Local Polynomial Kernel Forecasts

and Management of Price Risks using Futures Markets

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This study contributes to understanding price risk management through hedging strategies in a forecasting context. A relatively new forecasting method, nonparametric local polynomial kernel (LPK), is used and applied to the hog sector. The selective multiproduct hedge based on the LPK price and hedge ratio forecasts is, in general, found to be better than continuous hedge and alternative forecasting procedures in terms of reduction of variance of unhedged return. The findings indicate that combining hedging with forecasts, especially when using the LPK technique, can potentially improve price risk management.

Keywords: forecasts, hog sector, selective hedge, nonparametric local polynomial kernel

I. Introduction

Price risk has long been a concern for market participants in the hog industry who are faced with daily hedging decisions. Hog producers are exposed to the risks of hog prices decreasing and input price increasing, implying that it might be reasonable to hedge only when unfavorable price movements are expected. Hedging strategies can take a number of forms, but there is some evidence to suggest that selective rather than continuous hedging may offer the producer more attractive outcomes. Leuthold and Mokler (1980) and Kenyon and Clay (1987) examined livestock and found that selective profit margin hedging could raise average profits and/or reduce profit variance. Combining with forecasting techniques, selective hedging was found to produce less price variability in several studies (Brandt, 1985; Holt and Brandt, 1985; Park, Garcia, and Leuthold, 1989; Zanini and Garcia, 1997). Brandt (1985) and Zanini and Garcia (1997) forecasted hog prices using several forecasting alternatives such as econometric models, ARIMA, naï ve, and composites to generate signals that determined whether to hedge or not for each out-of-sample period. These studies suggest that the accuracy of forecasting prices is important for deciding when to hedge, thereby determining the performance of hedging. Thus, if price movements can be predicted accurately, hog producers are likely to have an opportunity to stabilize profits, or even improve them relative to hedging all the time.

Forecasting models are often derived assuming that the functional form of a model is correctly specified (usually linear), and that it coincides with the mechanism that generated the observed data. In addition, many assessments of economic forecasts have been based on the assumptions of a normal and constant, time-invariant, data generating process. And hence, forecasting results are likely to be biased when these assumptions are not realized in the forecasting procedure. Considerable development has been made to ease these assumptions. Among several, the nonparametric kernel approach suggested by Ullah (1987) is a good device to avoid the possible risk of specification errors. Nonparametric approaches focus on the information contained in the data themselves, and hence let the data show the appropriate functional form without depending on any specification assumption. In addition, nonparametric approaches can facilitate direct forecasting conveniently, obviating the need to estimate parameters. Only direct estimates of the conditional mean are required.

Nonparametric kernel forecasting procedures have not been used extensively, perhaps due to computational difficulty. Moschini, Prescott, and Stengos (1989) were the first to use classic Nadaraya-Watson (N-W) kernel forecasting in the agricultural economics literature, but no known research follows. These authors compared nonparametric classic kernel point forecasts with parametric econometric (OLS) forecasts, and found that the nonparametric kernel forecast performed as accurate as the parametric forecasts, despite small sample size.

This study examines the degree to which hedging decisions can be improved when combined with price forecasting techniques. Here, a relatively new forecasting method, the nonparametric locally polynomial kernel (LPK), is utilized, which is known for producing a better estimate at the boundary of the data than any other estimators. A selective hedging strategy is implemented based on the relationship of the forecasted price to the cost of production.

The forecasting performance of the LPK is then compared to the vector autoregression (VAR) and naï ve forecasts. This is done by measuring forecasting errors, and by examining whether they provide appropriate marketing signals. Well-forecasted prices may make it possible for hog producers to improve their marketing and hedging decisions.

Hedge ratios used to evaluate hedging decisions are also forecast in an *ex ante* context using the LPK and GARCH(1,1). In addition, a one-to-one hedge is conducted to compare the hedging performance with the LPK and GARCH(1,1). The effectiveness of selective hedging in conjunction with forecasting methods is generated based on the proportional decrease in the unhedged variance of profit, and these results are compared to the results of the unhedged, one-to-one hedged, and continuous hedged strategies.

The next section describes the feeding scenario (selective hedging is explained in this section), followed by details of the LPK forecasting procedure in section III. Sections IV and V report data and the empirical results of hedging effectiveness for forecasts, selective and continuous hedging, respectively. Section VI summarizes the study.

II. Framework for Analysis

Feeding Scenario

Hog producers face multiple price risks due to the volatile prices of live hogs and feed grains, and often achieve the objective of reducing these price risk by forward pricing through either the futures market or forward cash market[1]. Since buyers of hogs, such as meat packers, charge for their services, prices offered through forward cash contracts may be less than those offered using the futures market, and hence the futures market is often preferred to the forward cash market. Another advantage of using the futures market comes from marketing flexibility. It is not necessary to deliver on the futures contract since it can be offset at anytime. This allows the producer to carefully assess cash prices when ready to actually deliver the hogs. For these reasons, it is assumed hog producers will hedge using the futures market.

[1] Forward pricing is not the only alternative to managing pricing risk. Floor pricing through the options market provides a minimum price while allowing the producer to take advantage of any higher prices. Forward pricing on the other hand will provide more price protection against lower prices than will floor pricing, but precludes gains from higher prices.

Here, the feeding (final) stage of hog production (wean-to-finish) is considered because it is the main stage of hog production where large amounts of feed grains are consumed. It takes approximately 4 months to reach final market weight of hogs of about 225 pounds, a stage that begins when the hogs weigh nearly 60 pounds. Among the various feed ingredients, corn is the major feed grain, and about 615 pounds per hog are fed during this period[2]. Corn provides dietary energy in the form of carbohydrates and fat. The hedging decision is framed in two stages. The first stage, from t-6 to t-4, constitutes a planning period before feeding begins (t refers to when the output is marketed, and time is measured in months). At t-6, hedging occurs by simultaneously taking a long position in the input and a short position in the output in the futures market. Hedges on inputs are held for two months until the feeding begins. Corn is purchased for the feeding of hogs at t-4 in the cash market, and at the same time, those input hedges taken at t-6 are liquidated. After feeding, the live hogs are sold in the cash market at t and the associated output futures position held for six months is lifted. The two stages of this hedging decision framework are set up every week. Thus, the hog producer takes positions in futures market for a new lot every week and holds the same position for corn and hogs until feeding begins and hogs are marketed in cash market, respectively.

Description of Selective Hedging

A trigger price is developed for the selective hedging decision framework, which is the cost of hog production. Hog producers should cover their costs of production to maintain and expand their business. Farrow-to-finish producers have suffered from the low hog prices (even historical low prices in 1998) and the high costs of production for last 10 years. Table 1 provides USDA national average of profits and costs of production for farrow-to-finish hog producers (USDA, 2000).

Hog prices have moved unfavorably for hog producers, and downward risk has been substantial in recent years. The costs of production have risen from $39.85/cwt in 1988 to $67.39 in 1996 and $52.87 in 1998. Starting in 1992, the gross value of production has been less than the costs of production, generating negative profits. Specifically, market hog prices began 1998 around $35/cwt and moved to $43/cwt by mid-year. By December, however, they fell to near $11/cwt, 35-40% lower than in 1997. The decline in hog prices was partially offset by lower feed grain costs in 1998. Despite lower production costs, gross value remained far below the production costs. It has been a difficult time for hog producers to survive. Hog producers needed an average hog price of about $52.00/cwt to cover costs, 1988 - 1998 (table 1). If they expected output prices to move below their costs, they would be better off if they had hedged. Thus, production costs are used as trigger prices to hedge based on assumption that annual cost for year t-1 is retained for year t. The binary hedging decision-making is depicted as follows:

[2] Another potentially important input is soybean meal. However, the amount of soybean meal consumed per hog is approximately only 10% of total feed grains while corn takes around 85%. Also, in a similar analysis for live cattle, Noussinov and Leuthold (1999) found that the coefficient of soybean meal hedge ratio was insignificant and did not affect the overall hedging results. In addition, soybean meal adds a third dimension to the kernel estimation, which would make the procedure used in this study very complex. Hence, soybean meal will not be included in the empirical section of this study.

Hog Price → Cash price above a trigger price: No Hedge

Hog Price → Cash price below a trigger price: Hedge

III. Nonparametric Local Polynomial Kernel

Estimation and Forecasts

The local polynomial kernel model for forecasts can be represented as

$$Y_i = m(X_i) + s^{1/2}(X_i)u_i,\ i = 1,\ldots,n, \tag{1}$$

where $X_i = (X_{i1},\cdots,X_{id})^T$ are a set of independent and identically distributed $\Re^{d+1}$-valued random vectors, and the Y_i are scalar response variables. In words, Y_i are cash prices to be forecasted and the X_i are $\Re^d$-valued relevant predictor variables, futures prices, to help forecast prices, having common density f. Also, $s(x) = Var(Y|X = x)$, and $\{u_i\}$ are i.i.d. The conditional mean of Y in (1) can be expressed as

$$m(x) = E(Y|X = x). \tag{2}$$

The objective of model (1) is to estimate the conditional mean of Y, (2), which generates the partial derivatives up to the p^{th} order, $d^p m(x)/dX_i^p$, and forecasts values of Y without imposing the parametric family of functions for $m(x)$ and $d^p m(x)/dX_i^p$.

The local polynomial kernel method estimates the regression function at a particular point by "locally" fitting a p^{th} degree polynomial to the data via weighted least squares. The LPK is known to produce good fits, has known asymptotic properties (Fan, 1993), and is more general than the N-W kernel procedure used previously by Moschini, Prescott, and Stengos (1989).

Specifically, the local polynomial kernel estimator $\hat{m}(x;p,h)$ at a point x is obtained by fitting the polynomial $\boldsymbol{b}_0 + \boldsymbol{b}_1^T(x) + \cdots + \boldsymbol{b}_p^T(x)^p$ to the (X_i, Y_i) using weighted least squares with kernel weights $K_H(x - X_i)$. For simplicity, focus is placed on the local linear least squares kernel estimator, which corresponds to fitting degree-one polynomial (p=1). Then the multivariate polynomial takes the form, $\boldsymbol{b}_0 + \boldsymbol{b}_1^T(x)$ and $\boldsymbol{b}_1 = (\boldsymbol{b}_{11},\cdots,\boldsymbol{b}_{1d})^T$, and the problem is to find the arguments $\boldsymbol{b}$ that solve:

$$Min(Y - X_x\boldsymbol{b}_x)^T W_x (Y - X_x\boldsymbol{b}_x) \tag{3}$$

where $X_x = \begin{bmatrix} 1 & ((x_1,\cdots,x_d)^T - X_1)^T \\ \vdots & \vdots \\ 1 & ((x_1,\cdots,x_d)^T - X_n)^T \end{bmatrix}$, $Y = \begin{bmatrix} Y_1 \\ \vdots \\ Y_n \end{bmatrix}$, and $W_x = \text{diag}\{K_H(x - X_1),\cdots,K_H(x - X_n)\}$.

In this framework, K is a d-variate kernel, $K_H(v) = |H|^{-1/2}K(H^{-1/2}v)$, satisfying

$$\int K(z)dz = 1,\ \int zK(z)dz = 0,\ \text{and} \int zz^T K(z)dz = m_2(K)\mathrm{I},$$

where $m_2(K) = \int z_i^2 K(z)dz$ is independent of *i*, and I is a $d \times d$ identity matrix. The procedure assigns a weight to a particular point Y_i for estimation at a particular point x, where $x = (x_1, \cdots, x_d)$, based on how far a data point X_i is from the prediction point x. The observations close to x have more influence on the regression estimate at x than those farther away. H is a $d\times d$ symmetric positive definite bandwidth matrix, which remains of prime importance as it controls the trade off between bias and variance.[3] The matrix H controls how weight is apportioned among closer and more distant data points. Each data point X_i gets its own weight. Under the common assumption $H = \mathrm{diag}(h_1^2, \cdots, h_d^2)$, where h is a univariate kernel bandwidth, when H belongs to the subclass of diagonal positive definite $d\times d$ matrices, the higher values of bandwidth tend to discount distance between X_i and x less than the lower values. As the bandwidth gets smaller, the local linear fitting process depends heavily on those observations that are closest to x and tends to yield a more saw-toothed estimate. Thus, very low h would correspond to an interpolation of the data and very high h would give a least squares fit of a p^{th} order polynomial.

Forecasts in the nonparametric approach are estimated directly by constructing an empirical counterpart to (2). Then (3) can be solved as

$$\hat{\boldsymbol{b}} = \begin{bmatrix} \hat{\boldsymbol{b}}_0 \\ \hat{\boldsymbol{b}}_1 \end{bmatrix} = \begin{bmatrix} \hat{m}(x) \\ \hat{\boldsymbol{b}}_1 \end{bmatrix} = \left(X_x^T W_x X_x\right)^{-1} X_x^T W_x Y\,. \tag{4}$$

The prediction of the conditional expectation function $m(x)$ is given by the first element in (4), $\hat{m}(x)$, and out-of-sample forecasts, conditional on a set of known x values, can be calculated using

$$\hat{m}(x;H) = \hat{E}(Y|x) = e_1^T \left(X_x^T W_x X_x\right)^{-1} X_x^T W_x Y\,, \tag{5}$$

where e_1 is the $(d+1)\times 1$ vector having 1 in the first entry and all other entries 0. Thus, the value of $\hat{m}(x;H)$ is the height of the fit $\hat{\boldsymbol{b}}_0$. The remainder of the coefficients, $\hat{\boldsymbol{b}}_1$, in the locally linear case, represent estimates of the first partial derivatives with respect to each of the variables, X_i.

The choice of optimal bandwidth is critically important to produce a good fit to the sample. A direct plug-in approach is utilized in this study for local linear regression. Plug-in bandwidth selectors are based on the simple idea of "plugging in" estimates of the unknown quantities that appear in formulas for the asymptotically optimal bandwidth (Wand and Jones, 1995).

For hedge ratio at x, the second element in (4), $\hat{\boldsymbol{b}}$, can be written as follows,

$$HR_t = \hat{\boldsymbol{b}}(x;H) = e_2^T \left(X_x^T W_x X_x\right)^{-1} X_x^T W_x Y\,, \tag{6}$$

where e_2 is the $(d+1)\times 1$ vector with a 1 in its 2 coordinates and zero's elsewhere. A major advantage of (5) and (6) is that it is very simple to visualize how the estimator is using the data

[3] The simplest exa mple of bandwidth is a binwidth (interval) of histogram. See chapter III in Kim (2000) for more details.

when estimating m at a point x. The forecast, $\hat{m}(x;H)$, involves inference based on the local data to fit a regression line, i.e. located near the point of interest and the bandwidth matrix controls how much of "nearness" is considered.

Explicit formulas can be derived from (5) and (6) to estimate the regression function and hedge ratios for local linear (p=1):

$$\hat{m}(x;H) = n^{-1}\sum_{i=1}^{n}\frac{[\hat{s}_2(x;H)-\hat{s}_1(x;H)(x-X_i)]K_H(x-X_i)Y_i}{\hat{s}_2(x;H)\hat{s}_0(x;H)-\hat{s}_1(x;H)^2}\text{, and} \qquad (7)$$

$$HR_t = \hat{b}(x;H) = n^{-1}\sum_{i=1}^{n}\frac{[\hat{s}_0(x;H)(x-X_i)-\hat{s}_1(x;H)]K_H(x-X_i)Y_i}{\hat{s}_2(x;H)\hat{s}_0(x;H)-\hat{s}_1(x;H)^2}, \qquad (8)$$

where $\hat{s}_j = n^{-1}\sum_{i=1}^{n}(x-X_i)^j K_H(x-X_i)$.

IV. Data

The hog producer is assumed to begin planning for, and subsequently feeding, a new lot of hogs every week. Wednesday cash and futures closing prices are used to forecast how much those prices change during the out-of-sample period. Omaha cash and central Illinois bid prices are used as the cash prices for hogs and corn, respectively. Two sample periods are used, a full sample and the live hog period. The full sample period is January 3, 1990 through June 30, 1999 while the live hog period covers from January 3, 1990 to May 30, 1996.[4] Keeping constant the number of observations, 436 for the full sample period and 280 for the live hog period, percentage changes in both cash and futures prices are forecasted weekly for their respective hedging horizons. This generates 57 and 52 forecasted values (approximately one year) for the full sample period and the live hog period, respectively.

V. Results

Forecasting Performance

Three methods are used to forecast cash and futures prices two and six months ahead for both corn and hogs, namely the local polynomial kernel (LPK), various orders of vector autoregression (VAR) models, and naïve forecasts ($E[P_{t+i}] = P_t$).[5] Forecasted prices, denoted as $\hat{Z}_t$, may differ from the "true" value, Z_t, and the difference between these values should be minimized. The difference between $\hat{Z}_t$ and Z_t is called a forecast error and is often measured by the mean squared error (MSE) and mean absolute deviation (MAD). The results of forecasting performance are presented in table 2.[6]

The forecasting performance of the LPK is generally better than VAR and NAÏVE in terms of producing smaller forecasting errors in both MSE and MAD criteria. Using the MSE

[4] The final live hog contract is December 1996 and the first lean hog contract is February 1997. Lean hog prices are converted to live hog prices by multiplying by 0.74 to get overall hog hedge ratios, reflecting the average carcass yield of a 74% from live hogs. The time scale is divided into two groups to examine how hedging effectiveness change after lean hog contracts were introduced.

[5] VAR procedures are not described for brevity. See Clements and Hendry (1998).

[6] The second-order VAR model, denoted as VAR(2), produces the least forecast errors among various orders of VAR. For brevity, only the results of VAR(2) are presented.

criterion, the LPK dominates VAR(2), except for hog futures. However, the LPK has some difficulty out-forecasting the NAÏVE for hog prices. Using the MAD criterion, the LPK forecast errors for both hog cash and futures prices are smaller than those for VAR(2) and the NAÏVE model.

Hedging Strategies and Performance

Forecasted prices are used to signal whether to hedge or not, and to measure the performance of selective hedging relative to continuous hedging. The three forecasted price series generated by the LPK, VAR, and NAÏVE mechanisms are used to trigger whether a hog producer participates in the futures market to hedge price risks. A price of \$66.07 is used to trigger hedges during the full sample period, which is the cost of production in 1997 based on assumption that the cost for one year behind remains the same for the current year.[7] For example, the hog producer does not need to participate in the futures market if the hog price is \$65.00 this week and forecasted to go up to \$70.00 six months from now, which exceeds the trigger price \$66.07. If price is, however, expected to decline to \$60.00, below the trigger price of \$66.07, the hog producer should participate in the futures market to hedge his/her price risks.[8]

Two forecasts are made in selective hedging scenario: (1) a forecast of price (2 and 6 months ahead for corn and hogs, respectively) which, in conjunction with the trigger price, is used to decide whether or not to hedge; and (2) a forecast of the hedge ratio next week which is used if the hedge is placed. Hedge ratios are forecasted weekly, based on price differences over respective hedging horizons, and hedges are held for full hedging periods. Under the continuous hedge scenario, only the hedge ratio is forecast. Single and multiproduct refer to how the hedge ratios are determined. The hedge ratios for corn and hogs are determined independently in the single product case, while the hedge ratios are simultaneously determined in the multiproduct case.

Hedging is evaluated by the commonly used measure of variance reduction (Fackler and McNew, 1993). The larger the reduction in variance of unhedged return, the higher the degree of hedging effectiveness. Hedge ratios are estimated and forecasted weekly by using LPK and *BEKK* GARCH(1,1) models.[9] A one-to-one hedge is also used for comparison.[10] The hedging decision is evaluated for the two out-of-sample periods: June 1, 1998 - June 30, 1999 for the full sample period and June 1, 1995 - May 30, 1996 for the live hog period.

Forecasted prices range from \$10.00 to \$49.40 in the full sample period, June 1, 1998 - June 30, 1999, and none of them is above the trigger price, implying hedging is necessary for the whole period. Hence, the selective hedge becomes continuous hedge for this period. This was the most unfavorable period for hog producers during 57-years of hog price history (USDA, January 2000). Hogs prices plummeted dramatically, so that it was extremely difficult for hog producers to cover their costs even though production costs also fell. Thus, hog producers

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[7] Source is USDA (2000).

[8] Actually, results shown later are identical even if 1998 costs of production, \$52.87, are used.

[9] *BEKK* GARCH (1,1) model is conducted based on Baba et al. (1989).

[10] The term one-to-one hedge is used instead of NAÏVE hedge to differentiate from NAÏVE forecast.

should hedge their price risks to survive during this period, giving an advantage in performance according to the hedging results presented in table 3.[11]

All hedging instruments for the full sample period decrease the variance of return relative to unhedged. Both single and multiproduct hedging bring a reduction in variance by the range of 30.38% to 48.34% from variance of unhedged return. Multiproduct hedging models for both the LPK and GARCH produce more variance reduction than single product hedging. MGARCH performs slightly better than MLPK, but the LPK performs better than GARCH for the single product methodology.

Often, the one-to-one hedge is found to outperform other hedging strategies, and do better than single hedges for both the LPK and GARCH as presented in table 3. Both the LPK and GARCH multiproduct hedging strategies, however, outperform the one-to-one hedge. This finding indicates that the price risk of hogs and corn might be reduced more when the hedging decision on both commodities is made simultaneously rather than independently or naively.

Since the forecasted prices are all below the trigger price for the full sample period, selective hedging is not differentiated from continuous hedging. Selective hedging is conducted again in the live hog period to investigate how well it performs relative to unhedged and other hedging, June 1, 1995 - May 30, 1996. The same procedure is applied, and the cost of production for 1994, $56.57, is used as a trigger price. Again, three forecasting methods are used, the LPK, VAR, and NAÏ VE. Here, forecasted prices by the LPK, NAÏ VE and VAR procedures identify a no hedge position 22, 21 and 17 times out of 52, respectively. The results of effectiveness for both continuous and selective hedges are presented in panels A and B of table 4.[12]

Mixed results are found between the single and multiproduct hedging. Overall, continuous single product hedge by the LPK reduces the variance of unhedged return the most, followed by selective multiproduct hedge by the LPK[13].

While the results must be interpreted with care, they seem to favor the use of the LPK model. In the continuous hedge scenario, where only the hedge ratio is forecast, the LPK models produce the largest reductions in variance in both the single and multiproduct hedge cases. Similarly, in the selective hedge scenario, where both the price and the hedge ratio are forecast, the LPK models perform well. In both the single and multiproduct hedge cases, the use of the LPK model instead of the GARCH model to forecast the hedge ratio leads to the largest variance reductions regardless how prices are forecast. Similarly, in both the single and multiproduct hedge cases, the use of the LPK framework to forecast both the price and the hedge ratio results in the largest variance reduction. Overall, the largest reductions in variance appear when the LPK models are heavily involved either in forecasting the hedge ratio or in forecasting both the price and the hedge ratio.

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[11] The results in table 3 are not differentiated by price forecasting methods because the selective hedge and continuous hedge generate the same results due to all forecasted prices being under the trigger price.
[12] Price forecasts are not needed by the definition of continuous hedge. Thus, the results of the continuous hedge presented in panel A of table 4 are generated by using the hedge ratio forecast only.
[13] Further analysis of selective vs. continuous hedging will be conducted later in terms of mean-variance framework.

Regarding the one-to-one hedging, the results are somewhat mixed. In the continuous hedging scenario, the LPK models in both the single and multiproduct hedge cases out perform the one-to-one hedge. In the selective hedging scenario, the LPK models in multiproduct hedge generally produce larger variance reductions than the one-to-one hedges, particularly when the LPK models are used to forecast the hedge ratio. Overall, the largest reductions in variance relative to the one-to-one hedges emerge when using the LPK models.

The findings contribute to our understanding of hedging effectiveness. In general, they suggest that hedging in a multiproduct context improves its effectiveness relative to the single product context, which is consistent with Fackler and McNew (1993) and Garcia et al. (1995). Further, the results indicate that out-of-sample hedging effectiveness can be improved relative to the one-to-one hedge, which contrasts with Collins (2000), but is consistent with Garcia et al. (1995). With regards to the effectiveness of continuous relative to selective hedging based on forecast information, the overall findings are somewhat difficult to compare to previous literature whose results were based on only a price forecast. The most direct comparison (case 1 and case 6) suggests that it is difficult to improve on the one-to-one hedging effectiveness. It appears that the largest improvement on hedging effectiveness results from forecasting the hedge ratio either independently or in conjunction with the price forecast, and within this, the most improvement comes from using LPK for both price and hedge ratio forecasts.

VI. Conclusion

This study contributes to understanding price risk management through hedging strategies in a forecasting context. A relatively new forecasting method, the local polynomial kernel (LPK), is used and applied to the hog sector. Findings indicate that the LPK does well relative to traditional vector autoregression and naï ve expectation procedures.

Based on forecasted prices generated by these three methods, selective hedging is conducted and compared to various hedging strategies. The selective multiproduct hedge based on the LPK price and hedge ratio forecasts is found to be better than continuous hedge and unhedged in terms of producing reduction in the variance of unhedged return, except for continuous single product hedge by the LPK. The findings indicate that hedging in conjunction with price forecasting can contribute to the improvement of price risk management, and when hedges are based on both price and hedge ratio forecasts using the LPK procedures, the potential for reduced variability in returns is the strongest.

These findings suggest that the LPK framework may be a useful tool for developing hedging and forecasting strategies. Further investigation of the usefulness of the LPK framework needs to consider more completely the costs of understanding and implementing the procedure in realistic hedging situations.

Table 1. Total Gross Values and Costs of Hog Production, 1988-1998

Unit: $/lb.

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Gross Value	43.57	44.34	55.42	49.60	42.45	48.62	41.83	43.52	54.33	56.14	35.02
Costs	39.85	41.51	40.70	40.58	53.12	54.90	56.57	57.23	67.39	66.07	52.87
Profit	3.72	2.83	14.72	9.02	-10.67	-6.28	-14.74	-13.71	-13.06	-9.93	-17.85

Source: USDA annual report (2000)

Table 2. The Performance of LPK, VAR, and NAÏ VE Forecasts

(Full Sample Period)

MSE		LPK	VAR (2)	NAIVE
Corn	Cash	0.00279	0.00465	0.00301
	Futures	0.00263	0.00348	0.00271
Hogs	Cash	0.03523	0.06878	0.03521
	Futures	0.01396	0.01146	0.01015
MAD		**LPK**	**VAR (2)**	**NAIVE**
Corn	Cash	0.04078	0.05243	0.04558
	Futures	0.04022	0.04677	0.04056
Hogs	Cash	0.14177	0.18297	0.15855
	Futures	0.07761	0.07874	0.07984

Number in parenthesis is the order of VAR.

Table 3. The Effectiveness of Various Hedging Strategies, Full Sample Period

Unit: $/lb.

		Variance	Reduction in Variance
Unhedged		0.0813	
One-to-One		0.0500	0.3850
Single	LPK	0.0508	0.3752
	GARCH	0.0566	0.3038
Multiproduct	LPK	0.0434	0.4662
	GARCH	0.0420	0.4834

Table 4. Hedging Effectiveness for the Live Hog Period

Unit: $/lb.

Panel A: Continuous Hedge

		Variance	Reduction in Variance
Unhedged		0.0484	
Case 1. One-to-One		0.0276	0.4298
Case 2. Single	LPK	0.0225	0.5351
	GARCH	0.0298	0.3843
Case 3. Multiproduct	LPK	0.0264	0.4545
	GARCH	0.0307	0.3657

Panel B: Selective Hedge

	Price Forecast	HR Forecast	Variance	Reduction in Variance
Unhedged			0.0484	
Case 4.	LPK	LPK	0.0307	0.3652
	VAR		0.0322	0.3356
	NAIVE		0.0317	0.3444
Single	LPK	GARCH	0.0341	0.2951
	VAR		0.0329	0.3204
	NAIVE		0.0348	0.2802
Case 5.	LPK	LPK	0.0253	0.4782
	VAR		0.0269	0.4446
	NAIVE		0.0256	0.4720
Multiproduct	LPK	GARCH	0.0291	0.3988
	VAR		0.0299	0.3812
	NAIVE		0.0256	0.4708
Case 6.	LPK	One-to-One	0.0307	0.3640
	VAR		0.0322	0.3098
	NAIVE		0.0317	0.3571

Reference

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