregon State University. Prices represent $/cwt for USDA No. 1 and No. 2 barrows and gilts, as reported for Spokane, Washington.

Cash prices represent the price that exists when the futures contracts are terminated, that is, when the futures contract is bought back and the hogs are marketed in the actual cash market. The cash prices during the first week of the contract months considered in this study were used to construct the actual cash price series for both the Midwest and Spokane markets.

Futures Prices

Seven futures contracts for live hogs are traded on the Chicago Mercantile Exchange, corresponding to seven different months of the year. They are contracts which expire in February, April, June, July, August, October, and December. Price quotes for each contract month constitutes a specific futures price series. Futures prices were obtained from The Wall Street Journal for the period 1980(1)-1986(2). These prices are quoted daily. However, for this study a daily average of a specific week was used.

Of the seven contract months, the February, June, August, and December contracts were selected, corresponding to the most likely marketing periods of hogs following the U.S.D.A. quarterly Hogs and Pigs report, and the subsequent U.S.D.A. price forecasts. In other words, it was assumed that the decision to hedge or not hedge hogs was made shortly after U.S.D.A.'s price forecasts are released. The hogs would then be sold either three or six months later. The future contracts correspond to these marketing dates.

Futures Price "SELL" (FPS)

Futures prices "sell," correspond to futures prices that exist at the time when the forecasts are generated. Those futures prices were calculated averaging the daily futures prices of the last week of the quarter when the forecasts were generated. Since the U.S. Department of Agriculture barrow and gilt forecasts are generated quarterly at

approximately the 20th of December, March, June and September, the fourth week of these months was used to construct the futures price sell series. Given that two different forecast horizons were analyzed, three and six months in advance, two different futures price sell series were generated, three and six months, respectively.

Futures Price "BUY" (FPB)

The futures price "buy" series correspond to futures prices that exist at the expiration month. In order to avoid the unusual price fluctuations that occur during the final days of a contract, the daily average of futures prices during the first week of the expiring contract month was used to construct the futures price buy series.

Expected Pacific Northwest Basis

Basis is defined as the difference between a specific futures contract price and the cash price at a specific point in time and location. The Pacific Northwest (Spokane, Washington) expected basis is a forecast of the basis three or six months after the potential hedge is being evaluated. It is a forecast of the expected basis in Spokane, during the expiration month of the futures contract, when the hogs will be sold in the cash market.

This expected basis was forecast using a simple average of the Spokane basis for the previous two years at each marketing period, for each specific contract. Again, to avoid unusual movements in the

futures contracts during the expiration month, the first week of the contract month was used to construct this series.

Price Forecasts

As previously described in Chapter II, a quarterly forecast of the average barrow and gilt price in seven major Midwest hog markets was used in this study, as an illustration of how a readily available price forecast could be used by producers. These forecast prices were obtained from the United States Department of Agriculture monthly publication, World Agricultural Supply and Demand Estimates, for the period of 1980(1) to 1986(2). Forecast prices represent $/cwt for barrows and gilts. The forecasts used in this study were the forecasts generated immediately after the quarterly Hogs and Pigs report was released by U.S.D.A.'s Statistical Reporting Service. In general, these reports were around the 20th of December, March, June and September. In each case, two price forecasts were obtained, three and six months prior to the expected marketing date.

Before selecting the U.S.D.A. forecasts, some simple descriptive statistics of the forecast and actual time series were made. It is important to note that while potentially quite useful in helping to locate problems or weaknesses in particular forecast series, these measures are also quite arbitrary. They do not take into account any difficulties which might be inherent in a specific time series nor do they in any way indicate the possible source of problems. Further, these simple measures are not associated with any statistical tests of hypotheses regarding the "worth" or relative merit of the forecasts.

In short, when interpreted carefully these measures can be useful to an analyst in assessing forecasts, but they in no way give a definitive measure of the "success" of any forecasting effort.

A. Percent Error

A percentage error is measured as the differences between the predicted value and the actual value and is expressed as a percentage of the actual value. Summary statistics include average percent error, range of percent error and the percentage of underestimates and overestimates for each forecast.

The magnitude of percentage error is of obvious concern in evaluating a forecast. The percentage of underestimates and overestimates for each forecast may be used to detect forecast bias. An unbiased forecast should have an equal percentage of underestimates and overestimates. The formula used in the percent error calculation is:

$$E(t) = \frac{F(t) - A(t)}{A(t)} = 100$$

where:

E(t) = Percent error at time t.

F(t) = Forecast value at time t.

A(t) = Actual value at time t.

B. Theil-U Statistics

Two Theil statistics are calculated and for convenience, are labeled U-1 and U-2. U-1 compares the forecast to the alternative which predicts no change from the last year's <u>forecasted</u> value. U-2

compares the forecast to the naive no-change forecast, that is, to the forecast which would predict no change from the last year's observed value. The Theil-U statistics are computed as:

$$U\text{-}1 = \frac{\sqrt{\sum_{t=1}^{T} [(F(t) - F(t-f)) - (A(t) - A(t-f))]^2}}{\sqrt{\sum_{t=1}^{T} (A(t) - A(t-f))^2}}$$

$$U\text{-}2 = \frac{\sqrt{\sum_{t=1}^{T} (F(t) - A(t))^2}}{\sqrt{\sum_{t=1}^{T} (A(t) - A(t-f))^2}}$$

where

F(t) = Forecast value at time t.

A(t) = Actual value at time t.

f = Frequency of data (four if quarterly, one if annual).

The Theil-U statistic is equal to zero if and only if the forecast or forecasted change is perfect. The statistic is equal to 1 if the root mean squared error of the forecast is equal to that of the comparison (naive) forecast. Thus, using this root mean squared error as a measure of the relative worth of the forecast, the Theil-U statistic can be interpreted as follows:

U = 0	Forecast is perfect.
0 < u < 1	Forecast is better than naive alternative.
U = 1	Forecast is equivalent to naive alternative.
U > 1	Forecast is worse than naive alternative.

In using this criterion, it should be noted that the Theil statistic is biased toward favoring the forecasts when the lead for the forecast is less than one year. In these cases a forecast of one, two, or three quarters ahead is being compared with a naive forecast of four quarters ahead. Correcting for this bias, however, would require seasonal adjustments of the naive forecasts.

C. Directional Accuracy

Directional accuracy is measured by the number and percent of the forecast points which predicted the correct directional change as measured from the last known observation for the season of the forecast point being evaluated. That is, first quarter data is compared with the last known first quarter data, second quarter data with the last known second quarter data, etc.

These statistics are based on the comparative signs of the quantities:

$$\text{Actual change} = \frac{A(t - A(t-kf)}{A(t-kf)}$$

$$\text{Forecasted change} = \frac{F(k,1) - A(t-kf)}{A(t-kf)}$$

where:

$A(t)$ = Actual value at time t.

$F(t,1)$ = Forecasted value at time t made one period before t.

f = Frequency for the variable (four if quarterly, one if annual).

k = Number of years associated with the forecast lead time l (given in months); so k = 1 if $0 \leq l \leq 12$, k = 2 if $13 \leq l \leq 24$, etc.

D. Revision Ratios

Theil's revision ratio provides for comparisons of forecasts of an event made at different points in time. Hence, this measure can be used to determine whether forecasts improve as one gets closer to the event. $R_{t,i.j}$ is the revision ratio for the forecast made i periods before the event relative to the forecast made j periods (i j) before the event (which occurred at t). The formula for the revision ratio

$$R_{t,i.j} = \frac{F(t,j) - F(t,i)}{A(t) - F(t,i)}$$

where:

F(t,k) = Forecast value for the time t made k periods before t.

A(t) = Actual value at time t.

The revision ratio statistics can be interpreted as follows:

$0 < R < 2$ As a successful revision: the forecast made with lead j is closer to the actual value than the forecast made with lead i.

$0 < R < 1$ A successful revision, but the revision was too small.

T = 1 A perfect revision.

$1 < R < 2$ A successful revision, but the revision was too large.

$R \leq 0$; $R \geq 2$ The revised forecast is no closer to the actual value than was the earlier forecast. $R < 0$ indicates that the revision is also in the wrong direction.

Evaluation of U.S.D.A.'s Hog Price Forecasts

Using these descriptive statistics, U.S.D.A.'s three and six month price forecasts of barrow and gilts in the seven major Midwest markets are analyzed below. Table 2 shows the percent error of both the three and six month forecasts for each quarter from 1980(1) through 1986(2).

Table 2. Three and Six Month USDA Barrow and Gilt Price Forecasts.

Quarter	Midwest Cash Price	USDA 3 Month Forecast Price	USDA 3 Month Forecast % Error	USDA 6 Month Forecast Price	USDA 6 Month Forecast % Error
Feb. 80	36.31	38.00	4.65	32.00	-11.87
June.80	31.18	36.00	15.46	36.00	15.46
Aug. 80	46.23	37.00	-19.97	39.00	-15.64
Dec. 80	46.44	44.00	-5.25	39.00	-16.02
Feb. 81	41.13	44.00	6.98	48.00	16.70
Jun. 81	43.63	47.00	7.72	45.00	3.14
Aug. 81	50.42	53.00	5.12	57.00	13.05
Dec. 81	42.63	49.00	14.94	51.00	19.63
Feb. 82	48.17	45.00	-6.58	49.00	1.72
Jun. 82	56.46	51.00	-9.67	47.00	-16.76
Aug. 82	61.99	57.00	-8.05	55.00	-11.28
Dec. 82	55.12	60.00	8.85	56.00	1.60
Feb. 83	55.00	58.00	5.45	60.00	9.09
Jun. 83	46.74	52.00	11.25	57.00	21.95
Aug. 83	46.90	47.50	1.28	55.00	17.27
Dec. 83	42.18	41.50	-1.61	40.00	-5.17
Feb. 84	47.68	47.00	-1.43	44.00	-7.72
Jun. 84	48.91	51.00	4.27	47.00	-3.91
Aug. 84	51.21	55.00	7.40	60.00	17.16
Dec. 84	47.65	46.00	-3.46	54.00	13.33
Feb. 85	47.32	50.00	5.66	50.00	5.66
Jun. 85	43.09	44.50	3.27	51.00	18.36
Aug. 85	43.62	50.00	14.63	51.00	16.92
Dec. 85	45.05	42.00	-6.77	50.00	10.99
Feb. 86	43.30	47.00	8.55	48.00	10.85
Jun. 86	47.23	45.50	-3.66	46.00	-2.60

The summary statistics, average percent error, range, percent of the estimates which were either overestimated or underestimated and Theil's U statistics are listed in Table 3. As expected, the average percent error as well as the range is smaller for the three month forecast compared to the six month forecast.

Table 3. Summary Statistics of U.S.D.A. Barrow and Gilt Price Forecasts.

Statistic	3 Month Forecast	6 Month Forecast
Percent error		
Average	7.38	11.69
Low	1.28	1.60
High	19.97	21.95
Percent Underestimated	38.50	34.60
Percent Overestimated	61.50	65.40
Theil's U-1	0.674	1.199
Theil's U-2	0.442	0.738

Both price forecasts have a higher percentage of the forecasts overestimated rather than underestimated. This has been a tendency of U.S.D.A.'s forecasts with respect to all red meat animal groups during this time period, as this product group has been generally liquidating animal numbers. As may be expected, production has been underestimated while prices have been overestimated.

Theil's U-1 and U-2 statistics are also included in Table 3. They show that the three month forecast is better than either alternative which predicts no change from last year's forecasted value (U-1), and the naive no change from last year's observed value forecast (U-2).

However, the results for the six month forecast were not as clear. It appears that the six month forecast is worse than the alternative forecast of no change from last year's forecasted value (U-1). On the other hand, the forecast seems better than the alternative of no change from last year's observed value (U-2).

Theil's revision ratios, comparing forecasts of an event made at different points in time are shown in Table 4.

Table 4. Summary of R Statistics by Forecast Time Series of U.S.D.A. Barrow and Gilt Price Forecasts.

Result	6 to 3 Months	3 to 0 Months
No change forecasted	0%	0%
Successful Revision (Closed)	23%	69%
Unsuccessful Revision (Further)	77%	31%

In general, these revision ratios indicate that U.S.D.A.'s price forecasts made closer to the event were more successful than those made further away. For example, the three month forecasts of hog prices in the seven major markets were 69 percent successful three months in advance, while a six month forecast was only 23 percent successful relative to the forecast made three months before the event.

The last statistic calculated concerning the U.S.D.A. seven market barrow and gilt price forecasts was a summary statistic of the directional accuracy. As shown in Table 5, both the three and six month forecasts were approximately 60 percent accurate in predicting the correct directional change.

Table 5. Directional Forecast Summary of U.S.D.A. Barrow and Gilt Price Forecasts.

Category	6 to 3 Months	3 to 0 Months
Total Forecasts	25	25
Number Correct	16	15
Percent Correct	64	60

Pacific Northwest Naive Forecasts

The final data set used in this study is the array of prices generated when one assumes that today's cash price is an acceptable forecast of the price in some future time period. This particular series assumes that the Pacific Northwest cash barrow and gilt price which existed at the time that U.S.D.A. was generating their price forecasts, is the appropriate "naive" forecast. These forecasts were generated quarterly on approximately the 20th of December, March, June, and September. Therefore, the "naive forecasts" are the cash prices that existed the fourth week of each of these respective forecast periods. Two series were generated, one for the three month forecast horizon, and the second for the six month forecast, respectively.

CHAPTER IV

RESULTS

The purpose of this chapter is to present the results obtained from the empirical analysis of this study and provide an economic interpretation, keeping in mind the appropriate economic theory and its related assumptions.

Localizing Price Forecasts

To be practical, expected prices in the Pacific Northwest needed to be compared to the price forecast series readily available from U.S.D.A. This was examined by evaluating the correlation between the Midwest seven market barrow and gilt price series and comparable data for the Spokane, Washington auction market. To determine the degree of correlation between the two series, the Midwest price series was regressed on the Spokane prices, using quarterly data from 1980(1) to 1986(2). The statistical results are presented in Table 6. The coefficient of determination (R^2) indicates that 88 percent of the variability in barrow and gilt prices for the Spokane market can be attributed to the variation of the average seven market Midwest price. Furthermore, the Durbin-Watson statistic suggests that no autoregression is indicated, and we can retain the least squares estimates without fear of a bias of the estimated standard errors.

Table 6. Regression Equation for Spokane, Washington and Seven Market Midwest Barrow and Gilt Prices, 1980(1)-1986(2).

Model	Coefficient (St. Error)
Constant	0.71 (0.20)
Midwest Price	1.04** (13.34)
R^2	0.88
DW	1.94

**Significantly different from zero at the 99 percent confidence level.

The average price of barrows and gilts in the Pacific Northwest was $1.04 greater than the average price of comparable hogs in the Midwest during this time period. This price relationship persists, and may be explained by two factors. First, the Pacific Northwest region is considered a deficit supply area for slaughtered hogs, and hence, is expected to have a higher price for locally slaughtered hogs when compared to a surplus supply area, such as the Cornbelt. The second reason relates to the physical quality of pork over time. Unlike beef, which improves in quality as it ages, pork deteriorates as it ages, and retailers are willing to pay a premium to local packers for pork that has a longer retail shelf life.

Given that such a high degree of correlation was present between these two cash markets, it was further assumed that the quarterly U.S.D.A. barrow and gilt price forecasts for the average seven major

Midwest markets could be adjusted to reflect the expected price of barrow and gilts in the Spokane (PNW) market. Hence, the simple adjustment of adding the average difference of $1.04 to the U.S.D.A. price forecasts for the Midwest markets was made, transforming the forecasts into a series representative of Pacific Northwest prices. Of course, it is recognized that it may be possible to identify the influence of regionally specific variables that may improve these forecasts, but given the resource constraints of this study, no other adjustment factors were evaluated.

Evaluation of PNW Forecasts

The transformed U.S.D.A. forecasts for twenty-six quarter period, 1980(1) through 1986(2) were evaluated relative to the actual barrow and gilt cash price in the Spokane, WA auction. The mean, standard error and root mean squared errors, for both series are presented in Table 7. The means and standard deviations of the forecast series compare quite closely with those of the actual cash price series. When comparing the root mean square errors, it is obvious that the three month U.S.D.A. forecast model was most accurate. However, the only comparison that was statistically (5 percent level) different, appeared when the three month U.S.D.A. price forecast was compared to the naive model that assumed the cash price six months from the forecast would be the same as the cash price at the time the forecast was made.

Table 7. Quarterly Barrow and Gilt Price Forecast Performance, Spokane, Washington, 1980-1986.

Model	Mean Price	Standard Error	RMSE
Actual Spokane Price	$47.79	$6.57	
3 Month U.S.D.A. Forecast	48.66	6.04	4.84
6 Month U.S.D.A. Forecast	49.77	7.14	6.69
3 Month Naive Forecast	48.27	6.51	6.68
6 Month Naive Forecast	48.40	6.46	7.58

Combining Forecasts with a Hedging Strategy

As discussed earlier, a restrictive assumption was made that the decision maker made one of two choices, hedge or not hedge all the hogs which were to be marketed at a specific time. The decision rule followed was: a producer will hedge all of the hogs intended to be marketed if the current futures market price adjusted for the appropriate basis is larger than the forecast cash price for that quarter. On the other hand, a producer will not hedge if the basis adjusted futures market price is lower than the forecast cash price. An objective of this analysis was to evaluate whether producers could have received a return higher than the average cash market price by following this "hedging rule." In addition, this study was intended to evaluate if these hog producers could have reduced the uncertainty associated with price instability.

The results obtained from combining six alternative forecasts with a hedging strategy for Pacific Northwest hog producers are shown in Table 8. The most successful strategy, with respect to the highest mean price, was obtained when the U.S.D.A. forecast for barrows and gilts, forecast three months before the actual marketing date, was used in the hedging decision. In fact, the producer would have hedged eleven out of the twenty-six available opportunities, and would have netted an additional $1.14 per hundred weight for the hogs marketed, compared to the alternative of never hedging and always selling in the cash market.

Table 8. Statistical Summary of Alternative Forecasting/Hedging Strategies, Spokane, Washington Auction, 1980-1986.

Forecast Approach	Mean Price	Standard Error	RMSE	Number of Hedges
U.S.D.A. 3 months	48.93	6.21	3.59	11
U.S.D.A. 6 months	48.35	6.29	5.81	10
Naive 3 months	48.11	6.29	5.69	13
Naive 6 months	47.71	5.65	4.19	14
Routine hedge 3 month	47.27	6.11	2.30	26
Routine hedge 6 month	47.71	6.00	2.30	26
Actual cash price	47.79	6.57		

The next best alternative was to use the six month U.S.D.A. barrow and gilt price forecast, while the third best alternative was obtained by using the three month "naive" forecast. The remaining three forecast techniques yielded average returns which were less than the "no-hedge" alternative. These results confirm what has been argued elsewhere, that price forecast models which include demand and supply information ought to perform better than the naive (today's price) approach (Brandt, 1985). However, the price differences were quite small in all cases, with no statistical difference between any of the pairs of mean values.

Risk Reduction Evaluation

Peck (1975) indicates that economists traditionally have attempted to measure risk related to hedging by simply comparing standard deviations in the hedged series with those of the unhedged series. In this study, two different analytical approaches were used to evaluate risk reduction. The first approach is formulated to examine only that portion of variation in price which was not predictable. The second approach is the traditional comparison among variances of the alternative forecasting-hedging series.

The first approach to measuring risk reduction was to compare the root mean squared errors (RMSE) of the combined forecasting-hedging strategies presented in Table 8, with the RMSE for each of the original cash forecasting approaches, as presented in Table 7. The RMSE's of the combined forecasting/hedging strategies are all lower than those of their respective forecast series. The average reduction

was about 25 percent, with a range of 13 to 45 percent. However, none of these differences are statistically significantly different from one another.

One of the outcomes of this study confirms what Brandt (1985) discovered with respect to a routine hog hedging strategy of placing a hedge-without regard of any information related to barrow and gilt cash price forecasts. The mean prices and standard deviations for the routine strategy are similar to those of the other hedging strategies. However, the root mean square error of the routine hedge strategy is the lowest among all those compared in Table 8. This reduction in risk is at the sacrifice of about $1.66 per hundred weight difference compared to the mean price of the three month U.S.D.A. forecast/hedging alternative.

Although no significant difference between the variance of any of these alternative hedging strategies was observed, the composition of the total variance on prices received by the hog producers may help to understand the behavior of the variation in prices relative to hedging utilizing the futures markets. These statistics are summarized in Table 9, where each component of the total variance in price is calculated, as discussed earlier in Chapter II.

The cash price variances are the same for each of the models because the barrows and gilts are sold in the cash market, regardless if they are hedged or not hedged. The variances for both of the naive models with respect to both the futures buy and sell prices, where the producer assumes that the cash price today is the best forecast of

Table 9. Composition of the Total Variance in Prices Received by Hog Producers by Forecasting--Hedging Strategy.

Component	Price Forecasting Model			
	3-Month USDA	6-Month USDA	3-Month Naive	6-Month Naive
Variable Cash Price, CP	44.91	44.91	44.91	44.91
Variable Futures Price Sell, FPS	634.72	592.95	664.90	658.92
Variable Futures Price Buy, FPB	567.68	541.68	641.23	670.94
Covariable CP, FPS	-62.45	-48.94	0	6.88
Covariable CP, FPB	52.69	-40.54	8.48	34.71
Covariable FPS, FPB	594.27	560.96	646.47	644.91
Total Variable	39.26	40.81	41.14	29.29

cash prices three or six months from now, are larger than the variances for the two U.S.D.A. forecasting models. This result may be explained by the fact that the U.S.D.A. models incorporate expected supply and demand conditions into their forecasts, as do the futures markets. However, the naive forecasts do not.

The covariances between the futures prices and cash prices are expected to be directly related to the number of positive hedging signals which are encountered. That is, the more times hedging is utilized, the greater the covariance between the futures prices and cash prices. The same argument is valid with respect to the covariance of the futures price sell series and the futures price buy series. These expected results are confirmed in Table 9. The "naive" models which actually have a larger number of positive hedging signals

have higher covariances between cash prices and futures prices, and between futures buy and sell prices, as well.

A comparison among models, that is between the U.S.D.A. and the "naive" models, suggest that the greater variation in the three month naive forecast model comes from the larger variation in futures prices themselves. The low variation in the six month naive model is a result of a relatively large amount of hedging, as previously discussed, which dominates the large variation in the futures prices. However, a comparison within sources of models, that is between the three and six month U.S.D.A. forecasts, indicates that the largest impact on variability arose from the covariation that exists between cash prices and futures prices, and between the sell and buy futures prices. A closer examination of the components of the variation for the three and six month U.S.D.A. forecasts shows that the component of the total price variation which results in the three month forecast model being less variable relative to the six month hog price forecast model is the larger covariance between the sell and buy futures prices. This result is expected, since theoretically one expects that the futures prices at expiration time (futures buy) are more correlated to the futures sell prices only three months prior to expiration compared to the sell futures prices six months prior to expiration. As stated before, the futures prices three months before expiration are a better estimate of the supply and demand conditions which will ultimately exist at expiration, compared to the futures prices six months in advance of the actual event. The same argument holds when comparing the two "naive" models.

Leuthold (1979) argues this point as well. He further argues that price differences between a cash market and the futures market should differ from each other primarily due to location characteristics, and that this difference is reasonably accounted for in the basis estimates (Brandt, 1985).

A graphical view of the revenue and risk reduction discussion is presented in Figure 2. Prices of barrows and gilts received by Pacific Northwest hog producers, corresponding to each marketing strategy are plotted against their corresponding standard deviation.[3] The lack of statistically significant evidence of differences among marketing strategies makes it difficult to draw any definite conclusions. However, it is intuitively obvious by looking at Figure 2 that the three and six month U.S.D.A. forecast based strategies and the three month "naive" forecast based strategy represent to hog producers a higher price compared to the revenue received when no hedging was ever used, and at the same time, these three strategies represent a reduction in the risk associated with price--the best of all worlds.

On the other hand, when these three strategies are compared to the two strategies which followed routine hedging, without regard of any outlook information, and the six month "naive" forecast model, the "usual" expected trade off between price and risk is observed.

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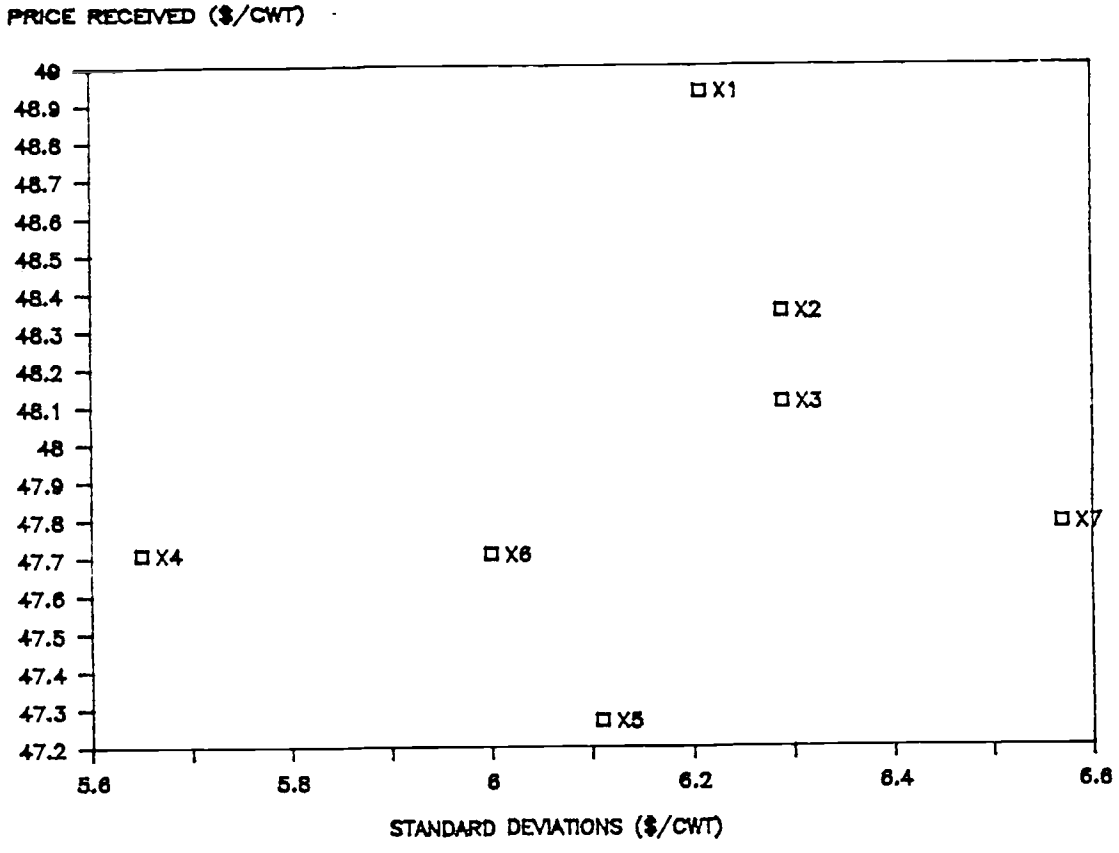
[3]Standard deviations were considered as an appropriate measure of risk rather than variance, because they are expressed in the same unit ($/cwt).

Figure 2. Average Net Price and Standard Deviation of Alternative Forecast Hedging Marketing Strategies of Barrows and Gilts, Spokane, Washington, 1980-1986.



X1 = 3-month USDA Price Forecast.

X2 = 6-month USDA Price Forecast.

X3 = 3-month Naive Price Forecast.

X4 = 6-month Naive Price Forecast.

X5 = 3-month Routine Hedge.

X6 = 6-month Routine Hedge.

X7 = No Hedge - Average Cash Price.

Foregone Opportunities

In this section of the analysis, the number of times a correct or incorrect marketing signal generated by each of the alternative barrow and gilt price forecast approaches was calculated. These results are summarized in Table 10. In addition, the magnitudes of the best price increase and the worst foregone price opportunity are presented. A foregone opportunity refers to an incorrect hedging signal. Therefore, the opportunity to increase revenue through the cash market is lost.

Table 10. Price Increases and Foregone Opportunities for Alternative Price Forecast Models.

	Price Increase Opportunity		Foregone Opportunity	
Forecast	No. of Hedges	Highest Level $/cwt	No of Hedges	Highest Level $/cwt
U.S.D.A. 3 month	9	11.65	2	9.92
U.S.D.A. 6 month	6	14.95	4	7.20
Naive 3 month	8	6.70	5	9.92
Naive 6 month	6	14.95	8	17.30

Of the eleven positive hedging signals generated by using the three month U.S.D.A. forecasting model, nine of those decisions were correct, an 82 percent success rate. The six month U.S.D.A. forecasting model generated six correct signals of the ten positive hedging opportunities identified. The hedging signals generated by

the three month naive model were correct 62 percent of the time. And finally, of the fourteen hedging signals generated by the six month naive forecasting model, six were correct (43 percent). As expected, these results show that it is easier to make correct three month forecasts compared to six months in advance. The magnitude of the correct signals generated by the U.S.D.A. models were large enough to offset the losses incurred by the incorrect signals. But, that is not true for the naive models where the foregone opportunities (losses) were larger than the increases in revenue garnered from the correct decision.

CHAPTER V

SUMMARY AND CONCLUSIONS

The overall objective of this study is to empirically evaluate whether Pacific Northwest hog producers could receive a higher price than the average cash market price, and whether these producers could reduce the related price uncertainty by using a selective hedging strategy in the live hog futures market. This selective hedging strategy combines various price forecasts with localized futures market prices. If the current futures market price, adjusted for the appropriate basis, was higher than the forecast cash price, the producer was assumed to have hedged all hogs marketable during that quarter. It is from this short-run point of view, using portfolio analysis, that this study explores the economic implications of hedging hogs in the Pacific Northwest.

The analysis was conducted using quarterly data for the 1980(1) through 1986(2) time period. The primary price forecasts were those obtained from U.S.D.A.'s analysis of quarterly barrow and gilt prices of seven major Midwest markets. Two forecast horizons, three and six months before the hogs were marketed, were analyzed. In addition, these Midwest based forecasts were compared and adjusted to reflect expected hog prices in the Pacific Northwest. Furthermore, the naive price forecast, assuming that prices three and six months from now will be the same as today's cash price, were utilized in setting the hedging strategies.

The mean squared errors (MSE) of each hog forecasting model were compared. The three month U.S.D.A. forecast was the most accurate

forecast, significantly better than the six month U.S.D.A. forecast and the three and six month "naive" forecasts.

Over the time span of this study, the hedging signals obtained from the three and six month U.S.D.A. forecasts, and the three month naive forecasts resulted in a higher mean price for Pacific Northwest hog producers, compared to the mean of the actual cash prices. The opposite was observed in the case of the six month naive forecasting model.

Two different analyses were conducted to evaluate risk reduction as a result of utilizing selective hedging. The first approach examined only that portion of the variation in price which was not predictable. The second approach utilized the traditional comparison among variances of the alternative forecasting-hedging price series.

The root mean squared errors (RMSE) of the combined forecasting-hedging strategies averaged 25 percent lower than those of their respective forecast series. However, none of these differences were statistically different from one another.

Although no significant differences between variances of the combined forecasting/hedging strategies was observed, the composition (component by component) of the total variance in price received by the PNW hog producers was analyzed. In general, these results suggest that the greater variability in revenue observed in the "naive" based strategies, relative to the supply and demand oriented U.S.D.A. forecasts, comes from the larger variation in the futures prices themselves. The covariance between the cash and futures prices were found, as expected, to be directly related to the number of hedges

generated by a specific forecast series. Comparison of these variances suggest that all the forecast-hedging strategies considered represented, if not significantly, modest reduction in the risk associated with instability of prices. However, the results suggest that producers may best utilize the three month U.S.D.A. price forecast to evaluate selective hedging opportunities.

Finally, efforts were made to evaluate the number of times the hedging signals generated by each combined forecasting-hedging models were correct or incorrect. Of the eleven hedging signals generated by the three month U.S.D.A. price forecast, nine were correct. The remaining forecasts generated results that were correct a considerably smaller percentage of the time (43 to 62 percent).

Conclusions

This study illustrates that Pacific Northwest hog producers could have received a higher price during 1980 to 1986, than the average cash market price, and could have also reduced the risk associated with price fluctuations, by combining the information from U.S.D.A. price forecasts and live hog futures markets into a selective hedging marketing model. However, the lack of evidence of statistical differences between the parameters studied make it difficult to draw strong, definite conclusions and subsequent marketing guidelines. The results of this study are consistent with the findings of other studies which have shown that the combination of cash price forecasts and futures market quotations can be effective in reducing risk associated with price.

Two major conclusions may be reached as a result of the empirical analysis related to the specific research objectives:

(1) Although the U.S.D.A. quarterly barrow and gilt price forecasts are generated for seven major Midwest hog markets, this study demonstrated that these forecasts can be used for the Pacific Northwest region with a good degree of reliability, after a simple average price adjustment.

(2) The empirical result suggest that Pacific Northwest hog producers may effectively combine U.S.D.A. price forecasts and live hog futures into a relatively simple selective hedging marketing program that could increase revenue while lowering price risk.

Suggestions for Future Study

This study was based upon quarterly data, which presents limitations since producers make marketing and pricing decisions on a much more frequent basis. In addition, price forecasts were for three and six months, while longer time horizons may be needed.

This study simply utilized price forecasts which were readily available. Clearly, additional research, dealing with regionally specific supply and demand estimates may improve the economic outcomes of using selective hedging strategies.

Some producers may produce enough hogs, that varying the amount of animals hedged in any one decision should be included in the analysis. This can be accomplished utilizing the same portfolio theory outlined in this study.

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