REOPTIMIZATION OF MOVING AVERAGES FOR USE IN HEDGING PROGRAMS

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REOPTIMIZATION OF MOVING AVERAGES FOR USE IN HEDGING PROGRAMS

John R. Franzmann and Philip W. Sronce*

In a world of imperfect knowledge producers find it necessary to assume risks in an effort to increase profits. Commitment of resources to the production process entails acceptance of production risks. In addition, producers are exposed to price risks which may exceed the production risks.

Hog production entails significant price risk. From the time resources are first committed until the time hogs are ready to market, price expectations may change dramatically. Production adjustments may be made but changes in price can outweigh the effects of the production adjustments. Since 1974 cash prices for barrows and gilts have fluctuated widely (Figure 1). Large fluctuations have occured even within a given year. In 1980, for example, average monthly prices ranged from a low of $28.86 per hundredweight to $48.30 per hundredweight. In 1980, futures prices for hogs exhibited even wider fluctuations ranging from $27.00 per hundredweight to $52.00 per hundredweight.

Extreme price variation can result in negative profit outcomes which, in turn, increase the potential for financial failure. One option for managing price risks is engaging in hedging operations. Futures trading in hogs began in 1966 and since then producers have been able to use futures markets to reduce price risks from hog operations.

In the past few years research concerning live cattle futures markets, feeder cattle futures and corn futures has suggested that profits from hedging operations may be increased through programs of multiple hedging.[1] The research investigated the use of technical tools of analysis such as point-and-figure analysis and moving averages to produce signals to establish and lift hedges several times over the course of the production period. Most of the work done with the cattle markets employed moving averages to determine the points to place and lift hedges.

The use of moving averages as a tool to manage price risk involves choosing an "appropriate" set of moving averages to employ.

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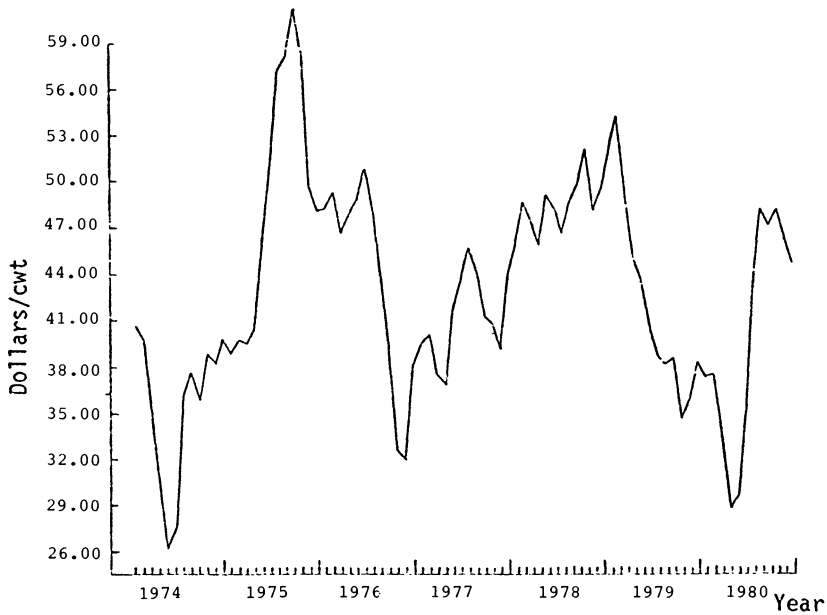
[1]Multiple hedging means to hedge the same product more than once over a given production period as contrasted with a forward pricing hedge which is placed during the production period and lifted only when the product is marketed.



Source: USDA, Livestock and Meat Situation (February, 1974-1981)

Figure 1. Monthly Average Prices for Barrows and Gilts from Seven Markets Combined, 1974-1980

In the cattle research by Franzmann and Lehenbauer and Franzmann and Shields[2] the number of averages to use and their respective lengths were determined using a data base of five years. It is not clear, however, that this is the "best" length of time over which to estimate the moving averages parameters. Profits might be increased, for example, by optimizing the length of the data base as well as the number and length of the moving averages. Optimum data base, in turn, determines the frequency with which the averages should be re-optimized. It was the objective of this work to address the question of the optimum length of the data base and the optimum frequency at which the averages should be reoptimized.

Procedure

Daily closing prices from selected live hog futures contracts were used to compute moving averages over the time period from October 1, 1975 through October 31, 1981. The selected data were considered representative of current hog price movements. In the past, analysis of optimizing moving averages parameters had been viewed in an ex post fashion. Moving average parameters were optimized and tested over the same data set. In this analysis, moving average combinations are chosen based on past performance then tested over a future time period. For example, data over the period January through September is used to optimize a set of moving averages and the resulting set of averages is used to make buy and sell decisions over the period October through December. Then, data from April through December is used to develop a new set of optimized moving averages and the new averages are used to make Buy and Sell decisions over the period January through March.

Selecting Optimal Moving Average Parameters

To complete the objective of this analysis an attempt was made to answer the following three questions: (1) what technique will be used to optimize moving average parameters, (2) with what frequency should moving average parameters be reoptimized, and (3) how much past price data should be used to update the moving average parameters.

The first question was answered through the implementation of a computerized moving average optimizer program. A moving average program, which simulates futures trading using moving averages to generate buy and sell signials, was incorporated into a direct search technique known as the Box Complex Procedure (Richardson, Ray, and

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[2]Franzmann, J. R. and Lehenbauer, J. D., Hedging Feeder Cattle with the Aid of Moving Averages, Oklahoma Agricultural Experiment Station Bulletin 746, July, 1979.

Franzmann, J. R. and Shields, M. E., Managing Feedlot Price Risks: Fed Cattle, Feeder Cattle, and Corn, Oklahoma Agricutural Experiment Station Bulletin B-759, October, 1981.

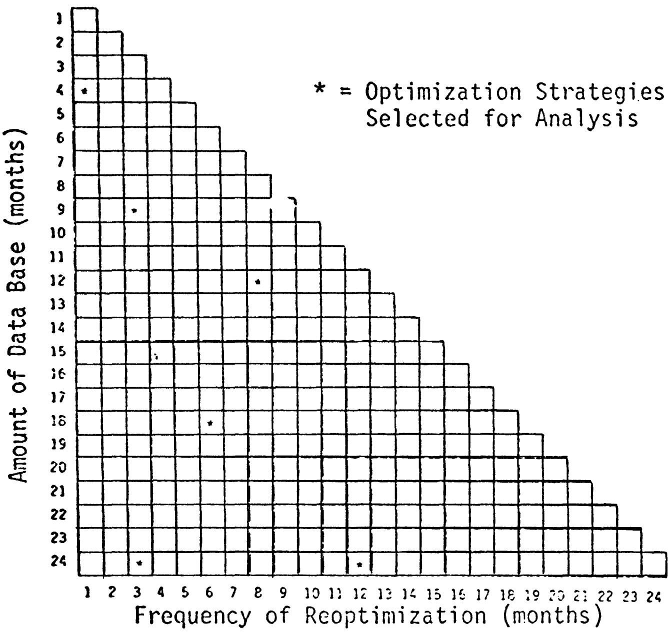

Figure 2. Possible Combinations of Frequency of Reoptimization and Size of Data Base

Trapp, 1979). This hill climbing procedure, which solves constrained optimization problems, employs a closed-loop feedback process to search the surface of a performance measure for its global maximum or minimum. In this case, the performance measure, net profit, was maximized. The constrained control variables include length and number of moving averages, the option of linearly weighting, and variation of the penetration level. The program also has the capability of incorporating a stop-loss option, but was not used since the penetration rule achieves similar results. An initial moving average was provided, then the program randomly generated four more moving averages. An iterative procedure continued to solve the constrained optimization problem until changes in the constrained control variables no longer improved the performance measure.

Limitations exist when using the Box Complex Procedure. One problem was that moving averages are discrete variables while optimal control techniques are designed for continuous systems. A 4.24 day moving average, for example, does not make sense because the closing price for each day was used to compute the average. The program was modified to accomodate for this difficulty by truncating the values of the constrained variables. Due to truncation and the fact that many profit hills existed, difficulties arose in determining whether a local or global maximum had been ultimately attained. Sometimes more than one search was necessary to determine if a maximum was global or local.

After several trial runs of the program and reviewing published moving averages on live hog price data, boundaries and an initial starting position were chosen for the program. Since many computer trials were involved in completing the selected reoptimization combinations, options within the Box Complex Procedure were limited to a set of two moving average parameters and a penetration rule. The lower boundaries for the short and long moving average were chosen to be zero. The upper boundaries chosen for the short and the long moving average were 7 and 21, respectively.

The moving average program[3] computed moving averages for live hog futures price data, then implemented trades according to buy and sell signals. To make the program as realistic as possible, trading rules were incorporated into the program as follows:

1. No trades occurred on days when the high and low prices were equal.
2. No trades were transacted on days when the closing price was up or down the daily limit.
3. Due to the threat of delivery, no new buy signals were honored after the first of the delivery month.
4. A charge of $50.00 per trade was assessed for commission cost.

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[3] The moving average program was designed by Dr. Meg Kletke at Oklahoma State University. Roberta Helberg, also at Oklahoma State University, made appropriate changes in the program to accommodate the live hog futures price data.

The output of the program provides a comprehensive set of trading data. For each contract, the date for each transaction is followed by the open, high, low, close, type of transaction (buy or sell), transaction price, trade number, profit for each trade, and cumulative profit for short, long and total trades. Additional information includes the total number of trades, total profit from all trades and average profit per trade. Below this output are the moving averages values and the respective dates on which the trades were executed. Percentages of profitable short, long and total trades are also included in the annual and final summaries.

Selecting Optimal Reoptimization Time Spans in Conjunction with Optimal Length of Data Base

Figure 2 is provided to illustrate possible combinations of data base requirements and frequency the data is to be reoptimized. Since investigation of all possible combinations would be too costly with respect to time and money, selected combinations were identified for testing. A maximum data base of 24 months of live hog futures price data per combination was employed due to the amount of data needed to adequately test the various combinations over time. The following combinations were examined:

I. Reoptimizing 4 months of live hog futures price data every month.

II. Reoptimizing 9 months of live hog futures price data every 3 months.

III. Reoptimizing 12 months of live hog futures price data every 8 months.

IV. Reoptimizing 18 months of live hog futures price data every 6 months

V. Reoptimizing 24 months of live hog futures price data every 3 months.

VI. Reoptimizing 24 months of live hog futures price data every 2 months.

Once computer trials were comleted for the selected reoptimizations, options within the Box Complex Procedure were expanded to include 3 linearly weighted or unweighted moving averages and a penetration rule for the reoptimization which provided the best results. The upper boundaries for the short, medium and long moving averages were 8, 20, and 26, respectively. The lower boundaries were set at zero. The penetration rule was limited to 40 cents at the upper extreme and zero at the lower extreme.

Results

Combination I

Four months of live hog futures price data were optimized each month. All 7 live hog futures contracts were used for this combination. They included February, April, June, July, August, October, and December contracts. Since the test period for all combinations was October 1, 1977 through March 31, 1981, optimization began 4 months prior to October 1, 1977. The first optimization period was from June 1, 1977 through September 30, 1977 and employed the October live hog contract. The set of moving average parameters which produced the highest net profit during this time frame, was tested on October 1977 price data using the December live hog contract. When optimizing over the second time period, price data from June 1977 were dropped and October 1977 was added to make a new four-month time frame. Since no trading was permitted after the first day of the delivery month, price data from the December contract were used for optimization. The resulting optimal moving average parameters with their respective optimization time periods are listed in Table 1.

A wide range of optimum moving average lengths resulted in this combination. The short moving average ranged from a length of 1 to 3 days and the longer average from 3 to 19 days. With a relatively small data base one would expect significant changes in the moving average parameters over time.

Combination II

The next combination, optimizing 9 months of live hog futures price data every 3 months, employed 4 contracts: February, April, July, and October. Each contract was assigned 3 months of price data. The first optimization time period included prices from January 1, 1977 through September 1, 1977 and employed the April, July, and October contracts. January 1, 1977 through March 31, 1977 prices came from the April 1977 contract, April 1, 1977 through June 30, 1977 were assigned to the July 1977 contract and July 1, 1977 through September 30, 1977 came from the October 1977 contract. After optimization for this time frame was completed, the results were employed on the ensuing 3 months of price data from the February 1978 contract. Each successive optimization dropped the oldest contract and added a new contract to the beginning of the series. The sets of moving average parameters developed from all optimizations are reported in Table 2.

The optimum moving averages in the strategy resulted in a smaller range of lengths compared to Combination I. The short moving average lengths ranged from a length of 3 days to 6 days while the long moving average ranged from a length of 7 days to 19 days. Of the 14 time periods, 4 time periods resulted in short moving averages 3 days in length, 4 time periods resulted in short moving averages 4 days in length, 4 time periods resulted in short moving averages 5 days in length and 2 time periods resulted in short moving averages of 6 days in length.

Combination III

The February, June, and October contracts were used to optimize 12 months of live hog price data every 8 months. Prices from January

TABLE 1. OPTIMUM MOVING AVERAGES DEVELOPED FROM 4 MONTHS OF LIVE HOG FUTURES PRICES AND REOPTIMIZED EACH MONTH (COMBINATION I).

Time Period of Optimization (dates)	Lengths of Moving Averages	
06/01/77 - 09/30/77	5	18
07/01/77 - 10/31/77	3	10
08/01/77 - 11/30/77	3	13
09/01/77 - 12/31/77	3	7
10/01/77 - 01/31/78	3	16
11/01/77 - 02/29/78	2	4
12/01/77 - 03/31/78	1	3
01/01/78 - 04/30/78	5	18
02/01/78 - 05/31/78	5	18
03/01/78 - 06/30/78	5	18
04/01/78 - 07/31/78	2	8
05/01/78 - 08/31/78	2	9
06/01/78 - 09/30/78	4	17
07/01/78 - 10/31/78	3	12
08/01/78 - 11/30/78	5	10
09/01/78 - 12/31/78	2	12
10/01/78 - 01/31/79	4	11
11/01/78 - 02/29/79	4	13
12/01/78 - 03/31/79	4	12
01/01/79 - 04/30/79	2	12
02/01/79 - 05/31/79	2	12
03/01/79 - 06/30/79	4	13
04/01/79 - 07/31/79	4	16
05/01/79 - 08/31/79	3	13
06/01/79 - 09/30/79	4	10
07/01/79 - 10/31/79	3	10
08/01/79 - 11/30/79	6	19
09/01/79 - 12/31/79	6	19
10/01/79 - 01/31/80	5	18
11/01/79 - 02/29/80	3	7
12/01/79 - 03/31/80	3	7
01/01/80 - 04/30/80	3	13
02/01/80 - 05/31/80	3	14
03/01/80 - 05/30/80	3	7
04/01/80 - 07/31/80	2	6
05/01/80 - 08/31/80	4	16
06/01/80 - 09/30/80	4	15
07/01/80 - 10/31/80	5	13
08/01/80 - 11/30/80	5	13
09/01/80 - 12/31/80	5	13
10/01/80 - 01/31/81	4	13
11/01/80 - 02/29/81	1	3

TABLE 2. OPTIMUM MOVING AVERAGES DEVELOPED FROM 9 MONTHS OF LIVE HOG FUTURES PRICES AND REOPTIMIZED EVERY 3 MONTHS (COMBINATION II).

Time Period of Optimization (Dates)	Lengths of Moving Averages	
01/01/77 - 09/30/77	5	13
04/91/77 - 12/31/77	5	8
07/01/77 - 03/31/78	6	19
10/01/77 - 06/30/78	5	18
01/01/78 - 09/30/78	3	12
04/01/78 - 12/31/78	3	14
07/01/78 - 03/31/79	4	12
10/01/78 - 06/30/79	4	11
01/01/79 - 09/30/79	4	13
04/01/79 - 12/31/79	5	18
07/01/79 - 03/31/80	6	19
10/01/79 - 06/30/80	3	15
01/01/80 - 09/30/80	3	7
04/01/80 - 12/31/80	4	15

TABLE 3. OPTIMUM MOVING AVERAGES DEVELOPED FROM 12 MONTHS OF LIVE HOG FUTURES PRICES AND REOPTIMIZED EVERY 8 MONTHS (COMBINATION III).

Time Period of Optimization (Dates)	Lengths of Moving Averages	
05/01/76 - 04/30/77	3	7
01/01/77 - 12/31/77	3	11
09/01/77 - 08/31/78	3	10
05/01/78 - 04/30/79	3	11
01/01/79 - 12/31/79	5	17
09/01/79 - 08/31/80	4	16

1 through April 30, May 1 through August 31, and September 1 through December 31 were taken from the June, October, and December contracts, respectively. The first optimization time period used the December 1976, June 1977, and October 1977 contracts. Each successive optimization dropped the 2 oldest contracts from the end and added 2 new contracts to the beginning of the series. Table 3 contains the optimization time period and respective optimal moving average parameters.

The optimum moving agerage lengths within this combination did not change significantly until the final two time periods. For the first 4 time periods the short moving average was 3 days in length. For the same 4 time periods the long moving averages ranged from a length of 7 days to 11 days. The short moving average lengths for the final 2 time periods were 5 days and 4 days, respectively, while the long moving average lengths were 17 days and 16 days, respectively. The final 2 sets of moving averages were slower responding moving averages compared to the moving averages of the first 4 time periods.

Combination IV

Table 4 contains the results of optimizing 18 months of live hog futures price data every 6 months. The contracts and price data assigned to each contract were the same as for Combination II. For this combination, 6 contracts were used for each optimization. On successive optimizations the oldest two contracts were dropped from the end and 2 new contracts were added to the beginning of the series.

The moving average lengths of this combination tended to be slower and less responsive than the moving averages in the previous combinations. Of the 7 time periods, 4 time periods resulted with a short moving average of 6 days in length. The long moving average lengths ranged form 11 days to 17 days.

Combination V

Optimizing 24 months of live hog futures price data every 3 months employed the same contracts and assigned price data as in Combination II. This combination employed 8 contracts for each optimization. The oldest contract is dropped from the end and a new contract is added to the beginning of the series for each successive optimization. The moving average parameters with their respective time period is pictured in Table 5.

The short moving averages ranged from a length of 3 days to 6 days, but 7 of the 14 time periods resulted in a short moving average of 4 days. The long moving averages ranged from a length of 5 days to 18 days. Six of the 14 time periods resulted in long moving averages ranging from 10 days to 13 days in length. Four of the time periods had long moving averages of a longer span than the previously mentioned time periods. The remaining 4 time periods were characterized by the shortest long moving averages depicted in Combination V.

TABLE 4. OPTIMUM MOVING AVERAGES DEVELOPED FROM 18 MONTHS OF LIVE HOG FUTURES PRICES AND REOPTIMIZED EVERY 6 MONTHS (COMBINATION IV).

Time Period of Optimization (Dates)	Lengths of Moving Averages	
04/01/76 - 09/30/77	6	11
10/01/76 - 03/31/78	6	15
04/04/77 - 09/30/78	6	15
10/01/77 - 03/31/79	3	12
04/01/78 - 09/30/79	4	13
10/01/78 - 03/31/80	4	11
04/01/79 - 09/30/80	6	17

TABLE 5. OPTIMUM MOVING AVERAGES DEVELOPED FROM 24 MONTHS OF LIVE HOG FUTURES PRICES AND REOPTIMIZED EVERY 3 MONTHS (COMBINATION V).

Time Period of Optimization (Dates)	Lengths of Moving Averages	
10/01/75 - 09/30/77	4	12
01/01/76 - 12/31/77	4	5
04/04/76 - 03/31/78	6	16
07/01/76 - 06/30/78	4	8
10/01/76 - 09/30/78	3	10
01/01/77 - 12/31/78	3	12
04/01/77 - 03/31/79	4	8
07/01/77 - 06/30/79	5	18
10/01/77 - 09/30/79	3	9
01/01/78 - 12/31/79	5	18
04/01/78 - 03/31/80	4	11
07/01/78 - 06/30/80	3	10
10/01/78 - 09/30/80	4	13
01/01/79 - 12/31/81	4	15

Combination VI

The final combination optimized 24 months of live hog futures price data every 12 months. Again, the contracts and respective price data for each contract were the same as Combination II. Eight contracts were used for each optimization. Four new contracts were added to the beginning and the oldest 4 contracts were dropped from the end of the series for each successive optimization. Table 6 contains moving average parameters derived from the optimization procedure with their respective time frames.

Of the four time periods in this combination, 2 of the short moving averages resulted in a length of 3 days and 2 resulted in a length of 4 days. The long moving averages ranged from a length of 9 days to 13 days.

Combination VII

Combination VII also optimized 24 months of live hog futures price data every 12 months. In this combination, the Box Complex Procedure included additional options of linearly weighted moving averages, a third moving average, and a penetration rule. The moving average parameters and their respective optimization time periods are reported in Table 7.

The short moving averages ranged from 2 days to 5 days in length. One of the short moving averages was a 4-day linearly weighted moving average. The medium moving average lengths ranged from 7 days to 15 days. Two of the medium moving averages were linearly weighted. The long moving averages ranged from 9 days to 17 days in length. The penetration levels ranged from 8 cents to 21 cents. These moving average parameters resulted in considerably fewer trading signals due to the addition of the confirming moving average and the penetration rule.

Profitability of the Reoptimization Combinations

Table 8 contains the results of trading in the live hog futures market with respect to each combination described above. Combinations III and VI were the only combinations resulting in positive total net profits. Combination III resulted in the highest total net profit and net profits on long trades. Combination VI resulted in the second highest total net profit, but outperformed Combination III with respect to short trades and percentage of profitble short trades. Combinations III and VI short trades netted $1,165 and $1,621, respectively. Total net profits were $5,158 for Combination III and $4,077 for Combination VI. Percentages of profitable short trades for Combinations III and were 30.0 and 34.8, respectively.

Since the results of this analysis are to be incorporated into hedging strategies at a later stage, short trade performance is viewed as an important criteria in choosing an effective combination. When multiple hedging slaughter hogs, a producer is in the futures market

TABLE 6. OPTIMUM MOVING AVERAGES DEVELOPED FROM 24 MONTHS OF LIVE HOG FUTURES PRICES AND REOPTIMIZED EVERY 12 MONTHS (COMBINATION VI).

Time Period of Optimization (Dates)	Lengths of Moving Averages	
10/01/75 - 09/30/77	4	12
10/01/76 - 09/30/78	3	10
10/01/77 - 09/30/79	3	9
10/01/78 - 09/30/80	4	13

TABLE 7. OPTIMUM MOVING AVERAGES WITH ASSOCIATED PENETRATION LEVELS DEVELOPED FROM 24 MONTHS OF LIVE HOG FUTURES PRICES AND REOPTIMIZED EVERY 12 MONTHS (COMBINATION VII).

Time Period of Optimization (Dates)	Lengths of Moving Averages*			Penetration Level
10/01/75 - 09/30/77	3	7	9	.21
10/01/76 - 09/30/78	5	W15	W17	.08
10/01/77 - 09/30/79	W4	W12	W17	.14
10/01/78 - 09/30/80	2	11	16	.18

*W denotes a linearly weighted moving average.

TABLE 8. RESULTS OF SEVEN OPTIMIZATION COMBINATIONS USING LIVE HOG FUTURES PRICES, OCTOBER 1, 1977 - MARCH 31, 1981.

	Total Net Profit	Net Profit from Long Trades	Net Profit from Short Trades	Total Net Profit Per Trade	Percent Profitable Long Trades	Percent Profitable Short Trades	Percent Profitable Trades
	($)	($)	($)	($)	(%)	(%)	(%)
I	-1704	377	-2081	-14.95	43.0	36.0	39.0
II	-1055	-135	-920	-12.41	47.6	32.6	40.0
III	5158	3993	1165	65.29	48.7	30.0	39.2
IV	-975	-20	-955	-12.50	51.4	31.7	42.3
V	-1273	-219	-1054	-13.40	50.0	30.6	40.0
VI	4077	2456	1621	45.30	45.5	34.8	40.0
VII	-433	-1106	673	-9.21	40.9	32.0	36.2

on short trades and out of the market on long trades. Due to a better performance on short trades, Combination VI was the reoptimization combination for expansion of options within the Box Complex Procedure. This combination was coined Combination VII and although short trades showed a short net profit ($673), total net profit was negative.

Since reoptimization indicated unfavorable results, another approach was sought to attain a viable moving average trading system. Some sets of moving averages parameters responded quite well within their respective time frames. These moving averages were selected for testing over the entire test period. After examining the results of the selected sets of moving average parameters, 4 sets of moving average parameters were selected which performed significantly better than any of the reoptimization combinations. Table 9 contains the results of these selected moving averages. The percentage of profitable total, long and short trades for the top 4 sets of moving average parameters outperformed each of the reoptimization combinations. The 4-11-14 moving average set with a 17 cent penetration level generated $12,504 in total net profits with 50.0 percent of total trades resulting in a net profit. Forty-five percent of the short trades resulted in a net profit of $5,309. A close second is the 4-10-12 moving average set with a 14 cent penetration level. This moving average set generated $12,207 in total net profits with 47.6 percent of total trades showing a net profit. Short trades netted $4,958 on a 43.5 percent success rate.

Summary

Producers of agricultural products often face significant price risks and hog producers are no exception. In recent history prices for hogs have fluctuated more than $20 per hundredweight in a one year span. Such variability can threaten the financial integrity of a firm.

Protection against significant price risk can be obtained by hedging hog production in the futures markets. Hedging through the basis can provide important price risk protection. Multiple hedging programs can afford price risk protection and provide an opportunity for increased average returns.

The use of moving averages in a multiple hedging program requires that an optimum set (most profitable) of averages be chosen. Once an optimum set of averages has been chosen, the question arises as to when the averages might need to be reoptimized. This work addressed the issues 1) what technique to use to reoptimize a set of moving averages, 2) how frequently should a set of averages be reoptimized, and (3) how much historical data should be used in reoptimization. The Box Complex Procedure provided the technique to reoptimize the moving average parameters and a figure was constructed to select combinations of the final two questions. The results of the combinations were disappointing. Profit levels from trading were significantly lower than profit levels obtained by employing a single set of moving average parameters over the entire test period. Thus,

TABLE 9. RESULTS OF SELECTED MOVING AVERAGE COMBINATIONS USING LIVE HOG FUTURES PRICES, OCTOBER 1, 1977 - MARCH 31, 1981.

Moving Average Combination[a]		Total Net Profit	Net Profit from Long Trades	Net Profit from Short Trades	Total Net Profit Per Trade	Percent Profitable Long Trades	Percent Profitable Short Trades	Percent Profitable Total Trades
		($)	($)	($)	($)	(%)	(%)	(%)
7-10	(.26)	7174	3774	3400	121.43	48.1	42,9	45.4
4-11-14	(.17)	12504	7195	5309	347.33	56.3	45.0	50.0
4-10-12	(.14)	12207	7249	4958	290.64	52.6	43.5	47.6
3-13-20	(.09)	6524	3807	2717	171.68	55.6	40.0	47.4

[a]Lengths are in days. The number in parentheses is the minimum penetration required.

objective one was accomplished. From the results of this analysis, reoptimization does not appear to improve trading results. Four sets of moving average parameters were found which demonstrated significantly better results than the reoptimization combinations.

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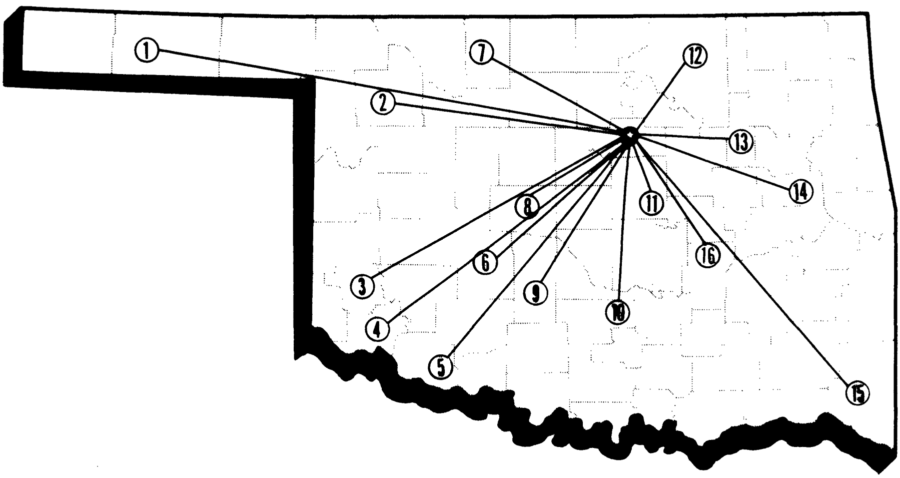

Main Station — *Stillwater, Perkins and Lake Carl Blackwell*

1. Panhandle Research Station — *Goodwell*
2. Southern Great Plains Field Station — *Woodward*
3. Sandyland Research Station — *Mangum*
4. Irrigation Research Station — *Altus*
5. Southwest Agronomy Research Station — *Tipton*
6. Caddo Research Station — *Ft. Cobb*
7. North Central Research Station — *Lahoma*
8. Southwestern Livestock and Forage Research Station — *El Reno*
9. South Central Research Station — *Chickasha*
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13. Vegetable Research Station — *Bixby*
14. Eastern Research Station — *Haskell*
15. Kiamichi Field Station — *Idabel*
16. Sarkeys Research and Demonstration Project — *Lamar*

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